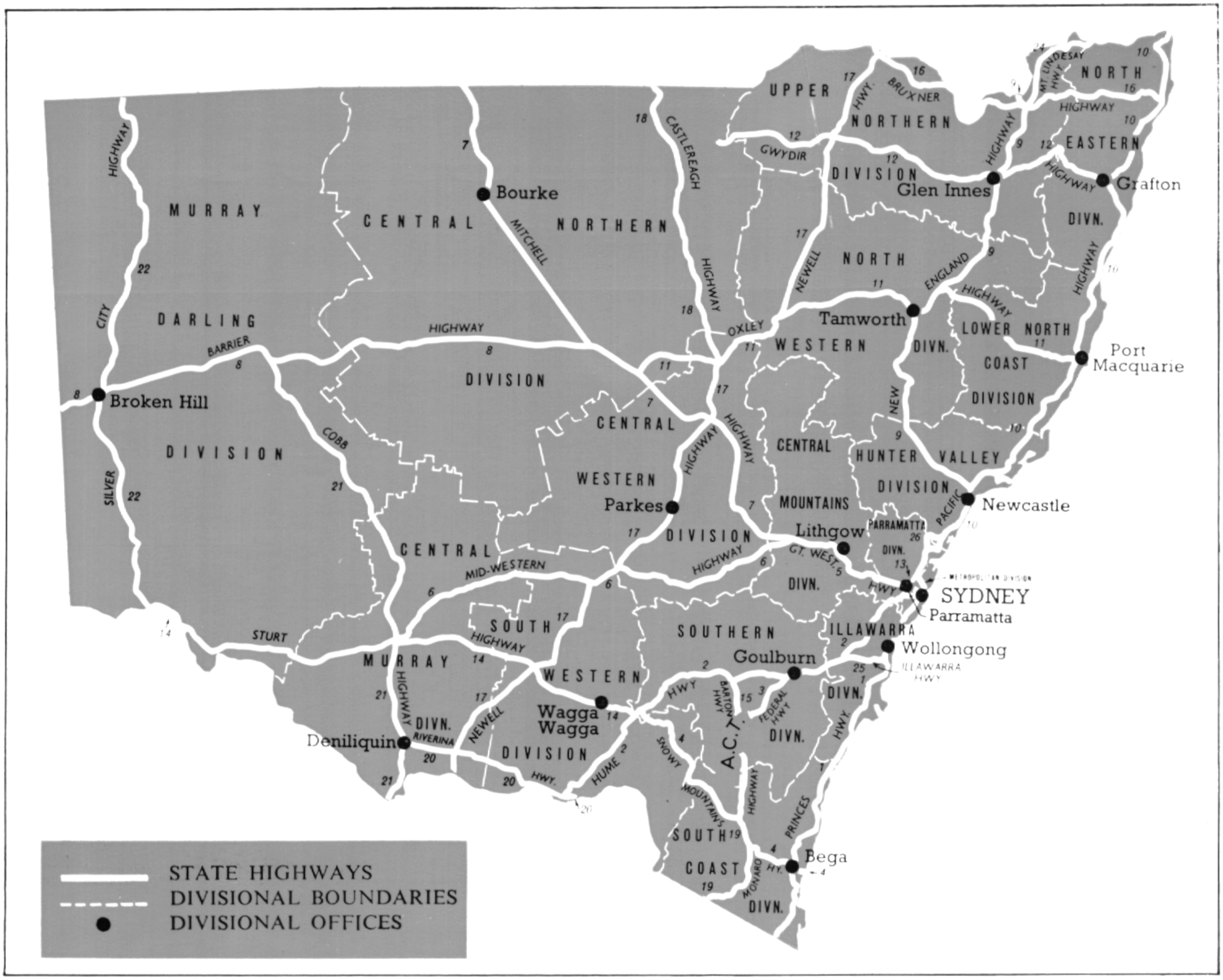
MAIN ROADS

MARCH 1974



New South Wales

Area—801 431 km² (309,433 sq miles)

Population as at 31st March, 1973—4 715 100 (estimated)

Length of Public Roads—208 890 km (129,745 miles)

Number of Motor Vehicles registered as at 30th June, 1973—2 328 037

ROAD CLASSIFICATIONS AND LENGTHS IN NEW SOUTH WALES

Lengths of Main, Tourist and Developmental Roads, as at 30th June, 1973. (Mileage equivalent shown in brackets.)

Freeways	63	(39)
State Highways	10 509	(6,527)
Trunk Roads	7 042	(4,374)
Ordinary Main Roads ..	18 470	(11,472)
Secondary Roads	290	(180)
Tourist Roads	396	(246)
Developmental Roads ..	3 896	(2,420)
Unclassified Roads	2 476	(1,538)
TOTAL	43 142 km	(26,796 miles)

MAIN ROADS

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CONTENTS

(Front Cover): Four piles for the bridge under construction at Bega frame a view of the old bridge crossing the Bega River

FREEDOM

Major road improvements for the inner Sydney area involve the construction of distributors and freeways to carry through traffic away from city streets. These routes have been planned for many years and a great deal of money has been spent on investigation, planning and preliminary design.

It is only now that new voices in the community are seeking to end the construction of these distributors and freeways before a satisfactory alternate means of public transport has been implemented or even planned. In fact, there is no real guarantee that the public can be weaned from its present dependence on, and love for, the motor car. If a massive new public transport scheme is built for Sydney, what are the assurances that it will develop and retain an appeal to the motorist? Is there evidence that he will not abandon it and return to his private car?

What are the chances of replacing a system of transport which so many people have already chosen and, as the numbers of motor vehicle registrations prove grows increasingly favourable each year, for an alternate system which at best cannot be as desirable or flexible as the chosen system?

There are facts available which show that freeways reduce the road toll—the Commonwealth Bureau of Roads stated that the opening of eight miles of freeway could be expected to save 10 to 15 fatalities and 150 to 250 casualties in a year. In a survey of community attitudes to road and road expenditure, the Commonwealth Bureau of Roads also found that the community generally favours expenditure by governments on roads ahead of rail and buses. Without doubt the community shows that it wants to retain the motor vehicle and that instead of being the tyrant it has recently been painted it is looked upon as a very convenient servant. No other means of transport can compete with its special door to door service.

The answer to the transportation crises is obviously to provide better roads. Not just to widen existing traffic routes, a temporary method of meeting traffic needs which is extremely expensive, but to build an integrated road network which can meet the expansion in the numbers of motor vehicles as well as catering for the total transportation needs of Sydney which includes rail and other fixed way systems for the mass transport of people and bulk freight for industry.

Finance to complete the Sydney freeway network and expand it to neighbouring centres of population must be found and the work continued at maximum speed. The geographic and economic features of Sydney demand that freeways leading to the city and around it remain part of the total freeway network.

The vocal opinions of one section of the community do not necessarily reflect the wishes of the majority and each true fact influencing freeway construction is looked at carefully remembering that the decisions made now will irrevocably influence the standard of living in this city right into the next century.●

GUNDAGAI

DOWN SOUTH

Design of new bridges at Gundagai and Bega

(*Above*): *An artist's impression of the bridge over the Murrumbidgee River at Gundagai*

Construction of the cast-in-place pile foundations for the new bridge over the Murrumbidgee River at Gundagai has been completed and construction of the substructure and superstructure of the bridge will commence early in 1974. The bridge is situated on a 4·4 mile (7·1 km) deviation of the Hume Highway. This article outlines the design features of the new bridge.

The new bridge, which will form part of the northbound carriageway of a future dual carriageway, will have an overall length of 3,750 ft. (1 143 m). The adopted design is similar to the design of the Macarthur Bridge over the Nepean River at Camden opened to traffic on 26th March, 1973.

On completion, the bridge at Gundagai will displace the Macarthur Bridge as the second longest road bridge in New South Wales and the longest ever built within the Department of Main Roads. (The longest road bridge is the Sydney Harbour Bridge, 3,770 ft. (1 149 m) long.)

Because of the topography at the bridge site, the abutment for the future second bridge, to carry the southbound carriageway, will be approximately 100 ft. (30 m) behind the abutment of the bridge now being constructed. The second bridge will require an additional span and would then become the longest road bridge in the State.

The bridge has three main spans across the Murrumbidgee River, 170 ft. (51·8 m), 260 ft. (79·2 m) and 170 ft. (51·8 m). The other 24 spans, each 130 ft. (39·6 m), form a viaduct across the flood plain on the southern side of the river.

The bridge has been designed as a composite steel and concrete structure. The main spans are comprised of two variable depth closed steel box girders with a concrete deck. The viaduct, has two open steel trough girders, trapezoidal in shape with a concrete deck.

The piers supporting the main spans are reinforced concrete walls, whereas the remaining 24 piers supporting the viaduct are single prestressed concrete columns with a prestressed headstock. The abutment at the northern end of the bridge is a counterfort retaining wall with subsidiary retaining walls. The abutment at the southern end of the bridge is an open spillthrough type frame.

The foundations are cast-in-place piles and these were placed using a Benoto pile boring machine.

LOCATION

Extensive investigations were conducted to determine the most suitable location for the new bridge. Particular care was taken to provide good alignment for the deviation with the minimum of interference to the built-up areas in Gundagai.

The site chosen is on the western outskirts of Gundagai, crossing the Murrumbidgee River adjacent to the Bluff, a prominent hill on the northern bank of the river. The new crossing is approximately one mile (1·6 km) downstream of the existing Prince Alfred Bridge, built in 1866. The Prince Alfred Bridge will remain in use for local traffic for the time being.

Although the new highway route will pass around Gundagai, adequate access to the town will be available from the new deviation.

WATERWAY REQUIREMENTS

Waterway studies for the bridge were carried out by the University of New South Wales, Water Research Laboratory and involved building a scale model which reproduced seven miles (11·3 km) of the Murrumbidgee River from 4·4 miles (7·1 km) upstream of the proposed bridge to 2·6 miles (4·2 km) downstream. The main purpose of the studies was to determine the length of embankment on the southern side of the flood plain which could be used as part of the crossing.

Various lengths of embankment were tested and the flood levels for each case, both at the bridge site and upstream at Gundagai, were noted. The velocity distribution at the bridge site for each length was also noted.

The main factors determining the position of the southern abutment were the effect of afflux at Gundagai, the location of high velocity flow over the flood plain, and local topography.

Using the scale model test results the the length of the southern approach embankment was determined at 1,000 ft. (305 m).

VERTICAL ALIGNMENT

The vertical alignment of the bridge is controlled by two factors:

(i) adequate clearance above the maximum probable flood predicted by the model tests; and

(ii) the provision of adequate clearance for Main Road No. 243 (Nangus Road) which skirts the Murrumbidgee River on its northern bank.

The adoption of a constant grade of 0·5% satisfies both factors and gives a clearance at the southern abutment approximately 8 inches (200 mm) above the maximum probable flood which has been predicted for this site. However, the clearance above the predicted once-in-100 year frequency flood, which is the flood level normally used for the design of highway bridges, is of the order of 6 ft. -6 in. (2 m).

The level of Main Road No. 243 will be lowered in the vicinity of the bridge by removing a short crest.

PILE FOUNDATIONS

Foundation test bores showed the presence of shale at approximately 80 ft. (24 m) below ground level. The top 20 ft. (6 m) or so of overburden is soil and the remainder sand and gravel.

The pile foundations for Piers No. 2 to No. 26 (inclusive) were placed using a Benoto pile boring machine. Material inside a steel casing was removed by a grab as the casing was driven into the weathered shale. A steel reinforcing cage was then placed inside the casing which was filled with concrete through a tremie. As the concrete was being poured the casing was withdrawn leaving a finished pile to act as a composite friction and end bearing pile.

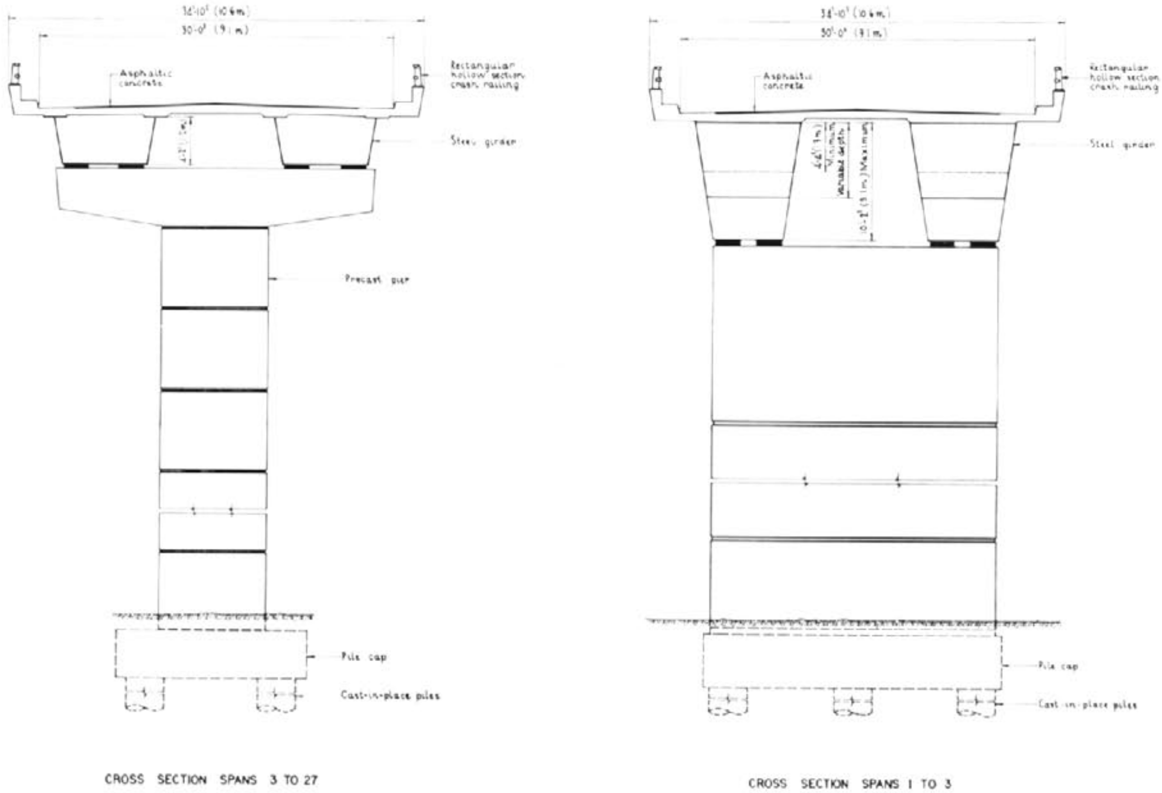
PIERS

(i) *Approach Viaduct*

The piers for the approach viaduct will be single columns with headstocks. The columns and headstocks will be precast units post-tensioned together on the site.

The direction of normal river flow in the channel is approximately 15° off square to the line of the bridge. This

Aerial mosaic of Gundagai showing the location of the new bridge and the proposed deviation



Cross section of spans of Gundagai Bridge

skew angle could increase to 35° at high floods.

At high floods the velocity of the water crossing the flood plains becomes greater than that of the water in the main channel. The highest flow velocities will occur near the centre of the flood plain and are predicted to reach 21 ft./sec. (6·4 m/sec.) for the maximum probable flood.

Investigations into the effects of afflux due to various types of piers showed that optimum type was a single rectangular column with chamfered ends, i.e. with cutwaters, aligned parallel to the flow. As the direction of flow is not constant across the flood plain, this arrangement is not practicable. The next most favoured pier type was a similar rectangular pier square to the centre line of bridge, or a single round column.

The cross section adopted for the pier is elliptical, which is a compromise between the circular and rectangular sections favoured. All piers will be founded on four piles and pier height will vary between 26 ft. (7·9 m) and 40 ft. (12·2 m).

(ii) *Main Spans*

The piers which support the main spans, i.e. Piers 1 and 2, will be elongated elliptically shaped wall-type piers.

The direction and velocity of flood flow are not as severe at the northern side of the flood plain and wall piers for the main spans do not present any difficulties in this regard.

The pier on the southern side of the river, Pier 2, will be founded on piles taken to shale approximately 40 ft. (12 m) below natural surface. This pier has two rows of piles.

Pier 1, located on the steep northern bank of the river will be constructed on a spread footing founded in shale.

ABUTMENTS

The northern abutment is a counterfort type retaining wall on shallow spread footings founded in shale.

The southern abutment is an "open buttress" type spillthrough abutment founded on cast-in-place piles. The face of the embankment will be protected from scour by pitching.

BEARINGS

Bearings will be provided at the top of all piers, with two sets of bearings on the

METRIC CONVERSION

m = metre (1 m = 3·28 feet), mm = millimetre (1 mm = 0·0394 inch), km = kilometre (1 km = 0·621 mile), km² = square kilometre (1 km² = 0·386 square mile), ha = hectare (1 ha = 2·47 acres), t = tonne (1 t = 0·984 ton), m² = square metre (1 m² = 1·2 square yards), m³ = cubic metre (1 m³ = 1·31 cubic yards), kg = kilogram (1 kg = 2·2 pounds), l = litre (1 l = 0·22 gallons), kPa = kilo-pascal (1 kPa = 0·145 p.s.i.)

piers at the superstructure expansion joints.

Fixed bearings will be provided at both abutments and at Piers 5, 9, 13, 17 and 21.

Sliding bearings will be provided at all other piers.

SUPERSTRUCTURE

(i) *Approach Viaduct*

The superstructure of the approach viaduct will be similar to the superstructure of the Macarthur Bridge at Camden. (Articles on the Macarthur Bridge appear in "Main Roads" June 1971, Vol. 36 No. 4 pp 98-103 and December, 1972, 38 No. 2 pp 58-63.)

The superstructure consists of two continuous steel trapezoidal trough girders each 9 ft. (2·74 m) wide acting compositely with a reinforced concrete deck. Each continuous four-span length of superstructure will be initially erected on temporary supports at the intermediate piers to introduce a temporary camber. After the concrete deck has been placed and cured, the superstructure will be lowered onto permanent bearings.

The lowering procedure redistributes the bending moments reducing the stresses at the piers and increasing the stresses at midspan. As well as avoiding major changes in cross section of the steel girder, this technique produces an initial compression in the concrete deck slabs to help counteract the effects of shrinkage and tensile stresses over the piers.

An investigation by the designers showed that the cost involved in lowering the structure at Camden was less than the cost of additional steel which would have been required if the superstructure had not been lowered.

There will be no stiffeners on the webs of the girders of the viaduct spans but the bottom flange will be stiffened longitudinally at the piers to prevent buckling.

Suitably stiffened diaphragms will be provided at the piers.

(a) *Main Spans*

The girders for the main spans are closed steel box girders of trapezoidal cross section acting compositely with a reinforced concrete deck.

The boxes will have a constant width of 10 ft. (3·05 m) at the top. They will be 4 ft. 4 in. (1·32 m) deep at Abutment A and Pier 3, and 10 ft 2 in. (3·10 m) deep at Piers 1 and 2.

The box girders will have a haunched soffit and, as the webs are tapered, the bottom flange width will vary accordingly.

The webs of the box girders, and the compression flanges over the piers, will require internal stiffeners. The outside of the box girders will be smooth. The maximum thickness of the flange plate will be 1¼ inches (32 mm).

PROTECTIVE TREATMENT

All metal surfaces will be abrasive blast cleaned and prime-coated with an inorganic zinc silicate primer. The final protective treatment will consist of a vinyl or chlorinated rubber type coating with a satin finish.

QUANTITIES

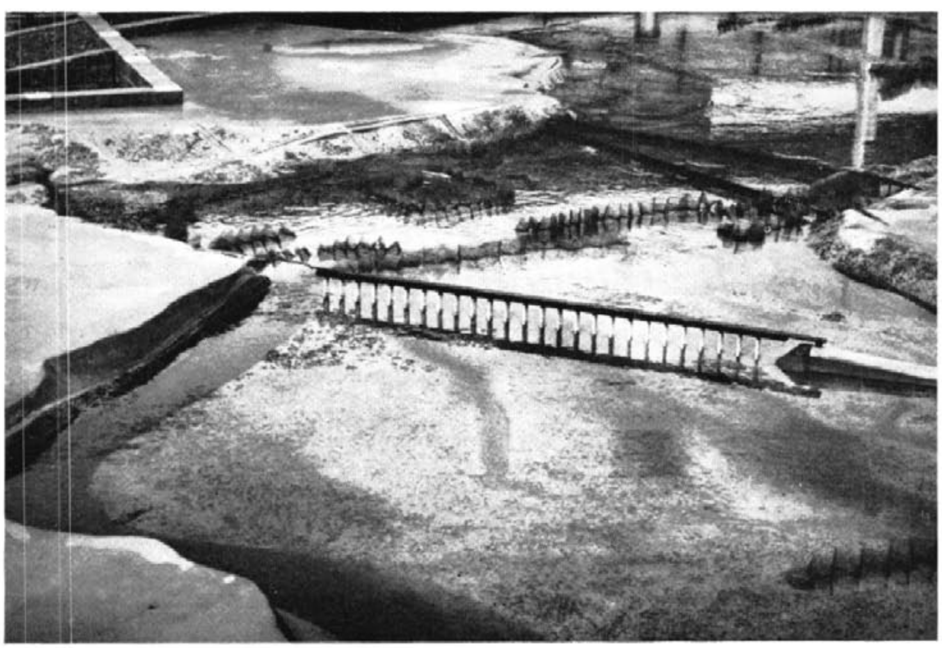
The approximate quantities of materials in the bridge are:

Cast-in-place concrete piles.	8,000 feet (2 438 m)
Structural steel:	
Grade 350 LO	253 tons (257 tonnes)
Grade 250 LO	1,165 tons (1 184 tonnes)
Grade 250	756 tons (768 tonnes)
Prestressed concrete (in piers).	
Class 6K (41 MPa)	939 cu. yd. (718 m³)
Reinforced concrete Class 3K. (21 MPa) and Class 4·5K (31 MPa).	5,418 cu. yd. (4 142 m³)
Reinforcing steel including prestressing bars	857 tons (871 tonnes)
Excavation	2 485 cu. yd. (1 900 m³)
Crash railing	7,540 lin. ft. (2 298 m)

CONSTRUCTION

Tenders for the construction of the bridge have been invited by the Department and it is expected that a contract will be let in April, 1974.

The total cost of the deviation including the bridge over the Murrumbidgee River, as well as a number of minor structures, is estimated at about $5 million●



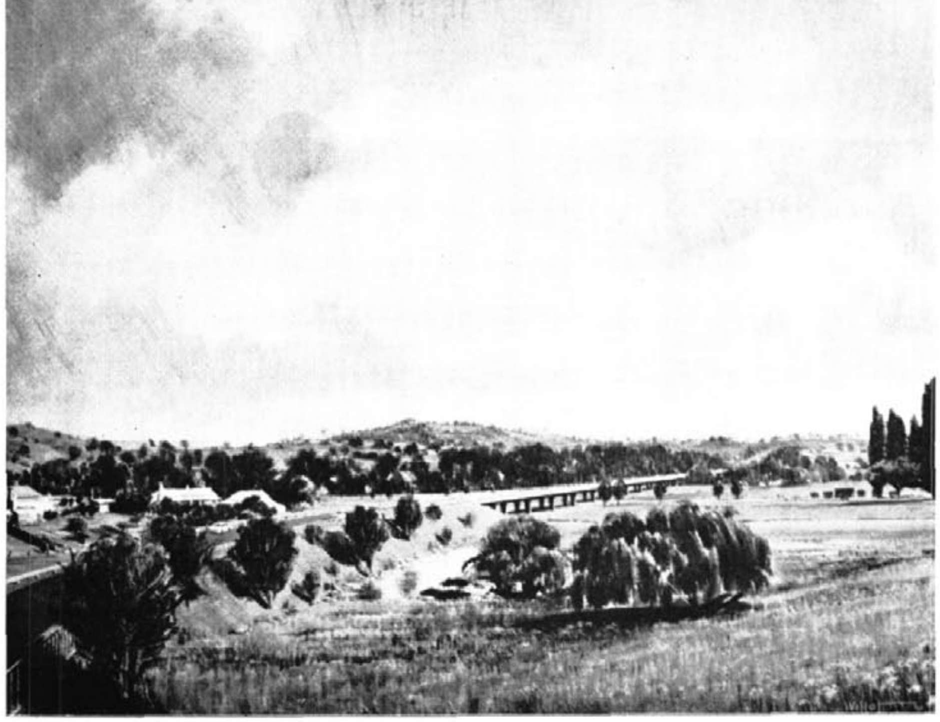
In this scale model, 7 miles (11·3 km) of the Murrumbidgee River was reproduced and a study made of the bridge site under all possible flood conditions. An embankment and the viaduct section of the bridge from the southern bank of the river is shown in the centre of the photograph

BEGA

Bega, a delightful South Coast town at the centre of a thriving dairying district is situated on the tree lined Bega River. Normally the river consists of shallow waters meandering across a broad sandy river bed. However, following heavy rains the river quickly rises to a raging torrent, which in the past has caused major damage to the bridges at Bega and Tathra.

The Prince's Highway passes through the centre of Bega and at present crosses the Bega River at North Bega by a 433 ft. (132 m) long timber bridge built in 1898. The bridge is only 15 ft. (4·6 m) between kerbs and its poorly aligned approaches are subject to major flooding.

A new 2,046 ft. (624 m) long reinforced and prestressed concrete bridge is now under construction to replace this old bridge. Situated only 600 ft. (180 m) upstream of the existing bridge, the new bridge is part of the first stage of a motorway which will ultimately by-pass the town.



Artist's impression of new Bega Bridge

SITE CONDITIONS

The new bridge is on the downstream end of a sweeping bend in the river. A wide flood-plain exists on the inside of the bend, with considerable flow occurring across it in major floods. The new bridge will extend across the river and almost the full width of the flood plain and will cause very little restriction to the passage of floodwaters. It will have a clearance of 4 ft. (1·2 m) above the level of the 1971 flood.

Foundation boring indicated that the bridge site crosses a sunken valley filled with alluvial sands and sandy clays. Depths to granite bedrock vary from about 20 ft. (6 m) to just over 100 ft. (30 m). The granite is generally sound with a thin layer of decomposed granite over it.

DESIGN OF THE BRIDGE

The new bridge, designed within the Department of Main Roads, consists of twenty-one 90 ft. (27·4 m) spans and two 75 ft. 9 in. (23·1 m) end spans. Eleven spans cross the main river channel and the gently sloping northern bank, and the remaining twelve spans cross the flood plain. The bridge will have the longest continuous length of bridge superstructure, unbroken by any deck joint, in this State and will also be the sixth longest bridge in the State.

Figure 1 shows a cross-section and a part elevation of the new bridge. The twin prestressed concrete box girders are supported on reinforced concrete piers and abutments.

FOUNDATIONS

With sound rock at an average depth of 70 ft. (21 m) below the ground level, and readily penetrated overlying material it was decided to take the foundation to rock. This permitted the use of a continuous bridge free from the problem of any possible differential settlements. Apart from material economy, continuous spans look better and, by eliminating the deck joints, give much improved riding qualities.

Steel H-Section piles of 14 in. x 14½ in. (356 mm x 368 mm) cross-section were selected for the foundations because of their economy and also because of the relative ease of handling and driving the long lengths of piles required.

Each pier, with the exception of the Pier 12, is supported on six piles, the four outer piles being raked and the two central piles vertical. The pile cap for these piers is dumb-bell shaped to suit the unusual pile configuration.

Pier 12 at the centre of the bridge is supported on eight raked piles. The abutments are supported respectively on six piles at the northern abutment and eight at the southern abutment, a combination of raked and vertical piles being used.

The maximum design load on a pile is 140 tons (1,395 kN).

As the pile caps are below the ground surface, the piles are completely buried. The tops of the pile are protected against corrosion by encasing the uppermost 15 ft. (4·6 m) length of each pile in concrete. The concrete encasement is 2 ft. 3 in. (0·7 m) in diameter and is reinforced with longitudinal bars extending into the pile cap.

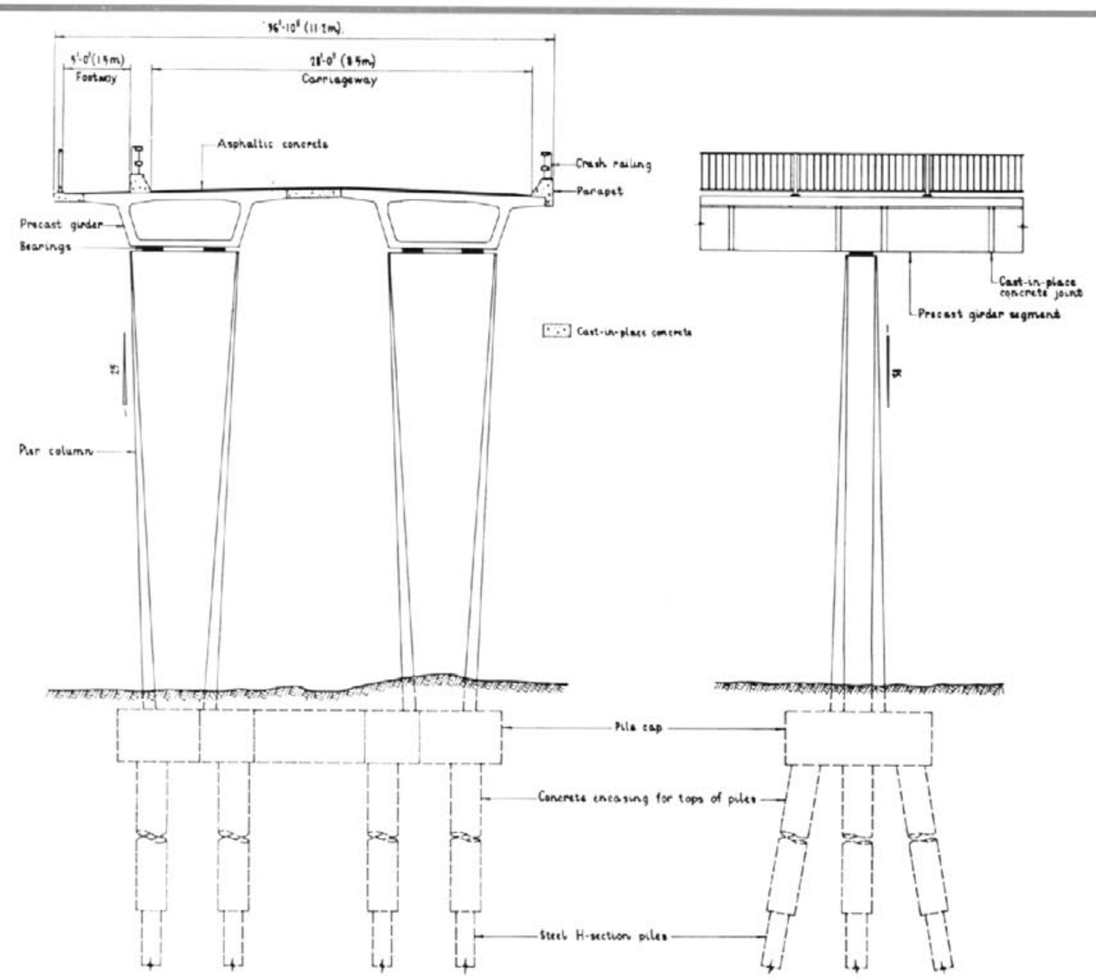
PIERS AND ABUTMENTS

Each of the twenty-two piers consists of two tapered concrete columns, one under each box girder, rising from a common pile cap. Although all the piers are similar, Pier 12 performs an additional function to that of the rest of the piers.

Pier 12, a short pier near the centre of the bridge, is the anchor pier to which the superstructure is fixed longitudinally. Relative movement between the superstructure and the other piers has been provided for by the use of expansion bearings.

Adopting an anchorage point near the centre of the bridge will result in the longitudinal friction forces developed at the bearings on the piers on either side of it being largely balanced. The anchor pier, however, has been designed to withstand an appreciable out-of-balance of friction forces and also for a substantial part of the longitudinal wind and traffic braking forces. This has resulted in Pier 12 being substantially stronger than the rest of the piers. Its columns are 6 in. (150 mm) thicker and more heavily reinforced.

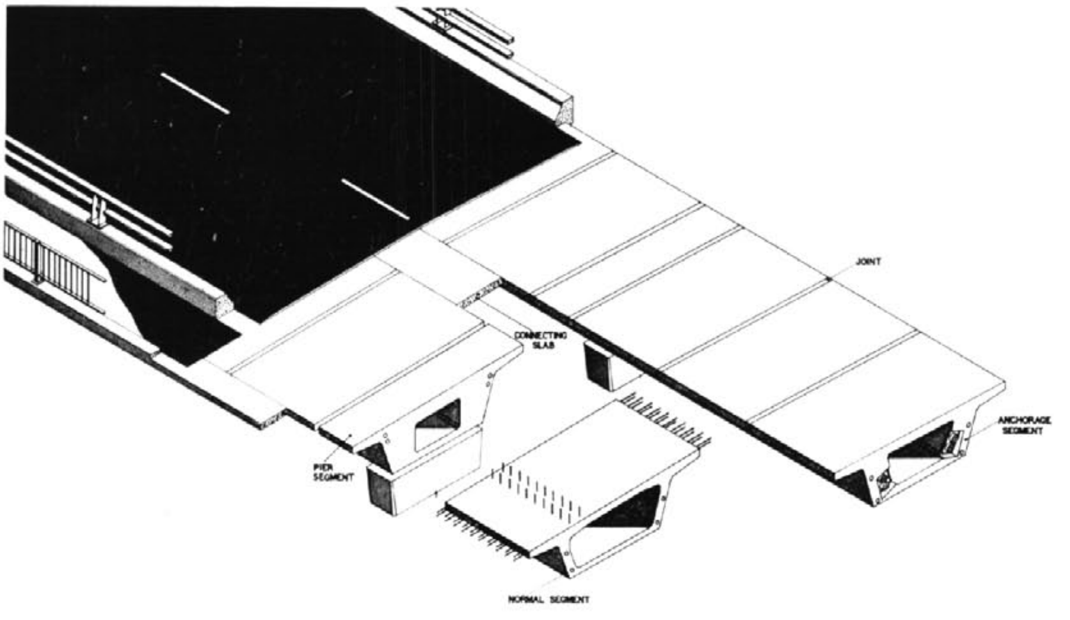
The pier columns are tapered in both directions, partly for aesthetic effect and partly for structural reasons. The columns



CROSS SECTION

PART ELEVATION

FIGURE 1



TYPICAL DETAILS OF SUPERSTRUCTURE

FIGURE 2

vary in height between 16 ft. (5 m) and 33 ft. (10 m), and the basic cross-section is octagonal. To allow maximum re-use of formwork, all piers have the same shape at the top and the same taper. The tops of the columns, with the exception of Pier 12, measure 8 ft. x 2 ft. 3 in. (2·4 x 0·7 m), the size being determined by the width of the girder and the dimensions of the bearings. The base of the tallest column is 5 ft. 4 in. x 4 ft. 0 in. (1·6 x 1·2 m) with 11 in. (0·3 m) chamfers.

Both abutments are of the buried "spill-through" type. Abutment A, the northern abutment, is 8 ft. (2·4 m) high and comprises a headstock supported directly on six piles. Abutment B, the southern abutment, is 30 ft. (9·1 m) high and the headstock is supported on four buttress walls 22 ft. (6·7 m) high founded on 8 piles in two rows.

SUPERSTRUCTURE

The superstructure provides a carriageway 28 ft. (8·5 m) between kerbs and a 5 ft. (1·5 m) footway on the downstream side. Steel crashrails mounted on low concrete parapets of a modified "New Jersey" shape, flank the carriageway. A grille type handrailing is provided on the outside of the footway. Both the carriageway and the footway are paved with asphaltic concrete.

The superstructure consists basically of twin concrete box girders as shown in Figures 1 and 2. The boxes, including the cantilevers of the top slab, are designed to be precast in 7 ft. 6 in. (2·3 m) long segments. Relatively small cast-in-place concrete sections complete the top slab and form the kerbs.

The precast girder segments are 4 ft. (1·2 m) deep on their centre-lines, with a bottom slab width of 8 ft. (2·4 m) and a top slab width of 15 ft. (4·6 m). The top slab thickness varies between 7 and 10 in. (180 and 250 mm) and the bottom slab is 6 in. (150 mm) thick. The webs are generally 8½ in. (220 mm) thick. Ducting is cast into the webs to allow the prestressing cables to be pulled through the girders. Reinforcing steel projects from all precast segments for attachment of cast-in-place slabs and parapets. Typical projecting reinforcement for the normal segment is shown in Figure 2 but the projecting reinforcement for the other segments has been omitted for clarity in this diagram.

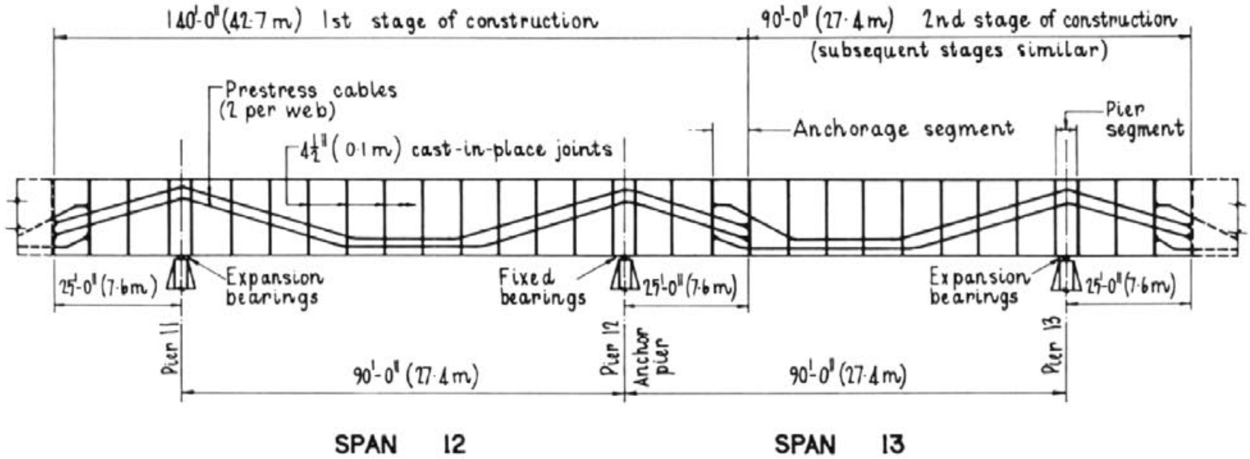
The bridge is designed to be constructed span-by-span commencing at the anchor pier and extending in both directions. Figure 3 shows diagrammatically the first two stages of construction. The first stage of girders to be erected is Span 12 together with 25 ft. (7·6 m) of each of the adjoining spans. The segments are correctly aligned and levelled on the falsework with 4½ inches (110 mm) gaps for in-situ joints between them. The ducts are made continuous across the gaps and the joints are then concreted. When the concrete in the joints is strong enough this length of girder is stressed with cables 140 ft. (42·7 m) long.

Thereafter, until the end spans are reached, the girders are extended in 90 ft. (27·4 m) lengths, with each length being stressed onto the end of the completed girder by cables 97 ft. (29·6 m) long. On the completion of each stage of stressing the structure is self supporting and all falsework may be removed.

The cables for each new length of girder to be added overlap the cables of the previously completed girder by a segment length. Thus two sets of cables are anchored at the opposite ends of the end segment of each stage. These anchorage segments have 2 ft. (610 mm) thick webs and the projection of the webs beyond the inside edges of the adjoining segment webs accommodate the heavy cable anchorages.

There are two cables in each web. Each cable consists of 19½ in. (12·7 mm) high strength steel strands for all the internal spans and 16½ in. (12·7 mm) for the end spans. The jacking loads are 610 (2713 kN) and 505 kips (2246 kN) respectively. The cables are stressed from the free end of the girder only, but observations and measurements can be made at the dead-end of the cable within the girder. Common anchorage plates are provided at the stressing ends for the two cables in each web at all intermediate stressing points. Individual anchorages are provided at the dead-ends and at the abutments.

The method of constructing the girders described above poses an unusual problem. The end of the completed girder moves longitudinally due to temperature variations, and the jointing concrete of the span being added must not be subjected to any applied forces



SPAN-BY-SPAN CONSTRUCTION
(Diagrammatic only)
FIGURE 3

prior to stressing. Fortunately, there are several methods of overcoming the problem. One method is to attach the falsework supporting the unstressed span to the stressed spans so that the unstressed segments and the jointing concrete move with the completed girder. Neither the weight of the falsework nor of the segments should be transferred to the cantilevered girder. Likewise no construction loads are permitted on the completed girder during the "stitching-on" process otherwise stresses not designed for would be "locked" in the structure.

The bridge has been specifically designed to allow for a high degree of repetition during construction. The two box girders are identical except for the protruding reinforcement and there are basically only four different types of segments in the bridge. Of the total 546 segments, 454 of these are the same shape and differ only in the position of the cable ducts. The cable profile is diagrammatically shown in Figure 3. There are 44 "in-span" anchorage segments as described above and a further four special end anchorages at the abutments. Over each pier there are special 3 ft. (0·9 m) long segments which are solid except for a 4 ft. 0 in. x 2 ft. 3 in. (1·2 x 0·7 m) access hole and therefore serve as diaphragms.

BEARINGS

The girders are supported at the piers and abutments by bearings under each web. Fixed bearings are provided at the anchor pier and the rest are all expansion bearings. The fixed bearings, which are hemi-spherical aluminium castings lined with P.T.F.E. (polytetrafluoroethylene), allow rotation in all directions, but are required to resist longitudinal movement. The expansion bearings are a combined type of bearing with the expansion provided by a stainless steel surface sliding on a P.T.F.E. sheet and the rotation by means of a "rubber pot" type bearing. The latter consists of a pad of rubber confined under pressure inside a steel "pot" and permits small rotations under very heavy loads.

The expansion bearings have to cater for varying magnitudes of movement which are proportional to the distance from the anchor pier. The bearings of the abutments have to cater for an estimated temperature movement of ± 3 in. (76 mm) and a long term shortening due to concrete shrinkage and creep of 2½ in. (64 mm). The maximum vertical design load on each of the pier bearings is 125 tons (1245 kN) and on the smaller abutment bearings 58 tons (578 kN).

DECK EXPANSION JOINT

All provisions for longitudinal deck movement is concentrated at the two abutments. The expansion joints comprise steel finger plates bridging the gap between the moving deck and the fixed abutments.

STAIRWAY

For people to walk more directly from North Bega to the business centre of Bega, a stairway is provided at Pier 18 connecting the bridge footway to Carp Street below. The three flight staircase is of reinforced concrete and is supported on concrete friction piles. Because of the longitudinal movement of the bridge superstructure at this location, the stairway is independent of the bridge.

QUANTITIES

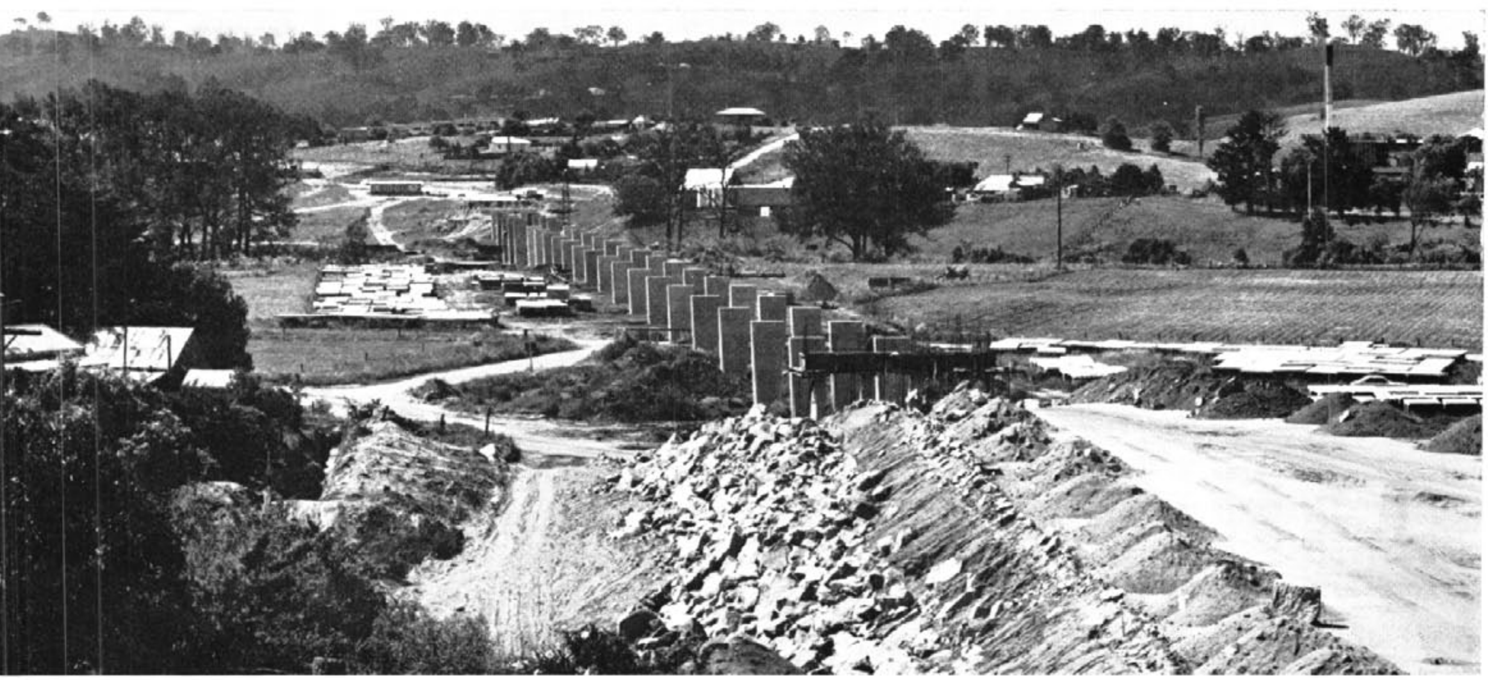
The approximate quantities of materials which will be used in the bridge are:

Steel piles	9,864 lineal feet (3 006 m)
Concrete Class 6K (41 MPa) in girder segments and joints.	3,023 cu. yd. (2 311 m³)
All other concrete, Classes 3K (21 MPa) and 4K (28 MPa).	2,635 cu. yd. (2 015 m³)
Reinforcing Steel	649 tons (659 tonnes)
Prestressing strand	79 tons (80 tonnes)

CONSTRUCTION

The bridge is being constructed by Peter Verheul Pty. Ltd. for the contract price of $1,173,581. The contract excludes the supply of the steel piles.

The bridge is expected to be available to traffic early in 1975 and the total cost, including approaches, will be about $2·5 million.



Progress on construction of the piers at Bega bridge site

VEHICLE OPERATING COSTS

The private car comes high on the list of expensive items in the budget of the average man. In addition to the initial cost of the vehicle and its maintenance and running expenses, the community logically expects the vehicle owner to contribute towards construction and maintenance of roads.

But how much does an average motorist contribute and where does his money go?

The answer, calculated here using a set of basic facts pertaining to a typical motor vehicle shows that very little of the high cost of owning and running such a vehicle is returned to the community for roadworks.

Although the motor vehicle holds an extremely predominant position in the lives of most people and its effective use is an integral part of our daily lives, funds for the roads it depends on are not reaching the roadbuilders.

So, where does the money go? Here are our calculations.

A Holden Kingswood 202 automatic sedan was selected as representative of the average vehicle. It was considered purchased new by cash transaction for $3,469 (1973 model) and kept for three years. The assumption was also made that it would travel an average 11,000 miles per year, would depreciate $578 annually, and would cost an average of $143 per year for maintenance and repairs. Figures were based on costs as at October, 1973.

Table A shows the dissection of annual running costs. From this data the fixed costs and operating costs together show an average running cost of 11·74 cents per mile.

Table B shows the total running cost per mile broken down into its various components.

The only amount being expended directly on roadworks during 1973–74 is motor vehicle taxation. From the average motorist's mileage cost this represents 0·31 cents or approximately 3% of the vehicle's running costs. In addition, it has been estimated that approximately 44% of fuel tax is returned to New South Wales for expenditure on roads. Of the registration and licence fees collected 14% is expended on road traffic facilities. The remainder helps meet the administrative costs of the Department of Motor Transport and police services connected with motor traffic.

Together these three components represent an expenditure on roadworks of 0·77 cents per mile and are apportioned as follows:

	cents
Department of Main Roads ..	0.66
Department of Public Works ..	0.09
Department of Motor Transport	0.02
	0.77

From these estimates it can be seen, therefore, that during 1973–74 about 6·5% of the average motorist's operating costs are being expended on roads and road facilities.

The balance of approximately 93·5% of the operating costs is absorbed in:

	%	%
(a) The cost of maintaining the car on the road		
1. Depreciation (excluding Sales Tax).	30·3	
2. Repairs and Maintenance.	11·1	
3. Insurance	13·3	54·7
(b) Operating Costs Fuel (excluding taxes) oil and tyres.		17
(c) Government taxes including Sales Tax (but excluding the amounts returned to the States for roadworks).		21·8

TABLE A

DISSECTION OF THE ANNUAL RUNNING COSTS OF AN AVERAGE MOTORIST IN NEW SOUTH WALES AS AT OCTOBER, 1973

MAKE: Holden Kingswood 202 (Automatic Transmission).

MODEL: 1973.

TARE WEIGHT: 25 cwt. 2 qrs.

Cost Items	$	*Current Cost* $
A. Fixed Cost		
1. Price including tax		$3,469.00
2. Depreciation (50% of purchase price) at $578.33 per annum for three years.	1,735.00	
3. Registration Fee at $6.00 per annum for three years ..	18.00	
4. Licence Fee at $6.00 per annum for three years	18.00	
5. Motor Vehicle Tax at $34.00 (MVT—$26.00 + Tax levy $8.00) per annum for three years.	102.00	
6. Comprehensive Insurance $135.70 per annum (N.R.M.A.) for three years.	407.10	
7. Third Party Insurance at weighted average of three Transport Districts $36.09 per annum for three years.	108.27	
8. Dealer Charges	50.00	
9. Stamp Duty	17.50	
		$2,455.87
B. Operating Cost		
10. Repairs and Maintenance at $143.33 per annum for three years.	430.00	
11. Tyres tubeless (set of 5) $26.20 each 6.45 x 14 x 4—Dunlop Guardian.	131.00	
12. Fuel Tax at 22·3c. per gallon for 500 gallons (Super) i.e., $111.50 per annum for three years.	334.50	
13. Fuel and oil (excluding taxes) at $175.00 per annum for three years.	525.00	
		$1,420.50
Total Fixed and Operating Costs		$3,876.37
Cost per mile $3,876.37 ÷ 33,000 = 11·74 cents per mile.		

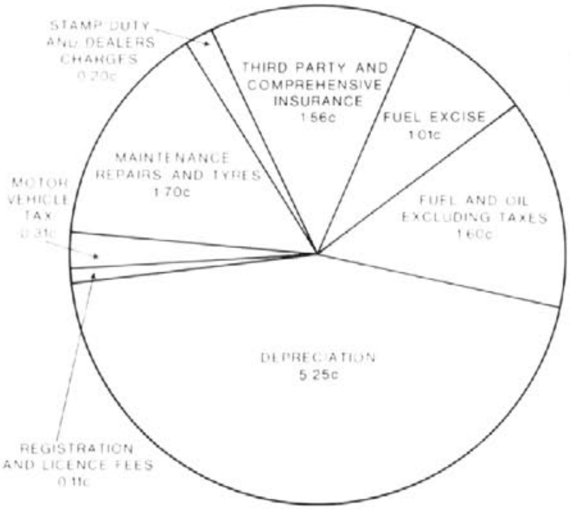
TABLE B

BREAKDOWN OF THE RUNNING COSTS PER MILE OF A HOLDEN KINGSWOOD 202 AUTOMATIC SEDAN AS AT OCTOBER, 1973

	c	c	c
Depreciation ..	3.56	5.25	
Sales Tax included in price ..	1.69		
Stamp Duty and Dealer Charges ..		0.20	
Maintenance Repairs and Tyres ..		1.70	
			7.15
Insurance (Third Party and Comprehensive) ..			1.56
Fuel and Oil (excluding taxes) ..			1.60
Fuel Tax ..		1.01	
Registration and Licence Fees ..		0.11	
			1.12
Motor Vehicle Taxation ..			0.31
Running Cost per mile ..			11.74c

If we are ever to see the fulfilment of the road network plans for New South Wales, a higher percentage of the motorist's tax money must be returned to the State for this purpose.●

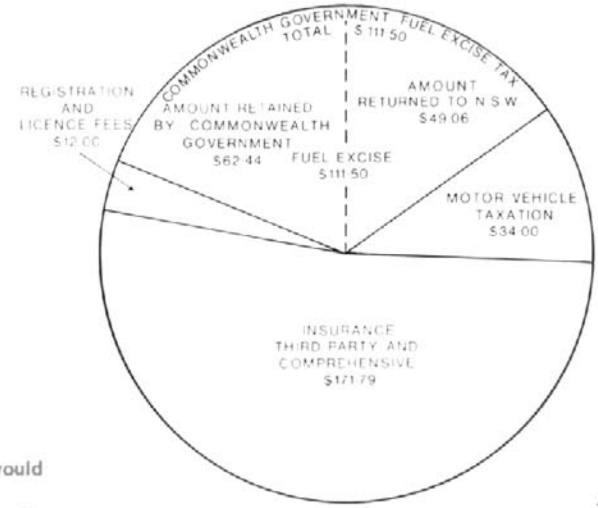
DIAGRAM 1



Total 11·74 cents per mile

1. A dissection of the 11.74 c, estimated to be the average cost per mile, into its individual components.

DIAGRAM 2

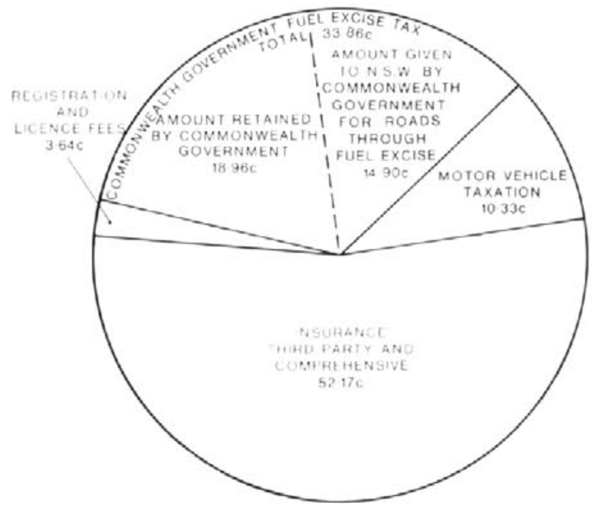


Total $329·29 per annum

2. An estimate of the amount a motorist would spend each year on statutory charges plus comprehensive insurance. The estimated figure of $329.29 does not include running costs such as depreciation, repairs, tyres, oil, servicing and fuel — other than the tax content of the fuel. The percentage of fuel tax expected to be returned to New South Wales by the Commonwealth Government in 1973/74 has been estimated to be 44%. This is shown in the diagram as $49.06 of the $111.50 expected to be paid in fuel excise by the average motorist in New South Wales during 1973/74.

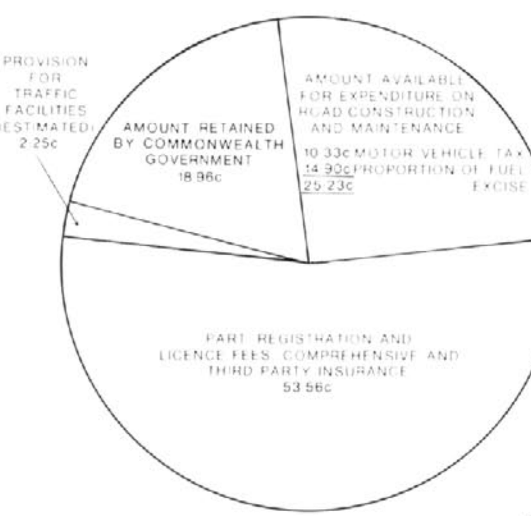
3. How each dollar spent by the motorist on statutory charges and insurance is apportioned in his annual running costs.

DIAGRAM 3



Proportion of $1·00

DIAGRAM 4



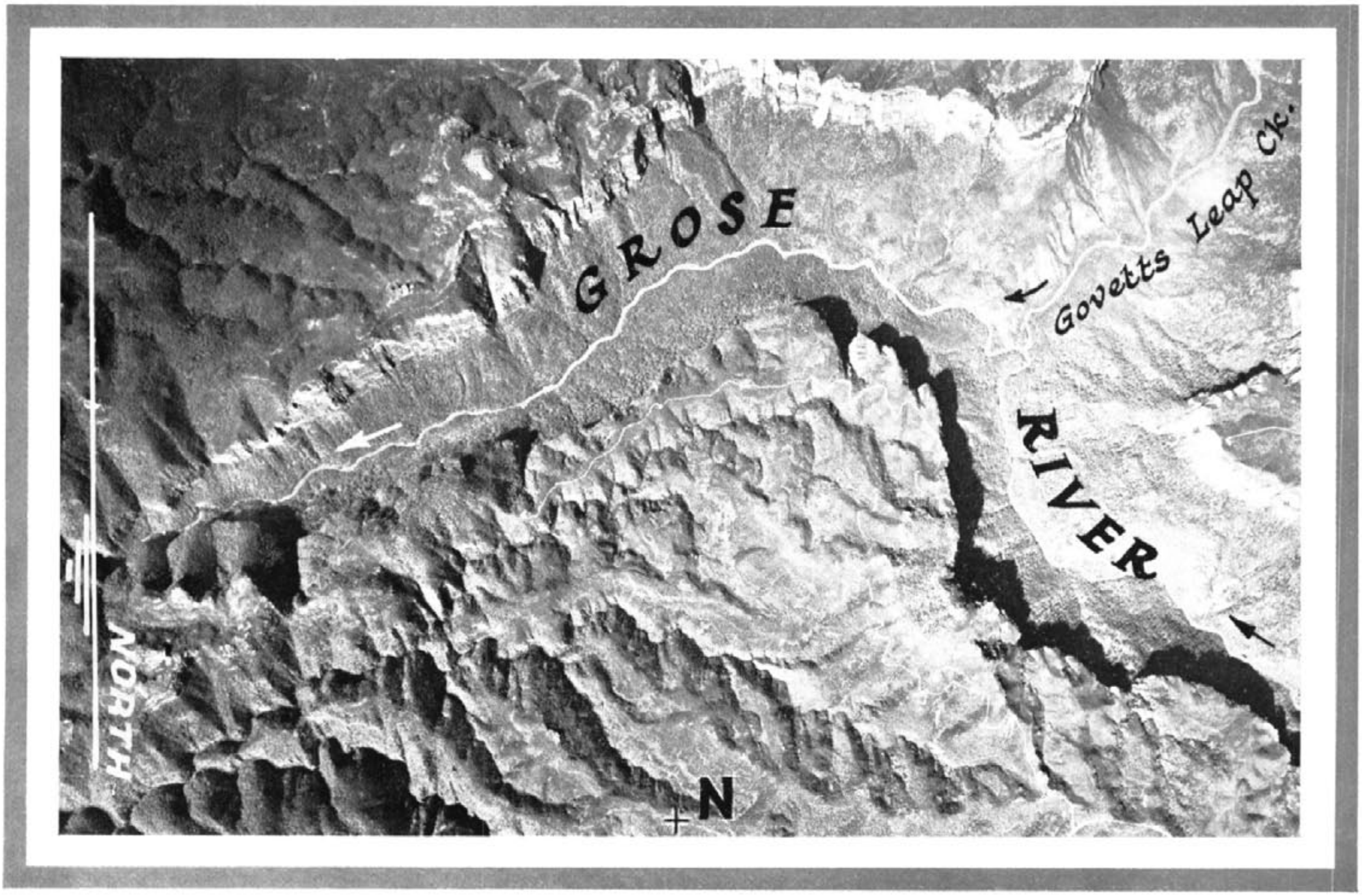
Proportion of $1·00

4. The proportion of each dollar spent by the average motorist which is finally available for expenditure on roadworks.

AERIAL CAMERAS for highway work

Aerial photography has become the normal basis for the production of general maps. The procedures followed, and the results attainable, are well known. Aerial photography is also widely used for the production of maps and plans for highway work. However, there is a basic difference in approach to aerial photographic survey for highway work from aerial photographic survey for general mapping. This difference principally relates to the highway engineer's need for a general map to

(Below): A super-wide-angle photograph of some spectacular natural terrain discontinuities in the Grose River valley, north east of Blackheath in the Blue Mountains. There are cliff faces on each side of both the main and the tributary valleys. Relative displacements of the tops and toes of cliff faces can be seen, while the phenomenon of dead ground can be deduced, for instance at the left of the picture where the river bed disappears from view as the valley constricts downstream. The nadir point (N) is shown, approximately, at the bottom of the picture.



identify approximate location for a highway, followed by a large scale map, or plan, prepared to the highest level of accuracy economically attainable, on which he can refine that location, and, if accuracy is good enough, on which he can express his final design.

From the commencement of preliminary road design through to construction, a very narrow corridor of the terrain is closely studied, and this is more demanding of attention to detail in the planning and performance of the aerial survey than would be the case with most mapping applications. On the other hand, the initial location study can be carried out effectively working from rather tenuous approximations to terrain form. This dual requirement must be understood by photogrammetrists who aim to assist highway engineers, for it seems rather paradoxical to those who specialize in mapping.

Most of the impetus for the development of aerial cameras and photogrammetric instruments for producing maps from their photographs has been generated by general mapping demands.

This led to the desire to contain more and more of the terrain in the one photographic exposure, and the pattern of the 1950's was towards wide-angle survey cameras. Likewise, the instruments used to produce plans from these photographs, called photogrammetric restitution instruments, developed to suit these wide-angle photographs.

From the late fifties through the sixties, the trend continued, and a range of "super-wide-angle" cameras and instruments came on the market. This trend suited the highway engineer very well in his location exercises, where he was interested in a relatively wide band of country, or in design work where heighting accuracies are more important than plan accuracies.

More recently—and for different reasons—there has been a revival of interest in narrower angle equipment—that which was called "normal angle" in the 1930's and 1940's. In those times, the common negative size was 180 mm x 180 mm, and the common focal length of the camera was about 210 mm. These days, the common negative size is larger (230 mm x 230 mm) and so the appropriate equivalent focal length for a "normal-angle" camera increases to about 300 mm. This revival of interest in the "normal-angle" camera has been partly brought about by the needs of highway authorities and other governmental agencies engaged in the detailed planning of urban transportation systems.

The Central Mapping Authority (of the New South Wales Lands Department) has a wide range of equipment for its mapping tasks, including modern aerial cameras and restitution instruments with wide-angle and super-wide-angle characteristics. However, that authority does not have sufficient of the particular type of work which would justify it in acquiring a normal-angle lens cone for mapping purposes. For the same reason, none of the locally established aerial photographic companies have yet equipped themselves with such a lens cone.

In these circumstances, the Department of Main Roads has decided to acquire a normal-angle lens cone for use with the aerial survey equipment of the Lands Department.

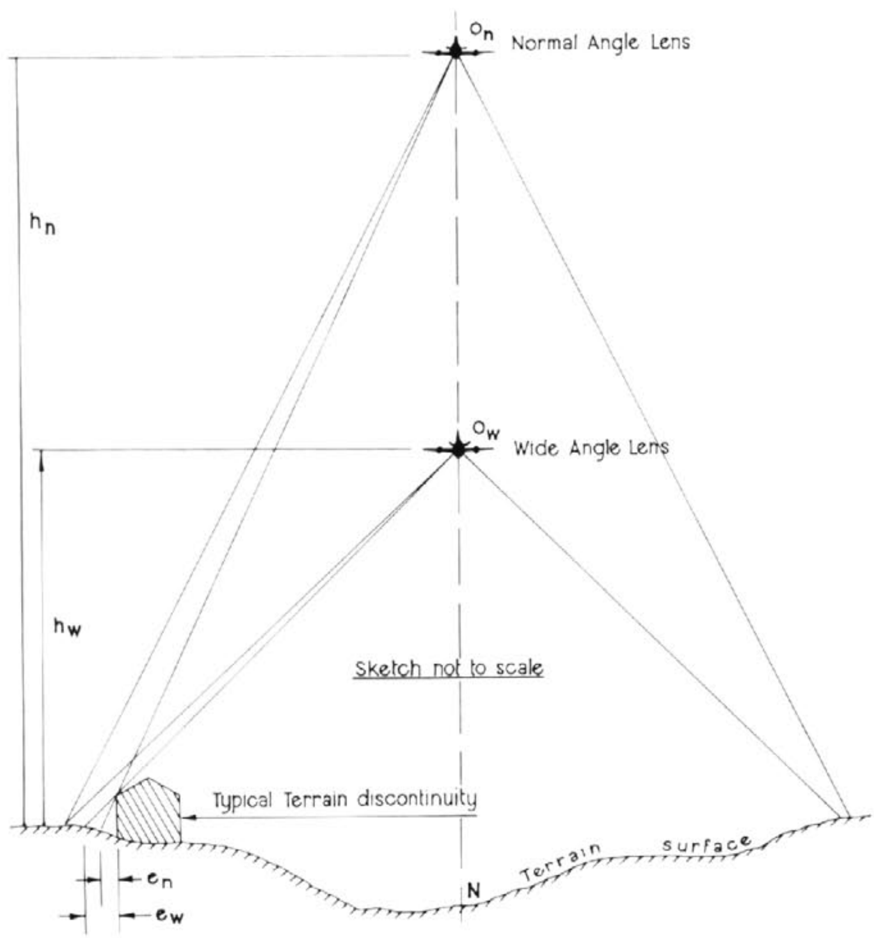


Diagram illustrating similar scales of aerial photography taken with wide angle w and with normal angle n lenses. The relationship between focal lengths is such that the flying height, h_n, for normal angle photography, will be about double that, h_w, for wide angle, while the planimetric error, e_n, will be about half e_w. The sketch is of an idealised situation with camera axes (from the respective perspective centres O_n & O_w) intersecting the terrain surface at the nadir point N. Any part of the terrain surface which is obscured by terrain discontinuities is known as dead ground.

ORTHOPHOTOGRAPHY

While the normal-angle lens cone particularly suits projects where plan accuracy is more important than height accuracy, advantage is more marked in photographing urban or suburban terrain, where the amount of man-made detail on the ground calls for a large scale. Particularly is this so where areas have a fairly high density of largely single storey buildings. In such areas, the portrayal of detail by conventional photogrammetric mapping procedures requires the plotting of a large number of points and lines in order to record the outlines of buildings and other man-made features. This is a tedious and time-consuming exercise, being therefore rather costly.

For decades, photogrammetrists have hoped to combine the optical and image qualities of the photograph—with its wealth of detail requiring little effort to interpret—with the geometrical qualities of the orthogonal map. The conventional photograph is a close approximation to a perspective projection, creating the analogy that light rays generated by objects in the field of view travel in straight lines and pass through a point in the lens system (the "focal" point) to generate images in the emulsion of the negative, which lies in a plane. The actual path of light rays through lens systems is very complex, but the geometrical analogy is approached quite closely.

The orthogonal projection of the map-sheet assumes parallel generating rays (or a "focal" point at infinity) thus portraying horizontal distances correctly and without scale variations due (in the perspective projection) to differences in distance between the relevant image plane and the plane of the negative.

During the 1960's, devices capable of producing a close approximation of an orthogonal projection from the images of a perspective projection were developed from research prototypes to productive units. The output product is referred to as orthophotography. There are two features of orthophotographs which warrant mention in relation to lens cones.

Dead Ground

This desirable combination of optical photographic detail and geometrical plan accuracy can only be achieved where there are no significant discontinuities in the terrain. Any abrupt change in level, due to a feature such as a cliff face or the side of a building, will result, in an ordinary photograph, in the displacement of the image of the top of that feature from that of the bottom (the cliff or the wall appears sloped). This can be seen in the photograph of buildings in Sydney or it could be illustrated by an example, as in the sketch. This sketch shows the magnitude of apparent shift in plan location of a building when photographed respectively with a wide-angle lens and with a normal-angle lens. The two photographs are represented to the same scale.

On that side of a discontinuity which is nearer to the camera, such as in the case of a building, the vertical face would have some apparent dimension, in the photograph, while on the remote side of the discontinuity the vertical face would not be seen, and there would be an area behind it (dead ground) which would be obscured. It can be deduced from looking at the sketch and the photographs that there are advantages in minimizing these affects. It can also be deduced that this can be done by having narrower angular coverage in the photography used. In other words, the use of a normal-angle lens would be preferable.

Want of Correspondence

The orthophoto machine transforms an ordinary (perspective) photograph to an approximation to an orthogonal picture by scanning the photography in bands of a width which may be selected by the operator. In the scanning process, the operator endeavours to maintain the scanning point at the level of the terrain surface at the centre of the relevant band. Where there are significant height differences between adjacent scanning bands, the image displacements due to the differences in height between a particular terrain discontinuity and the observed band levels may differ sufficiently between adjacent bands to show a want of correspondence between two parts of the image of such a feature at the line between the scanning bands in the final orthophotograph.

Such affects may be reduced by reducing band widths and consequently increasing scanning times. For a specified tolerance of relative image displacements, scanning widths for normal angle photography may be expected to be about double those for wide angle photography.

(Right): A wide-angle photograph of the Harbour Bridge approach, Milsons Point Station, Kirribilli and Careening Cove, portraying numerous man-made terrain discontinuities. If all lines in the photograph which represent vertical features in the terrain are extended, they will meet in the nadir point of the photograph. Vertical and near-vertical faces of many structures are visible, but the "remote" faces of these structures—and the dead ground obscured behind or beneath those structures—are not.

(Photograph reproduced by courtesy of Adastra Airways Pty Ltd)

LAND BOUNDARY DEFINITION

The cadastral surveyor, whose responsibility is associated with land boundary definition, is typically concerned with portraying the horizontal or plan positions of points in the terrain. He is not usually concerned with portraying the vertical or height positions of those points.

Photogrammetric methods have been used experimentally by the Department of Main Roads—and by some other authorities both in Australia and elsewhere—to fix horizontal positions for use by cadastral surveyors in defining land boundaries. This experimental work by the Department is part of a research programme which aims to determine whether the cadastral surveyor may use photogrammetric methods in his work in certain circumstances, to the satisfaction of the appropriate legal authority.

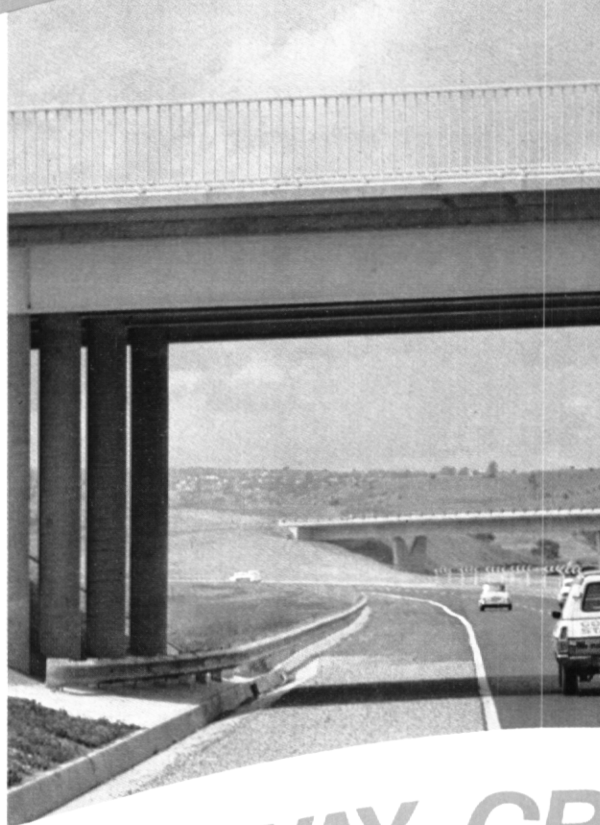
In pursuing this area of research, there is a persuasive case for the use of normal angle photography. For large scales of photography, there is a distinct advantage in flying at a greater height, as air turbulence at low altitudes reduces with height. The longer focal length of the normal-angle lens cone means that the height of flying can be about doubled while retaining the same scale of photography as would be provided by a wide-angle lens cone at the lower height. Or, to put it another way, for a chosen flying height a much larger scale of photograph may be obtained using normal-angle lens cones than would be the case with wide-angle or super-wide-angle lens cones.

DISADVANTAGES OF NORMAL-ANGLE LENS CONES

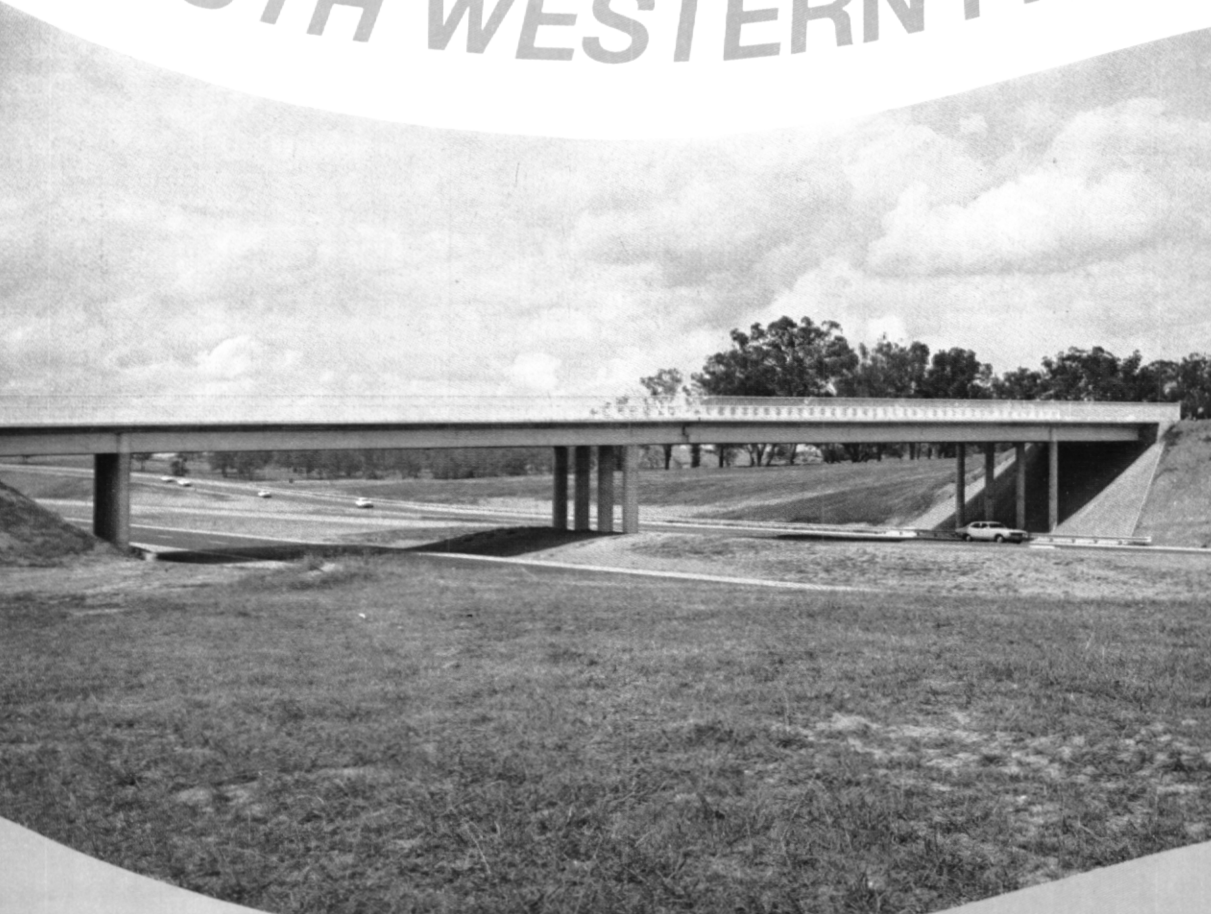
While the new lens cone which the Department is acquiring offers real advantages for horizontal representation of the terrain, the wide-angle and super-wide-angle cones must continue to be used generally for the portrayal of terrain form, where heighting accuracy is of greater importance than planimetric accuracy. The wider angle coverages give a more favourable base to height ratio, and a more accurate height representation than do the narrower angle coverages. The new lens cone thus represents an added option for specialised purposes, but it cannot replace the use of other lens cones for all purposes●

(Below) Sweeping curves of the freeway looking north towards the crossing at St Andrews Road.

(Centre) Looking under Raby Road bridge to northbound loading ramp.



SOUTH WESTERN FREEWAY~CR

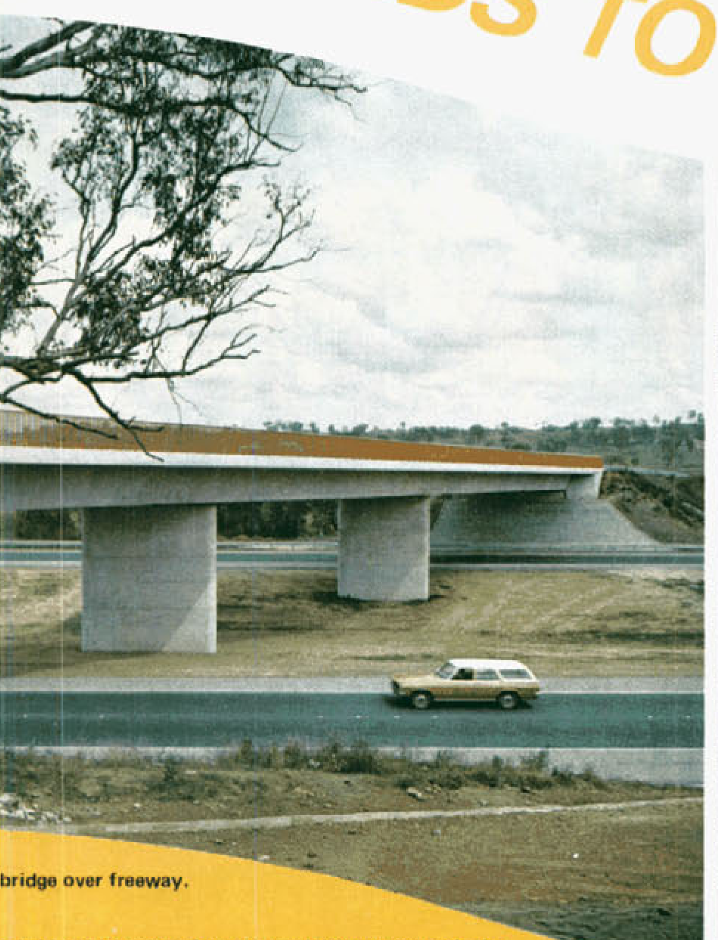


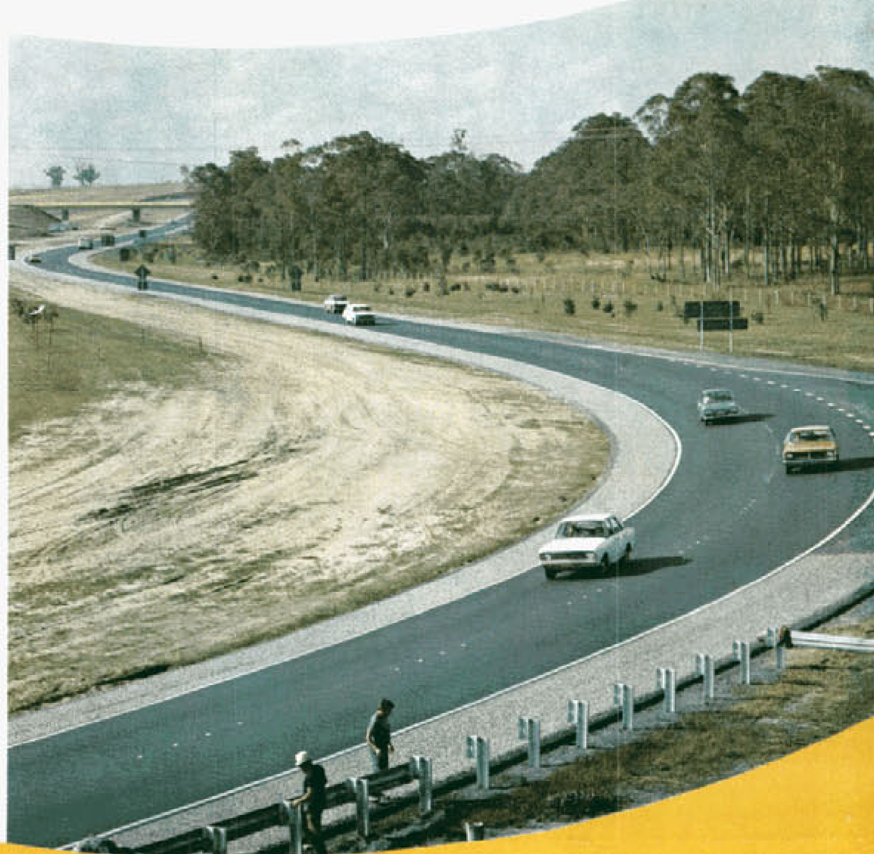
(Centre) St Andrew

(Above) Bridge carrying Raby Road over freeway.

(Right) Northbound loading ramp leading to Campbelltown Road (M.R. 177).

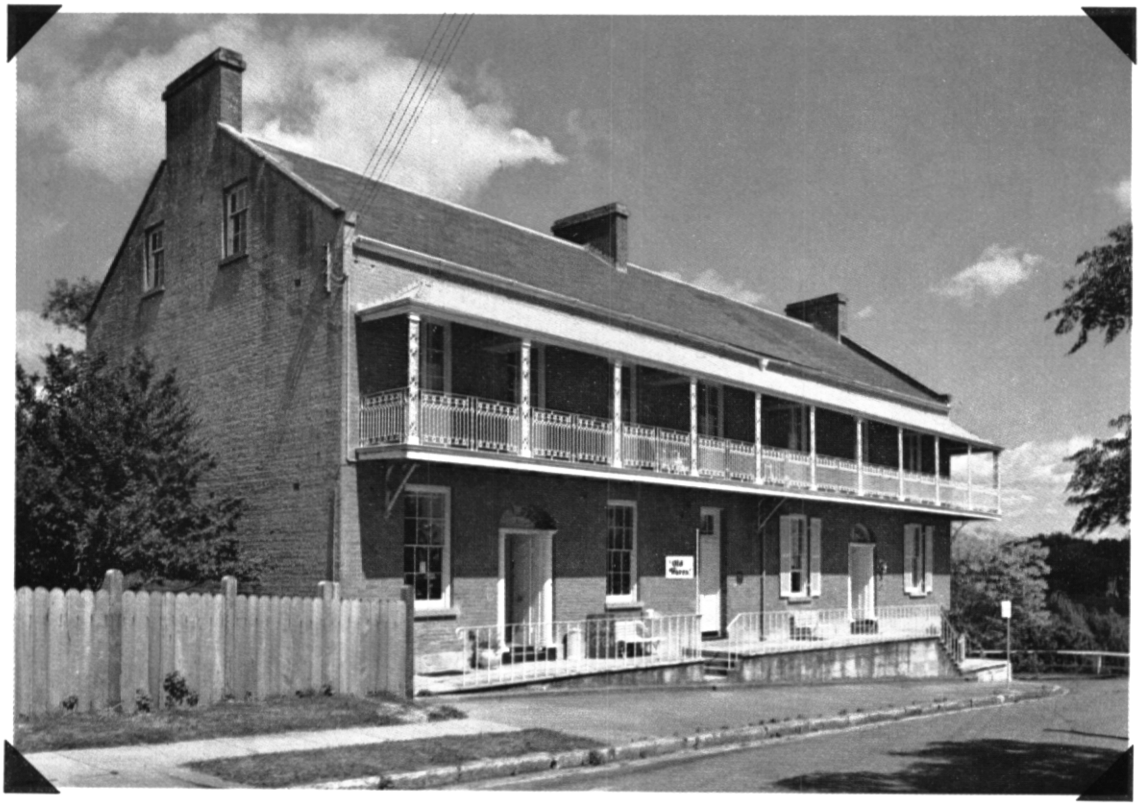
SS ROADS TO CAMPBELLTOWN





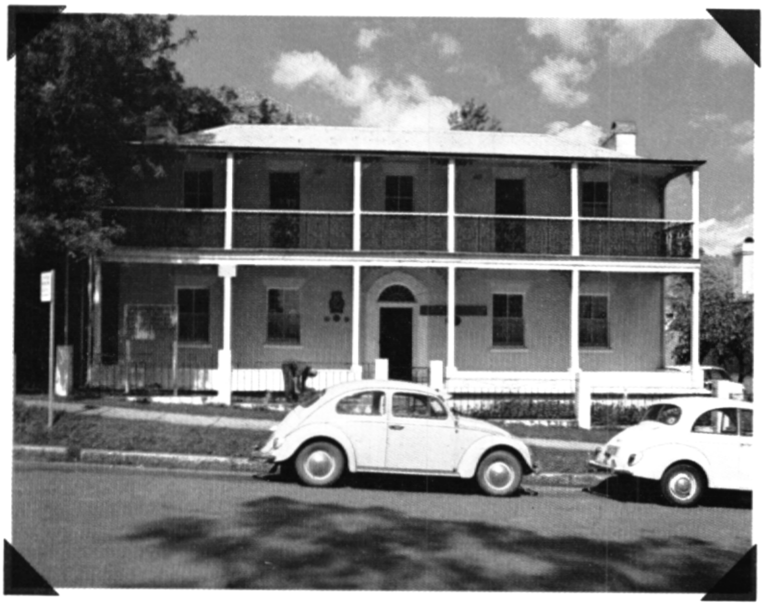
bridge over freeway.

ight) Looking south from Hume Highway towards the bridge on Campbelltown Road which forms the



Left and
below left:

Thompson Square, Windsor, is surrounded by beautifully restored buildings which overlook a small park beside the Hawkesbury River. The Square was named after Andrew Thompson, builder of the first permanent crossing over South Creek.



Above right:

St Matthews Church, Windsor was designed by Francis Greenway and opened on 18th December, 1822. Andrew Thompson's grave is the oldest in the cemetery, established before completion of the church.

Right:

Just across the road from the Church is the gracious Rectory, built in 1825 by William Cox, the man responsible for constructing the first road across the Blue Mountains. The Rectory is another fine example of the many restored buildings in Windsor which contribute to its attractions for visitors.

South Creek Windsor

New bridge, for an historic crossing

The bridge on Windsor Road (Main Road No. 184) over South Creek, is soon to be replaced by a new high level three span prestressed concrete girder bridge 82 m (270 ft.) long and 8·5 m (28 ft.) wide between kerbs, with a 1·5 m (5 ft.) wide footway for pedestrians.

Construction of the new bridge, which is being undertaken by Pearson Bridge (N.S.W.) Pty. Ltd. for the contract price of $335,546, is expected to be completed by the end of 1974.

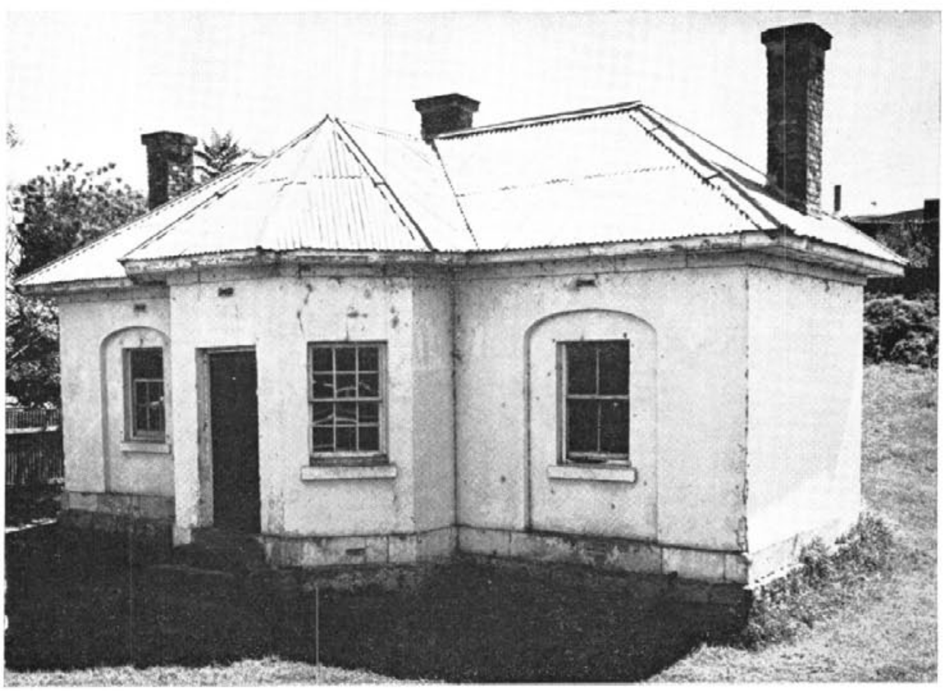
Consideration was given in the design of the bridge to the construction of an adjoining duplicated bridge at a future date, when warranted by increased traffic volume. The bridge was designed within the Department of Main Roads.

South Creek, Windsor, has been the site of numerous bridges since the enterprising emancipist Andrew Thompson first erected a temporary floating structure there in 1802. Thompson had resided in the Green Hills area (now Windsor) since 1796 and, in his position as constable, earned much well-deserved praise for service to the district. Between 1800 and 1806, Thompson's interests were many and varied—as toll-keeper, brewer, farmer, pastoralist, manufacturer and ship builder, in addition to being Chief Constable. In 1810, Governor Macquarie appointed Thompson magistrate at Hawkesbury, the first emancipist to be given that honour.

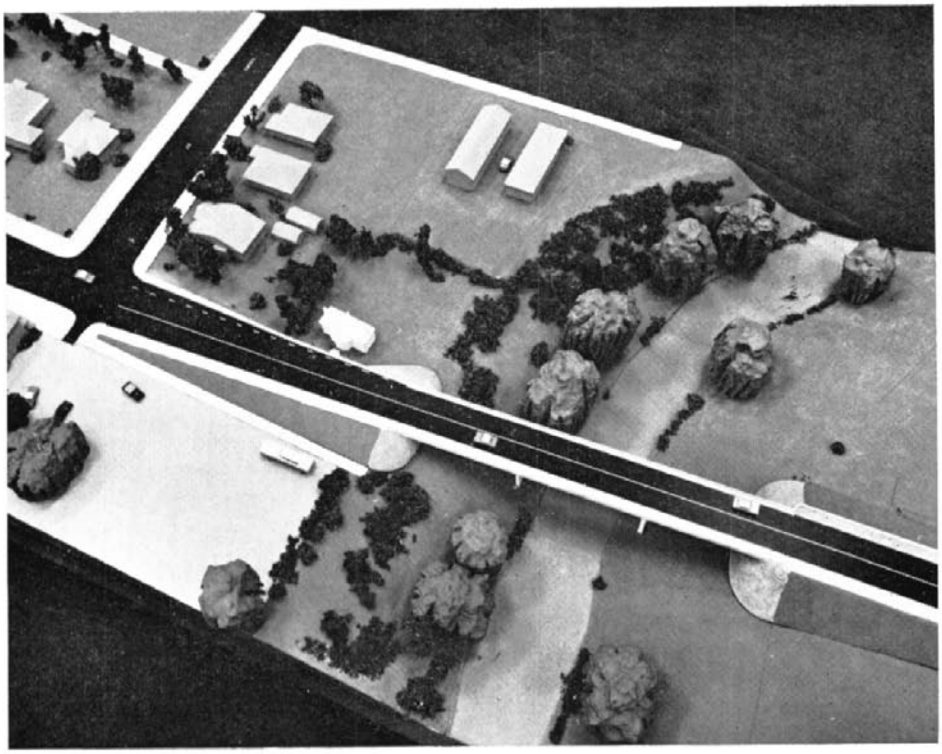
However, it is the toll-keeper aspect of his activities which holds most interest for us. Prior to construction of the first bridge, traffic frequently encountered difficulty in fording the crossing. Governor King approved the building of a floating type bridge, contributed government money and labour to it, and allowed Thompson to levy a toll, the first of its kind in the colony and made particularly necessary by the constant maintenance required on this type of bridge. For Thompson, the toll bridge was a shrewd venture because the main road passed through his property and farmers lodging grain in the government stores or visiting the business centre of Green Hills were obliged to pay him for the privilege of access. The government welcomed the bridge in such a flood-prone area as the Hawkesbury where it was essential for growers to move their grain into the granary immediately after harvesting.

On 23rd October, 1810, at the age of 37, Thompson died from consumption, ironically brought about as a result of saving others in the 1809 flood. His bridge was replaced in 1813 by a more permanent structure on a higher level. It was named "Howe Bridge" after John Howe, contractor for the job, and was at the time the largest bridge in the colony, being 65 m (214 ft.) long, 7 m (24 ft.) wide and 6 m (20 ft.) above normal water level, supported over the creek by four rows of piles, each penetrating about 3 m (10 ft.) into the creek bed.

A structural fault in the bridge made regular extensive repairs necessary. A major disaster occurred in 1823 when a section of decking collapsed with a tremendous roar which caused the inhabitants of Windsor to believe, at first, that they were in the path of an earthquake. Decking fell once more in



Although the old Toll House carries a neglected air today, for years it was the centre of activity at the South Creek crossing where travellers were required to pause and pay a toll. The angle of the windows flanking the front door gave the toll keeper a view of vehicles approaching from either direction.



This model was built to show the location of the Toll House (white building, centre) in relation to the new bridge and its approaches.

1829 and again in 1835 while further repairs were made in 1845.

The sufferings of travellers over South Creek were thought to be over when the new Fitzroy Bridge was opened in 1853. Its designers avoided sinking piles into the bed of South Creek, considered one of the reasons for the failure of the previous bridge.

But Fitzroy Bridge, with its distinctive laminated arches, had a structural problem too which manifested itself in a "swinging motion" when crossed by heavy vehicles. Repairs were carried out in 1857 and 1860 but its life was short, ending in replacement by an iron bridge in 1881—the present bridge—which also carries the name Fitzroy Bridge.

Andrew Thompson's grave stone carries a tribute to his good works during a fairly short life

It has three spans supported by iron cylinders 64 m (210 ft.) long, with a 6·5 m (21 ft.) wide deck and stands 9·5 m (32 ft.) above water level. In 1895 the timber was replaced by concrete.

And now, in place of this tired old bridge which has served the traveller for 93 years, a new bridge is about to rise and span the historic crossing.

TOLLS AND TOLL HOUSE

The collection of tolls on these bridges continued until 1887. The charges varied over the years, the first tolls being "For each Foot Passenger, 4d., or 10/- per annum; For each Horse 2/6 or £2 10s. 0d. per annum; For every cart or carriage 1/6 or £1 10s. 0d. per annum."*

In designing the new bridge, consideration was given to the need to preserve the historic toll house standing on the Windsor bank of the creek. At first the possibility of moving the toll house to a position further from the bridge approach was suggested, but it was found that the condition of the building made this proposal unrealistic. The toll house will now be within 3 m (10 ft.) of the approach road to the bridge and a footpath from Court Street down the north-eastern side of the embankment to the toll house has been included in the design. Access to the toll house will also be available along a pathway beneath the bridge.

Historical research into origins of the toll house reveals many discrepancies between information sources. The foundations of the present building appear to date from early in 1814 when the toll house was designed for toll collection on the Howe Bridge. Israel Rayner is shown as the "Toll Gate Man" in the Muster Book for Windsor in 1814. As the years passed, however, the toll house was probably reconstructed several times because of flood damage—possibly about 1835 and more definitely in 1867 as a result of the particularly disastrous floods of 1864.

The "Illustrated Sydney News" on 16th July, 1864, reports of that flood—

"During Sunday all was excitement; the South Creek had swollen over its banks and bridge, stopping traffic on the Parramatta Road, and flooding out the inhabitants on our side; the river rising rapidly and continuing to do so till Monday 13th at 2 p.m., when the waters reached their highest point, the houses between McGrath's Hill and the Bridge were either swept away or totally submerged; the toll house and houses adjoining were all swept away, or nearly so; McDonald's public house, and the whole block of houses at one end of the town, were either down or falling, and all flooded roof high; and a great part of the old Barrack wall had fallen."

The toll house foundations apparently remained because the roughly hewn sandstone block foundations are in keeping with the 1814 period while on top of these, another row of sandstone blocks had been set in place by a skilled stonemason. Therefore, although the foundations are original, the building now standing substantially dates from reconstruction work carried out in 1867●

A detailed article on turnpikes and toll collecting appeared in "Main Roads"—Vol. 16, No. 4, p. 107, June 1951.

Sources of reference for the information on the toll house, the bridges at South Creek and the life of Andrew Thompson, included:

"Historical Records of Australia"—Vol. 3, Series I 1801–2, 28th May, 1802.

"Macquarie Country" by D. G. Bowd.

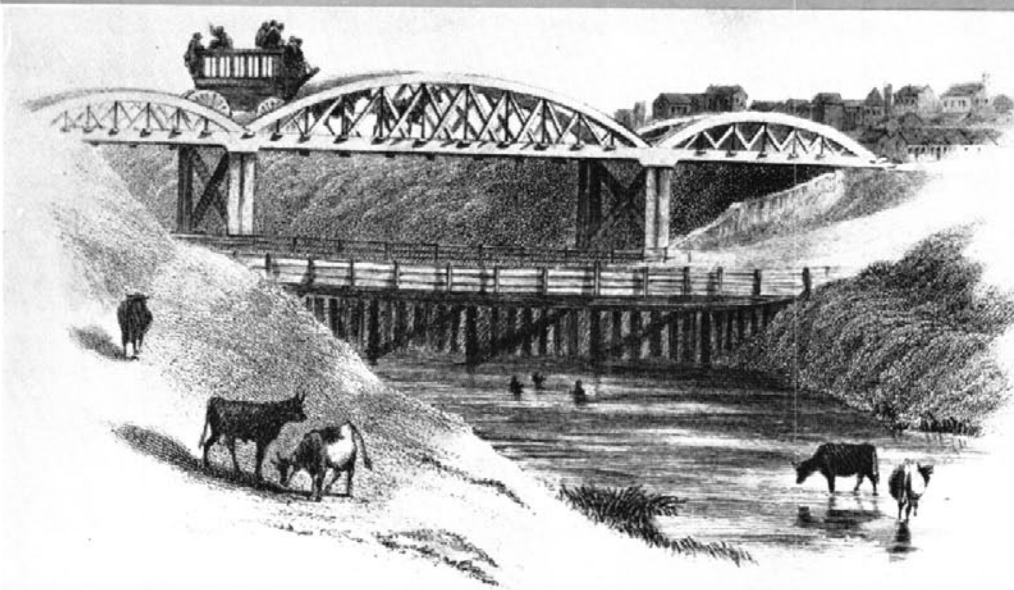
"Pitt Town"—a booklet from the "Nepean District Historical Society".

"Andrew Thompson, 1773–1810, Pt. 1"—by J. V. Byrnes, R.A.H.S. Journal, Vol. 48, Pt. 2, June 1962.

Hawkesbury Historical Society—detailed information about the toll house was kindly supplied by D. G. Bowd, Honorary Secretary.

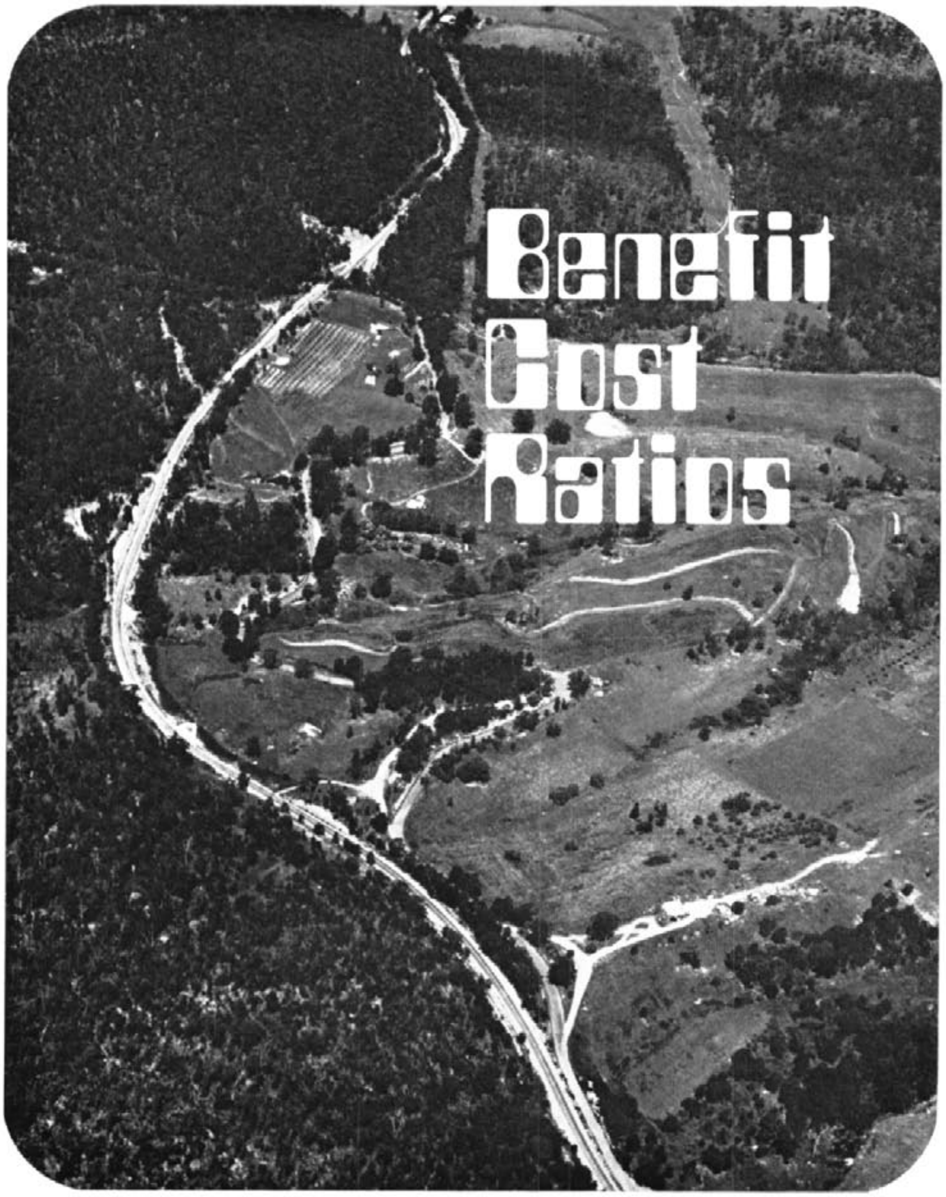
(Right): The Fitzroy Bridge over South Creek, Windsor—a photograph taken in 1872.

(Below): The same bridge, with its distinctive laminated arches, forms the subject of a drawing dated 1853. *(By Frederick Charles Terry from "Landscape Scenery . . . Sydney and Port Jackson". Reproduced by permission of the Mitchell Library, Sydney).*



Accompanying the story about the 1864 *flood of the Hawkesbury which is partly quoted in the text of this article, the "Illustrated Sydney News" printed this view of "Ryan's House Punt, &c, Sunday, June* 12*th,* 1864, *from Baker Street". The flood was described in the newspaper " . . . from McGrath's Hill to the Barracks below the School of Arts there was nothing but a sea of water, dotted here and there by the roofs and chimneys of the houses."*

Benefit Cost Ratios



Benefits in safety and saved travelling time are immediately obvious from this photograph of a section of the Great Western Highway (State Highway 5) between Hartley and South Bowenfels. To the right of the present route, the former route of the highway, (known in its time as "Forty Bends"), still exists and its winding nature can be compared with the smooth curve of the new alignment

Benefit-cost ratios are a practical way of assessing alternative courses of action open to engineers in the preparation of programmes for future road works.

Each proposed project represents a community investment in the transport requirements of the State. Obviously the projects will vary enormously in cost, and there will be many more projects competing for funds, than there are funds available. Sometimes there are many alternative ways of carrying out a single project.

In order to provide a common basis of comparison of the relative merits of each proposal, recently developed techniques of benefit-cost analysis are being increasingly used. The techniques provide a long view of each proposal, in the sense of looking at the effects in the far, as well as the near future, and also a wide view in the sense of allowing for the side effects on road users and the community at large.

Conventionally, financial evaluation and budgeting in the private sector are concerned with those costs and revenues which directly influence profits—the overall objective being profit maximisation. The essential difference between this and the techniques of benefit-cost analysis in the public sector, is the consideration of a project from the community viewpoint, involving all the costs and benefits resulting from an investment, including those to third parties.

Thus benefit-cost analysis will differ from a private investment appraisal in the way it answers four fundamental questions

1. What are the objectives and constraints of the analysis?
2. What items of cost and benefit should be included?
3. How are they to be valued, and should money be used as the ""common measure"?
4. How are the results to be interpreted, and how are differences due to time taken into account?

OBJECTIVES AND CONSTRAINTS

The technique can be utilised in two ways. First to calculate the costs and benefits accruing from any road improvement in the future. From this, priorities for various projects can be fixed on a rational basis. Second, for a given section of road, the optimum type of improvement can be found from a number of alternatives, and also the optimum timing of construction.

The constraints on the analysis include:

(i) a lack of reliable data in some areas, e.g. the cost to the community of road accidents;

(ii) necessary simplifications, e.g. dividing the total traffic flow into a few standard categories, and applying average values to these categories;

(iii) a large volume of calculations—mostly overcome by the use of an electronic computer.

A fundamental assumption of the analysis is that money provides a satisfactory common measure of costs and benefits. This is reasonable for the capital costs of construction, maintenance, vehicle operations, and savings in time for commercial vehicles. It is less reliable—but still used for want of something better—for measuring items such as savings in "leisure" time, the cost of accidents, and changes in social conditions, e.g. noise and pollution. A further assumption is that the marginal utility of money is equal for all members of the community—which is a doubtful point.

The usual end objective of the analysis is to estimate, in money terms, the values of all the benefits and costs of a particular project or alternative over a period of time. This time span (or "life" of the project) is normally taken at 20 to 30 years. The costs and benefits, suitably discounted to present day values, are then expressed in a single measure—the benefit-cost ratio. Benefit-cost ratios for different projects can then be ranked, and thus assist in the planning of priorities for future expenditure.

COSTS AND BENEFITS

The costs associated with roads and road transportation fall into three broad groups: road construction costs, road maintenance costs, and road user costs (including vehicle, occupant's time, and accident costs). The sum of all these is the total transportation cost. The analysis compares the construction costs of a road improvement project, with the benefits of savings in maintenance and road user costs. Side benefits to the general community are also considered.

The data needed for the evaluation of a particular project comprises existing traffic volumes, forecast traffic growth rates, traffic composition, road width and surface type, vertical and horizontal road characteristics, road conditions and capacity. Mathematical functions have been developed to relate vehicle speeds and roadway characteristics to vehicle operating costs, accident costs, and road user costs.

In more detail, the various benefits arising from a road improvement are:

1. A reduction in vehicle operating costs, comprising fuel, oil, tyres, maintenance and repairs, and depreciation. The benefits vary considerably for different types of vehicles, and a standard classification is often used. The operating cost is based on the average speed of each vehicle type. The average speed is calculated according to road width, curvature, surface type, gradient, and also hourly traffic volume and composition.

2. A reduction in vehicle occupant's time costs. The value of time for drivers and passengers of commercial vehicles is based on average wage rates. The value placed on private (or "leisure") time depends on the purposes of travel, but broad estimates are usually made. An occupancy rate, derived from surveys, is adopted for each type of vehicle, and the cost savings are calculated from the appropriate traffic volume, speed and unit cost of travel time.

3. A reduction in accident costs. This is an important element in the economic benefits arising from road improvements. Accidents can be classified into fatal, casualty, and property types. Although there is wide variation in the type and frequency of accidents, a general accident cost figure can be derived for different road types and conditions.

4. Road maintenance benefits. In many instances, maintenance costs are reduced by improvement works. For example, the sealing of a gravel road, or the widening of a pavement to reduce edge wear. In other cases, such as the construction of dual carriageway facilities, the benefit may be negative.

5. Special cases of benefits arise when:

(i) A project will generate new additional traffic, not anticipated from normal growth patterns.

(ii) A new seal on an existing gravel road provides extra comfort benefits to travellers and eliminates pollution due to dust.

(iii) A new structure eliminates a ferry, level crossing, floodway, or some other obstruction to safe and convenient movement.

(iv) A special project (such as a freeway) removes through traffic and commercial vehicles from local streets, thus making the environment more amenable for living.

In addition to the benefits accruing to the road user, benefits also occur for the community at large, in providing increased and cheaper trade, and a reduction in resources lost through traffic congestion.

DISCOUNTING

In order to establish a valid basis of comparison, all future benefits are discounted to their present day value. This procedure is not an allowance for inflation, but a reflection of the economic fact that a dollar received in the future is worth less than a dollar received now. Most studies use a discount rate of 10% per annum, however special circumstances may dictate otherwise. Discounted cash flow techniques are relatively new in application. Previously, only a single year rate of return was calculated, representing the net benefits in the first year, as a percentage of the capital cost. This was only valid as a ranking criterion, however, if the compared projects had similar time profiles of costs and benefits—a situation which does not often occur. The large volumes of time series data required for discounting techniques nearly always make the use of a computer essential.

THE BENEFIT-COST RATIO

The end result of the analysis is a single figure for each project—the ratio of total net benefits to total net costs. This benefit-cost ratio represents the economic worth of the project, and competing projects can thus be ranked in a priority order. A benefit-cost ratio less than unity means that the project will not "pay its way".

It is evident that the benefit-cost ratio of a project cannot fully account for factors which are not expressable in money terms. Environmental, social, and political issues may outweigh a purely economic criterion. Nevertheless, the benefit-cost ratio provides decision makers with a rational starting point●

HUME HIGHWAY REPORT

The Hume Highway is the major road link between Sydney and Melbourne and with the Federal Highway connects Sydney to Canberra. It is controlled for its 573 km (356 miles) in New South Wales by four Divisions—Parramatta, Illawarra, Southern and South Western.

The section of the Highway from its commencement at the junction with the Great Western Highway at Ashfield to just south of Leppington is under the direct control of the Parramatta Division. With the exception of a few short lengths, dual carriageway conditions exist on the Highway where it traverses the ubran and outer urban areas of Sydney.

Outside the County of Cumberland the three other Divisions are undertaking construction of dual carriageways along the route of the Highway to the Murray River, the border between New South Wales and Victoria.

The ultimate aim is to convert the full length of the Highway to dual carriageway standard. This is a very ambitious project for any public authority to instigate and the construction of each new section of dual carriageway is commenced according to a series of priorities including available finance.

This report is intended to summarise dual carriageways completed and opened to traffic, under construction or planned for commencement in the near future.

ILLAWARRA DIVISION

The 126 km (78 miles) of the Hume Highway from just south of Leppington to Uringalla Creek at 11 km (7 miles) north of Marulan is controlled by the Illawarra Division.

The South Western Freeway, now being constructed from Cross Roads near Liverpool to Aylmerton about 116 km (72 miles) south of Sydney, parallels most of this section of the Hume Highway and the need for dual carriageways is lessened.

From 6 km (4 miles) north of Mittagong the South Western Freeway will connect with proposed dual carriageways on the Hume Highway to Mittagong where the existing route through the town will be developed to urban type dual carriageways.

Current Dual Carriageway Construction Projects

The works on the Hume Highway in the Illawarra Division which have received priority in recent years include the construction of a flood-free route around Camden.

This deviation, extending from Narellan to South Camden, 55 km (33·9 miles) to 64 km (39·6 miles) south of Sydney, is being constructed with dual carriageways in the approaches to the new Macarthur Bridge and construction is well advanced. The $2·5 million Macarthur Bridge over the Nepean River was opened to traffic in September, 1973 and when combined with the approach roads will form the flood-free route around Camden.

Also, as an extension of this work and to provide traffic relief at South Camden, the reconstruction of the existing 6 m (20 ft.) wide pavement to dual carriageway standards as far as the Camden Municipality/Wollondilly Shire boundary, 65·9 km (40·9 miles) from Sydney is in progress. The cost of this work has been estimated at $5·5 million. The planned South Western Freeway between Finns Road, 7·5 km (4·7 miles) south of Camden and Alpine will obviate the need for dual carriageways on the Hume Highway over this length.

The replacement of old timber bridges at Medway Rivulet 4·8 km (2·9 miles) and at Paddys River 27·3 km (17·2 miles) south of Berrima, and the replacement of a narrow concrete arch bridge on substandard alignment at Black Bobs Creek 12·4 km (7·7 miles) south of Berrima were planned with dual carriageway standards in view.

The first of new twin concrete bridges being constructed at Paddys River has been completed and the second is expected to be available to traffic by November, 1974. A short section of dual carriageway forming the approaches to these bridges is being constructed at an estimated cost of $375,000.

At Black Bobs Creek between 8 km (5·2 miles) and 13 km (8·3 miles) south of Berrima, the southbound carriageway of the planned dual carriageways on the approaches to the new bridge, was completed in 1973. This involved a major realignment of the highway between Comfort Hill, 8 km to 11 km (5·2 to 7·2 miles) south of Berrima and the new bridge over the creek and cost over $1¼ million.

Future Works

Preliminary investigations are in hand to locate a Traffic Relief route 2·5 km (1·6 miles) north to 2·5 km (1·5 miles) south of Berrima.

Detailed plans are being prepared for dual carriageways from the approaches to the new bridge at Medway Rivulet between 2·5 k (1·5m miles) and 9 km (5·6 miles) south of Berrima. This work will involve a major deviation north of the bridge to eliminate a sharp curve with a high accident record and will provide an extension of the completed work between Comfort Hill and Black Bobs Creek.

Between the junction with the Illawarra Highway (State Highway 25) at Hoddles Cross Roads and Uringalla Creek, 14 km (8·5 miles) to 33 km (20 miles) south of Berrima an extension in each direction of the work now in progress at Paddys River is also being planned. This will involve some major departures from the present route of the Highway which has a few narrow and winding sections between Paddys River and Uringalla Creek.

On completion of the work now in progress at Paddys River and Medway Rivulet, the priority for the construction of dual carriageways is planned as follows:

- Construction of the southbound carriageway in the approaches to Medway Rivulet between 2·5 km (1·5 miles) and 9 km (5·6 miles) south of Berrima.
- The construction of dual carriageways between Paddys River and Uringalla Creek to link with the existing dual carriageways south of Uringalla Creek.
- Construction of dual carriageways between Hoddles Cross Roads and Paddys River.
- Construction of the northbound carriageway between Berrima and Hoddles Cross Roads to provide dual carriageways. This work will include duplication of the bridges at Black Bobs Creek and Medway Rivulet.
- Construction of a Traffic Relief Route at Berrima.
- Construction of the northbound carriageway between the northern end of the Traffic Relief Route at Berrima and Mittagong. The existing Highway which has been re-constructed on an improved alignment at Fitzroy and Cutaway Creeks and Bendooley Hill will

DUAL CARRIAGEWAYS

form the southern carriageway. A section of the old road, about 1·5 km (0·9 miles), at Bendooley Hill is the northbound carriageway of dual carriageways on this short length.

The total cost of constructing these dual carriageways is of the order of $15 million.

If progress can be maintained at the present rate these works could be completed by 1983.

SOUTHERN DIVISION

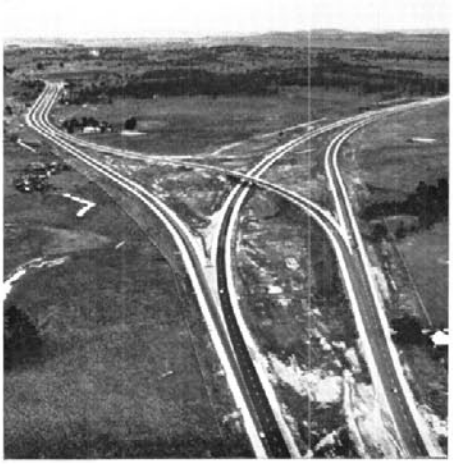
The Hume Highway extends for a distance of 248 km (154·8 miles) from Uringalla Creek north of Goulburn to the Tarcutta Range south of Gundagai. About 29 km (18·4 miles) of dual carriageways have been constructed within the Division while 9 km (5·5 miles) are being constructed. At the same time, investigation, planning and design are being carried out over the remaining length of the Highway to provide dual carriageways as funds become available.

Dual Carriageways Already Constructed

Prior to July 1973, dual carriageways had been constructed from Boxers Creek to Governor's Hill on the northern approach to Goulburn, and from 4 km (2·3 miles) to 14·4 km (8·8 miles) south of Goulburn to the junction with the Federal Highway. The work south of Goulburn included the construction of a grade separation of these two important roads and the construction of 1·6 km (1 mile) of dual carriageway along the Federal Highway. In addition to the north of Goulburn a short length of dual carriageway had been constructed in the approaches to the new duplicate structures over Uringalla Creek.

Subsequently, dual carriageways from Narambulla Creek to Towrang Hill, 13 km (8 miles) to 20 km (12·5 miles) north of Goulburn, which included a duplicate bridge at Narambulla Creek, were opened to traffic in August 1973. Total cost of the work was about $1·4 million including the cost of the new bridge. This length of dual carriageway replaced a section of Highway which was undulating with restricted sight distances. The bitumen surface generally 6 m (20 ft.) wide was additionally unsatisfactory because of its age.

Dual carriageways, including new duplicate bridges over Bowning Creek, were completed late in 1973 on a



This grade separated interchange, 14 km (8·8 miles) south of Goulburn, links dual carriageway sections of the Hume and Federal Highways

A duplicate bridge over Narumbulla Creek was constructed on this section of dual carriageway work between Marulan and Towrang Hill north of Goulburn

Above:

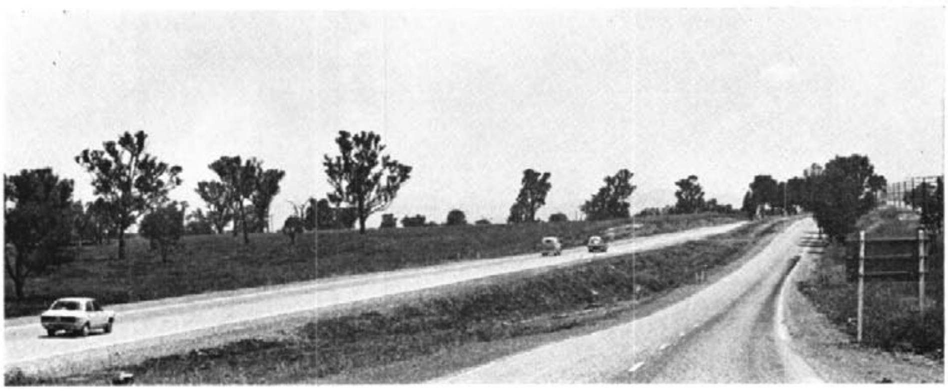
Construction of new bridge over Paddys River

At right:

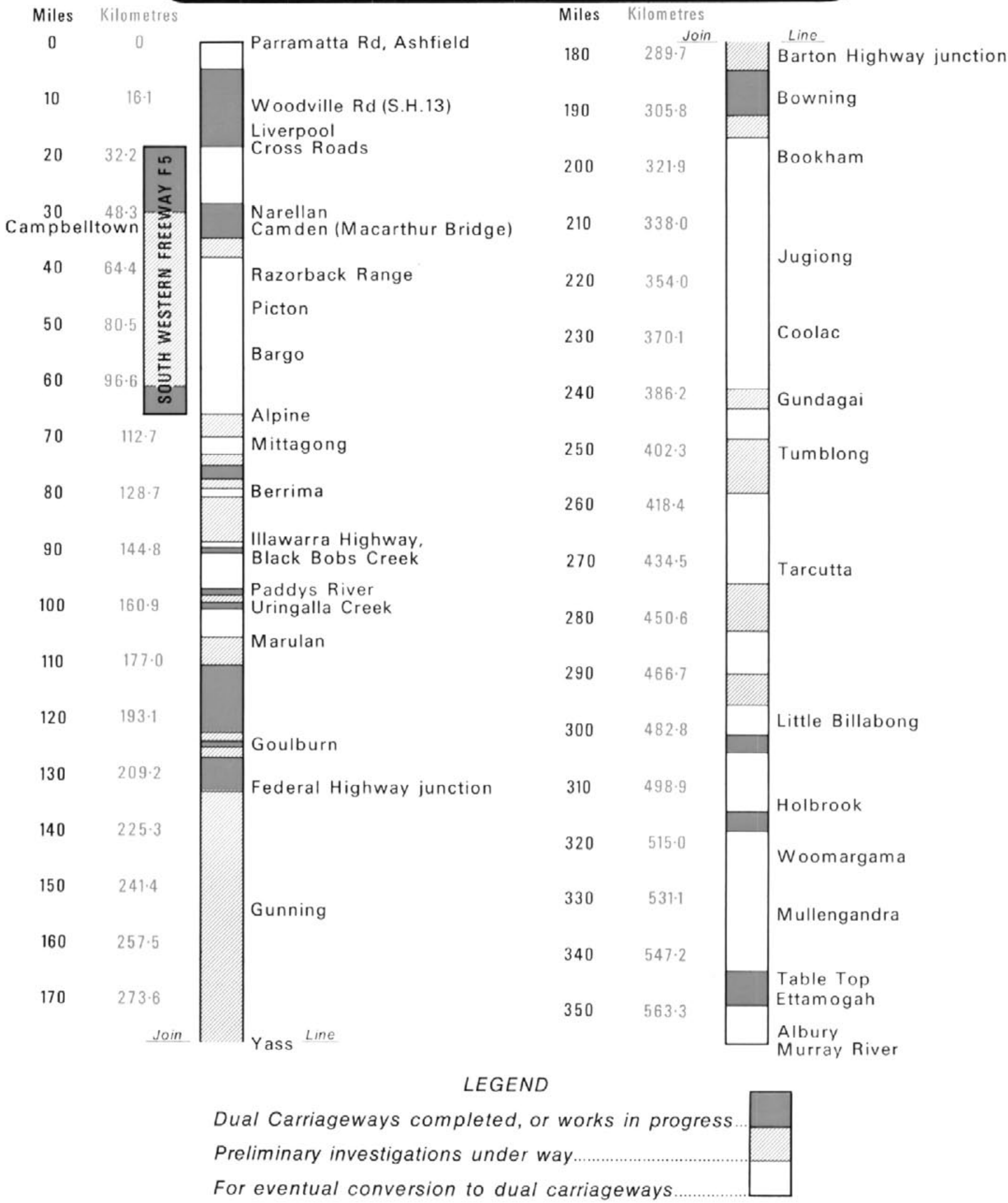
Looking south along the old bridge at Gundagai. This bridge will be replaced by a new bridge now being constructed on a deviation with dual carriageways

Below:

Completed dual carriageways 50 km (31 miles) south of Holbrook



Dual Carriageway Progress on the Hume Highway



deviation by-passing the Village of Bowning between 10·5 km (6·5 miles) and 17 km (10·5 miles) south of Yass. The final cost is of the order of $900,000 including bridge works. This deviation replaced a section of Highway 6 m (20 ft.) wide, a narrow bridge and removed through traffic from the Village of Bowning.

Dual Carriageways Now Under Construction

North of Goulburn the construction of dual carriageways from Marulan to Narambulla Creek, 5·5 km (3·4 miles) is in progress. This section, estimated to cost $970,000, is expected to be available to traffic in the early part of 1974.

South of Goulburn work has commenced on the construction of dual carriageways which includes a new bridge over Derringullen Creek between 6·4 km (4 miles) and 11·2 km (7 miles) south of Yass. The completed work will form an extension of the dual carriageways already constructed at Bowning. This section, estimated to cost $850,000 is expected to be available to traffic early in 1975.

Proposals for Further Dual Carriageways

Future reconstruction of the Hume Highway throughout the Southern Division will be to dual carriageway standard. Plans are nearing completion for reconstruction from Uringalla Creek, the northern boundary of the Division, to Marulan. Plans have been completed for the construction of dual carriageways at North Goulburn. This proposal provides for the extension of dual carriageways into the urban area of Goulburn and construction of dual bridges over the Main Southern Railway Line, the Crookwell Branch Railway Line and the Mulwaree Ponds.

In addition to these works for which plans are prepared, progress continues in planning construction of dual carriageways from the Bowning Deviation to Conroys Gap 17 km (10·5 miles) to 21 km (13 miles) and also from 32 km (20 miles) to 39 km (24·5 miles) south of Yass.

The foundations for a major bridge over the Murrumbidgee River at Gundagai were completed in December 1973 and tenders have been invited for the construction of the new bridge. In conjunction with the new bridge a dual carriageway Traffic Relief Route will be constructed around Gundagai. This Traffic Relief Route will commence approximately 4·8 km (3 miles) north and end at 4·8 km (3 miles) south of Gundagai and is expected to be available to traffic in 1977. (An article on the design of the bridge over the Murrumbidgee River at Gundagai appears on page 34 of this issue).

In the longer term, proposals are also being examined for the construction of dual carriageway Traffic Relief Routes around the City of Goulburn and the Municipality of Yass and for dual carriageways between Goulburn and Yass.

SOUTH WESTERN DIVISION

The Hume Highway extends through the South Western Division from south of Gundagai in the Tarcutta Range for 145 km (90 miles) until it crosses into Victoria at the Murray River at Albury.

Completed Dual Carriageways

In February 1968, construction of dual carriageways commenced between 49 km (30·4 miles) and 56 km (34·9 miles) south of the town of Tarcutta. Dual carriageway standards were achieved by using the improved existing pavement for southbound traffic and constructing a new carriageway for northbound traffic. The northbound carriageway was opened to traffic in January 1970 and cost approximately $359,000.

In February 1972 a further section costing about $480,000, between 49 km (30.47 miles) and 53·5 km (33·2 miles) south of Holbrook was made available to traffic. On this section the new carriageway carried southbound traffic.

Under Construction

Construction commenced in August 1972 on a new section of dual carriageway between 1 km (0·6 miles) and 9 km (5·7 miles) south of Holbrook. The extensive deterioration of the old pavement and an increasing volume of traffic dictated the need for the provision of two new carriageways. The estimate for this work is $610,000 and it is expected that this length will be opened to traffic about mid 1974.

Future Proposals

The extension of the work south of Holbrook from 53·5 km (33·2 miles) to 59 km (36·9 miles) is about to commence and again the existing pavement with improvements will be used for traffic in one direction only. The estimated cost, including a new bridge over the main southern railway line at Ettamogah and improvements at the junction of the Hume Highway with the Olympic Way (Trunk Road No. 78) is of the order of $550,000. The new bridge over the main southern railway line will eliminate the sharp curves in the approaches to the existing narrow railway overbridge. In addition about $100,000 will be spent on upgrading a narrow winding length of Highway in the northern approach to Albury, 59 km (36·9 miles) to 61 km (37·8 miles) south of Holbrook.

Other proposed future works involve sections on the Tarcutta—Holbrook length of the Highway and investigations of sections with narrow pavement, steep grades and sharp curves is in hand preparatory to design and planning.

While the construction of some projects is in hand, planning for immediate works is nearing completion and proposals for future works are being examined. The current annual average daily traffic figures show that approximately 8,000 vehicles per day travel on the single two lane carriageway leading into Goulburn and a very large proportion of heavy vehicles is included in this traffic volume. In the financial year 1972–73 loads totalling about 4,000,200 tons passed through the Department of Motor Transport's Checking Station at Marulan.

The Hume Highway cannot sustain a satisfactory level of service under these conditions.

In the five financial years to 30th June, 1973 about $35·9 million was spent on maintenance and construction work on the Highway. Of this total $29·1 million was spent on construction and the balance ($6·8 million) on maintenance.

It will be necessary for substantially increased funds to be provided if the rate of construction of dual carriageways on the Hume Highway is to be increased to a level which will provide obvious improvements for the safe movement of traffic.

Record to date on the work carried out indicate a significant reduction in all accidents on dual carriageway sections. This is indicative only at this stage as sufficient time has not yet elapsed for a proper statistical analysis to be made●

DEATH OF MR C. W. MANSFIELD

Mr Cecil Worthington Mansfield, Secretary of the Department of Main Roads, collapsed in his office and died suddenly on Friday, 1st February, 1974.

Mr Mansfield's career in the Department spanned a period of 44 years commencing with his appointment as Junior Clerk with the Main Roads Board on 4th November, 1929. His first years of service were spent in Head Office Sections until 1937 when he was appointed Cost Clerk at Dubbo in the Central Western Division, returning to Head Office in 1940.

During the years 1942–43, Mr Mansfield served in the Northern Territory as Chief Clerical Officer on the construction work on the North-South Road between Adelaide River and Katherine. The following years of Mr Mansfield's career were in Head Office Sections.

On 12th April, 1962 he became Assistant Secretary followed by his appointment on 1st June, 1964 to the position of Deputy Secretary. He was appointed Secretary on 21st September, 1964.

In 1958 Mr Mansfield attended the Australian Administrative Staff College at Mt Eliza, Victoria.

Mr Mansfield held membership in a number of professional associations. He was Associate Member of the Australian Society of Accountants, Associate Member of the Chartered Institute of Secretaries, Fellow of the Royal Institute of Public Administration and Fellow of the Chartered Institute of Transport. He was elected Chairman of the Institute of Transport, New South Wales Section, for 1970–71.

He was active in the Public Service Association for a period of time and was a delegate to the Government Agencies Division representing the Main Roads Sub-Division.

Mr Mansfield was prominent in the foundation of the Main Roads Staff Credit Union Limited and was Chairman of the Union from its inception in 1964.

Mr C. W. Mansfield

APPOINTMENT OF MR CLAUDE A. GITTOES

Mr Gittoes, who previously held the position of Assistant Secretary, was appointed to the position of Secretary of the Department of Main Roads, New South Wales, on 5th February, 1974.

In 45 years of service, Mr Gittoes has served in several areas of the State in both permanent and relieving capacities. Appointed as a Junior Clerk on 11th March, 1929, at Wagga Wagga, he was transferred to the country section of the Chief Engineer's Branch in 1936. From 4th February, 1943, Mr Gittoes took up the position of Chief Clerical Officer responsible for clerical administration on the North-South Road from Darwin to Mataranka. He returned to the Chief Engineer's Branch in February 1944, and was attached to this Branch for almost 12 years, except for a period as Chief Clerical Officer in the Divisional Office, Parkes.

Mr Gittoes was appointed Senior Clerk in the Branch on 1st March, 1952 at which time his duties were combined with the organisation of the new Weight of Loads Section. On 9th January, 1956, he was appointed the first Weight of Loads Officer.

Two years later, Mr Gittoes became Senior Clerk, Correspondence Section and held this position until appointed Assistant Secretary on 18th January, 1965.

In 1960, Mr Gittoes attended the Advanced Course at the Australian Administrative Staff College, Mt Eliza. During 1966, Mr Gittoes travelled overseas to Great Britain, Europe and U.S.A. with the then Assistant Commissioner when he made a special study of records procedures, toll collection and methods of handling political correspondence.

From 1959 to 1963 Mr Gittoes was Secretary of the National Association of Australian State Road Authorities. He is an Associate of the Town Clerks Society and an Associate of the Institute of Municipal Administration (Australia).

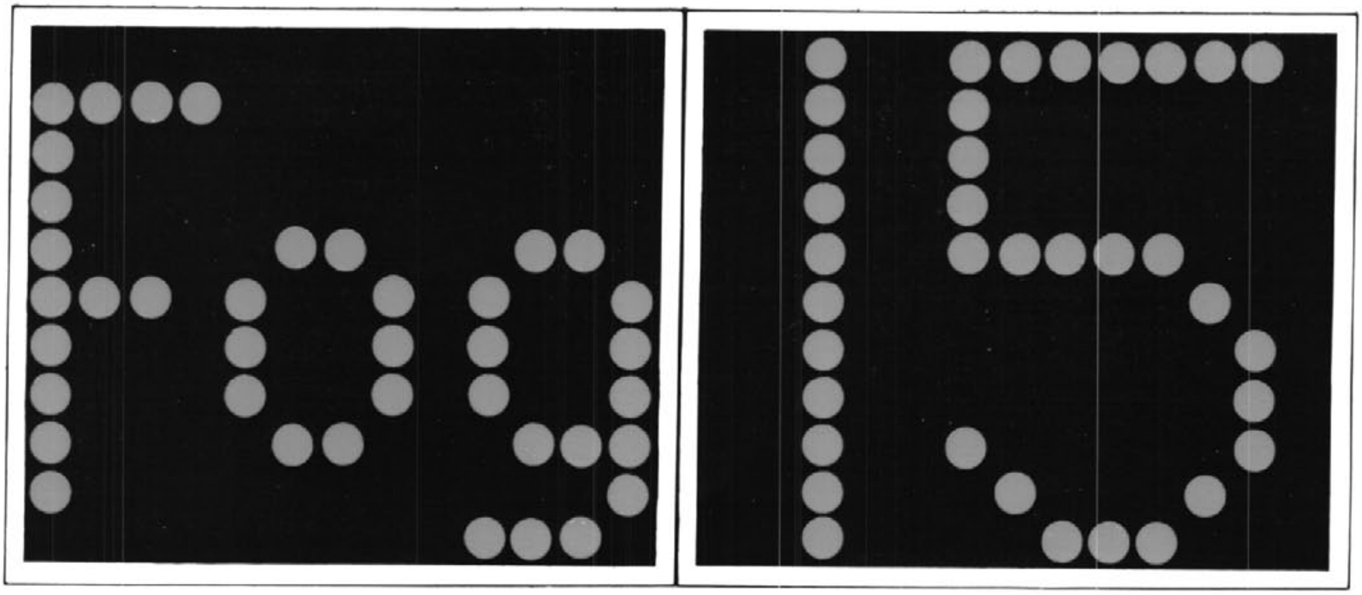
Mr Claude A. Gittoes

ENGINEER-IN-CHIEF

Amendment

On page 56 of the previous issue of "Main Roads" (December 1973) a textual error stated that Mr R. E. Johnston, recently appointed Engineer-in-Chief of the Department of Main Roads had been active in the Sydney Division of the Institution of Engineers for six years. The text should have read—"He was a member of the Advisory Council, Australian Road Research Board for a period of six years. He has also been active in the Institution of Engineers, Australia, and was Chairman, Sydney Division, in 1972."

Mr Johnston has, in fact, been a member of the Institution of Engineers since he joined as a student in 1933.



ELECTRONIC DRIVER AID SYSTEM FOR THE SOUTHERN TOLLWORK

"Fog 15" is one of the warning signs of the electronic driver aid system which will be installed on the Southern Tollwork.

This system will be the first of its kind in Australia and one of the most advanced driver aid systems in the world.

The 21 km (13 mile) section of Southern Tollwork, under construction between Waterfall and Bulli Pass, traverses an area subject to fogs. Investigations have been carried out on the fog situation by the Department with assistance from the Bureau of Meteorology, Sydney, the Metropolitan Water Sewerage and Drainage Board, the Maritime Services Board at Port Kembla and local residents of the area. The resulting information shows that fogs prevail between Helensburgh turnoff from Prince's Highway (approximately 8 km (5 miles) south of Waterfall) southerly to Mount Kembla 24 km (15 miles) south of the southern end of the Tollwork and to approximately 1·6 km (1 mile) west of the edge of the escarpment. Generally, the fogs are of the orographic type caused by warm moist air from the sea rising up the 300 m (1,000 ft) escarpment nearby and cooling to settle as fog over the adjacent area. This type of fog may last from half an hour to a week or more. Radiation fog brought about by moisture on the ground in the early morning of a clear day also occurs in this area.

From records held at Bulli Pass Kiosk, fogs of sufficient density to impair vision and require reduction in speed below the normal travel speed, could occur on about 31 days each year. The section of the tollwork most fog prone is a 9.5 km (6 mile) length immediately north of Bulli Pass which includes the complex interchange area at the top of Bulli Pass.

While there is no known practical method of providing a fail safe system for motorists during fog the particularly severe fog conditions which prevail on the Southern Tollwork warrant special measures to ensure safe conditions for motorists.

Following extensive research by the Department on the problem, including investigations of fog warning systems on freeways overseas, an electronic driver aid system is to be installed on the 21 km (13 miles) of southern Tollwork. This electronic driver aid system includes a system of advisory speeds for traffic control and is as advanced as any of its kind in the world. A contract for the design, supply and installation of the system has been awarded to Plessey Telecommunications Pty. Ltd. at a price of $639,096.

The system is to be controlled by a traffic supervisor from the control centre at Waterfall. At this control centre, the supervisor can activate the roadside equipment through computers and monitor his operations on a large electronic display or mimic diagram of the tollwork.

When fog conditions are alarmed, the supervisor will instruct the computer to warn of fog in that particular area. That message is transmitted to field stations called responders which then activate the nearby signs. A typical sign would then show

There will be 36 of these signs located about every 1·6 km (1 mile) along the tollwork. The signs will be cantilevered over the shoulder and are approximately 2 m x 1 m (77 in x 43 in) in size. The amber legend of the signs is formed on two matrix display panels by carrying light along fibre optic strands from a single lamp to selected lenses. Electronic switching at the back of the sign, allows different legends to be formed.

The traffic supervisor can display different legends for specific purposes. The advisory speed can be altered in multiples of 10 km.p.h. up to 95 km.p.h.

He can warn in advance of lane blockage caused by an accident or a maintenance operation.

The left-hand panel here uses the United Kingdom symbol for lane closure, often called the "wicket sign".

As these signs will only operate when motorists need to be warned of hazardous conditions, amber lanterns at the four corners of the sign will flash in pairs to ensure that the sign message is noticed.

When conditions become too hazardous for travel on the motorway, the supervisor can call up the STOP sign in which case legend and lanterns are red.

At most sign locations, an emergency telephone will be provided. This phone will be linked through the roadside responder to the control centre. When a motorist lifts the handset of an emergency phone, the supervisor is alerted by an alarm and a light on the mimic diagram shows the location of the caller. Emergency services can be directed positively with this information.

Adjacent to the signs along the tollwork, are vehicle detection devices to count vehicles and to measure their "percentile speed". At the control centre the computer monitors this information and shows the supervisor the traffic flow at each site on a visual display screen. The computer will give an alarm when traffic patterns are abnormal, allowing the supervisor to detect lane blockages or possible accident sites. The "percentile speed" reading is a measurement of the percentage of vehicles exceeding the advisory speed. If this is high, the supervisor checks to see whether the conditions have cleared or he may use red flashing lanterns instead of the amber lanterns as an attempt to reinforce the warning.

The computer system is actually two identical computers—one carries out the work while the other continually "watches" and checks that all operations are correct. The computers continually communicate with field stations collecting information and checking that the system is functioning correctly.

Above the Bulli escarpment the Department is shortly to construct a weather station which will continually monitor humidity, wind direction and speed. When conditions conducive to fog formation occur an alarm will sound in the control centre. Automatic fog detectors along the tollway will be switched on an alarm when fog occurs in that location. These operate by measuring the attenuation of a light beam in fog. However, suitable units will not be immediately available. As an interim measure, on receipt of the alarm from the weather station vehicles with 2-way radio will patrol and will radio in whenever fog is encountered.

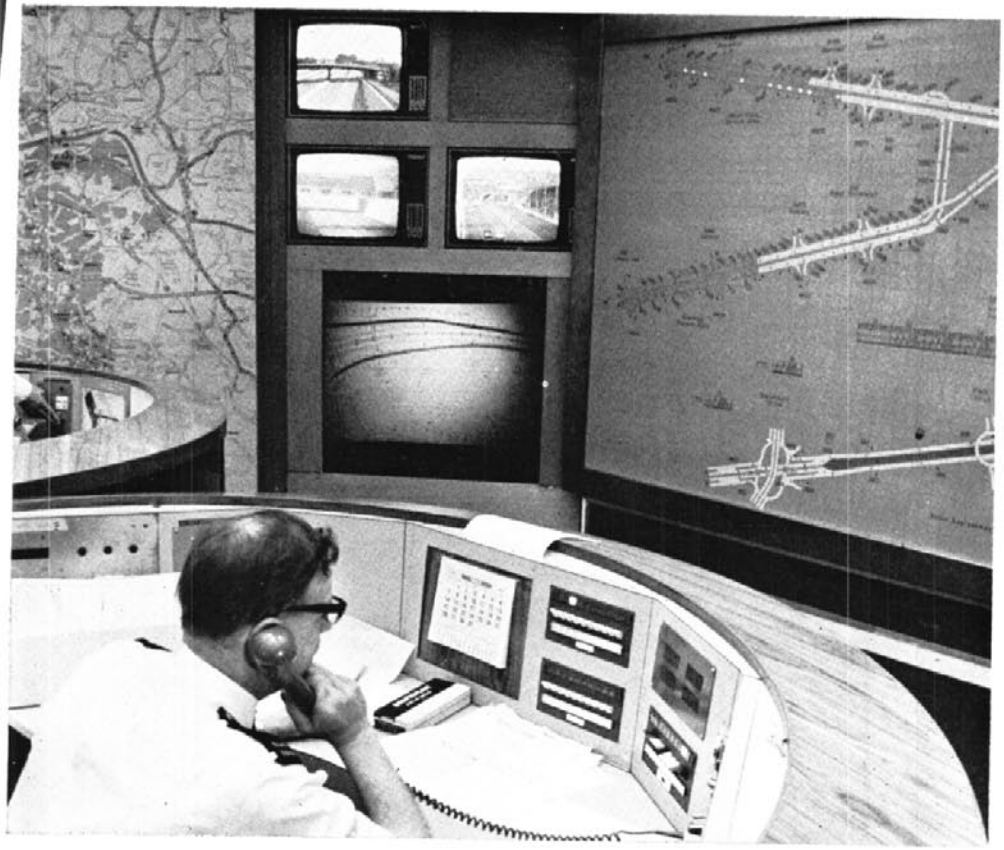
The computer is also linked to toll collection and carries out toll accounting.

The Traffic Control Centre will be manned continuously over 24 hours.

Standard safety features associated with modern freeways will also be featured on the tollwork to aid drivers during conditions of poor visibility. These include external illumination on all direction signs, special lighting at areas where traffic merges, such as the Waterfall Toll Plaza and the Waterfall Interchange and delineation of lane and edge lines with reflective pavement markers.

By the use of modern electronics, a driver aid facility for safer freeway motoring has been developed. The system whilst providing an emergency telephone service and advising speeds and warnings for hazards commonly encountered, also caters for the special conditions of fog ●

This 1972 photograph shows a section of the Illawarra escarpment where fogs occur. The route of the Southern Tollwork is inland of the Prince's Highway



(Left): The console of a typical computer centre where traffic supervisors monitor traffic flow and driving conditions

(Below): The Gravelley Hill Interchange (Gantry No. 2) nearby at the junction of M6 and A38 in Birmingham. Although the signs on the Southern Tollwork will be of the roadside type both systems incorporate similar electronic mechanisms to produce a variety of messages for traffic control

TENDERS ACCEPTED BY COUNCILS

The following tenders (in excess of $20,000) for road and bridge works were accepted by Councils for the three months ended 31st December, 1973.

Council	Road No.	Work or Service	Name of Successful Tenderer	Amount
				$
Coffs Harbour	M.R. 151	Construction of a 3 cell 3·7 m x 3·7 m (12 ft x 12 ft) reinforced concrete box culvert over Star Creek 67·6 km (42 miles) south of Grafton.	M. O. & P. J. Kautto	34,994.24
Dumaresq	T.R. 74	Construction of a 4 cell 4·3 m x 3·1 m (14 ft x 10 ft) reinforced concrete box culvert over Rigney Creek 76·5 km (46·9 miles) east of Armidale.	Enpro Constructions	43,333.68
Tamarang	T.R. 72	Construction of a 6 cell 3·4 m x 2·9 m (11 ft x 9·5 ft) reinforced concrete box culvert over Colley Creek 13·2 km (8·2 miles) south of Quirindi.	J. Parkinson	26,676.15

TENDERS ACCEPTED BY THE DEPARTMENT OF MAIN ROADS

The following tenders (in excess of $20,000) for road and bridge works were accepted by the Department for three months ended 31st December, 1973.

Road No.	Work or Service	Name of Successful Tenderer	Amount
			$
Western Freeway	Municipality of Auburn. Construction of a services bridge over Haslam's Creek.	Peter Verheul Pty Ltd	97,680.00
South Western Freeway	Shire of Mittagong. Construction of earthworks, drainage, fencing and a bridgework on the section of the freeway between 110·9 km (68·9 miles) and 116·2 km (72·2 miles) south of Sydney.	G. Abignano Pty Ltd	1,441,515.00
State Highway No. 1	Prince's Highway. Shire of Shoalhaven. Construction of a 7-span prestressed and reinforced concrete bridge 150·4 m (493 feet) long over Currumbene Creek 10·3 km (6·4 miles) south of Nowra.	The Hornibrook Group (Southern Division).	349,348.00
State Highway No. 2	Hume Highway. Shire of Hume. Construction of a 4-span prestressed and reinforced concrete bridge 67·7 m (222 feet) long, over the main southern railway near Ettamogah, 54·2 km (33·7 miles) south of Holbrook.	John Evans Civil Engineering Co. Pty Ltd.	108,752.26
State Highway No. 3	Federal Highway. Shire of Mulwaree. Construction of twin 10-span prestressed and reinforced concrete bridges 54·9 m (180 feet) long and a 5-span prestressed and reinforced concrete bridge 31·5 m (90 feet) long over Wologorang Creek at 18·8 km (11·7 miles) and 20·1 km (12·5 miles) south of Goulburn respectively.	Siebel Concrete Constructions Pty Ltd.	130,735.80
State Highway No. 6	Mid Western Highway. Shire of Bland. Construction of a 6-span prestressed and reinforced concrete bridge 32·9 m (108 feet) long and a 9-span prestressed and reinforced concrete bridge 49·4 m (162 feet) long, both over Humbug Creek at 18 km (11·2 miles) and 6·6 km (4·1 miles) west of West Wyalong respectively.	Dankert Constructions Pty Ltd	67,384.85
State Highway No. 9	New England Highway. City of Maitland. Supply and delivery of up to 1,700 tonnes (1,666 tons) of 20 mm (¾ in) graded asphaltic concrete for construction of dual carriageway 23·3 km to 25·9 km (14·5 to 16·1 miles) west of Newcastle.	Bituminous Pavements Pty Ltd	22,576.00
State Highway No. 10	Pacific Highway. Shire of Ulmarra. Supply, delivery, and laying of up to 816 tonnes (832 tons) of asphaltic concrete between 13·5 km and 14·2 km (8·4 and 8·8 miles) north of Grafton.	Bituminous Pavements Pty Ltd	20,151.20
State Highway No. 11	Oxley Highway. Shire of Coonabarabran. Construction of a 10 cell 3·05 m x 1·53 m (10 ft x 5 ft) reinforced concrete box culvert at 67·4 km (39·6 miles) and four prestressed and reinforced concrete bridges east of Coonabarabran. A 10-span 57·9 m (190 ft) long bridge at 65·7 km (40·8 miles), a 7-span 40·6 m (133 ft) long bridge at 66·3 km (41·2 miles), a 13-span 75·3 m (247 ft) long bridge at 66·7 km (41·4 miles) and a 16-span 92·7 m (304 ft) long bridge at 66·8 km (41·5 miles).	M. & E. Firth Civil Constructions (Tamworth) Pty Ltd.	278,630.60
State Highway No. 21	Sturt Highway. Shire of Hay. Demolition of old bridge over Murrumbidgee River at Hay.	Ackra Explosives	76,355.00
Trunk Road No. 68	Shire of Central Darling. Construction of a 3-span steel box girder bridge 107·7 m (353 ft) long over the Darling River at Menindee.	L. M. Robertson Construction Co.	466,622.00
Main Road No. 178	Municipality of Camden. Manufacture, supply, and delivery of precast, prestressed concrete bridge units, parapet panels and footway slabs to construction of twin bridges over the water race canal, west of Kenny's Hill.	Peter Verheul Pty Ltd	30,835.60
Main Road No. 184	Municipality of Windsor. Construction of a 3-span prestressed and reinforced concrete bridge 82·4 m (270 feet) long over South Creek at Windsor.	Pearson Bridge (N.S.W.) Pty Ltd	335,546.00
Main Road No. 286	Shire of Snowy River. Loading, hauling, and tipping 13,005 m^3 (17,000 cu. yds) of free-draining base-course material for reconstruction 32·3 km to 35·6 km (20 to 22·1 miles) west of Jindabyne.	Kevin Brown	39,100.00
Future Main Road	City of Parramatta. Construction of a single span prestressed and reinforced concrete bridge 29·3 m (96 feet) long over Belmore Street, Dundas.	Graham Evans & Co. Pty Ltd	281,936.00
Various	Winning, crushing, and stockpiling of 30,000 cu. metres of conglomerate rock at 43·5 km (27 miles) north of Coffs Harbour.	Blue Metal and Gravel (Country) Pty Ltd.	67,200.00
	Construction of aggregate stockpile retaining walls and reclamation conveyor tunnel at Central Asphalt Depot, Granville.	John Holland (Constructions) Pty Ltd.	316,937.00

On the Hume Highway, between 10 km (6.2 miles) and 17 km (10.4 miles) south of Yass, a section of dual carriageway known as the Bowning Deviation, was opened to traffic in August last year.

Also opened last year, this 11 km (6.6 mile) length of divided carriageway between Narambulla Creek and Towrang Hill south of Mittagong, includes twin bridges over Narambulla Creek.

Construction work involving duplication of the existing carriageway is at present underway on the Hume Highway 64 km (40 miles) south of Mittagong.