SOUTH WESTERN FREEWAY

FREEWAY F5

from The Cross Roads near Liverpool
to Aylmerton near Mittagong

DMR DEPARTMENT OF MAIN ROADS NEW SOUTH WALES

THE SOUTH WESTERN FREEWAY

The planned route of the F5 — South Western Freeway extends from the proposed F6 — Southern Freeway at Tempe, in a general westerly direction to The Cross Roads near Liverpool and thence in a southerly direction through semi-rural and rural areas via Campbelltown, Menangle and Douglas Park towards Mittagong.

Construction of the F5 from The Cross Roads to Aylmerton, just north of Mittagong, has been undertaken in three stages. The first stage from the Hume Highway at The Cross Roads to the intersection with Main Road No. 178, Camden Road at Kenny Hill, near Campbelltown, was completed in December 1974. The second stage, from the Hume Highway at Yanderra to the Hume Highway at Aylmerton was opened to traffic in May 1977. The third stage is from Camden Road to Yanderra. With the completion of this third stage, an uninterrupted 64 km length of freeway is now available to roadusers.

The completed freeway provides substantial saving in travelling time between The Cross Roads and Aylmerton as well as reducing the distance by approximately 13 km. Annual roaduser benefits are estimated to be more than $13 million. In addition, the diversion of heavy commercial vehicles from the Hume Highway should significantly improve safety and living conditions in townships such as Picton, Tahmoor and Bargo. It is expected that tourism will develop further in the area and that there will be a general growth in population based on easier access to the larger centres of employment, and also on the improved residential environment.

The route of the F5 is through country varying from gently undulating pastures in the north to rugged sandstone country on the edge of the Nepean River catchment area in the south. Special attention was paid in the design to the blending of the roadworks and bridgeworks into the countryside and extensive landscaping has created an overall visual environment of high standard. Some 30,000 trees and shrubs have been planted, approximately 500 per kilometre.

The design of the freeway provides for dual carriageways of ultimate three lane width. Each of the two carriageways will be 12.8 m wide, initially having two 3.65 m wide traffic lanes with shoulders on each side. The two carriageways have been designed independently with variable median width to provide maximum flexibility in location. For the safety of traffic and delineation, some 300 km of thermo-plastic linemarking and 50,000 raised pavement markers have been provided.

Carrying the freeway across obstacles and the provision for grade separation of cross traffic along the total 64 km length involved the construction of 35 bridges of which 14 are twin structures. The total length of these 49 bridge structures is approximately 4.5 km.

The bridges range in length from the twin structures 305 m long over the Nepean River at Pheasants Nest to the 12.3 m long twin bridges over the Sydney Water Supply Channel, approximately 3 km south of Camden Road.

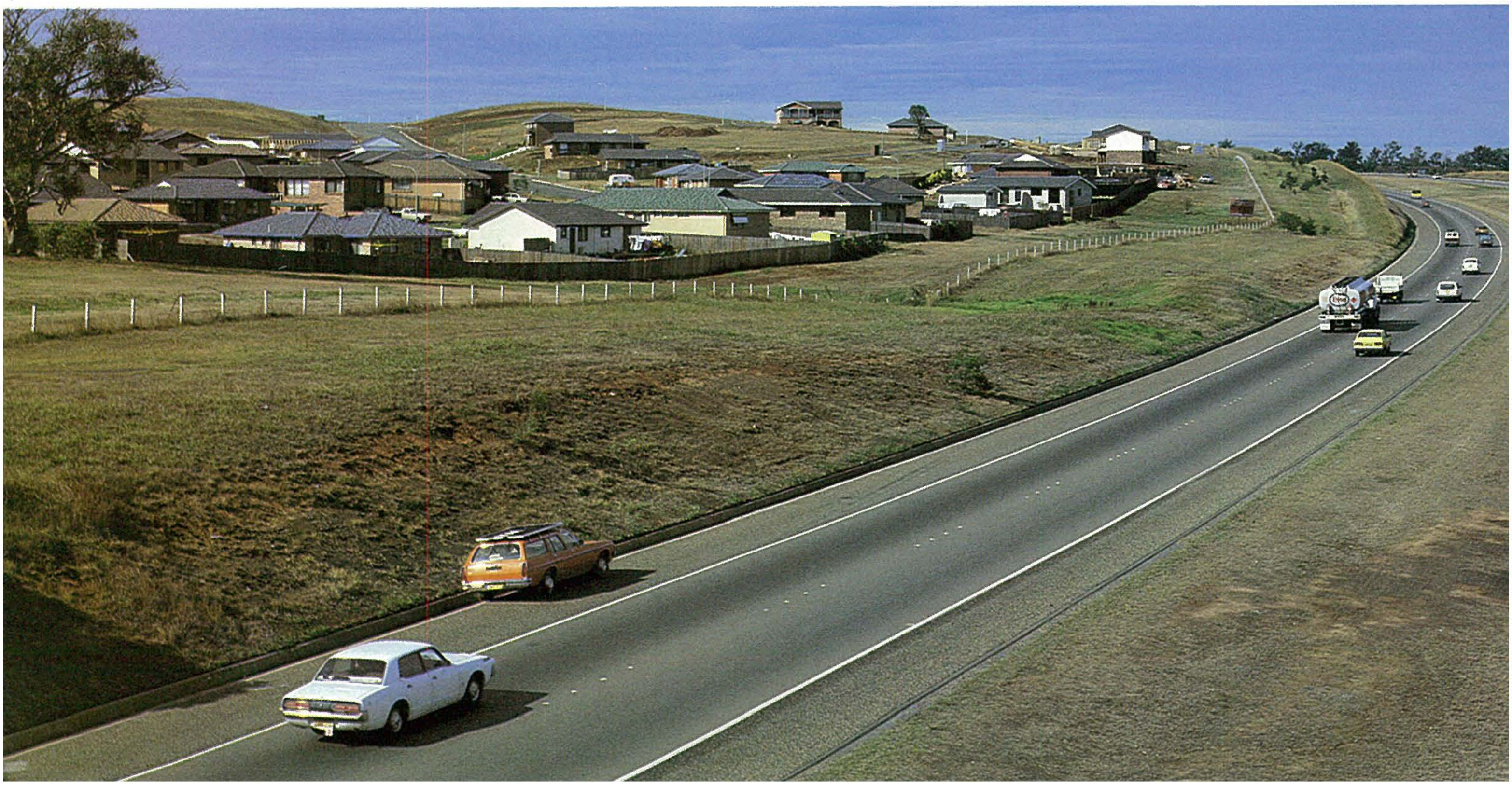
As freeways provide safe travel by eliminating cross traffic conflict, access is provided by specially designed traffic interchanges. Initially, there are seven interchanges . . . at The Cross Roads, Raby Road, Camden Road, Wilton, Avon Dam Road, Yanderra and Aylmerton.

Provision has been made for additional interchanges to cater for future development in the Campbelltown-Camden-Appin growth centre.

The construction of the F5 between The Cross Roads and Aylmerton required the excavation and compaction of 10 million cubic metres of earth and rock, as well as the provision of 2.2 million square metres of road pavement and shoulders. The deepest cut is 23 m and the highest fill is 45 m. The pavement is up to 425 mm thick, on lime stabilised selected sub-grade material.

An automatic emergency telephone system has been provided over the full length of the freeway as a service to motorists who may require road service, police or ambulance assistance. The system has been designed in conjunction with Telecom and incorporates the latest technology.

With a total cost of approximately $136 million, which includes construction, land acquisition and administrative costs, the construction of the F5 from The Cross Roads to Aylmerton has been the biggest project yet undertaken and completed by the Department. Since this project was classified as part of the Sydney-Melbourne National Highway in mid 1974, it has been fully funded by the Commonwealth Government.



STAGE 1

THE CROSS ROADS TO KENNY HILL

The first section, 9.8 km long, from The Cross Roads to Raby Road near Campbelltown was opened to traffic on 26 October 1973. The second section, 5.8 km long, from Raby Road to Main Road No. 178 (Camden Road) near Kenny Hill was opened on 16 December 1974, completing the 15.6 km length of Stage 1 from The Cross Roads to Camden Road.

The deepest cut on this section is 21.3 m and the highest fill is 12.2 m. The maximum grade along the freeway is 2.5%. Construction involved approximately 2.3 million cubic metres of earthworks and there are 450 000 square metres of road pavement, incorporating 100 000 tonnes of asphaltic concrete.

A total of 12 bridges were built on this section at a total cost of over $4 million. They include four crossings where twin bridges have been provided and one, at Main Road No. 178 (Camden Road), where the structure for eastbound traffic was built as part of Stage 1 and the duplicate structure for westbound traffic was constructed as part of Stage 3 (see page five). One crossing, on Main Road No. 177 (Campbelltown Road) over Bunbury Curran Creek, was required because of the freeway construction but is not part of the freeway system.

The bridges are listed below and the numbers refer to their location on the appropriate map on page 10.

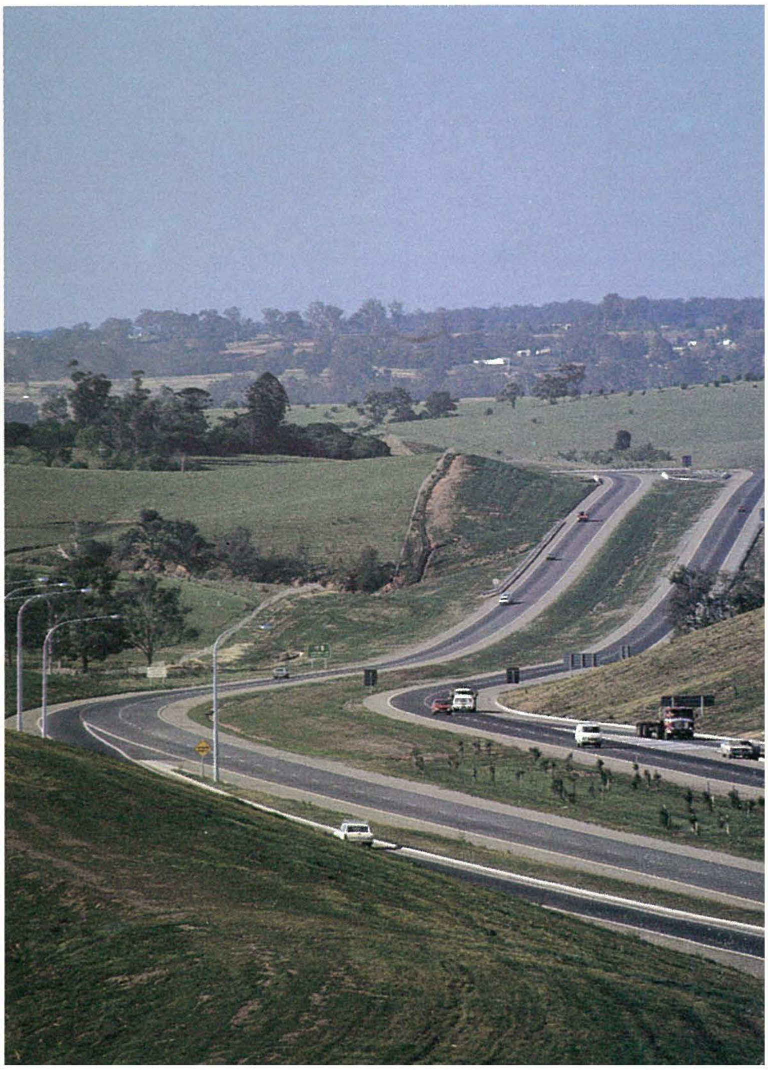
1. Bridge to carry Hume Highway over F5.
2. Bridge to carry Main Road No. 177 (Campbelltown Road) over F5 (first crossing).
3. Twin bridges to carry F5 over Aero Road.
4. Bridge to carry Brooks Road over F5.
5. Twin bridges to carry Main Road No. 177 over F5 (second crossing).
6. Bridge to carry Main Road No. 177 over Bunbury Curran Creek.
7. Twin bridges to carry F5 over Bunbury Curran Creek.
8. Bridge to carry St. Andrews Road over F5.
9. Bridge to carry Raby Road over F5.
10. Bridge to carry loading ramp from Campbelltown (for northbound traffic) over F5.
11. Twin bridges to carry F5 over Badgally Road.
12. Bridge to carry eastbound traffic on Main Road No. 178 (Camden Road) over F5.

Left: One of the residential developments springing up beside the South Western Freeway near Campbelltown.

Below: Brooks Road overbridge near Ingleburn in February 1973, prior to the opening to traffic of the first section of freeway.

An aerial view looking south, showing construction of the Camden Road interchange.

A completed section of the F5, looking north near Campbelltown, photographed in August 1975.



STAGE 2

YANDERRA TO AYLMERTON

The 13.5 km section between Yanderra and Aylmerton was opened to traffic on 24 May 1977. This section, built on a more direct alignment than the existing Hume Highway, has a minimum curve radius of 1650 m and a maximum grade of 6.5%. It becomes the replacement route to a section of the Hume Highway which had 42 curves of which 11 had advisory speed signs varying from 75 km/hr to 25 km/hr.

The highest fill on this section is 45 m and the deepest cut is 12 m.

Construction work involved 2 million cubic metres of earthworks and there are 350 000 square metres of road pavement, using 80 000 tonnes of asphaltic concrete.

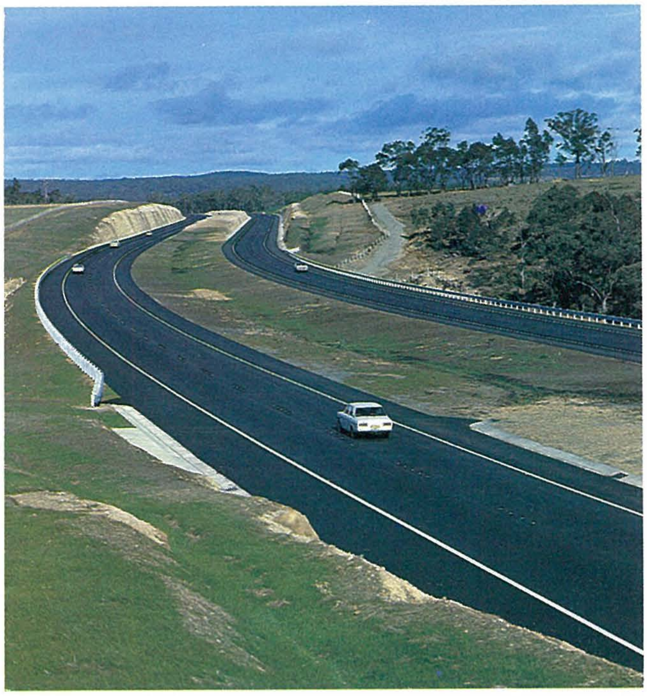
This section involved the construction of five bridges (including three twin structures) at the following locations. (The numbers again refer to their location on the appropriate map on page 11.)

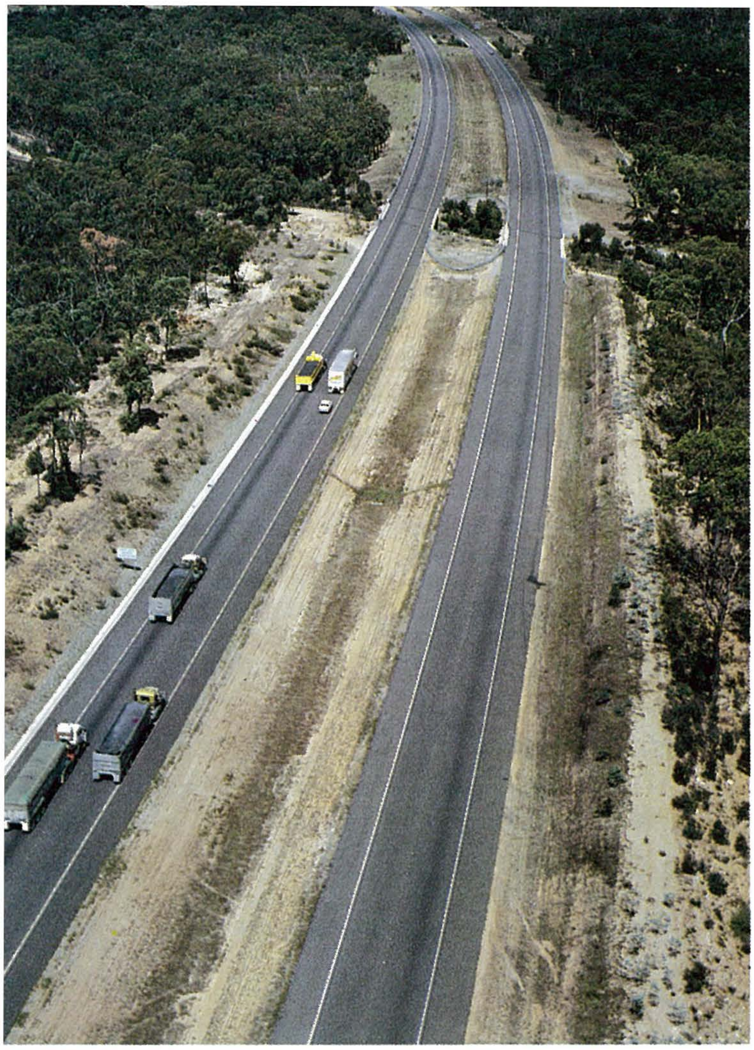
30. Twin bridges to carry F5 over Main Southern Railway Line at Yanderra.
31. Twin bridges to carry F5 over Main Southern Railway Line at White Horse.
32. Twin bridges to carry F5 over Hume Highway at White Horse.
33. Bridge to carry Sierra Road over F5 at Yerrinbool.
34. Bridge to carry Church Avenue over F5 at Alpine.
35. Bailey pedestrian bridge over F5 at Aylmerton (temporary) . . . to provide a safe crossing over the Hume Highway-F5 connection at Aylmerton particularly for school children, until a permanent overbridge is built during construction of the F5 south of Aylmerton.

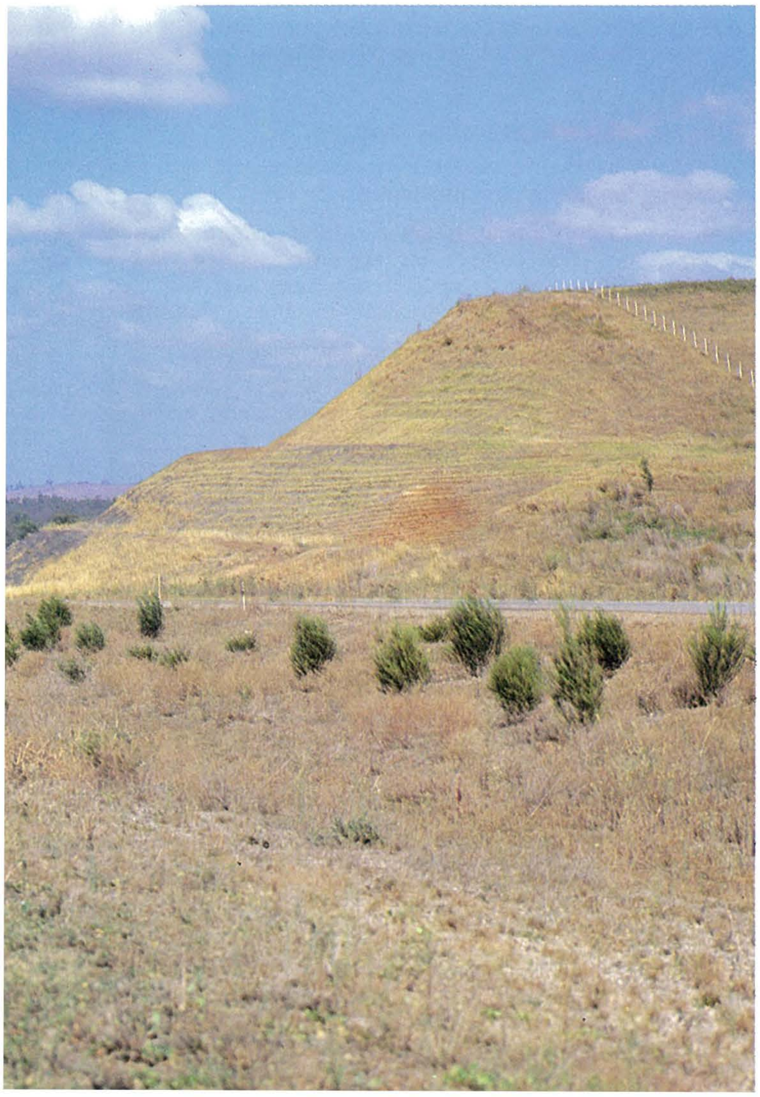
Above left: Construction under way at the Church Avenue overbridge near Aylmerton, February 1976.

Below left: The same location photographed in August 1977, showing how construction scars soon heal, particularly with sympathetic care.

Below: Completed carriageways between Yanderra and Aylmerton, May 1977.







STAGE 3

KENNY HILL TO YANDERRA

The 35 km section of the F5 between Kenny Hill and Yanderra was the last to be constructed.

A $993,704 contract was awarded to White Industries Ltd in May 1976 for the construction of earthworks, drainage and fencing for the 2.9 km length between Avon Dam Road and Yanderra. In February 1977, G. Abignano Pty Ltd contracted to undertake construction of earthworks, drainage and fencing for the 9.5 km length between Pheasants Nest and Avon Dam Road for $2,302,844. The balance of the construction work on this section was undertaken primarily by the Department's own workforce but with a number of tasks being carried out by contractors.

Construction of this 35 km section involved 5.7 million cubic metres of earthworks and 1.4 million square metres of road pavement, using 250 000 tonnes of asphaltic concrete. The highest fill on this section is 13 m and the deepest cut 23 m.

As listed below, there are 17 bridges, including 7 twin structures, on this section.

13. Bridge to carry westbound traffic on Main Road No. 178 (Camden Road) over F5.
14. Twin bridges to carry F5 over Main Southern Railway Line near Glenlee.
15. Twin bridges to carry F5 over Sydney Water Supply Channel.
16. Bridge to carry Minto Road over F5.
17. Bridge to carry Main Road No. 179 (Menangle Road) over F5.
18. Twin bridges to carry F5 over Nepean River at Menangle.
19. Bridge to carry Moreton Park Road over F5 near Menangle.
20. Bridge to carry Moreton Park Road over F5 near Douglas Park.
21. Twin bridges to carry F5 over Nepean River at Douglas Park.
22. Bridge to carry Mount Keira Road over F5.
23. Twin bridges to carry F5 over Moolgun Creek.
24. Bridge to carry access road to Niloc Pty Ltd over F5.
25. Bridge to carry Trunk Road No. 95 over F5.
26. Twin bridges to carry F5 over Nepean River at Pheasants Nest.
27. Bridge to carry Avon Dam Road over F5.
28. Bridge to carry Metropolitan Water Sewerage and Drainage Board pipeline over F5.
29. Twin bridges to carry F5 over Main Southern Railway Line and southbound loading ramp near Yanderra.

Above left: An aerial view south of Yanderra, showing the twin bridges over the Main Southern Railway Line.

Below left: A cutting on the Kenny Hill — Yanderra section of the freeway, showing the improved batter design and quick growing grass cover.

ROAD CONSTRUCTION FEATURES

Some innovative and unusual techniques have been used by the Department during construction of the F5.

Watering Material in Cuttings Before Removal

It is usual in road construction to spray water on materials spread on the fill area before and during rolling.

On this work, very large water tankers of up to 45 000 litres capacity were used to spray water in the cut areas prior to removal of material to fill areas. These tankers were converted from earthmoving machines and can traverse very rough ground, spraying material before it is excavated from the cut. During the excavation process, the water is mixed with the material allowing easier rolling and less plant congestion in the fill areas as well as better control of dust during the whole earthmoving operation.

Swimming Pools

A typical innovation was the use of above-ground swimming pools for water storage. During construction, large quantities of water were required for dust suppression, compaction of fill material, lime stabilisation and the testing of drainage.

To ensure the minimum delay in refilling water tankers, elevated above-ground prefabricated swimming pools were used as storage dams.

The dams or swimming pools were filled from a permanent water supply and were, in turn, used to fill water tankers using a gravity feed system through a large diameter pipe. This quick and uninterrupted supply of water at times reached one million litres per day.

Batter Treatment

Normal road construction practice is to create cuttings with a constant batter slope or angle (such as 2:1). In undulating country, this results in batters of varying height and gives a rather severe appearance to the cuttings.

On this project, in areas other than solid rock, the length of each cut batter (that is, the slope length) has been made constant. The result is that where the cutting depth is reduced towards the ends, the batter "rolls" outwards to blend with the landscape.

Precast Drainage Structures

Where many drainage structures of identical or very similar dimensions are used in construction it is generally more economical to have the items constructed off the job in a workshop environment, rather than constructed on site.

The drainage pits under the concrete drainage gutters on the F5 are all of identical size and are precast units. Each unit is 1.1 m in diameter, 900 mm deep and has a hole cast in the side. The stormwater pipe is butted against the hole in the precast unit, and a concrete floor is poured to complete the drainage pit.

Subgrade Drains on Fills

Water enters a road pavement through cracks and imperfections on the surface and, unless removed, softens the underlying material and leads to premature road failure. Continuous removal of this water is a preventive maintenance measure which can be built into a pavement during construction.

Modern pavement design requires the top of the filling on subgrade to be waterproofed and given a transverse crossfall so that it will shed water which has entered and filtered down through the pavement layers.

To collect and dispose of this water, drains were placed along each side of the pavement in the subgrade. These subgrade drains are 600 mm deep and 300 mm wide, with a slotted corrugated plastic pipe in the bottom and backfilled with a specially designed permeable filter material.

Reinforced Earth Retaining Wall

The first reinforced earth retaining wall built by the Department was constructed in 1976 to form part of the abutments for the twin bridges which carry the F5 over the Main Southern Railway Line at Glenlee.

The wall is 85.5 m long, generally 6 m high and is faced with interlocking precast concrete panels. The reinforcement consists of galvanised steel strips which extend 5.5 m into the fill. The segments are constrained from moving outwards by the friction on these strips.

A vertical filter drain runs for the full length and depth at the back of this wall.

Lime Stabilisation

Even a high standard road pavement can fail if excessive moisture is allowed to reach the sub-grade material.

On the F5, as on most other heavily trafficked roads, the "wearing" surface consists of asphaltic concrete. As this material is permeable, the sub-grade beneath it must be rendered moisture insensitive if it is to perform satisfactorily.

This result has been achieved on the F5 by means of a lime stabilising process. This process involves mixing a predetermined percentage of lime with the natural material. The chemical reaction provides a stronger, more stable and non-water-susceptible sub-grade material.

All F5 stabilisation was carried out with quicklime, hydrated on the ground prior to mixing, resulting in appreciable economy.

Slip Formed Concrete for Gutters

The slip forming of concrete gutters has proved to be an efficient high production technique.

Slip form machines are now available with automatic steering and level control and are usually fitted with a trimming head to trim the bed of the gutter and minimise wastage of concrete. They run automatically on accurately

The reinforced earth retaining wall at the northern abutments of the Glenlee railway bridges.

A hopper spreading quick lime (above) as part of the pavement stabilisation process which included mixing and watering (below)

preset stringlines and require about seven men in a gang to produce a good quality job.

The concrete used is a specially designed mix which retains its shape after it emerges from the machine.

A typical daily output can be about 1000 m of gutter, using about 150 cubic metres of concrete.

Guardrail Post Driving

For traffic safety, long lengths of guardrail were constructed along the shoulders of the F5 and sections of associated access roads. The guardrail is carried on posts made from rolled steel channel sections.

Rapid erection was desirable for economy and posts were driven with a tractor-mounted mechanical hammer.

This method allowed more accurate placement for line and level than excavating and backfilling. As the embankment material is virtually undisturbed, a better embedded post results.

Erosion Control

Great care was taken during construction operations to control erosion and scouring by water.

The soil was tested for acidity and nutrient requirements and appropriate fertilizer, seed and sometimes lime applied with the assistance and advice of the Soil Conservation Service of New South Wales.

Large disturbed areas such as batters and medians were treated by scarifying, fertilizing and seeding with appropriate quick growing and heavily rooted grasses, such as millet, oats and clover.

Areas needing special protection from heavy rain and erosion effects were further protected by a hay and bitumen mulch in which the grasses germinated.

Drainage channels were shaped by hand and a protective layer of jute mesh and bitumen prevented water flow from washing away the grass seeds and seedlings before they were established.

Landscaping

More than 30,000 trees and shrubs have been planted over the 64 km length of the freeway.

Typical species of the trees and shrubs planted are Red Gums, Cootamundra Wattles, River Oaks and Coastal Rosemary. Before selecting the species, consideration was given to their suitability for the areas affected by the roadworks. Those chosen have a quick and healthy growth rate and provide a natural appearance complementary to other flora in the region.

Bared areas were treated as soon as possible after completion of the earthworks in order to obtain a dense cover of grasses and thereby minimise scouring both during and after construction. Some of the grasses planted are Rye, Couch, Rhodes, Clover, Kentucky Blue and Bent.

For areas requiring special attention against scouring by rainwater run-off, a hay and bitumen mulch, impregnated with seed and fertiliser, was applied. This hydromulching accelerates natural regeneration over large areas and retains valuable top soil. On rocky areas, kikuyu turf was used to give immediate protection and close ground cover.

Attractive Bridge Abutments

There are two main problems associated with the batters beneath bridges. Firstly, erosion of the batter can lead to settlement of the bridge approaches and secondly the batters themselves can be unsightly unless treated in some way.

Some form of cosmetic treatment is therefore desirable both to prevent batter erosion and at the same time to enhance the appearance of the structure.

Since vegetation (grass, ivy, etc.) does not thrive within the shadow lines of bridges, a number of contrasting treatments were experimented with along the F5 and found to be successful.

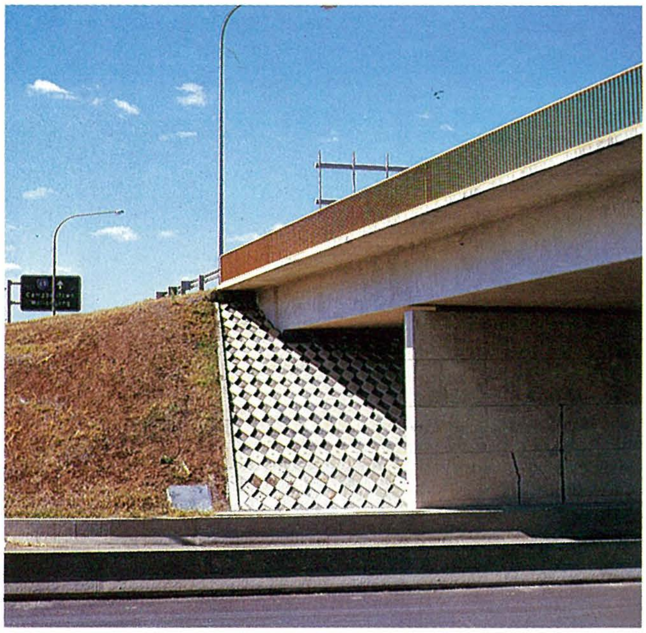
Some of the different materials used were large (150 mm diameter) river stones, precast concrete slabs (with space for grass growth) and V blocks, as well as diamond blocks cast on site and laid corner to corner on a mortar bed.

VARIATIONS ON A THEME . . . of bridge abutments

Church Avenue overbridge

Menangle Road overbridge

Camden Road overbridge



Campbelltown onloading ramp

Emergency Telephones

One hundred emergency telephones have been installed over the full length of the Freeway, spaced at approximately 1½ km apart. The system was designed in conjunction with Telecom Australia and is possibly the most modern development in this field. When the user lifts the handpiece and presses a button, the Department's Emergency Centre in Sydney is dialled automatically. As the call is connected, its location is also automatically displayed on a mimic board in the Emergency Centre. Depending on the assistance required by the motorist, the call to the appropriate service at the appropriate centre is also dialled automatically through a pre-programmed push-button system.

The phone units are so designed that the calls are only connected whilst the handpiece is held in the hand. The pillar is such that the handpiece cannot be placed anywhere other than back on the hook. If it is left hanging, the call is automatically cut off. This is important as the Freeway traverses five STD areas.

No field repairs are required as all phone units are a "plug out — plug in" type.

High-technology emergency telephones are situated approximately 1½ km apart along the freeway.

TECHNICAL DETAILS OF PAVEMENT DESIGN AND CONSTRUCTION

Two methods were used in the design of the freeway pavement south of Kenny Hill. The first was based on elastic theory analysis using pavement deflections at subgrade level as measured by a Benkelmann Beam. The pavement thickness required to take 15 million passages of a Standard Axle load was then calculated. In moisture saturated conditions an alternative method, (using the California Bearing Ratio) was used to cross-check the subgrade bearing capacity. Where the latter calculations indicated a thicker pavement was required, this was adopted.

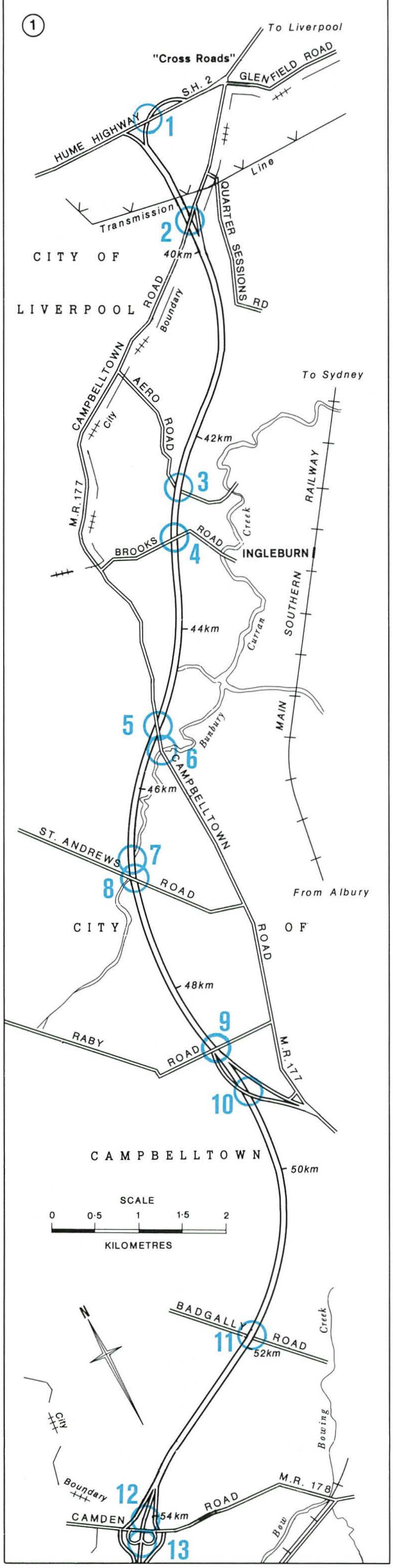
Longitudinal subgrade drains were provided over the full length of the carriageways, located under the outer edges of the asphaltic wearing surface.

A sub-base layer of 300 mm of selected sandstone or shale was provided in all instances. The top 150 mm of this was stabilised (using quick lime) to make it virtually non water susceptible. This assisted in collecting and channelling the water entering the pavement to the longitudinal subgrade drains. To ensure that this would occur, a special free draining layer (interface) was designed and achieved by using up to 150 mm blast furnace slag "sculls" as the lower base course. A minimum of 125 mm of 20 mm crushed slag was used to form the upper base course. Depending on the quality of subgrade, the total pavement thickness varies from 600 mm to 750 mm. This includes 75 mm of asphaltic concrete wearing surface of which the top 25 mm is open grade asphalt to reduce the occurrence of aquaplaning.

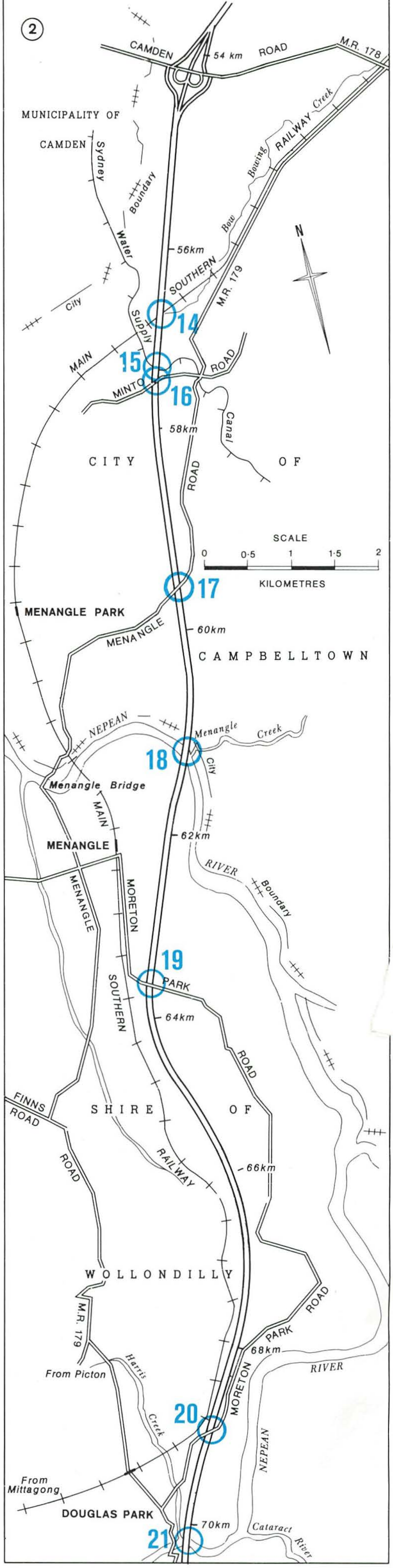
It was a design requirement that the deflections at base course level (as obtained by the Benkelmann Beam) would be less than 0.4 mm, with a target of 0.2 mm and maximum average of 0.3 mm. This was achieved without undue difficulty.

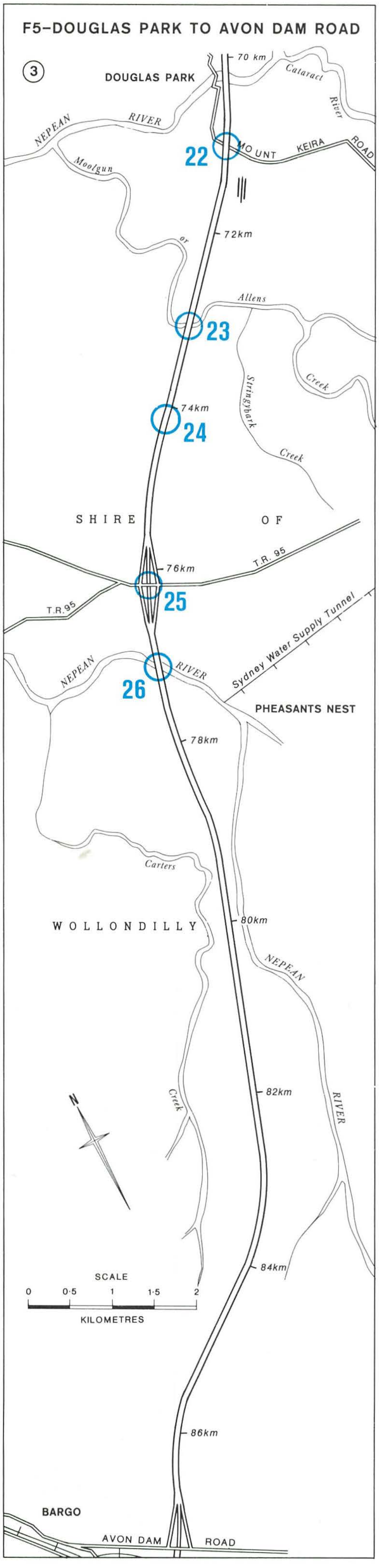
Early stages of earthworks in progress, April 1974.

F5–CROSSROADS TO M.R. 178



F5–CAMDEN ROAD TO DOUGLAS PARK




F5–DOUGLAS PARK TO AVON DAM ROAD
3
DOUGLAS PARK
70 km
Cataract
River
NEPEAN
RIVER
22
MOUNT
KEIRA
ROAD
Moolgun
72km
Allens
23
Creek
Stringybark
74km
24
Creek
SHIRE
OF
76km
T.R. 95
25
T.R.95
Sydney Water Supply Tunnel
NEPEAN
RIVER
26
PHEASANTS NEST
78km
Carters
WOLLONDILLY
80km
NEPEAN
82km
RIVER
Creek
N
SCALE
0
0·5
1
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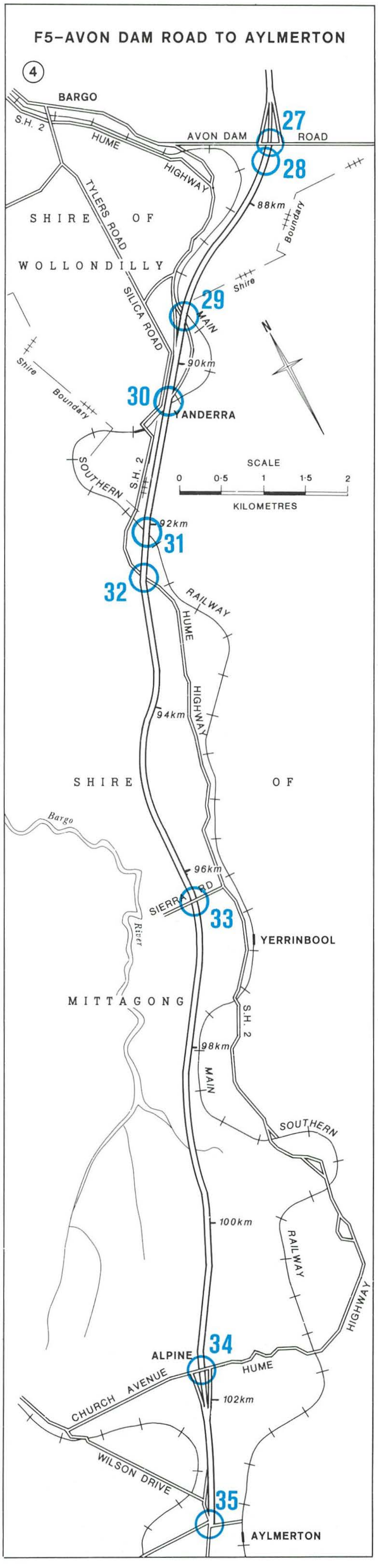
2
KILOMETRES
84km
86km
BARGO
AVON DAM
ROAD


F5–AVON DAM ROAD TO AYLMERTON
4
BARGO
S.H. 2
HUME
HIGHWAY
AVON DAM
ROAD
27
28
88km
Boundary
SHIRE
OF
TYLERS ROAD
WOLLONDILLY
SILICA ROAD
Shire
29
MAIN
N
90km
Shire
Boundary
30
YANDERRA
SOUTHERN
S.H. 2
SCALE
0
0·5
1
1·5
2
KILOMETRES
92km
31
32
RAILWAY
HUME
HIGHWAY
94km
SHIRE
OF
Bargo
96km
SIERRA RD
33
River
YERRINBOOL
MITTAGONG
S.H. 2
98km
MAIN
SOUTHERN
100km
RAILWAY
HIGHWAY
ALPINE
34
HUME
CHURCH AVENUE
102km
WILSON DRIVE
35
AYLMERTON

BRIDGE CONSTRUCTION

The South Western Freeway between The Cross Roads and Aylmerton has required the design and construction of 35 bridges of which 14 are twin structures. One structure, on Main Road No. 177 over the Bunbury Curran Creek, has been constructed in conjunction with the freeway but is not part of the freeway system.

Of the 34 bridges, 13 twin structures carry the freeway carriageways over other roads, railway lines and water-courses. To provide complete grade separation of cross traffic, 20 other bridges have been built to carry a State Highway, a Trunk Road, numerous main and local roads, an access road, and a pipeline over the F5. In addition, as mentioned earlier, it has been necessary to provide a temporary pedestrian overbridge at Aylmerton.

Structure types vary from simply supported steel universal beams to continuous precast prestressed concrete segmental box girders.

The designing of the bridges was divided between the Department's own design staff and consultants. Similarly, construction was by both direct Departmental control and by contract.

The unit cost of the bridges varied from $129 per square metre for the bridges over Bunbury Curran Creek to $730 per square metre for the bridge over Nepean river at Menangle.

The total cost of construction for all the bridges on the 64 km length of F5 between The Cross Roads and Aylmerton was approximately $30 million.

BRIDGES DESIGNED BY CONSULTANTS

Slab and Voided Slab Construction

Bridge spans of 25 m to 35 m were required to clear the carriageway of the freeway. These spans are rather long for precast concrete girders, and prestressed concrete hollow box girder construction is often adopted for such spans.

However in 1972 a new design incorporating a voided (i.e. hollow) slab was introduced for a bridge to carry the freeway over Badgally Road (near Campbelltown). This bridge has a centre span of 30 m and a superstructure approximately 0.9 m deep with 0.6 m diameter voids and long deck cantilever sections.

The bridges designed later to carry Minto Road (north of Menangle) and Moreton Park Road (near Menangle) over the freeway are of similar construction but without deck cantilevers to allow possible widening in the future.

Voided Spine Beam Construction

The bridge constructed over the F5 at Church Avenue, Alpine is of the voided slab design and, in addition, has a compact central spine section 1.2 m deep with six 0.85 m diameter voids.

The bridge carrying Menangle Road (Main Road No. 179) over the freeway is of a similar type with a more compact spine section 1.2 m deep with four 0.85 m voids.

The voids were formed with cardboard, steel (which is not much more expensive) or solid polystyrene. In all cases, specifically designed anchorages were required to ensure that the voids were not displaced during concreting.

The bridge to carry the access road to Niloc Pty Ltd across the F5 is also of the voided spine beam type, although the width of the spine beam in this case makes it difficult to distinguish it from a voided slab.

Painted handrails are a feature of many of the F5 overbridges, including this one at St. Andrews Road.

Twin bridge structures carry the South Western Freeway over Aero Road near Ingleburn.

Spine Beam with Solid Slab Construction
The bridge at Moreton Park Road near Douglas Park has a narrow, deep (approximately 2.5 m x 1.5 m) spine beam without voids and very long deck cantilever sections each measuring 4 m. This type of bridge has a greater simplicity of construction than the bridges having voided superstructures.

Prestressed Concrete Hollow Box Girder Construction
Certain locations on the freeway required bridges with three spans. When built of prestressed concrete, three span bridges with short end spans may encounter problems with possible uplift forces at the abutments.

In the case of the bridge carrying the Hume Highway over the F5 at The Cross Roads, the problem of uplift was overcome by casting solid end sections to the box superstructure and extending them beyond the bearings for some distance.

A different solution was found in the case of the two bridges carrying Camden Road over the freeway. Here, uplift forces were resolved by tying the ends of the superstructure back to the pier footings. Although these bridges have 48 m centre spans, the absence of any abutments helped to make their construction very economical, and the costs compare favourably with those for voided slab bridges with lesser spans.

The bridges to carry St. Andrews Road (near Campbelltown) and Mount Keira Road (south of Douglas Park) over the F5 are conventional structures of the hollow box, prestressed concrete girder type with cantilever deck sections.

Steel Portal Frame Construction
The attractive 49 m long twin bridges which carry the F5 over the Hume Highway at White Horse were designed as three-span, steel portal frame structures with inclined piers.

Prestressed Concrete Standard "I" Girder Construction
For economy's sake, standard structures of the prestressed concrete "I" girder type were chosen for the twin bridges to carry the F5 over Aero Road (south of The Cross Roads); over the Main Southern Railway Line at White Horse; and over the Main Southern Railway Line and the southbound loading ramp near Yanderra.

Prestressed Concrete "T" Girder Construction
The twin bridges to carry the F5 over the Main Southern Railway Line near Glenlee each have three spans (32.4 m, 18.4 m, 32.4 m) with an overall length of 84.4 m. The width between kerbs is 16.5 m and the bridges are founded on bored piles having a diameter of 500 mm at the piers and 450 mm at the abutments.

The decks consist of precast, post-tensioned concrete "T" girders with reinforced concrete infill panels between the top flanges. These girders were cast in three segments in a casting yard and were then joined and post-tensioned on site before being launched into position. The northern abutment was constructed in reinforced earth to allow for provision of additional railway tracks in the future.

Prestressed Concrete Precast Plank Construction
The 12.3 m long twin bridges carrying the F5 over the Sydney Water Supply Channel, just south of Camden Road, have short spans which made the use of precast prestressed concrete planks the most economical solution. The planks were precast off site which reduced the amount of *in situ* work required to be carried out over the channel.

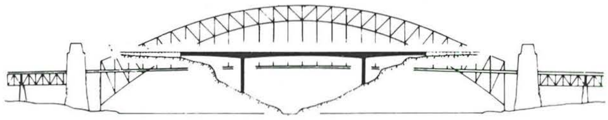
BRIDGES DESIGNED BY THE DEPARTMENT

The Department has designed 18 of the 35 bridges required between The Cross Roads and Aylmerton. A variety of structure types were used, as listed below.

- Steel Universal Beams with Composite Concrete Deck
  — at Brooks Road, Raby Road and Avon Dam Road
- Built-Up Steel Girder
  — at Trunk Road No. 95 and the Metropolitan Water Sewerage and Drainage Board Pipeline near Yanderra
- Prestressed Concrete Solid Slab
  — at both crossings of Campbelltown Road (Main Road No. 177)
- Prestressed Concrete "I" Girders
  — at Bunbury Curran Creek (on both F5 and Main Road No. 177) at Sierra Road
- Prestressed Concrete Planks
  — at the Main Southern Railway Line near Yanderra
- Prestressed Concrete Box Girders
  — northbound loading ramp from Campbelltown
- Bailey Bridge (temporary)
  — Pedestrian overpass at Aylmerton

In addition, the Department designed the bridges for the three major crossings of the Nepean River (at Menangle, Douglas Park and Pheasants Nest) as well as over Moolgun Creek. These four bridges cost $17 million out of a total cost of $30 million for all the bridges on the F5 from The Cross Roads to Aylmerton.

TWIN BRIDGES OVER NEPEAN RIVER AT PHEASANTS NEST



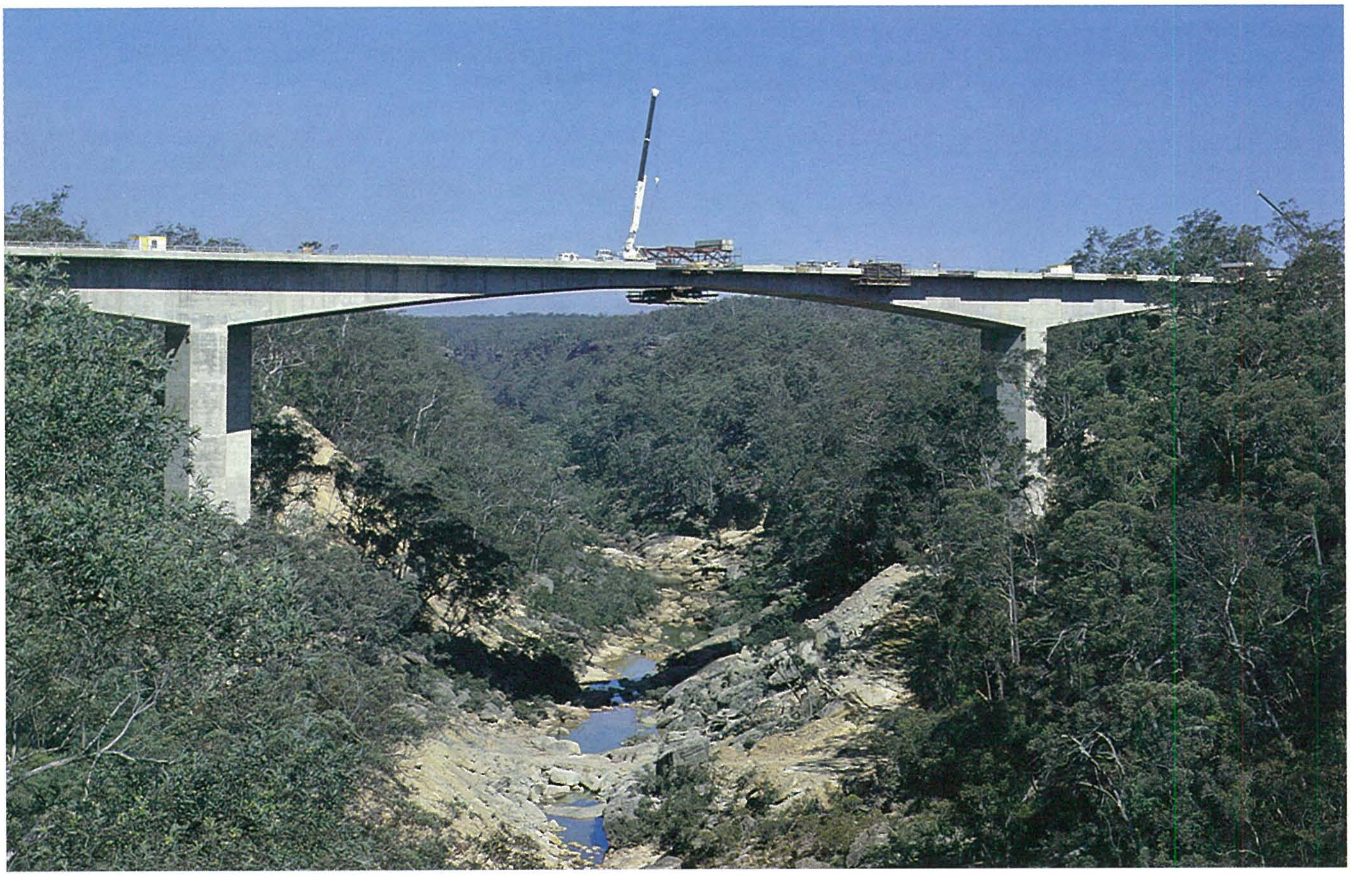
The twin bridges at Pheasants Nest are two independent prestressed concrete bridges which cross the Nepean River at a skew of 40°. The 304.7 m long bridges are identical but are offset relative to each other by 11 m because of the skew, and have a 50 mm gap between them.

The bridges have three spans, a main span of 150 m and two side spans of 77.4 m. Each deck consists of a single cell box girder, 13 m wide and varying in depth from 8.2 m at the piers to 2.5 m at the abutments and at the centre of the bridges.

At their centres, the bridge decks are 76 m above normal water level, making them higher than the deck of Sydney Harbour Bridge. The two piers, situated part way up the side of the gorge, are 36 m and 44 m high. These piers are rectangular hollow reinforced concrete sections, 6 m by 5 m with walls 600 mm thick. The pier footings are 10 m by 9 m by 3 m deep, reinforced concrete pads, anchored to the ground with rock anchors.

These bridges were built using the cast-in-place, balanced cantilever construction method. A 14.5 m length of the superstructure was constructed on top of each pier, but extending 2.3 m further on one side than the other. The cantilever arms were then constructed — 4.7 m segments

The gap is closed — final stages of construction on the twin bridges over the Nepean River at Pheasants Nest.



with no falsework required from the ground. Formwork carriers to hold the segments were assembled on the pierhead. As each segment was poured and stressed, these carriers were jacked forward ready for the next segment. Segments were poured alternately on each side, starting with the shorter arm of the pierhead, so that one arm of the cantilever was always one half segment longer than the other.

Work proceeded from the two piers at once and where the cantilever arms met at the centre of the bridge they were joined by a special hinge segment. All expansion movement in the bridge is taken in this segment which will also allow relative rotation between the two cantilever arms.

At the abutment end of the cantilever arms, the superstructure and the abutment are connected by prestressed, high tensile steel bars.

The bridges incorporate 22 km of prestressing cable, 1500 tonnes of steel reinforcement and 27 000 tonnes of concrete.

Prestressed concrete cantilevered bridges are particularly sensitive to shrinkage and creep effects. To monitor these, a joint research project by the Department and the School of Civil Engineering at the University of Sydney, was initiated. As part of this project, instruments were installed on the bridges, including temperature gauges, internal strain gauges linked to a data logger, external strain gauges consisting of targets used in conjunction with a Huggenberger extensometer, and strain gauges measuring abutment reactions. Rotations of the pier tops are measured using an electro-level.

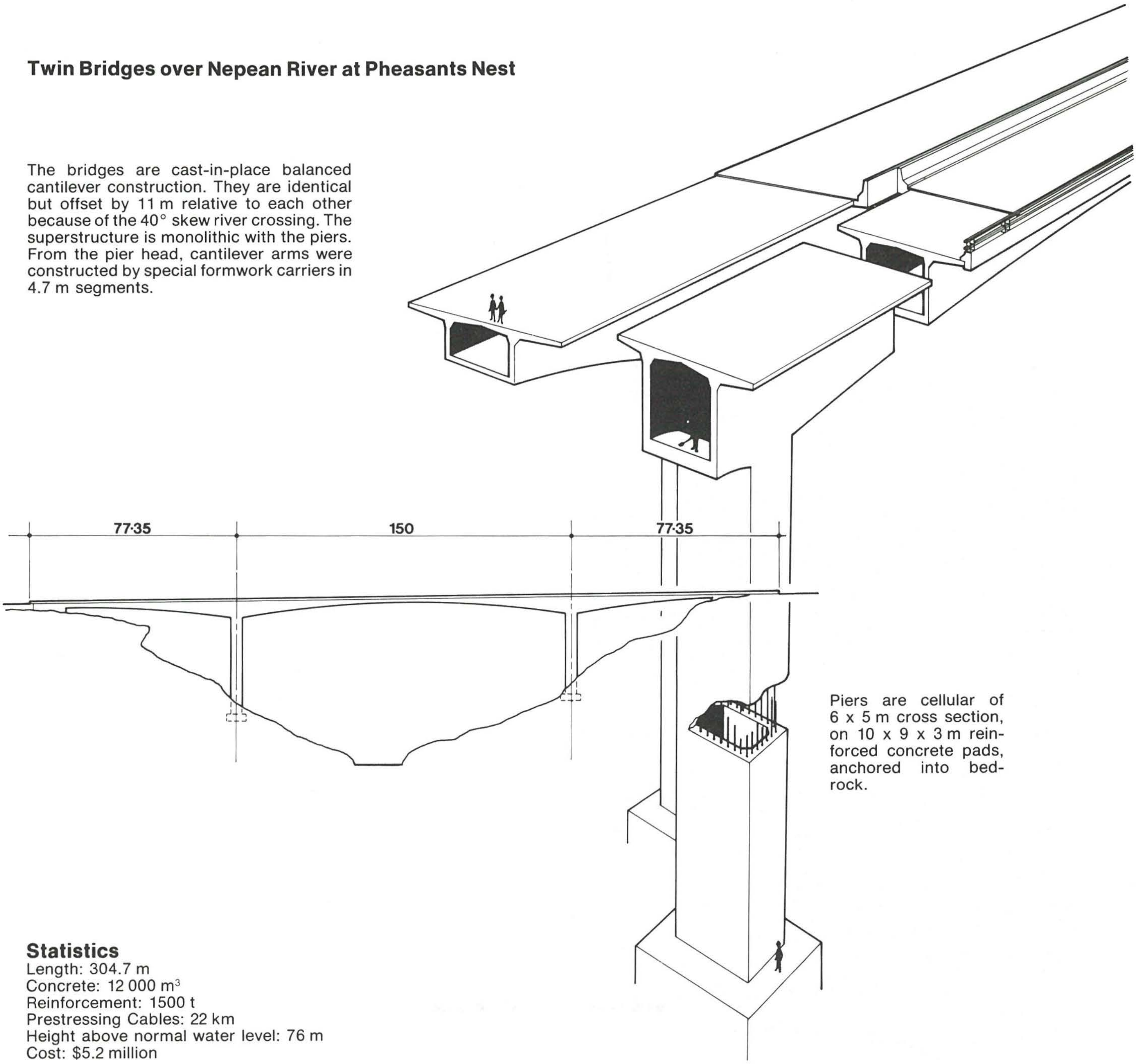
It is envisaged that the information obtained from this project will aid in accurately predicting deflections in these and future prestressed concrete cantilevered bridges.

The bridges were designed to allow for possible stresses due to earthquake and mining subsidence effects.

In June 1978, a $4,599,560 contract was let to White Industries Ltd to build these twin bridges. The eastern structure was the last bridge on the whole project to be finished, being completed in November 1980, just prior to the opening.

Twin Bridges over Nepean River at Pheasants Nest

The bridges are cast-in-place balanced cantilever construction. They are identical but offset by 11 m relative to each other because of the 40° skew river crossing. The superstructure is monolithic with the piers. From the pier head, cantilever arms were constructed by special formwork carriers in 4.7 m segments.



Piers are cellular of 6 x 5 m cross section, on 10 x 9 x 3 m reinforced concrete pads, anchored into bedrock.

Statistics
Length: 304.7 m
Concrete: 12 000 m³
Reinforcement: 1500 t
Prestressing Cables: 22 km
Height above normal water level: 76 m
Cost: $5.2 million

TWIN BRIDGES OVER MOOLGUN CREEK AND OVER THE NEPEAN RIVER AT DOUGLAS PARK AND MENANGLE

For these six bridges, a modular design was evolved, based on a 50 m standard span and variable length approach spans. This enabled total bridge lengths to be varied to suit conditions at each of the three sites, without altering the standard superstructure construction method.

The superstructure of each bridge is a three-cell, precast post-tensioned segmental concrete box girder. The width between kerbs is 12.8 m and the overall width, 13.9 m. The segments for each bridge are identical and horizontal curves were created by tapering the segmental joint.

The piers of these six structures are twin reinforced concrete tapered columns tied together with post-tensioned cross beams, to act as a frame in resisting lateral forces. In each case, the deck is hinged to the taller flexible piers. Expansion bearings were required on the shorter piers.

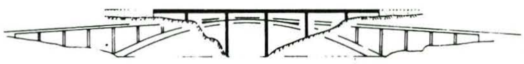
The provision of an expansion bearing in the central span of each bridge and hinged bearings at the abutments enables all longitudinal deck loads to be transmitted to the abutments. Permanent hinges were placed at points of natural inflection in the other spans.

As with the Pheasants Nest bridges, these structures have been designed to cope with earthquake movement and settlement following coal mining operations.

Moolgun Creek

Twin five-span structures have been constructed, each with an overall length of 235.9 m and consisting of three 50 m spans flanked by 42 m end spans. Pier heights vary from 14 m to 58 m and are all founded on spread footings, as good sandstone lies close to the natural surface. The height of the decks above normal water level is 52 m, that is higher than the peak of Gladesville Bridge. The abutments are founded on bored piles of 750 mm diameter. In June 1977, White Industries Ltd undertook to build these bridges for the Department at a contract price of $3,239,253. They were completed in July 1980.

Douglas Park

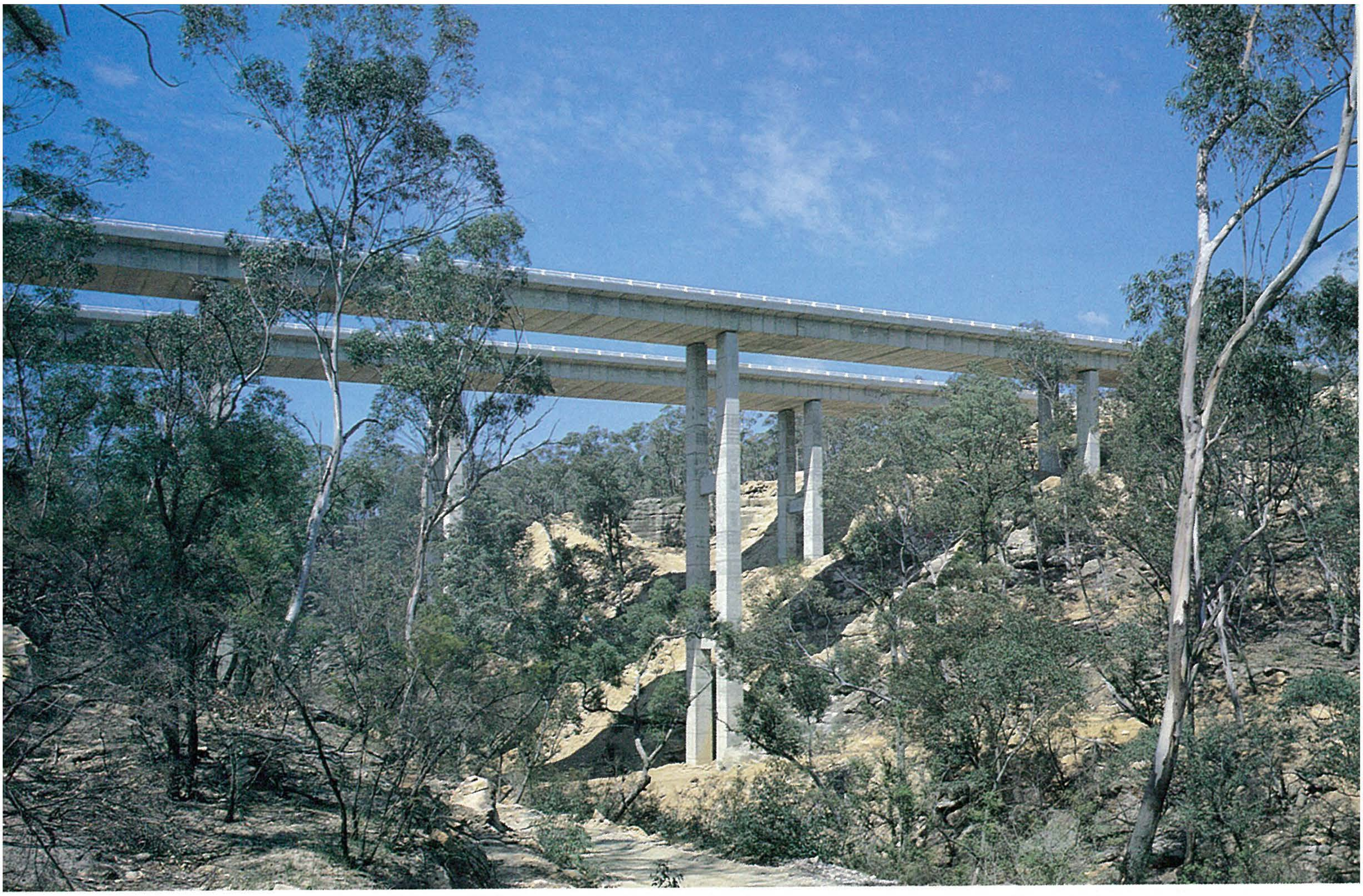


At this site, twin six-span structures were built, having an overall length of 285.9 m on the western structure and 236.4 m on the eastern structure. The western structure has four 50 m spans flanked by 42 m end spans. The eastern structure has two 30 m spans flanked by 42 m and 25 m spans at each end. Pier heights vary from 12 m to 55 m and the decks are 56 m above normal water level, which again is higher than the peak of Gladesville Bridge. Bored piles were required under the abutments and under the central piers at river level. A $4,052,557 contract was let in March 1977 to White Industries Ltd to build these bridges, which were finished in September 1980.

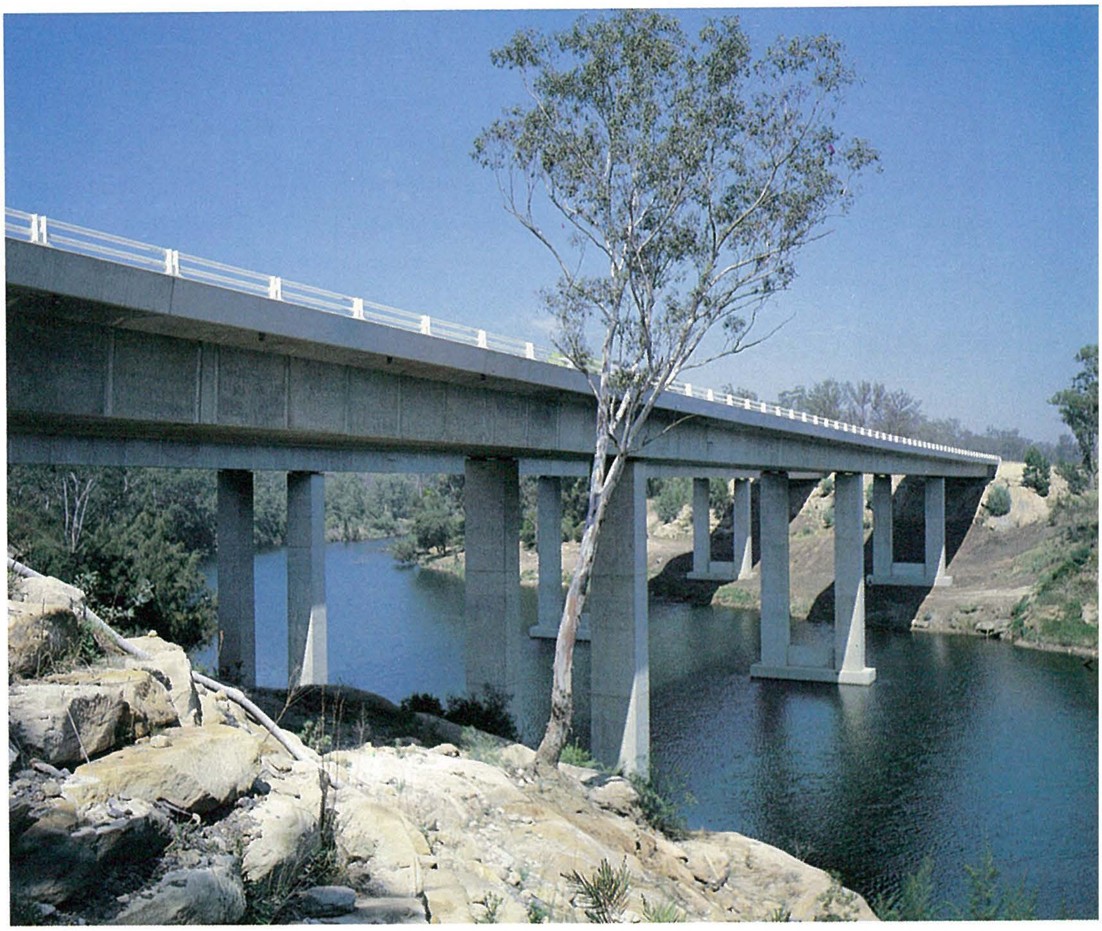
Menangle

Here the design was for twin four-span structures, having an overall length of 185.9 m and consisting of two 50 m spans and 42 m end spans. Piers are approximately 20 m high and are founded on bored piles of 1000 m diameter. The abutments are founded on 750 mm diameter bored piles. A $3,096,485 contract for the construction of these bridges was let to Transbridge Pty Ltd in January 1977. This contract was completed in October 1980.

A spectacular aerial view of the twin six-span structures bridging the Nepean River at Douglas Park.



Towering piers support the dual carriageways of the F5 over Moolgun Creek.



The twin four-span bridges at Menangle, where the South Western Freeway again crosses the Nepean River.

DEPARTMENTAL PROJECT MANAGEMENT

Divisional Engineers

E.W. King	July 1969 — March 1974
J.B. Anderson	March 1974 — February 1978
L.R. James	April 1978 — December 1980

Supervising Engineers

M.R. Foster	February 1971 — May 1974
A. Tinni	May 1974 — December 1980

Works Engineers, Campbelltown Works Office

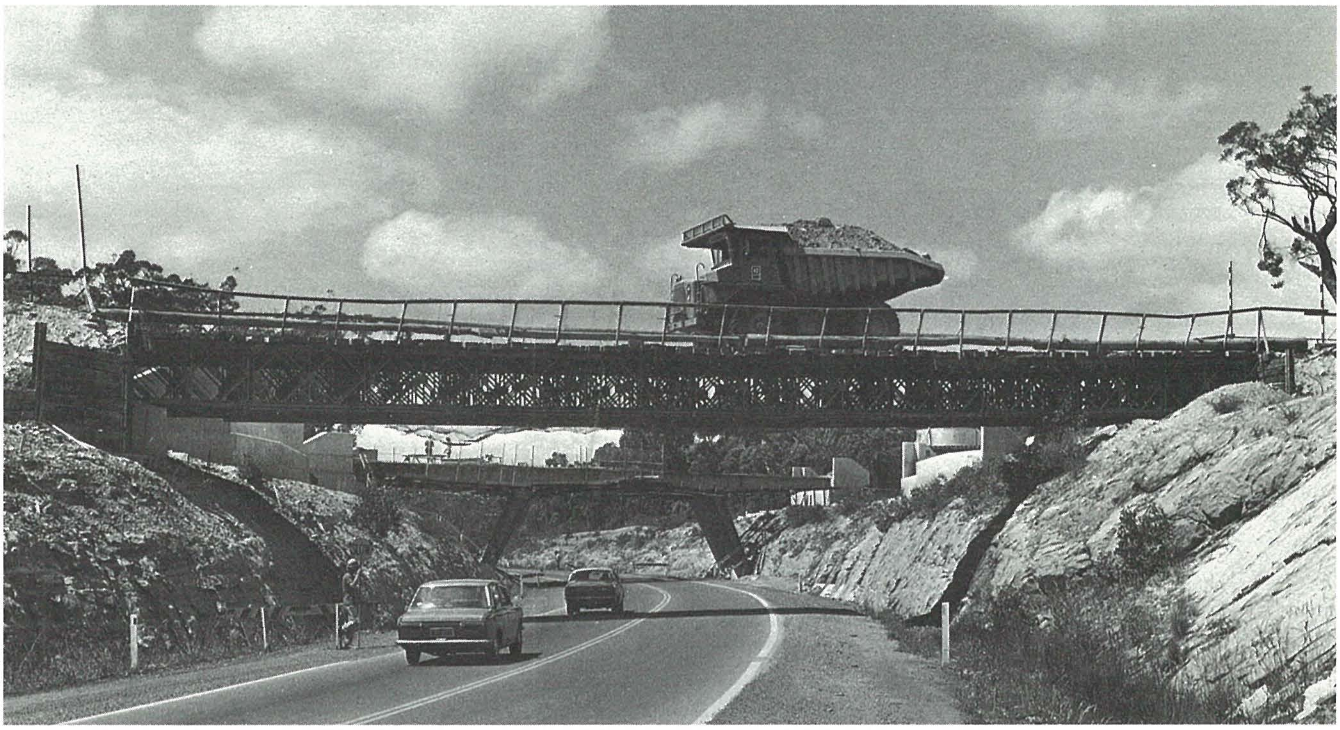
P.G.L. Wolfe	November 1969 — January 1971
J.R. Fenwick	January 1971 — March 1971
I.G. Hope	March 1971 — June 1973
B.R. Fishburn	June 1973 — August 1975
L.C. Laing	August 1975 — December 1980

Works Engineers, Bargo Works Office

A.J. Wesley	October 1973 — February 1975
G.J. Strike	February 1975 — December 1977
R.W. Chaseling	December 1977 — July 1979
S.J. Vine	July 1979 — August 1980

Resident Engineers

Pheasants Nest Bridge	
F.G. Cleary	October 1978 — December 1980
Douglas Park Bridge	
C.D. Jones	May 1977 — December 1980
Menangle Bridge	
A.J. Wilson	April 1977 — December 1980



Temporary Bailey bridging of unusually high load-carrying capacity provided access for F5 construction vehicles while twin bridges were being constructed at White Horse — January 1976.

MAJOR CONSTRUCTION AND SUPPLY CONTRACTORS

G. Abignano Pty Ltd	Roadworks and bridgeworks
A.N.I. Engineering	Bridge girders
Beaumonts Concrete	Concrete
Blue Circle Southern Cement Ltd	Quicklime
Blue Metal & Gravel Ltd	Filter material, sandstone and slag base course
Boral Resources (N.S.W.) Pty Ltd	Aggregate
Central Constructions Pty Ltd	Bridgeworks
Citra Constructions Ltd	Bridgeworks
Concrete Industries (Monier) Pty Ltd	Sand, pipes
E.E. Emmett & Sons Pty Ltd	Concrete, aggregate and sand
E.P.M. Concrete Pty Ltd	Bridge units
Farley and Lewers Ltd	Concrete, aggregate
John Holland (Constructions) Pty Ltd	Bridgeworks
Humes Ltd	Culverts
I.S.K. Constructions Pty Ltd	Bridgeworks
Kleensands (N.S.W.) Pty Ltd	Filter sands
Leewil Constructions Pty Ltd	Bridgeworks
Menangle River Soil & Sand Supplies Pty Ltd	Filter material
Monier/Bachy Joint Venture	Bridgeworks
Oneata Investments Import Pty Ltd	Bridgeworks
Pearson Bridge Pty Ltd	Bridgeworks
Pioneer Concrete (N.S.W.) Pty Ltd	Aggregate, crushed rock and concrete
Readymix Group (N.S.W.)	Basecourse, aggregate, concrete
Soil Filters Australia Ltd	Filter sock, concrete blocks
Soil Treatment Services Pty Ltd	Hay mulching
Specified Concrete	Concrete
Spray Grass Services Pty Ltd	Hay mulching
Spraypave Pty Ltd	Linemarking
Stewart Bros. Pty Ltd	Drilling
Transbridge Pty Ltd	Bridgeworks
Transbridge Investments Pty Ltd	Bridgeworks
Peter Verhuel Pty Ltd	Bridge units
White Industries Ltd	Roadworks and bridgeworks
White Industries/Enpro Constructions joint venture	Bridgeworks

More than 200 other contractors have been involved in the supply of materials and services, as well as in the hire of plant and equipment, but because of space limitations it has not been possible to list them all in this publication.

Final stages of work on the Wilton interchange which links the freeway with Maldon, Picton and the Hume Highway to the west, and with Wilton, Appin and the Princes Highway to the east — August 1980.

The front cover shows the sweeping lines of the F5 between Menangle and Douglas Park on the most recently completed section of the freeway.

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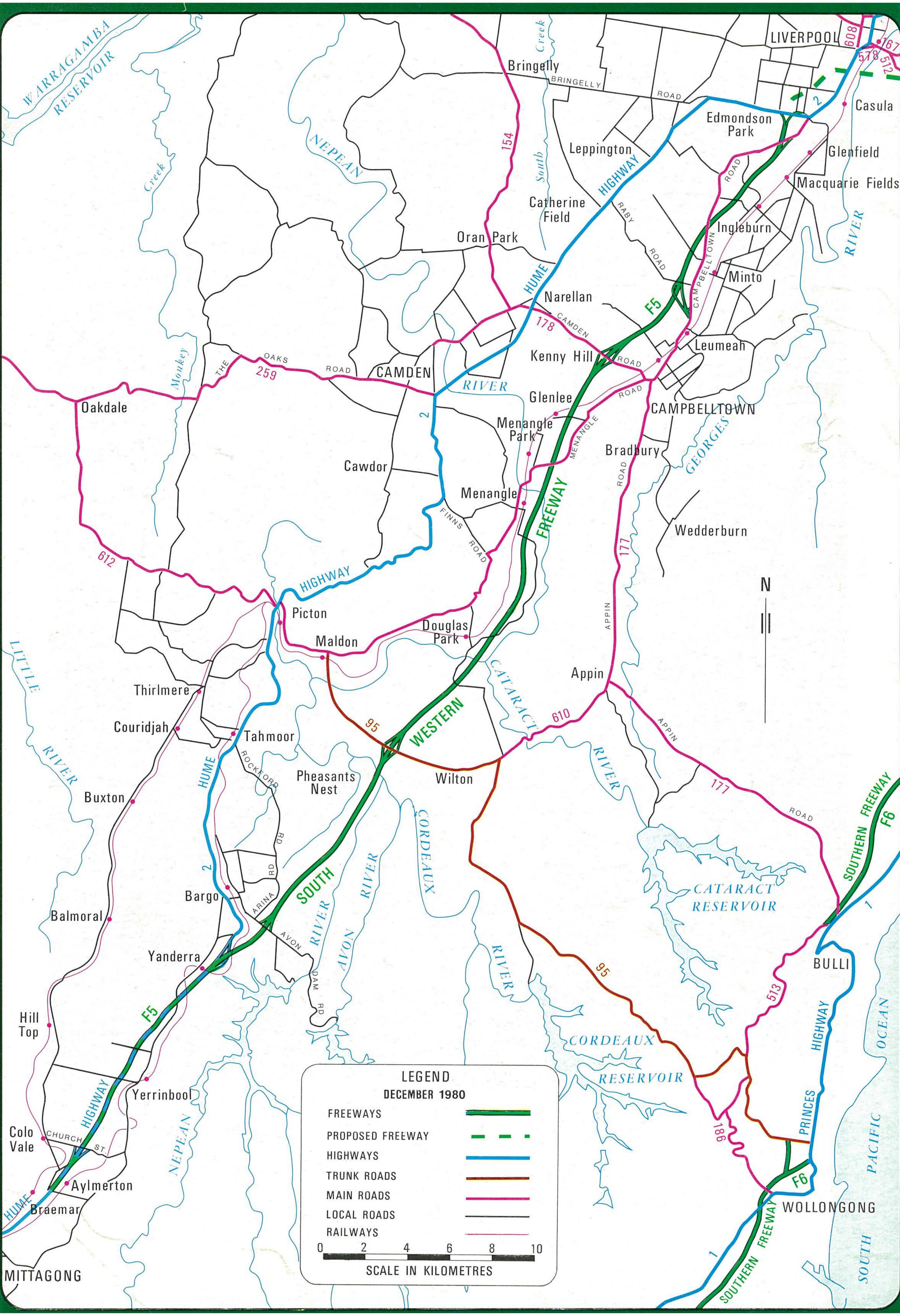

LEGEND
DECEMBER 1980
FREEWAYS
PROPOSED FREEWAY
HIGHWAYS
TRUNK ROADS
MAIN ROADS
LOCAL ROADS
RAILWAYS
0 2 4 6 8 10
SCALE IN KILOMETRES
N
WARRAGAMBA RESERVOIR
LIVERPOOL
Bringelly
BRINGELLY ROAD
Casula
Edmondson Park
Leppington
Glenfield
Macquarie Fields
Catherine Field
Ingleburn
Oran Park
Minto
Narellan
Leumeah
Kenny Hill
CAMDEN
Glenlee
CAMPBELLTOWN
Menangle Park
Bradbury
Cawdor
Menangle
Wedderburn
Oakdale
Picton
Maldon
Douglas Park
Appin
Thirlmere
Couridjah
Tahmoor
Pheasants Nest
Wilton
Buxton
Bargo
Balmoral
Yanderra
Hill Top
Yerrinbool
Colo Vale
Aylmerton
Braemar
MITTAGONG
BULLI
WOLLONGONG
HUME HIGHWAY
SOUTH WESTERN FREEWAY
F5
F6
SOUTHERN FREEWAY
PRINCES HIGHWAY
THE OAKS ROAD
CAMDEN ROAD
RABY ROAD
CAMPBELLTOWN ROAD
MENANGLE ROAD
FINNS ROAD
APPIN ROAD
ROCKFORD RD
ARINA RD
AVON DAM RD
CHURCH ST.
NEPEAN RIVER
GEORGES RIVER
CATARACT RIVER
CORDEAUX RIVER
AVON RIVER
LITTLE RIVER
South Creek
Monkey Creek
CATARACT RESERVOIR
CORDEAUX RESERVOIR
SOUTH PACIFIC OCEAN