PROPOSED NORTHERN TERMINAL — PINJAR TRANSMISSION LINE

APPENDICES

SECWA

Report No. T83
March 1989

Appendix A

GUIDELINES

PUBLIC ENVIRONMENTAL REPORT
PROPOSED NORTHERN TERMINAL – PINJAR TRANSMISSION LINE

The guidelines identify issues that should be addressed within the Public Environmental Report (PER). They are not intended to be exhaustive and the proponent may consider that other issues should also be included in the document.

The PER is intended to be a brief document; its purpose should be explained, and the contents should be concise and accurate and able to be readily understood by interested members of the public. Specialist information and technical description should be included where it assists in the understanding of the proposal.

Where specific information has been requested by a Government Department or Local Authority, this should be included in the document.

SUMMARY

This section should contain a clear and concise summary of the document.

1. INTRODUCTION

- Background, objectives and scope of the proposal
- Identification of the proponent
- Location and timing of the proposal
- Relevant legislation requirements and approval processes
- The EIA process

2. NEED FOR THE PROPOSAL

Describing the rationale for the project and the broad costs and benefits to the proponent, the State and the community.

3. THE PROPOSAL

A description of the important elements of the proposal including both construction and operation.

4. ALTERNATIVES

An evaluation of the alternative routes considered, and a description of the process leading to the selection of the preferred route, including the factors which led to alternative routes being rejected should be addressed.

5. THE EXISTING ENVIRONMENT

A description of the existing environment, including the physical, biological and social elements should be given. This section should also include a statement on existing and future land uses, and any associated land use implications.

6. ENVIRONMENTAL IMPACTS

Predicted environmental impacts to be addressed include:

- visual impact
- impacts on historic, archaeological and ethnographic sites
- biological impacts
- impact on resources
- the impact of electro-magnetic radiation (EMR)
- requirements for clearing of vegetation and justification for clearing requirements
- impacts during construction
- long term impacts during operation.

This section should show the overall effect on the environment and the region. Where possible effects should be quantified and uncertainties highlighted.

7. ENVIRONMENTAL MANAGEMENT

Appropriate management techniques for minimisation or amelioration of adverse impacts to be discussed. The objectives, scope and details of the management programme should be described. Assignment of responsibility for environmental management should be stated and commitments for implementation given.

Monitoring proposals should be described as well as how the environmental management programme will be adapted in response to monitoring results. Procedures for reporting results of monitoring should also be discussed.

Discussion of the results of a programme of public information dissemination, including a review of comments received should be included.

8. CONCLUSIONS

A brief synthesis of the proposal, the receiving environment, the likely impacts on that environment and the management procedures that are proposed.

9. BIBLIOGRAPHY

10. GLOSSARY

11. APPENDICES

- PER GUIDELINES
- TECHNICAL DETAILS
- LIST OF ENVIRONMENTAL COMMITMENTS

Appendix B

STATE ENERGY COMMISSION

WESTERN AUSTRALIA

TRANSMISSION LINE CORRIDORS NORTHERN TERMINAL TO PINJAR

CORRIDOR & LINE SELECTION

K.A. ADAM & ASSOCIATES

WITH

BOWMAN BISHAW & ASSOCIATES

& P & M TOOBY (1984) PTY. LTD.

DECEMBER 1988.

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Southern California: Edison 1972
(reproduced in Seddon and Polakowski 1977)

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Queensland Electricity Generation Board, 1984

MAPS

1. INTRODUCTION

1.1 THE BRIEF

The State Energy Commission Western Australia (SECWA) proposes to construct a new gas turbine power station at Pinjar, about 40km north of the Northern Terminal and 12km west of Muchea. The station will be approximately at the point of divergence of the existing Muchea-Eneabba and Muchea-Yanchep 132kV sub-transmission lines.

In July 1988 SECWA commissioned K.A. Adam and Associates to carry out the task of identifying corridors for two 330kV transmission lines between Northern Terminal and the coastal plain north of Perth, and a corridor and route for a 132kV transmission line to link the proposed power station and Northern Terminal.

The Brief was originally based upon the assumption that the Overseas Telecommunications Commission (OTC) radio communication facilities at Cullacabardee, about 5 kilometres north of Northern Terminal, was classified as a Category B facility in terms of its sensitivity to man-made noise. Subsequently it became known to SECWA that the OTC high-frequency receiving facility was regarded by OTC as a Category A facility, requiring a much higher level of separation from sources of interference, including overhead electricity transmission lines.

Consequently the Brief was broadened to take in a much more extensive area of investigation, in order to minimise any violation of OTC's separation requirements. The Study area is shown, in its regional context, at Map 1.

1.2 THE NEED FOR THE TRANSMISSION LINES

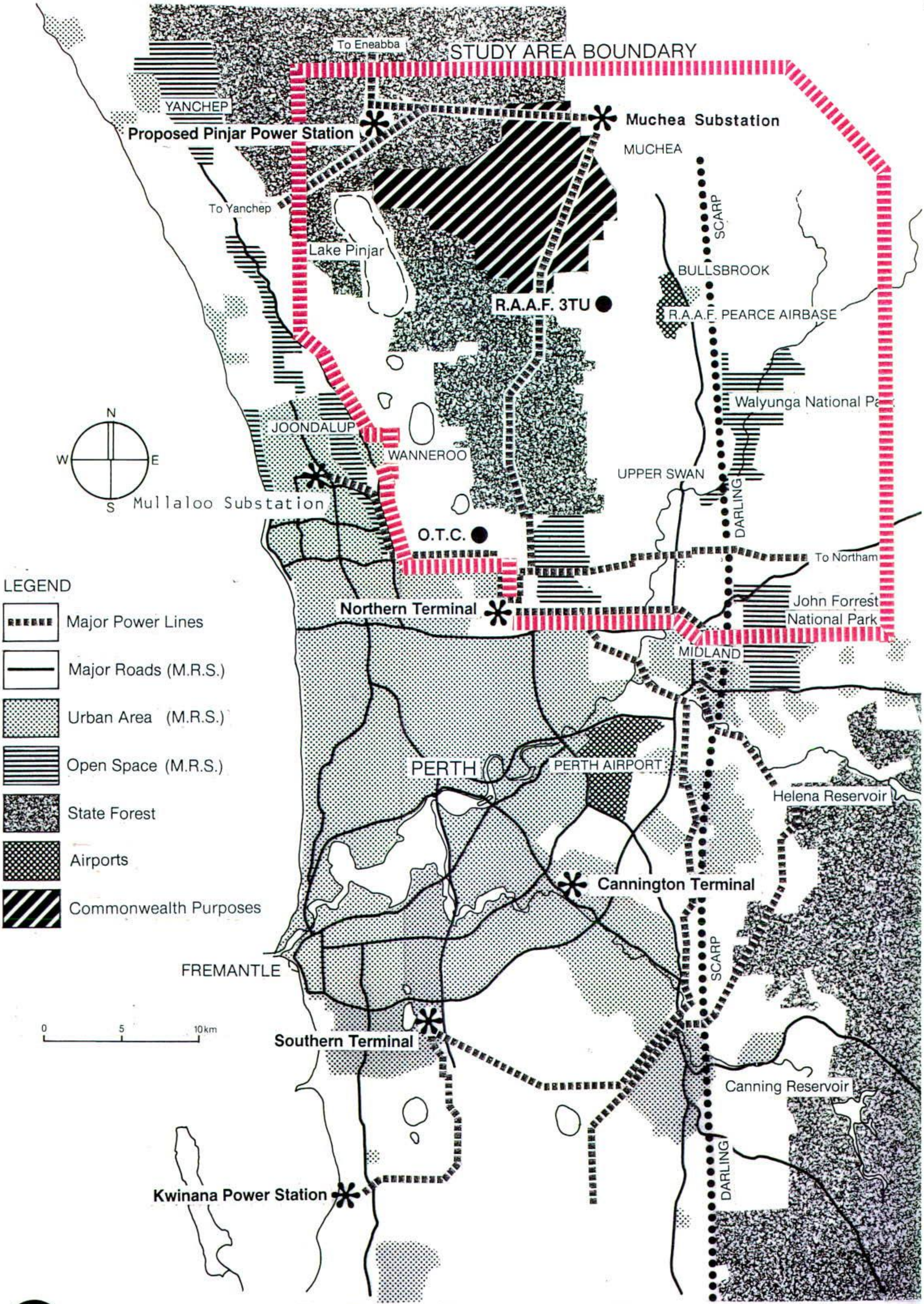
Following submission of a Notice of Intent (Bowman Bishaw and Associates, April 1988) the Environmental Protection Authority (EPA) has given its approval to the proposed gas turbine power station at Pinjar.

When the generation station at Pinjar is established a high capacity transmission interconnection will be required between the station and Northern Terminal at Ballajura. This interconnection with Northern Terminal will provide back-up and support to SECWA's metropolitan sub-transmission and transmission systems.

SECWA has identified the need for three double-circuit transmission lines between Northern Terminal and Pinjar. In the short term a double-circuit 132kV transmission line will be required. Subsequently there will be a need for two double-circuit 330kV transmission lines. Ideally these lines would be between one and three kilometres apart.

There are no realistic alternatives to a strong, direct interconnection between Northern Terminal and Pinjar.

Construction of the first transmission line is programmed to commence in the third quarter of the 1989 calendar year.



S.E.C.W.A. NORTHERN TERMINAL TO PINJAR
TRANSMISSION LINE STUDY

K. A. ADAM & ASSOCIATES December 1988

STUDY AREA

MAP 1

1.3 OBJECTIVES AND STATUS OF THE STUDY

The objectives of the present Study are essentially to:

- recommend the methodology, design criteria and principles for corridor and route selection appropriate to the region north of Perth;

- recommend a transmission line corridor and route for the 132kV line between Northern Terminal and Pinjar; and

- prepare and evaluate options for the two 330kV transmission line corridors from Northern Terminal to the coastal plain north of Perth.

For practical purposes the 330kV corridors have been taken as linking Northern Terminal and Pinjar.

The Study is to review and build upon the work of the report "Power Transmission South Western Australia" (Seddon and Polakowski, 1977) as it may apply to the region north of Perth.

The Study report is expected to be incorporated in an environmental document for assessment by the Environmental Protection Authority (EPA). The report has been designed, therefore, to form, with as little modification as possible, the first part of a two part document. The second part, essentially the assessment of environmental impacts and their management, is to be prepared by other consultants. Concurrently, the environmental report will deal also with transmission lines north of Pinjar.

1.4 CONSTRUCTION

The interconnection between Pinjar and Northern Terminal will be constructed on double-circuit structures. There is a strong likelihood that the structures will be of the lattice steel tower type. Towers will typically be spaced at up to about 400 metre centres.

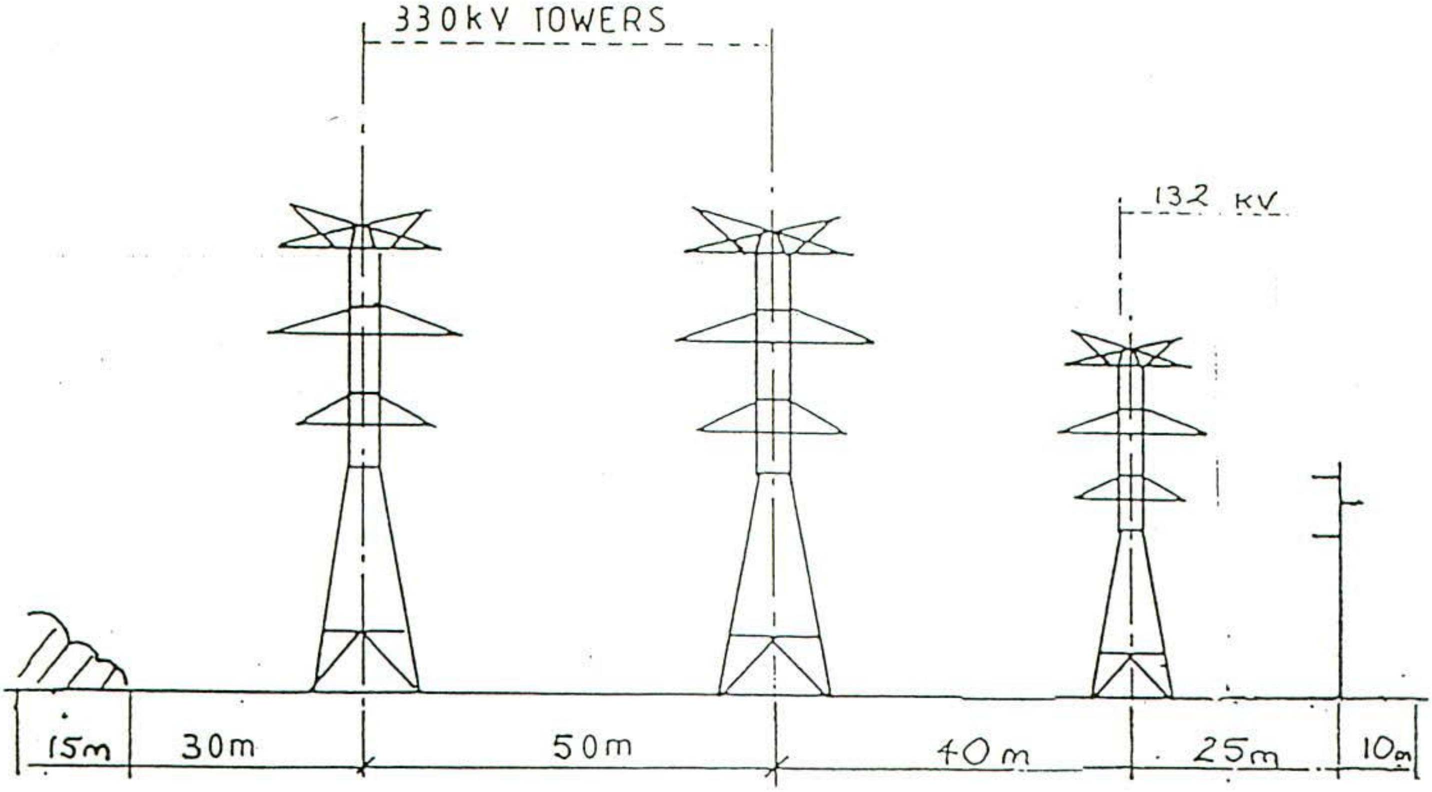
Typical tower structures are shown at Figure 1. The 132kV double-circuit towers will typically be between 26m and 30m in height.

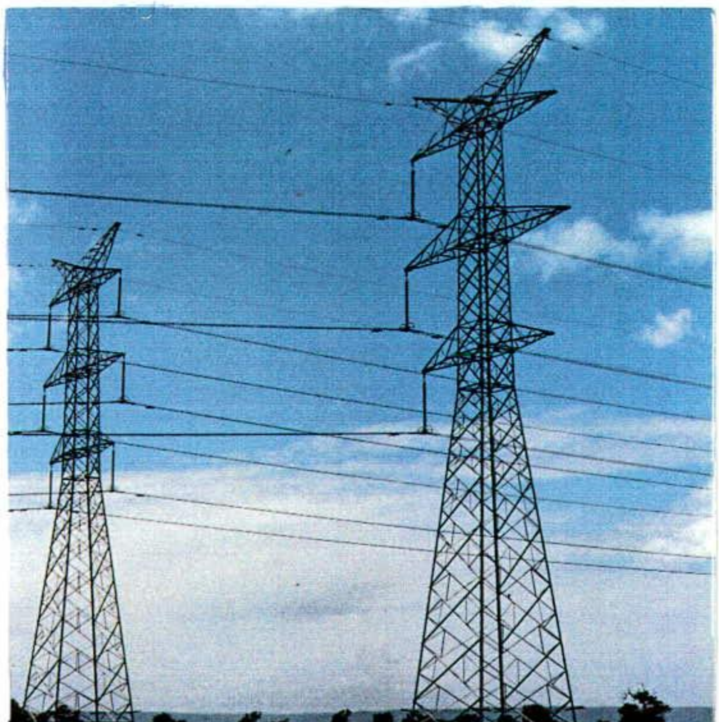
Double-circuit 330kV towers with overhead earth will be between 35m and 42m in height.

In certain situations where it is necessary to reduce the height of the towers - for example in the vicinity of aircraft take-off and landing approach areas - it is possible to reduce the tower height by about 4.5m or 5.0m by deleting the overhead earth.

A double-circuit 330kV line can be arranged as two separate single-circuit lines of about 25m height.

Construction of the lines will be undertaken by contractors under SECWA supervision.





TOWER STRUCTURES

FIGURE 1

2. THE PROCESS OF CORRIDOR AND ROUTE SELECTION

2.1 REVIEW OF PROCEDURES

2.1.1 General

Over the past twenty or so years there have been marked changes in awareness of and attitude to major engineering works, particuarly, perhaps, those of public utilities. Power transmission lines have been no exception. During that time there has been increased sensitivity to their impact, firstly on property, subsequently on landscape and townscape, and more recently on the natural environment.

Where once it would have been sufficient for the SECWA to select transmission line routes essentially on the basis of cost and engineering constraints it has progressively had to take into account the sensitivities and views of other groups in the community.

The SECWA has responded positively to the successive challenges that have been posed. The 1977 report by Seddon and Polakowski (Power Transmission, Western South Western Australia: A Review of Route Selection Procedures. George Seddon and Polakowski. State Energy Commission of Western Australia, April 1977) was somewhat ahead of its time, both in recognising environmental values and in establishing a methodology for corridor and route selection and assessment, and principles for route design.

Of course, it is very much in the interest of SECWA to be perceived by the community at large as a "good neighbour" since such a perception will create the goodwill necessary to obtain the support and cooperation needed to enable it to do its work effectively. Further, SECWA's role in the corporate State structure requires that it be congnisant of and respect a broader scale of values than it might pursue in isolation.

Nevertheless there will be significant conflicts between the legitimate objectives of SECWA and those of other groups within the community, and the process of determining corridors and routes for transmission lines needs to take account of these.

The consultant's Terms of Reference for this Study state:

> "The Commission believes that its earlier route review selection procedure for transmission lines in South Western Australia (Report: Seddon and Polakowski, April 1977), was a successful document and provided the basis for powerline development south of Perth."

During the course of this study we have therefore kept under review the methods used by Seddon and Polakowski to determine line corridor selection and also principles for siting of transmission line routes.

We have also examined the methods reported in a comparatively recent study carried out for the Electricity Commission of New South Wales (Mount Piper to Marulan Transmission Line Environmental Impact Statement. Kinhill Stearns, 1987).

In addition we have taken note of the corridor selection and design guidelines published by the Queensland Electricity Generating Board (Powerline Route Location Guidelines. QEGB, 1984). Extracts from Seddon and Polakowski and the QEGB Guidelines are at Appendix 2.

2.1.2 Seddon and Polakowski, 1977

Seddon and Polakowski, of the Centre for Environmental Studies, University of Melbourne, were commissioned by the SECWA to undertake an assessment of transmission line route planning procedures in general and to suggest appropriate policies and design philosophies for future 330kV transmission lines in the coastal plain. At the same time they were asked to review the Muja-Forrestdale route; suggest the most appropriate Muja-Southern Terminal route, and comment generally on the SECWA's 330kV transmission system from an aesthetic standpoint. Their work was thus set in the context of southwestern Western Australia.

Their work clearly established a procedural framework, working from the general planning description and criteria through a process of evaluation to choice of corridor. Choice of route follows choice of corridor. As the report states:

> "The choice of corridor should precede route selection, which is the process of precise location of an easement within a corridor ... route selection primarily requires detailed attention to technical and design criteria, although the broader economic, social and conservation criteria are still relevant at the detailed design phase."

In setting criteria for corridor selection Seddon and Polakowski noted the emphasis that had been placed hitherto on visual and land use considerations, and pointed to the importance of not dismissing ecological criteria, notably the spread of phytopthora (die-back disease) and increased salinity in water catchments.

While noting the inevitably subjective nature of the relative importance of various criteria the report stresses the value of making these explicit, and puts the following forward (page 2):

Relative Importance	Alternative corridors evaluated according to:
(high)	a. least disruption to human settlements
(low)	b. least disruption to agric. practices
(high)	c. least disruption to forestry practices
(high)	d. least disruption to extractive practices
(high)	e. least disruption to recreation uses
(high)	f. least disruption to natural systems
(medium)	g. least visual impact
(high)	h. least impact upon projected uses
(high)	i. least financial investment
(medium)	j. maximum utilisation of rights-of-way
(high)	k. greatest system reliability
(medium)	l. greatest accessibility.

The next stage in the process outlined by Seddon and Polakowski is that of comparative evaluation of alternative corridors. The procedure involves ascribing an "importance value" to each selection determinant or criterion, and setting out the impact of each on each corridor, as shown in the following table extracted from the report (page 22):

TABLE 2: DETERMINANTS FOR CORRIDOR SELECTION AND THEIR IMPACT ON EACH CORRIDOR

SELECTION DETERMINANTS	Importance Value	Impact Level (Eastern Corridor)	Impact Level (Central Corridor)	Impact Level (Western Corridor)
Disruption to human settlements	H	L	L	M
Disruption to agric. practises	L	L	L	M
Disruption to forestry practices	H	M	M	L
Disruption to extractive practices	H	L	M	L
Disruption to recreational uses	H	L	M	L
Disruption to natural systems	H	M	H	L
Visual impact	M	L	L	M
Impact upon projected uses	H	N	L	L
Financial Investment	H	H	L	L
Utilisation of rights-of-way	M	L	L	M
Systems reliability	H	M	M	H
Accessibility	M	M	L	M

H High
M Medium
L Low
N Negligible

Each corridor is described and evaluated in a written analysis which covers comparative advantages and disadvantages.

No attempt is made to quantify the process of evaluation, nor does the report address the question of how alternative corridors are generated in the first place.

The report addresses in some detail the question of route analysis and design, and sets out "design principles and planning criteria" for route design. It also incorporates "tower design and siting guidelines" taken from "Design Guide: Aesthetic Guidelines for Electric Transmission" (Southern California Edison, 1972). Both of these are reproduced at Appendix 2 of this report. Collectively they provide a sound set of design criteria for transmission line routes, as relevant now as they were in 1977.

2.1.3 Kinhill Stearns, 1987

The report "Mount Piper to Marulan Transmission Line. Environmental Impact Statement" (Consultants: Kinhill Stearns. Electricity Commission of New South Wales, 1987) contains a very detailed exposition of the process of selection of the proposed 550kV transmission line route.

The process is summarised in Figure 2, taken from the report.

As described in the report the process was a rigorous one, as well as being comprehensive and thorough (and, doubtless, expensive).

The following brief comments touch on aspects of the adopted methodology which may be relevant to the present study.

Firstly, the report places great emphasis on the spatial aspects of route selection factors: in nearly all cases these are mapped and given a set of values in terms of the degree of constraint they pose for transmission lines. The process followed is very much akin to sieve-mapping techniques, which lend themselves to a geographic information systems approach.

Secondly, the process rigorously identifies the source of selection factors in terms of the interest groups to whom they are of concern.

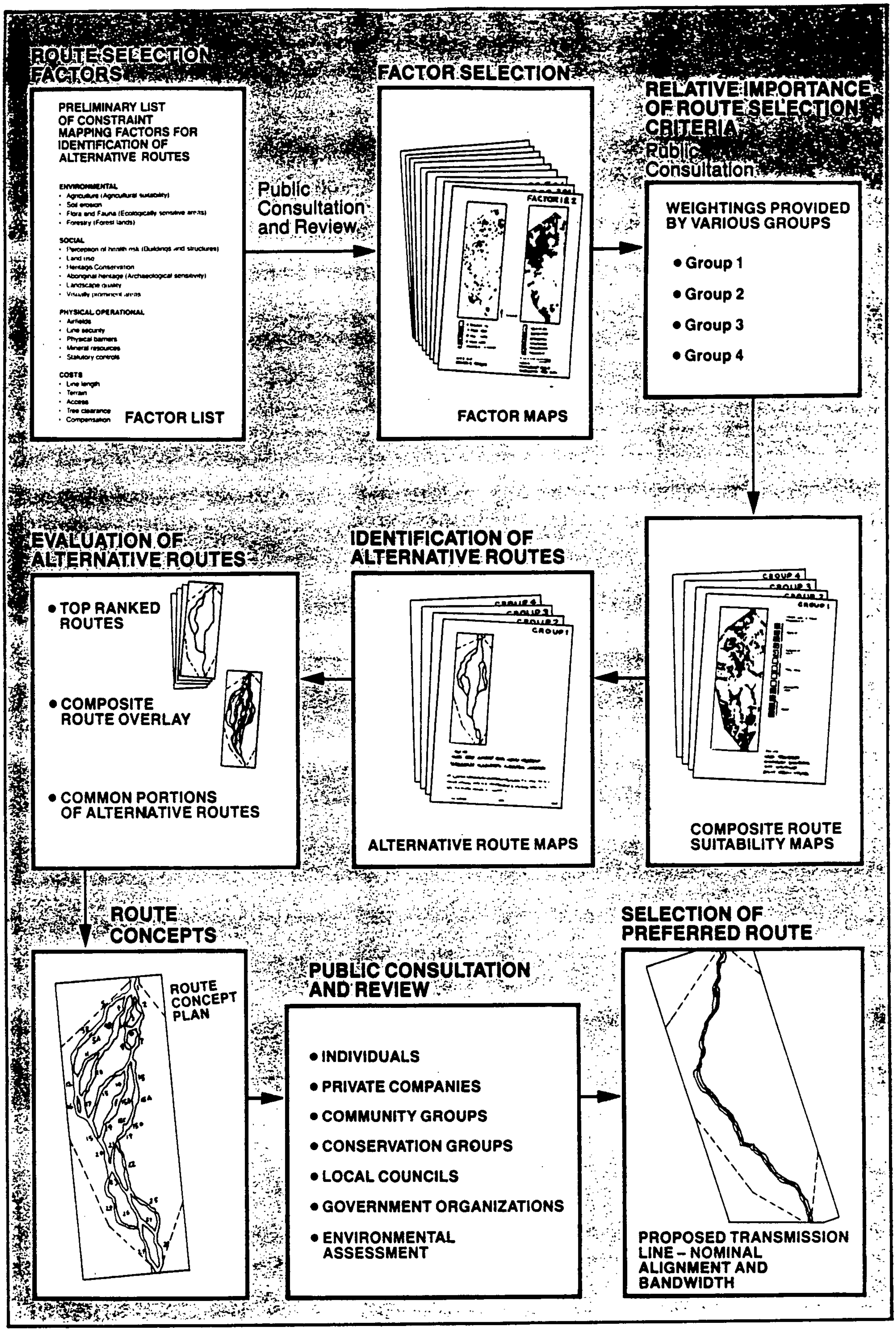
Thirdly, the selected factors themselves were derived from a process of consultation with identified interest groups, including the Electricity Commission, the general public (as a result of submissions), the Department of Environment and Planning, and other public authorities.

Fourthly, the route selection factors were weighted with respect to one another on a 4 point scale from "Extreme Importance" to "No Importance" after subjecting them to scrutiny by a number of interest groups and assessing the perceived importance of each factor to each group. The groups included the Electricity Commission, conservation groups, local interest groups and others.

Fifthly, four alternative "route concepts" were developed from a composite route suitability map formulated on the basis of the weighted factors.

Sixthly, the alternative route concepts were evaluated in two ways. Firstly, a matrix was prepared, evaluating the potential effect of each route on each factor, according to a four-point scale ranging from least to most potential effect. Secondly, a concise written evaluation, in table form, was also prepared, summarising the factors as they applied to each route.

If a rigorous numerical evaluation of alternatives was made it was not illustrated in the report.



Source: "Mount Piper to Marulan Transmission Line. Environmental Impact Statement." E.C.NSW 1987. Figure 3.1.

MT PIPER TO MARULAN: ROUTE SELECTION METHODOLOGY

FIGURE 2

Finally, it should be noted that the report does not draw a deep distinction between "corridor" and "route"; the process was devised to elicit the best route. The extent to which this route would be refined and developed in detailed design is not clear.

2.1.4 Queensland Electricity Generating Board, 1984

In 1984 the Queensland Electricity Generating Board published "Powerline Route Location Guidelines", a manual setting out in some detail the process of defining the location of transmission line corridors and routes.

The Guidelines identify three stages in the process of route selection:

- defining the study zone;
- selection of a corridor; and
- defining a finite location for the route.

The Guidelines set out a number of factors to be considered in the process of reduction of the study zone to one or more feasible corridors.

The Guidelines set out a simple "Evaluation Summary" to accompany written evaluations of alternative corridors. This is essentially a matrix allowing for numerical scoring of alternative corridors against individual determinants. The matrix provides for a numerical weight to be applied to each determinant, enabling the evaluation to be sensitive to differing sets of values.

The Guidelines then deal with "finite location", that is, with selection of a transmission line within a corridor, by reference to a number of design and technical criteria.

Aesthetic guidelines for transmission line location are set out in graphic form. These are founded on principles similar to those set out by Seddon and Polakowski, and are reproduced at Appendix 2.

2.2 METHOD OF THIS STUDY

2.2.1 Some Observations on Process

It is apparent from a review of other transmission line studies that they have much in common, in terms of methods adopted. For example, all stress the need to begin with an examination of regional influences and criteria. All stress the importance - perhaps the inevitability - of identifying alternatives and undergoing a process of evaluating them against stated criteria.

The distinction between broad corridors and precise routes is also generally a common factor.

Finally, all recognise that there are established design principles which ought to be applied to detailed route design.

Most reported discussion of transmission line selection conveys the impression of a rather linear process, whereas in practice the process is implicitly a somewhat cyclic or iterative one, as is common with complex problem-solving. For example, the study area cannot be identified without reference to the major factors influencing the outcome, but these cannot be determined without an assumed study area in the first place. After detailed investigation it may be found necessary to extend or reduce the area of investigation. In the same way, the process of evaluation may generate a need for further investigation, and so on.

One further observation may be made relating to the process of transmission line selection. In very few reported studies is the process of generating corridor or route options explained. Potential solutions do not automatically emerge from the process of factor or constraint analysis. There is a creative or design process involved, which involves the making of informed judgements and the synthesis of a number of different factors. These potential solutions need to be evaluated - tested for performance - against specific criteria. There is a very close relationship between the factors which are brought into play to generate potential solutions and the criteria which are used to evaluate the solutions. If it were possible to construct a perfect linear spatial problem-solving model, the twin processes of selection and evaluation would be able to be merged. This is in fact what occurs when constraints are so heavy as to admit of only one solution, or so absent as to allow the most direct solution.

2.3 THE ADOPTED APPROACH

The method adopted in this Study is to carry out the process of corridor and route selection in several well defined stages:

(1) Identification of the study area (Section 3.1);

(2) Identification of relevant factors affecting corridor and route selection (Section 3);

(3) Selection of alternative corridors (Section 4);

(4) Evaluation of alternative corridors (Section 5);

(5) Selection of Preferred Corridors for the 132kV line and for the two 330kV lines (Section 5.4); and

(7) Selection of the recommended route for the 132kV line (Section 6).

Details of the methods used are set out in each section. It is worth noting here, however, that because of the complexity of the task - due to the complexities of current and future land use, the variability of the physical and social character of the region, and the uncertainty associated with some of the major constraints - no simple method of selection and evaluation of corridors is feasible.

The report, therefore, explores as far as it can, the factors which have a bearing on the routing of transmission lines, identifies a number of different options and suboptions, and then evaluates them according to different criteria.

The evaluation method is part-numerical, part-discursive, because some factors are susceptible to numerical analysis, while others are not.

3. CORRIDOR AND ROUTE SELECTION FACTORS

3.1 IDENTIFICATION OF STUDY AREA

Map 1 shows the metropolitan regional context within which the study is set. It shows how the proposed site of the Pinjar gas turbine power station relates to the Northern Terminal, major transmission lines and other terminals and power stations, and the spread of existing urban development in the Region.

Map 1 also identifies the location of some of the more obvious major constraints on transmission line development, notably the Overseas Telecommunications (OTC) installation, the RAAF Pearce base at Bullsbrook, the RAAF receiving installation (3TU) and some major regional reserves.

The boundaries of the area of investigation are determined by the constraints imposed by the following factors:

- existing and committed major urban development areas;
- the presence of sensitive receiving installations at OTC and 3TU;
- regional parks and recreation reserves; and
- areas identified in the Environmental Protection Authority System 6 Study (EPA, 1983).

Each of these factors imposes an extremely high level of constraint, generally claimed to be totally prohibitive of the presence of major transmission lines within defined areas.

It was necessary, therefore, to define the Study area in broad enough terms to ensure that acceptable corridors and routes could be found within it.

The western boundary of the area of investigation is determined primarily by existing and committed urban development, as reflected in the Metropolitan Region Scheme (MRS).

The southern boundary is determined by the obvious factors of existing urban development and the fact that the transmission lines must run north from Northern Terminal.

The northern extremity was determined essentially by the need to ensure that lines approaching Pinjar from the east could provide sufficient clearance for aircraft in the vicinity of RAAF Pearce.

The eastern extent of the Study area has been determined by the constraint sought to be imposed by OTC. This is elaborated on later. In brief, when the Study was first commissioned OTC was believed to require a relatively small radius of exclusion around it, which would have confined investigation to potential corridors aligned between OTC and 3TU. Subsequently, OTC gave notice that a much larger zone of exclusion would be required, and the area of investigation had to be extended to allow for corridors east of RAAF Pearce. The presence of the Walyunga National Park and Darling Scarp has required that the Study area extend sufficiently far east to ensure viable corridors along the Darling Plateau.

Selection of these factors to delimit the area of investigation required a degree of judgement. Had subsequent investigations revealed factors requiring a broader area, it would have been necessary to backtrack. Accordingly, within reason, the Study area was conservatively and broadly defined. The boundaries have not been rigidly followed in the detailed investigations carried out. Where sensible the factor under investigation has affected the extent of land covered.

3.2 REGIONAL LANDFORMS, SOILS AND GEOLOGY

The significant landforms, soils and geology of the Study area are shown on Map 2 and Figure 3. A broad description of the landform types that occur within the study area are given in this section. Evaluation of landform types that will be encountered is necessarily conducted at both broad scale and in detail as construction methods and costs are affected by land stability, slope and alignment whilst operation and maintenance will be influenced by these factors as well as others, such as inundation risk.

The information provided here is based on reports and mapping compiled by the Geological Survey of W.A. (1986) and the Department of Conservation and Environment (1980).

In broad terms the study area can be considered to include two physiographic units: the topographically subdued Swan Coastal Plain and the heavily dissected Darling Plateau. The division between these units is marked topographically, geologically and geomorphologically. For convenience, the study area has been broken into three sectors for description:

The Western Sector includes those areas that lie entirely in dune and sandplain terrain of the Swan Coastal Plain;

The Central Sector includes those areas that lie between sandplain terrain and the base of the Darling Scarp and contain landforms and soils associated with alluvial processes; and

The Eastern Sector includes those areas that lie within the Darling Plateau and Darling Scarp.

Western Sector

The western part of the study area includes Swan Coastal Plain landforms that can be broadly described as topographically subdued sand plain and aeolian dune terrain. Local variations occur in places where unconfined groundwater is very shallow, enabling wetlands to develop, and where alluvial silts and clays lie close beneath the surface sands, causing damp or wet conditions during winter. Two principal landforms can be recognised:

- the Bassendean Dune landform; and
- the Southern Rivers landform.

The Bassendean landform comprises dune terrain and deep grey-white siliceous sands, whilst the Southern Rivers landform consists of sandplain and dune terrain with grey-white siliceous sands overlying alluvial silt and clay sediments. The two landforms are distinguished largely by the type of wetlands they contain. Bassendean Dune landform contains wetlands with peaty sediments whereas the Southern Rivers landform contains wetlands with clayey sediments reflecting the presence of alluvial sediments at relatively shallow depth. Localised short term inundation is a feature of Southern Rivers landform in some locations, although for the most part drainage development has flood potential largely under control.

In general engineering terms, landforms within the western part of the study area are well suited to transmission lines, as their topographic characteristics are amenable to the placement of towers in linear alignment and foundation conditions are generally suitable for tower construction. Localised occurrences of wetland sediments need to be avoided in the location of tower structures and therefore may require minor route deviation.

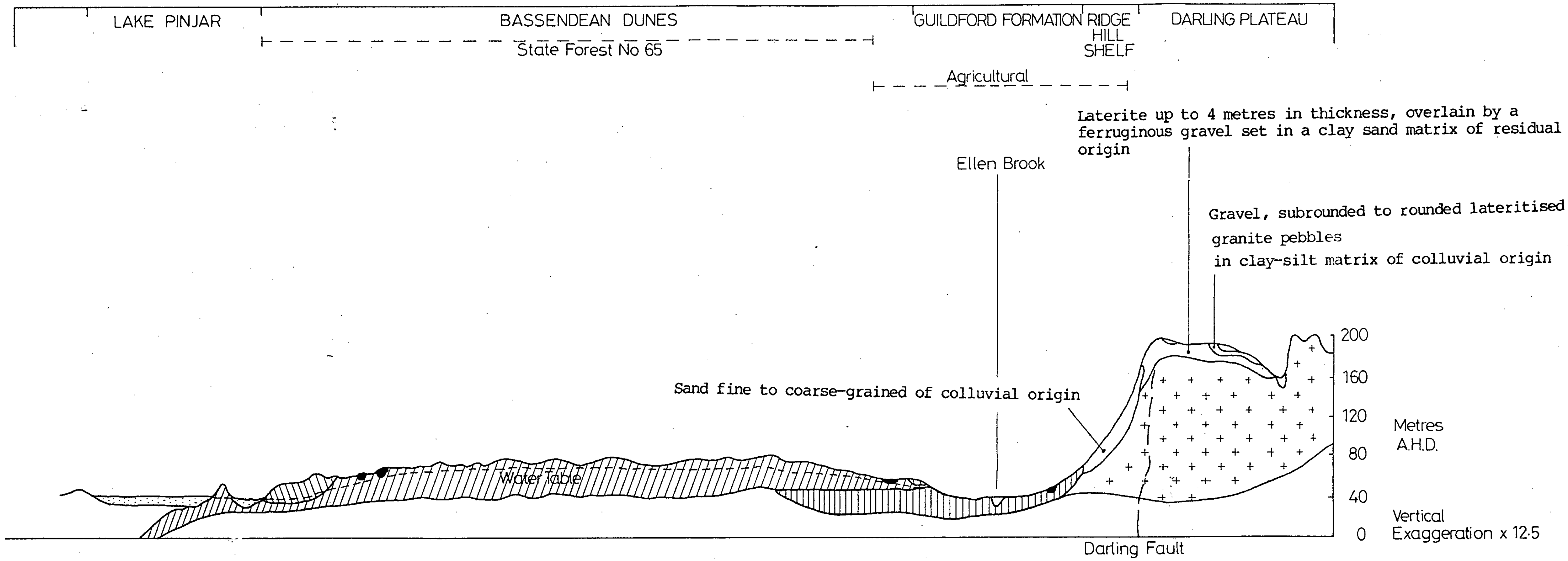
Central Sector

The central part of the study area includes dune and sandplain landforms, together with a transition area where coastal plain sandplain and dune terrain gives way to landforms and soils of the alluvial plains formed at the base of the adjacent plateaux. In turn these landforms are bounded to the east by undulating colluvial deposits and eroded steep slopes of the Darling Scarp. Six landform types occur within the central part of the study area. The Bassendean and Southern Rivers sandplains and dune terrain are flanked to the east by the fluviatile Swan, Yanga, Beermullah and Guildford landforms. The Forrestfield landform comprising foothills of the Darling Scarp is also encountered. The fluviatile deposits are poorly drained and in specific locations may undergo short term flooding.

As with the Western part of the study area, the Central area contains landforms well suited to transmission lines. The topography is quite featureless and will generally allow towers to be aligned in linear form. Areas requiring special consideration include the valleys and terraces of the Swan River, Bennett Brook and Ellen Brook where slope, flood potential and the geotechnical nature of shallow sediments need consideration.

Eastern Sector

The eastern part of the study area includes upland and valley landforms of the Darling and Dandaragan Plateaux. The landforms encountered in these physiographic units are vastly different from the topographically subdued aeolian and alluvial formations of the coastal plain. Landforms of the plateaux are the residual products of planation and dissection of a vast ancient lateritised plateau. Remnants of the ancient surface occur in the form of uplands with lateritic duricrust underlain by kaolinitic clays and granite bedrock. The adjacent valleys have colluvial sandy and gravelly soils on the slopes, occasional outcrops of the granitic basement sediments and localised deposits of alluvium.



LEGEND

- Swamp deposits of medium to coarse-grained quartz sand
- Bassendean Sand, fine to medium-grained quartz sand
- Thin Bassendean Sand over Guildford formation sand over pebbly silt
- Swamp deposits of peaty clay with variable sand content
- Guildford formation of pebbly silt, heavily weathered granite pebbles and some fine to medium-grained quartz sand
- Granite, fine to coarse-grained

Ref : Muchea 1 : 50 000 Geological Survey of Western Australia

Scale 1: 25 000

0 500m 1000m 1500m 2000m

LANDFORM CROSS SECTION

FIGURE 3

Topographically the plateau landforms are a hundred or so metres higher above sea level than the coastal plain and feature persistent undulation which is gentle on the uplands and may be steep on the valley slopes. Major and minor valley landforms are traversed in which slopes are commonly 3-10% and 10-30% or slightly more respectively. Very steep slopes are encountered in deeply incised river valleys of the major plateau drainages or sharp "breakaways", between upland and valley landforms.

Eight landform types are encountered within the eastern part of the study area. They are listed and described below:

Darling Plateau

Darling	-	scarp
Dwellingup	-	lateritic upland
Yalanbee	-	lateritic upland
Helena	-	major valley
Yarragil	-	Murray - major valley
Cookalin	-	minor valley

Dandaragan Plateau

Mogumber	-	lateritic upland
Reagan	-	scarp

From an engineering perspective the upland valley landforms of the eastern part of the study area are less suited to transmission line construction than are the central and western parts. Tower alignment needs to take careful consideration of topographic form, which will inevitably require directional changes in the transmission line route. The location of individual towers may also be constrained by foundation conditions on clayey valley slopes, and span considerations in locations where the transmission route crosses deeply incised valleys.

3.3 REGIONAL LANDSCAPES

3.3.1 Significant Landscape Features

In broad terms the area of study comprises a section of the basically flat coastal plain and the Darling escarpment with the Swan River Valley cutting through the latter and then running along its base.

Very little of this broad landscape has retained its original vegetation cover, although the land on and east of the escarpment is generally the least disturbed. The clearance and subsequent development of the land has in some cases enhanced it or opened up attractive longer views, and has in others degraded it to the point where it is perceived as ugly.

The quality of the landscape is therefore very variable, but the range of quality is not so much determined by natural features as by the level of human disturbance. Again in the very broadest terms the most important natural features - the Swan River and the escarpment - are on the eastern side, and the level of disturbance is greatest to the west.

The three most significant landscape features are the Darling Escarpment, the Swan River, and the Gnangara plantation.

The Darling Escarpment is the most visible of these features, not only in terms of its size, but also by virtue of the location along its base of the Great Northern Highway throughout the whole of the study area. Not only is it highly visible, but, because of its richly varied topography and its patterning of vegetation cover, it is also of the highest quality.

The Swan River and its immediate margins is in itself more variable in quality. Through its deeply incised gorge it has a wildness and ruggedness all of its own (particularly in winter) and as it emerges from the escarpment it wanders through its own silt deposits before settling into a deep, broad, still bed through the coastal plain.

For the most part the immediate margins are intact, but the land on either side has been cleared to make use of its fertile alluvial flats, and then treated with very mixed sensitivities. Along its length it has been subjected to dumping of brickworks wastes, to overworn and badly managed recreation areas, to carefully tilled vineyards, to rich alluvial pastures, and to residential developments ranging from the quaint to the vulgar.

The Gnangara Pine Plantation is the dominant cultured landscape by virtue of its enormous area and the virtual total elimination of the natural landscape. Because it is so particularly dense its size is not appreciated from ground level unless the observer moves through it rather than just along its margin. Its area can be appreciated from the escarpment but the view is tempered by distance.

It is tempting to regard the plantation with less favour than the other features because of its mass and its homogeneity, and perhaps because it is an imposition on the natural landscape. To do so is to neglect its very real and quite distinct qualities, which, again, cannot be appreciated from a vehicle moving along its edge.

To the west of the plantation the landscape is gently undulating with low lying wetlands between rolling dunes. This is a different landscape again, being largely cleared and presenting views which vary in depth and in quality. It is less striking than the escarpment or the river valley, but in many ways more subtle. The generally less attractive nature of this landscape is due to the generally less impressive scale of its natural cover and often poor husbandry in cleared areas.

At the other geographic extreme the landscape to the east of the escarpment is deeply incised with clearing in some broader valleys and on some wider plateaux, but otherwise largely tree covered. Both in its cleared and uncleared state it is of very high quality indeed. Whilst it is less visible than the escarpment itself its intrinsic qualities are just as high and in some cases (such as parts of the Chittering Valley) higher.

The landscapes of the Study area, together with an assessment of their quality, are shown on Map 3.

3.3.2 Visually Exposed Areas

The degree of visual exposure of an area is a significant factor because the visibility of a transmission line is the main criterion by which the public judges its acceptability.

In assessing the impact of a transmission line on the landscape the extent and degree of visibility (or aesthetic impact) is, of course, only one factor, albeit the most important for most people.

The determination of visibility is by a combination of landform and vegetation cover.

The study area breaks into five very broad units from west to east:

- the coastal dunes with intervening wetlands;
- the broad expanse of flat coastal plain;
- the Swan River valley (and Ellen Brook to a lesser extent further north);
- the escarpment; and
- the deeply incised forest land to the east.

The coastal dunes have the potential for low visibility if routes are kept at a distance from the viewpoints and roads. Even where they are cleared of their low vegetation cover there is still the possibility that the route can be picked through low areas with intervening high ground (so long as the low areas are not wet).

The coastal plain offers no such topographical screening and depends, if it is to absorb the line visually, on vegetation cover or distance. The natural cover of banksia and puddybark is not high but is reasonably dense and if it is close to the viewpoint, is quite adequate as a screen. Much of the area of study, however, has been developed as a commercial pine plantation. This has a very high potential for screening, depending on the crop rotation. For the first ten years from planting the screening effect would be no better than the native scrub, and for the first five years it would be less effective. Since much of the Gnangara plantation is going to be cropped during the life of the line it should not be assumed that the whole solution can be found here without some consideration of plantation management.

The river valleys across the plain do not offer much in the way of visual screening potential. As is normal in the flood plain they are not deeply incised but the waters meander through shallow courses in their alluvial flats. The meandering also makes their relatively low courses a poor proposition for a line route, as does the likelihood of occasional flooding.

The escarpment is the most exposed element of the landscape, because it is the major topographical feature, because it is substantially cleared, and because the main Great Northern Highway is never far from its base.

The only moderation of exposure here comes from the degree of vegetation cover close to the Highway viewpoint. In fact this is quite extensive, particularly as there is a likelihood that clay extraction will take place along the intervening strip, and will be screened from the road. This is already happening in some cases. In Upper and Middle Swan buildings perform the same function.

East of the escarpment the high proportion of uncleared land and the deeply incised topography present the highest potential to screen the line route. There are also very few roads and public viewpoints.

In this area it is not visibility that will dictate the acceptability of a route as much as the quality of the landscape and the degree of physical damage necessary to build and maintain the lines.

3.3.3 Areas of High Scenic Value

All landscape types have an intrinsic scenic value, but judgements are inevitably subjective, which makes them difficult to defend against objective statements of need.

There are, however, well documented public preferences for landscapes, and rather than put forward personal opinions these preferences are offered as a means of assessing the area of study.

Of all landscapes, water margins are the most preferred. Falling or rapidly moving water is the highest, followed by large expanses of still water, and then by smaller expanses of still water.

This suggests that, within the area of study, the river gorge through the forest and escarpment would be the most preferred, followed by open water bodies to the west, and then by the major river courses of the Swan Valley and Ellen Brook.

Broken landscapes are preferred to flat open expanses, which suggests that the dunes to the west and the escarpment and hills to the east would be preferred to the flatter coastal plain between them.

This is also a factor in determining length of view, because long views are preferred to short ones. The other determinant here is vegetation cover. The implication is that long views to or from high ground are valued, therefore placing the escarpment highest in the preferences from the topographic viewpoint, since it is seen from the greatest distance.

Because trees are so highly valued, both as specimens and in woodlands, vegetation cover is also important, even though it may be a negative in the preference for long over short views. Trees around water are highly rated, and a long view with trees is preferred to a long view without them.

There is a further consideration here. That is that the preference studies were done on the eastern seaboard of the United States (Schaffer 1965) and in Scotland (Tooby 1970). It is likely that slightly different values would be attributed to vegetation cover in Western Australia in 1988, because of our climate and the increasing awareness of the effects of overclearing.

The effect of this is that local opinion would favour tree cover to the extent that it might demonstrate weaker preferences for long views in forms of the benefits of shade and shelter.

Because of this there is likely to be greater support for preserving views of the tree lined river and brook than of the open water of, say, Lake Gnangara or Joondalup, and for the forested hills over the rolling dunes.

Western Australians also have a strong preference for native forest over plantation forests, which is an emotive issue but a real one. Very few people ever venture into pine plantations to experience their very specific qualities, and it is likely that, if they did, and if they were less heavily influenced by the conservation lobby and media, this antipathy could change. (The public preferences expressed in the United States and Scotland did not make a distinction because native forests have been largely removed in the former study area and almost completely in the latter.)

Since this area of study is in Western Australia in 1988, however, and since the chosen criterion of quality is public preference, it is likely that native forest would be preferred to plantation pines.

3.3.4 Physically Vulnerable Landscapes

Some landscapes are intrinsically more vulnerable than others to any form of physical damage, and others are more drastically affected by power lines specifically.

Construction of power lines is itself potentially damaging, with the need to take heavy equipment on to the site of every tower, and to install large foundations. In broken country the scars tend to remain.

The longer term implications, however, are very variable indeed. In cleared areas with established pasture the only long term physical impact is the 'footprint' of the individual towers. In less accessible areas there is a need for a permanent maintenance track along the line route, and in uncleared areas there is the need for a permanent clearance to ensure continuity of supply and maintenance. Within the area of study the most forgiving landscapes from this viewpoint are therefore the flat open pastures on the coastal plain and perhaps also the flatter slopes of the dune landscape to the west.

The wetter areas, which will be avoided where possible for other reasons, also need to be treated with caution. It is necessary in such areas to construct access tracks for the construction equipment and to ensure access for maintenance purposes. The tracks and the construction pads at the tower base are therefore left in place. In very steep country the construction tracks and pads are difficult to construct, often requiring major earthworks and blasting. These tracks and tower bases are retained to ensure future access, and invite use by recreating public in four-wheel drive vehicles.

The erosion potential of these earthworks is very high in some areas, leading to down-slope destruction of vegetation and to possible stream turbidity if it remains uncontrolled.

Where there is tree cover the worst scarring of all takes place as the line route is cleared and re-growth discouraged, leaving a considerable swathe through the forest (whether it is natural tree cover or plantation forest).

Where tree cover occupies wet ground or steep hillsides a combination of these elements occurs.

3.4 ECOLOGICAL AND CONSERVATION ASPECTS

3.4.1 Areas with Ecological Conservation Value

The presence of ecological systems worthy of conservation represents a primary constraint to the location and alignment of transmission lines.

The primary reference material utilised in this Study has been:

- Conservation Reserves for Western Australia. The Darling System - System 6, Part II Recommendations for Specific Localities (Department of Conservation and Environment, 1983);

- Regional Management Plan 1987-1997, Northern Forest Region (Department of Conservation and Land Management Western Australia, 1987);

- Planning for the Future of the Metropolitan Region (State Planning Commission, 1987);

- Environmental Significance of Wetlands in the Perth to Bunbury Region (W.A. Water Resources Council, 1987).

- Colour aerial photography covering the Study area at a scale of 1:25,000.

Areas of ecological and conservation significance are shown on Map 4. The areas marked on the map are listed in Table 3.4, which also summarises the desirable ecological features of each location and proposed future management. Further areas that have ecological value, but may not necessarily be as vital to the success of the conservation strategies that have been adopted by the regulatory authorities, are also identified in Table 3.4. For the most part, these areas constitute stands of natural vegetation that have escaped previous agricultural clearing programmes.

An essential ingredient of any management plan for conservation reserves is that the population and species diversity of biological communities is maintained and if possible enhanced. In simple practical terms this requires the preservation of vegetation structure, species composition of flora and fauna communities, soil stability and water relations, and the special protection of any plant or animal communities known to be under stress. The ability of conservation reserves and other ecologically significant areas to sustain the effects of concurrent usage for transmission, needs to be assessed in relation to these requirements.

Conservation reserves are not inherently well suited to concurrent usage for major transmission lines. At specific locations it may be possible to construct and maintain transmission lines without effective detriment to conservation objectives. However, the preliminary selection process for transmission corridors has treated both statutory conservation reserves and recommendation areas as zones of exclusion.

Table 3.4 sets out identified areas of conservation value within the Study area.

TABLE 3.4: AREAS OF CONSERVATION VALUE

Area Name/ Location	Reference	Conservation and Ecological Attributes	Proposed Management
M13 Whiteman Park	EPA, SPC, WAWRC	Vegetation, flora, fauna wetlands, open space	Regional Park (DCE 1983) Metropolitan Park (SPC 1987)
M8 Wanneroo Wetlands Eastern Chain	EPA, WAWRC	Vegetation, flora, fauna wetlands, open space	Regional Park (DCE 1983) Nature Reserve (CALM 1987)
M9 Melaleuca Park	EPA, SPC, CALM	Vegetation, flora, fauna wetlands	Management Priority Area Conservation of flora, fauna landscape (DCE 1983) Metropolitan Park (SPC 1981)
Pine Forest LMN	WAWRC	Wetlands, vegetation, fauna	State Forest (CALM 1987)
M4 Ridges MPA MPA	PLE	Vegetation, flora, fauna landscape, opens space	Management Priority Area for conservation of flora, fauna and landscape. Regional Park (DCE 1983)
East Gnangara 12, 13	WAWRC	Wetlands, vegetation, fauna	Freehold land privately owned.
Bennett Brook	WAWRC, SPC	Wetland, vegetation, fauna	Metropolitan Park (SPC 1987)
M17 Ellen Brook and Twin Swamp Nature Reserves Upper Swan	EPA	Tortoise, fauna habitat, wetlands	Protection of gazetted rare fauna and flora
Ellen Brook	WAWRC	Wetland	
M19 Swan River to Guildford to Walyunga	EPA, SPC, WAWRC	Fringing vegetation permanent river	Regional Park (DCE) Metropolitan Park (SPC)
Jane Brook No. 1	WAWRC	Natural watercourse fringing vegetation	Freehold land privately owned
M18 Walyunga National Park	EPA, CALM, SPC WAWRC	Vegetation, flora, fauna, landscape	Regional Park (DCE) National Park (CALM) Metropolitan Park (SPC)
M15 Pearce Aerodrome	EPA	Vegetation and flora	Management, Commonwealth Defence purposes, maintenance of vegetation cover (DCE)
M14 Reserve Bullsbrook Bullsbrook	EPA	Vegetation, flora, fauna	Conservation of flora and fauna (DCE)
C25 Mound Springs Muchea	EPA	Rare flora	Protection of conservation value

3.4.2 Vegetation Complexes

While many parts of the Study area have been wholly or partly cleared, there are also a number of areas where human development has been minimal and the indigenous vegetation remains. These range from small, isolated patches of vegetation in areas where landform or location has favoured agricultural development, urban expansion or forestry, to larger tracts in areas where land has been unsuited to large scale development as a result of flood risk, soil type, slope or remoteness of location.

The descriptions of vegetation type given in this section are broad and only brief mention is made of the degree of clearing that has occurred. Unless it is specifically stated it can be assumed that the description of vegetation given in the following sections refer principally to remnant stands.

As in the case of landform, in relation to vegetation it is convenient to consider the Study area as consisting of three sectors - western, central and eastern - as the distribution of vegetation complexes between these areas results at least partly from the analogous distribution pattern of landform and soil types.

Descriptions are based on the work of the Heddle, Loneragan and Havel (DCE 1980), together with analysis of 1:25,000 scale colour aerial photography and brief field inspections.

The Western Sector

The western sector has been substantially cleared for agriculture and forestry. The central-western and south-western parts of the Study area, in particular, have mostly been cleared. The north-western area still contains relatively large tracts of native vegetation in good condition.

The vegetation complexes that are found in the western portion of the Study area, in either remnant patches or stands of larger extent, are described below.

The Southern River Complex comprises open woodlands of Eucalyptus-calophylla - E.-marginata and Banksia spp. (marri - jarrah - banksia), together with woodland of E. rudis - Melaleuca rhaphiophylla (flooded gum - swamp paper bark) along creek beds and drainage lines. Within the Study area, much of this complex has been cleared for pastoral purposes so that only clumps of the large trees and patches of vegetation within wet ground remain. For the most part understorey vegetation has been completely removed from these areas.

The Bassendean Complex North - vegetation ranges from a low open forest and low woodland of Banksia spp. - E. todtiana to low woodland of Melaleuca spp. and sedgelands, which occupy the moister sites.

The Bassendean Complex - North - Transition Vegetation Complex - comprises a transition complex of low open forest and low woodland of Banksia spp. - E. todtiana (Banksia - prickly bark) on a series of high sand dunes. The understorey species refect similarities with both the Bassendean - North and Karrakatta Complex - North vegetation complexes.

Understorey species within areas of deep pale yellow and deep pale grey sands include Boronia purdieana, Scholtzia involucrata, Leucopogon conostephioides, Calectasia cyanea, Conospermum stoechadis and Jacksonia floribunda. Localised patches of yellow sand are indicated by the presence of species such as Mesomelaena stygia and Synaphea polymorpha.

The Karrakatta **Complex** - North consists of predominantly low open forest and low woodland of Banksia spp. - E. todtiana (Banksia - prickly bark). Banksia attenuatea and B. menziesii are prominant with the occasional B.ilicifolia on the lower slopes. Common understorey species include Conospermum triplinervium, Hakea trifurcata, Mesomelaena stygia, Eremaea pauciflora, E. frimbiata, Jacksonia sternbergianna, Stirlingia latifolia and Calothamnus sanguines.

The Pinjar Complex ranges from a woodland of E. marginata - Banksia (jarrah - banksia) on the upper dune slope to a woodland of E. rudis- M. pressiana and sedgelands in the depressions. The area differs in the degree of development of swamp vegetation associated with semi-permanent and permanent lakes. Other plants common in these depressions include Regelia ciliata, Hakea varia, Leptospermum ellipticum, Hypocalymma angustifolium and species of Baumea, Juncus, Scirpus and Leptocarpus.

The Central Sector

The range of vegetation complexes found within the central parts of the Study area reflect the presence of alluvial soils and landforms along the boundary between the Swan Coastal Plain and the Darling Scarp. The inherent suitability of the alluvial soils for agriculture, particularly viticulture and grazing, has resulted in large scale clearing within these areas, such that for the most part only remnant patches of the indigenous vegetation complexes remain. The vegetation of the sandplains and dunes has been less extensively cleared. The vegetation complexes that occur within the central study area include the following:

The Southern River Complex and Bassendean Complex North, as above.

The Bassendean Complex - Central and South ranges from woodland of E. marginata - Casuarina fraseriana - Banksia spp. (Jarrah - Sheoak - Banksia) to low woodland of Melaleuca spp. and sedgelands on the more moist sites. This complex also includes the transition from E. marginata to E. todtiana (prickly bark). The three banksia species B. attenuata, B. grandis and B. menzesii are common on the upper slopes whilst B. ilicifolia, B. littoralis and M. preissiana are common on the low lying moister soils, where E. calophylla replaces E. marginata in dominance. Other plant species include Kunzea vestita, Hypocalymma angustifolium, Adenanthos obovatus and Verticordia spp.

The Karrakatta Complex - North - Transition Vegetation Complex has affinities with the Bassendean-North, Bassendean-North-Transition and Karrakatta-North as they all support a low open-forest and low woodland of banksia-prickly bark. Floristically, this complex differs from the others in the dominance of the understorey species which reflect the presence of yellow sand at various depths. Common understorey species on these yellow sands include Mesomelaena stygia, Synaphea polymorpha, Calothamnus sanguineus, Eremaea pauciflora, E. fimbriata, Jacksonia floribunda, Conospermum stoechadis and Acacia sphacelata. In addition there are small pockets of grey sand which support species such as Leucopogon conostephioides, Scholtzia involucrata and Boronia purdieana.

Alluvial Plains

The Beermullah Complex includes extensive stands of swamp sheoak (Casuarina obesa) on the moister flats. Elsewhere on the Swan Coastal Plain smaller stands and isolated plants of swamp sheoak are found on **Yanga** and **Swan** complexes. Despite agricultural clearing, remnant understorey species still include Hakea varia, H. prostrata, Hypocalymma angustifolium, Leptospermum ellipticum, Beaufortia squarrosa, Regelia ciliata and Viminaria juncea. These species, unlike C. obesa are widespread and occur in the moister low-lying areas of a large section of the Darling System. Minor components on the wetter areas include a closed-scrub of Melaleuca spp., and occasional Actinostrobus pyramidalis and on the small rises an open-woodland of marri-wandoo-jarrah.

The Yanga Complex is similar to **Beermullah** on the low-lying flats, where a low open-forest of swamp sheoak (C. obesa) occurs, with patches of Actinostrobus pyramidalis and Melaleuca spp. (including M. lateritia and M. hamulosa). On the drier sites of Yanga the vegetation reflects the adjacent Coonambidgee and Bassendean complexes, with the resulting mixture of a low open-forest of banksia-prickly bark and an open-woodland of marri-banksia, the latter being on the moister low-lying areas.

The Swan Complex is dominated by a woodland of E. rudis-M. rhaphiophylla, with localised occurrences of low open-forest of C. obesa and M. cuticularis. This vegetation was subject to early disturbances associated with the settlement of the south-western corner of Western Australia, therefore there are only a few remnant undisturbed areas. Other plants present include species of Leptocarpus, Juncus, Cyperus, Schoenus and Scirpus.

The Guildford Complex is dominated by a mixture of an open-forest, in sections a tall open-forest, of marri-wandoo-jarrah and a woodland of wandoo, with minor components including the fringing woodland of E. rudis-M. raphiophylla along the streams and the rare E. lane-poolei. Most of this area has been subject to logging and clearing since European settlement. E. lane-poolei is restricted in the main to the Guildford unit between Keysbrook and Cardup in the Darling System. Beyond the boundaries of the Darling System this rare species is known to occur near Jurien Bay. The other remnant plant species in this complex include Banksia grandis, Kingia australis, Xanthorrhoea preissii and species of Hardenbergia and Hibbertia.

The Coonambidgee Complex consists of vegetation ranging from a low open-forest and low woodland of prickly bark-banksia (E. todtiana-B. attenuata-B. menziesii-B. ilicifolia) with local admixtures of B. prionotes, to an open-woodland of marri-banksia. The former reflects the drier conditions found on the sands in the north. The floristic composition of the understorey of this complex has affinities with the **Reagan** complex of the Dandaragan Plateau. On the moister low-lying soils marri appears as an emergent among the Banksia spp. to form an open-woodland. Common plant species in the understorey include Persoonia comata, Stirlingia latifolia, Nuytsia floribunda, Mesomelaena stygia, Casuarina humulis, Calothamnus sanguineus, Hibbertia hypericoides and species of Conospermum and Petrophile.

Darling Scarp and Foothills

The Forrestfield Complex is dominated by an open-forest of marri-wandoo-jarrah on the heavier gravelly soils and of jarrah-marri-sheoak on the sandier soils. The complex is dissected by a series of streams which support a fringing woodland of E. rudis-M. rhaphiophylla. The open-forest of marri-wandoo-jarrah now approximates a woodland as a result of logging and clearing since

European settlement. Remnant plant species on these gravelly soils include Banksia grandis, Xylomelum occidentale, Dryandra sessilis, Macrozamia riedlei, Xanthorrhoea preissii and species of Hibbertia. On the sandier soils there are remnant pockets of the jarrah-marri-sheoak open-forest with common species including B. attenuata, B. grandis, Stirlingia latifolia, Mesomelaena tetragona and Nuytsia floribunda.

The Darling Scarp Complex includes a large variety of flora on a unique geological feature. Although this vegetation complex, which coincides with the Darling Scarp unit, has not been subdivided, several features are evident. These include the dominance of wandoo along the entire length of the Darling Scarp; the admixture of marri and the occurrence of the geographically restricted butter gum (E. laeliae) on the northern areas. The vegetation ranges from a low open-woodland of wandoo with admixtures of marri, butter gum and mountain gum, through low open-forest of C. huegeliana, through heath, through herblands of Borya nitida to lithic complex (on the granite rocks). Shrub species include Thomasia glutinosa, Verticordia acerosa, Hakea incrassata, H. stenocarpa, Grevillea bipinnatifida, Hovea pungens, Goodenia fasciculata, Petrophile biloba, Conospermum huegelii and Grevillea endilcherana.

The Eastern Sector

The eastern part of the Study area, nominally considered to be those parts east of the base of the Darling Scarp, has vegetation that is dominated by jarrah-marri forest and wandoo woodland. The distribution of vegetation complexes and plant communities is strongly related to landforms and soils, and on this basis a number of complexes can be readily recognised. Whilst the dominant strata of the common vegetation complexes normally contain jarrah, marri, yarri (E. patens) or bullich (E. megacarpa), variation of the understorey floristic composition enables the different complexes to be distinguished.

Agricultural development has resulted in widespread clearing, particularly within valley landforms. However, there are good stands of vegetation within uncleared blocks of farmland, on ridges that have lateritic duricrust, on the sides of valleys where the slope is very steep, and within the Walyunga and Avon National Parks. The vegetation complexes that occur within these areas are as follows.

Lateritic Upland

The Dwellingup Complex, in medium to high rainfall, consists of open forest of E. marginata-E. calophylla.

The Yalanbee Complex, in low rainfall, consists of woodland of E. wandoo-E. accedens and less consistently an open forest of E. marginata-E. calophylla.

Valleys

The Helena Complex, in medium to low rainfall, has vegetation ranging from a mixture of open forest of E. marginata-E. calophylla to woodland of E. wandoo through heath and herbland to lichens on the granitic rocks.

The Murray and Bindoon Complex, in low to medium rainfall, includes wandoo woodland on the valley slopes, intermixed with some open-forest of jarrah-marri-yarri and a woodland of E. rudis-M. rhaphiophylla on the fringes of the water courses.

The Yarragil Complex (Minimum Development Swamps), in medium to high rainfall, has open forest of E. marginata-E. calophylla on upper slopes with admixture of E. patens (yarri) and E. megacarpa (Bullich) on the valley floors.

The Coolakin Complex, in low rainfall, is dominated by woodland of wandoo with a mixture of E. marginata-E. calophylla (jarrah, marri and yarri).

The Pindalup and Yarragil Complex, in low rainfall, has open forest of E. marginata-E. calophylla on slopes and open forest of E. wandoo with some E. patens on the lower gullies.

Dandaragan Plateau

Lateritic Upland

The Mogumber Complex - South has open woodland of E. calophylla, with some admixture of E. marginata and a second storey of E. todtiana B. attenuata-B. menziesii-B. ilicifolia.

Scarp

The Reagan Complex vegetation ranges from low open woodland of Banksia spp.-E. todtiana to closed heath, depending on the depth of soil.

3.4.3 Rare Flora

There are several locations within the Study area where populations of gazetted rare or high priority plants are known to exist. As it is CALM policy not to publish the precise location of these populations, only a general indication of location has been given on Map 4. However, the precise locations of relevant plant populations has been referred to in detailed route planning.

Gazetted species of rare flora and high priority flora within the Northern Forest Region are listed in Appendix 1. CALM has advised also that pre-construction transmission line route surveys should include a flora survey for relevant species listed in Appendix 1 to augment existing surveys.

All locations known to contain gazetted rare or high priority flora species are treated as exclusion zones for construction of transmission lines.

3.4.4 Rare Fauna

Investigation of the presence of gazetted rare or geographically restricted fauna within the Study area necessarily referred to the location of relevant habitats, rather than to the locations of populations. The preservation of habitat through the establishment of appropriate conservation reserves is the approach to protection of relevant fauna species that has been adopted by the State government regulatory authorities. Therefore the location of the statutory conservation reserves (for example, the Ellen Brook Nature Reserve which supports the Western Swamp Tortoise Pseudomydra umbrina) as noted in 3.4.1, are the relevant constraints to transmission that have been observed by the corridor identification process.

3.4.5 Dieback

Dieback is a major plant disease of concern. The disease is fatal to many native plant communities on lateritic soils and poorly drained soils within the south west of the State in the Department of Conservation and Land Management (CALM) northern forest regions.

Although the Study area is considered to be outside the primary "disease risk area" identified by CALM (CALM 1987) dieback is known to occur at specific locations within the Study area and can be further introduced and/or spread by inappropriate clearing and construction procedures.

The location of transmission corridors will not be constrained by the presence of land infected with or susceptible to dieback as such. However, the acceptability of installation and maintenance of transmission equipment within any chosen route will depend on the incorporation of procedures that minimise risk of site infection and spread. These involve preconstruction "disease interpretation survey" of the the transmission route and appropriate hygiene practice in the deployment of machinery, earthworks and scheduling.

The CALM has developed procedures to minimise risk of dieback infection spread which will need to be incorporated in the SECWA's transmission line installation procedures.

3.4.6 Salinity

The salinisation of rural land that has resulted from the clearing of land for agriculture is a well recognized phenomenon in Western Australia and is a cause for significant environmental, economic and social concern. The installation of new transmission lines will require land to be partially cleared in areas where the route traverses vegetation of height greater than 1.5m and hence offers a potential risk of increasing land salinisation.

There are four factors which together indicate that installation of new transmission lines within the study area should not create any significant risk of additional land salinisation.

Firstly, the occurrence of salt problems resulting from clearing of vegetation is most strongly associated with land in the eastern Darling Range where annual rainfall is low and salt storage in the upper sediment profile is high. By comparison the Study area mostly consists of Swan Coastal Plain landscape, together with a portion of the western - high rainfall - extent of the Darling Range.

In neither case is salinisation potential considered significant.

Secondly, clearing for agricultural purposes totally removes native vegetation whereas clearing for transmission line installation selectively removes vegetation higher than 1.5m. Understorey vegetation need not be removed. Clearing for transmission line installation is not likely to result in the same degree of change to rainfall infiltration as results from agricultural clearing. Substantial increase in rainfall infiltration is a primary component of the salinization process.

Thirdly, much of the Darling Scarp landform within the study area has already been cleared for agriculture, and has not resulted in significant salinisation.

Fourthly, the area of land required to be cleared for transmission lines is very small compared to areas cleared for agriculture. Further it is likely to be spread over a number of localised catchments, thus diffusing the potential for increases in groundwater level and stream salinity.

3.5 FORESTRY, AGRICULTURE AND WATER RESOURCES

3.5.1 State Forest 65

A large proportion of the Study area is occupied by State Forest 65 (the Gnangara and Pinjar Pine Plantations), the extent of which is shown on Map 5.

State Forest 65 consists largely of plantations of the coniferous tree *Pinus pinaster* that have been established on low fertility soils of the Bassendean and Southern Rivers landforms. Most of the areas within the State Forest boundaries have been planted out with *P. pinaster* over a period of some decades. The plantation contains stands of various stature and density (and therefore economic value) as determined by age and previous management (such as thinning). There are also areas that have been recently harvested as well as areas that have never been planted and still support native vegetation, principally Banksia and Jarrah-Banksia woodland or open forest.

The pine plantations contain a network of limestone forestry tracks which provide access for inspection, fire fighting, maintenance and harvesting. They also contain a network of fire breaks and a number of light aircraft landing areas which are utilised by aircraft conducting fire surveillance and control and aerial fertilisation.

The routing of transmission lines through the pine plantation will result in varying degrees of economic cost depending on the need to prematurely harvest trees, the loss of future production capability and the requirement to modify forest management procedures to accommodate the transmission lines.

The potential impacts of transmission lines on State Forest 65 are:

- premature harvesting of crop trees;
- loss of production area;
- decreased maintenance efficiency due to realignment of existing roads and firebreaks and possible creation of sub-optimal areas for management;
- loss of aircraft landing areas;
- adverse impact on management practices and hence on economics of the forestry operations; and
- impacts on the WAWA Gnangara Mound water resource.

The most significant and enduring effects are likely to be on management practices. The economics of the forest are heavily reliant on aerial operations for fertilisation, fire-spotting and burning-off. The presence of a transmission line itself reduces potential for aerial operations. In addition, restrictions on flight paths may affect the location and number of aircraft landing areas, and hence the potential for aerial burning-off and fertilisation.

Further, the risk of "flashover" from transmission lines (ionisation and arcing through atmospheric carbon) would restrict the type of burning-off for fire control in the vicinity of the line. This would be most acutely felt in the case of wildfire.

From the State Forest point of view the preferred location for transmission lines is north-south through the forest, preferably along its western boundary. Any east-west crossing should, as far as possible, avoid fragmentation of the forest into subeconomic management areas.

3.5.2 Agriculture

Most of the cleared and partly cleared land within the Study area is used for agricultural purposes including:

(i) grazing of beef cattle, sheep and horses agistment;
(ii) orchards and market gardens;
(iii) viticulture; and
(iv) hobby farming.

Land use for grazing is most common on the heavier alluvial soils along the base of the Darling Scarp and within the valleys of the Darling and Dandaragan Plateaux. Grazing is also practiced on the southern rivers landforms in the central south of the Study area.

Orchards are also largely confined to the heavier soils within these areas, whilst market gardens are common within the sandy soil areas along the western fringes of State Forest 65.

Viticultural activity is intensive within the aluvial plains and river terraces associated with the Swan River, at various locations along the base of the Darling Scarp and on sandy loam soils on the Reagan Scarp.

Whilst the usage of land for grazing and agistment would not be significantly hindered by concurrent usage for transmission, and therefore does not constitute a significant constraint, vineyards and market gardens may well be disadvantaged by installation of tower structures. The loss of vines or fruit trees that would potentially be required to enable tower positioning within a vineyard or orchard, would have tangible costs arising from loss of vines and productive ground. The height of fruit trees within orchards may be a cause of concern in instances where they would be located beneath the conductors. Vegetation having a height greater than 1.5m is normally removed from transmission easements prior to construction, although exceptions may be made, on the merits of the case.

3.5.3 Water Resources

The Study area contains a number of areas where the production of potable water is either a current or potential land use. These are shown in Table 3.5.

A number of statutory reserves for the purpose of "Water" have been declared by State and local government statutory authorities, to protect the beneficial uses of these resources. These include the Wanneroo Groundwater Reserve, Wanneroo Public Water Supply Area and the Swan Groundwater Area. At the present time, the Gnangara groundwater mound is being used as a source of potable water for the metropolitan area. In addition to operating borefields at Mirrabooka and Wanneroo, a new bore field is currently under construction adjacent to Lake Pinjar, and a further bore field is planned for the Lexia area, as shown on Map 5.

TABLE 3.5: WATER RESOURCE AREAS

	Water Resource	Type
(i)	Gnangara groundwater mound	Currently utilised for public water supply and undergoing increasing development for abstraction
(ii)	Jane Brook Catchment	Potential surface water catchment
(iii)	Susannah Brook	Potential surface water catchment
(iv)	Ellen Brook	Potential surface water catchment.

The use of land within the catchments noted above should not be significantly affected by the establishment of a transmission line and therefore water production should not be considered to be a constraint to corridor identification. However, in delineation of a transmission line route the presence of capital works associated with water production, for example production bores and pipelines, needs to be considered, especially in relation to tower placement. Parallel routing of transmission lines beside water supply pipelines is normally avoided where possible. In instances where parallel routing cannot be avoided, cathodic protection devices are normally fitted to the pipeline creating additional costs to transmission line installation.

3.6 URBAN DEVELOPMENT

3.6.1 Existing and Committed Urban Development

Map 6 shows the extent of land which is already developed or committed for urban use. These areas are largely defined on the Metropolitan Region Scheme (MRS).

Land in the immediate vicinity of Northern Terminal to its south, west and immediate north is either developed or zoned for industrial purposes.

Land in the area to the north as far as Hepburn Avenue and east as far as Tonkin Highway is also committed for urban - largely residential - development. Much of this land is covered by the Ballajura (North) Outline Development Plans Nos. 10, 11 and 12 of the Shire of Swan.

The area immediately east of Northern Terminal - Ballajura South - has been the subject of an Outline Development Plan of the Shire of Swan. The plan covers the area bounded by Tonkin Highway, Hepburn Avenue, Ballajura North, Northern Terminal and Marshall Road. The Plan, which provides for residential development, was publically advertised and sent to SECWA for comment in August 1988. The Plan makes allowance for the existing easement along Marshall Road.

Urban development east of Tonkin Highway is confined to areas south of the North Perimeter Highway.

Other minor existing areas of urban development within the Study area are the townsites of Muchea and Bullsbrook East.

An aboriginal fringe settlement - Cullacabardee - is located west of Beechboro Road, between Park Street and Coollcott Avenue.

3.6.2 Potential Urban Areas: Preferred Metropolitan Strategy

In November 1987 the report "Planning for the Future of the Perth Metropolitan Region" (Review Group to the State Planning Commission) was published. The report contains a Preferred Strategy for future metropolitan growth, to replace the Corridor Plan as a basis for future amendments to the Metropolitan Region Scheme.

The Preferred Strategy outlines three major new urban development areas within the Study area. These are shown on Map 6.

The first (Area 2 of the Preferred Strategy - East of Wanneroo Road) is a substantial area bounded by Wanneroo Road on the west, State Forest 65 on the east, Hepburn Avenue on the south, and Lake Adams to the north. Part of this land would be a major industrial area, linking two existing industrial areas on Wanneroo Road and Gnangara Road.

The second (Area 3 of the Preferred Strategy - West Swan and Beechboro) comprises two parcels of land east of Tonkin Highway, between Whiteman Park and the Swan Valley proper, separated by the RAAF communications base at Caversham (formerly Caversham airfield), and running generally north-south. Existing 300kV lines pass through part of this land.

The third area (Area 4 of the Preferred Strategy - Middle Swan) lies along the foothills of the Darling Scarp between Toodyay Road and Walyunga National Park. This area at present consists of highly fragmented holdings, with a mixture of intensive rural activities.

Between Areas 3 and 4 the Swan Valley is proposed to remain Rural under the Preferred Strategy.

All of these areas are likely to be taken up for urban - mainly residential - subdivision. Areas 2 and 3 of the Preferred Strategy are likely to precede Area 4 because of the difficulties of servicing, fragmented holdings, and political opposition to urbanisation in the Foothills areas generally.

The urban development potential of Areas 2 and 3 is considered to impose a high level of constraint on future transmission line development, with the proviso that an additional route might be added to the existing 330kV lines through that area. The potential urbanisation of Area 4 imposes a lesser but still significant constraint.

3.6.3 Other Potential Urban Areas

In addition to the areas outlined in the Review Group's Preferred Strategy there are at least two other major areas of land which are currently the subject of serious investigation or proposals for urban development. These are:

- the Santa Maria Estate; and
- the Ellenbrook proposals.

The Santa Maria Estate area is owned substantially by the Crown and is currently under investigation by Landcorp.

The area under investigation includes a substantial proportion of the total OTC site, allowing, however, for continued use and expansion of the OTC operations, and for a 1 kilometer buffer against residential development around the reduced OTC site. The Landcorp study allows for extension of the Tonkin Highway, bifurcating just south of Gnangara Road, to the north east and south west. It also allows for a 200 metre wide transmission line corridor immediately to the east of Tonkin Highway, to connect Northern Terminal to Pinjar via the State Forest. The corridor would contain two double circuit 330kV lines and three 132kV lines.

The proposals need to be taken seriously and represent a low level constraint on transmission line development.

The Ellenbrook proposals have been prepared by private sector interests.

They cover an extensive area extending west and south from The Vines Estate at Upper Swan. The area takes in large sections of Whiteman Park and the Gnangara Pine Plantation (State Forest 65). For clarity Map 6 shows only those sections which are not within Whiteman Park, existing urban zoned land, land designated urban in the Preferred Strategy, or areas allocated for non-urban uses (such as a proposed conservation area adjacent to the pine plantation).

The proposals envisage substantial residential development, together with a town centre, golf resort, regional sporting venues incorporating Whiteman Park facilities, and the nature conservation area.

The proposals have no formal status. Although likely to proceed to some degree they represent a very low level, if any, of constraint to transmission line development.

Taking a long term view, as SECWA must, it appears likely that in 20 years or so from now - when the population of the Perth region may well be double its present level - urbanisation will overtake other parts of the Study area. The whole of State Forest 65 and the Gnangara Mound Groundwater area may conceivably become urban, and indeed has already been the subject of broad brush proposals for development by private sector interests.

Similarly, the land between lake Pinjar and Wanneroo Road is likely to become urban also.

In the long term it is difficult to see the Overseas Telecommunications Commission land not eventually succumbing to the onset of urban growth. The same may be true of the RAAF facility at Caversham. This land has already been the target of Housing Industry Association pressure for release for residential development ("West Australian", 12 November, 1988).

3.6.4 Tonkin Highway Extension

There have been numerous proposals over the years for the extension of Tonkin Highway, but no urgency to finalise them. However, it is clear that serious consideration is now being given to the question, especially in the light of the Preferred Strategy and other proposals under consideration.

It seems likely that an extension to the north-west will occur, skirting the west side of the State Forest. More problematic is the possible bifurcation towards the north-east and thence to Great Northern Highway.

The possibility of transmission lines sharing a parallel or common corridor for at least part of the distance between Northern Terminal and Pinjar should be considered seriously, especially in the vicinity of Northern Terminal.

The concept of large scale service corridors, within which major services such as transmission lines share space with major roads, is not by any means new. It is understood that the Main Roads Department has not favoured such sharing in the past.

However, there is much to be said for the idea, for several reasons. One of these is that it tends to minimise large scale disruptions to land use, particularly urban, parkland and forestry uses.

Another is that the scale of major regional roads and of transmission lines are well matched. Against that is increased visual exposure of a transmission line running parallel to a major road.

3.6.5 Existing and Committed Rural-Residential Areas

Existing rural-residential areas within the Study area are shown on Map 6. Three of these are within the Swan Valley - Henley Brook, Whiteman, and The Vines-Belhus Estate.

Within the Hills are three rural-residential areas.

The Brigadoon Estate is the most substantial, extending from the railway north of Millendon and wrapping around the southern and eastern edges of Walyunga National Park.

The second area abuts the northern edge of Walyunga National Park.

The third area lies further north, near Bullsbrook.

Other rural-residential areas occur in the west of the Study area, in the Shire of Wanneroo.

These areas are considered to be a constraint on transmission line development. However, it would be possible to plan for transmission line easements through sections of them which have not yet been subdivided, and in some cases through already subdivided and developed lots.

3.6.6 Potential Rural-Residential Areas

The only known significant potential rural-residential development currently being proposed within the Study area is a large scale extension of the northernmost of the three existing Special Rural Zones in the Hills part of the Study area. This has been tentatively earmarked by the Shire of Swan for future rural-residential subdivision.

Other possible areas include infill between existing rural-residential estates east of Whiteman Park.

These areas are considered not to offer a constraint to transmission line development.

3.7 LAND OWNERSHIP

Land ownership is a factor in corridor and route selection, although not necessarily a highly significant one. In general, publically-owned land is to be preferred to privately-owned land, because of compensation and political factors. Most significant, however, are other factors, such as the purpose for which land is used.

There are large areas of land in the Study area which are in public ownership, most committed to specific uses. Those of regional, state or national interest include:

- State Forest 65;
- Whiteman Park;
- Walyunga National Park;
- Pearce Air Base and its installations at Caversham and 3TU;
- The RAAF bombing range (leased by the State to the Commonwealth);
- Avon Valley National Park;
- Lake Pinjar; and
- Melaleuca Park.

Because of its extent, location and use, as well as its ownerhsip, State Forest 65 has been viewed as a desirable location for transmission line corridors.

3.8 RECREATION AND TOURISM

3.8.1 Existing Regional Recreation Areas

Map 7 shows existing areas reserved for Parks and Recreation under the Metropolitan Region Scheme. These are:

- Whiteman Park;
- Walyunga National Park and its Swan River extensions, including an isolated section south of Belhus; and
- a small section of John Forrest National Park.

In addition to these Map 7 shows other major recreation areas, including:

- Avon Valley National Park
- Melaleuca Park
- The Swan River environs

Most of these areas have been created as possible recreation areas because of their natural attributes - for example landscape, water, flora or fauna resources. In terms of their capacity to accept transmission lines they are considered both in terms of their significance as recreation areas and in terms of their other attributes.

As recreation areas they are considered to impose a high level of constraint, although sections of the extensive Whiteman Park, for example, do not rate highly.

3.8.2 Potential Regional Recreation Areas: The Preferred Metropolitan Strategy

The report of the Review Group referred to in 3.6.2 contains, as part of the Preferred Strategy, proposals for an extensive Metropolitan Parks System. The proposed system envisages extensive additions to the existing MRS Parks and Recreation Reserves, and a comprehensive linking of regional parks.

The major proposed additional areas of parks are shown on Map 7. They include:

- the Avon Valley National Park;
- continuous reserves along the Avon and Swan Rivers, linking Avon Valley and Walyunga National Parks and other areas;
- substantial extensions to Whiteman Park taking in Bennett Brook to the south and extending into State Forest 65 to the north;
- the string of lakes to the west of the Study area (Lakes Adams, Mariginiup, Jandabup and Gnangara);
- creation of a massive new Gnangara Metropolitan Park (one of four proposed conglomerate Metropolitan Parks) out of Whiteman Park, the lakes, much of State Forest 65, the RAAF bombing range, and other areas covering, inter alia, the Pinjar Power Station site.

There is some doubt as to how much significance should be attached to such broad proposals, because of the lack of qualitative information provided and because they are so broad. There is also some evidence of hasty preparation - for example discrepancies between different maps in the report of the Review Group. Consequently, with the exception of areas which are known to have distinctive recreational, landscape or conservation value, a relatively low level of constraint in relation to transmission lines has been postulated.

3.8.4 Specific Regional Recreation Sites

Table 3.8 lists, respectively, existing developed recreational sites which are publically and privately owned and managed, together with an assessment of their level of usage.

Those in urban areas are not included.

TABLE 3.8: RECREATION SITES

Location	Resources	Activities	Level of use
PUBLIC			
Whiteman Park (Mussell Pool)	Watercourse, landscape, flora and fauna	Picnic and barbecue, walking nature study	Medium
Gnangara Old Mill	Pine Plantation	Picnic, walking horseriding	Low
Gnangara motor cycle area	Offroad trail bike tracks	Unlicensed trail bike riding	High
Pine Drive picnic area	Pine plantation	Picnic/barbeque, walking	Low
Melaleuca Park	Wildflowers, banksia woodland, fauna	Picnic, bushwalk, nature study	Medium
Pinjar Motor Area	Offroad trail bike tracks	Unlicensed trail bike riding	High
Pinjar Settlement	Pine plantation, historic buildings	Picnic, bushwalk	Low
Swan River	River foreshores, navigable waters	Watercraft, swimming, picnic barbeque, fishing, walking, nature study	High
Walyunga National Park	River; river gorges natural vegetation and fauna	Watercraft, swimming, picnic barbeque, bushwalking, nature study, lookouts	High
Avon Valley National Park	River gorge; river, natural vegetation and fauna	Watercraft, picnicing, camping bushwalking, nature study	High
PRIVATE			
Wanneroo Park Raceway	Motor racing circuit	Motor racing	High
State Equestrian Centre	Equestrian Facilities	Equestrian activities	High
Caversham Wildlife Park	Captive Fauna	Fauna/vegetation/services	Medium/ High

3.8.5 Tourism

The significance of tourism in the study area relates to three principal factors:

- the passage through the study area of a number of arterial roads and other routes carrying significant numbers of tourists;
- the presence of a network of wineries and other points of interest within the interesting landscape of the Swan Valley; and
- the scenic attractions of the Darling Scarp, Reagan Scarp and associated valley and plateau hinterland, and the Swan River.

Scenic Routes

A number of scenic routes of significance traverse the Study area. They are shown on Map 7.

Brand Highway and Great Northern Highway are the principal regional arterial roadway links between the Perth metropolitan area and the State's northern and north-eastern tourist destinations. Both enter the study area at Muchea, where they join and continue south along a route that follows flat or gently sloping land, at the base of the Darling Scarp.

Toodyay Road is also an important arterial roadway, providing a link between the metropolitan area and eastern and northeastern rural centres.

In addition to these arterial routes, West Swan Road fulfills an important role in providing local road access to tourist facilities and resources within the Swan Valley. Scenic routes within the study area utilized by tourist bus operators as well as private vehicles include Chittering Road and Gingin Road, both of which traverse land having high scenic appeal. Other scenic drives within the Hills area are Bindoon Road, Taylor Road, Clinton Road and Campersie Road.

The standard gauge railway between Perth and the Eastern States also traverses the Study area, along a superb route that follows the Swan and Avon Rivers.

The Swan River itself functions as a significant tourist route as well as destination. It is the focus of "wine cruises" that convey tourists and other social groups along the Swan River by boat to winery destinations in the Swan Valley.

The Swan Valley

In the Swan Valley a combination of attractive and interesting landscape, a well developed grape-growing and wine-making industry, and ready availability of fresh orchard products, has created significant potential for tourist-based development and industries. Whilst recent investigations (Ernst and Whinney 1986) indicated that this potential has been poorly realised, there are development plans in place and in operation that have the objective of strengtheing the importance of tourism in the area.

In addition to wineries, vineyards and orchards, the area contains a number of buildings of historic significance.

A network of heritage trails linking places of interest has also been proposed. For the most part the walkways follow the alignment of the Swan River and traverse foreshore and river terraces.

Darling Scarp

The visual qualities of the Darling Scarp, the Reagan Scarp and the adjacent undulating valley and plateau hinterland provide natural resources that have value to the region's tourist industry. Whilst services and facilities are not well provided for in this area, the scenic road routes are regularly utilized by tourist bus operators as well as sightseers using private vehicles.

In all these cases the visual exposure of transmission lines is perceived generally to be detrimental to the tourist function. Given the importance of tourism to the State's economy, areas falling within the foreground or middle ground view from these routes and locations constitute a significant constraint against transmission line construction.

3.9 MINING AND EXTRACTIVE INDUSTRY

Map 5 shows identified mining and extractive industry sites in the Study area.

The location and status of mining tenements, including mining leases, exploration licences and prospecting licences on Crown land within the Study area was determined from records of the Mines Department. These are listed in Table 3.9.

Mining activity on private land is referred to as extractive industry and is administered by local authorities. Extractive industry sites have been identified from inspection of aerial photography and local knowledge.

At the present time there are two active mines administered by the Mines Department and at least ten active extractive industry sites within the study area. The active mines are:

- a sand mine for silica and aggregate sand at Gnangara (Silica Sales Pty Ltd); and

- a sand mine at Gnangara (Bell Brothers Pty Ltd)

Active extractive industry sites within the study area include those listed below.

(i) Granite quarry at Redhill (Pioneer Concrete);

(ii) Clay and gravel pits and small granite quarries at Redhill (Midland Brick);

(iii) Sand quarries at Gnangara Road (Monier, Homeswest);

TABLE 3.9: MINING TENEMENTS

Tenement Listing	Status	Licensee
Exploration Licences (1)		
E70/787	Pending*	Metana Minerals NL
E70/562	Pending*	Vost, Elsbury, English, Donucan Nominess Pty Ltd
E70/653	Pending*	Ravensthorpe Mining and Investment Ltd
E70/795	Pending*	Metana Minerals NL
E70/629	Pending*	Bell Basic Industries Ltd
E70/479	Pending*	Bell Basic Industries Ltd
Mining Leases (2)		
M70/198	Live 1985-2005	Bebich
M70/423	Pending*	Westralian Sands Ltd
M70/217	Live 1985-2006	ACI Operations Pty Ltd
M70/326	Live 1988-2009	Stefanelli Developments P/Ltd
M70/238	Live 1988-2009	Bebich
M70/351	Pending*	Law-Davis, Brouschon
M70/163	Live 1988-2009	Bell Bros Pty Ltd
M70/365	Pending*	Pilsley Investments Pty Ltd
M70/364	Pending*	Pilsley Investments Pty Ltd
Prospecting Licences (3)		
P70/834	Pending*	Metana Minerals NL
P70/837	Pending*	Metana Minerals NL
P70/840	Pending*	Metana Minerals NL
P70/841	Pending*	Metana Minerals NL
P70/842	Pending*	Metana Minerals NL
P70/843	Pending*	Metana Minerals NL
P70/812	Pending*	Monier Ltd
P70/811	Pending*	Monier Ltd
Mineral Lease		
ML70/437	Live 1970-1990	Midland Brick Comp Pty Ltd

<u>Notes</u>

* The term "pending" applies to a tenement when an application has been lodged with the Mines Department and is awaiting approval.

(1) Exploration Licences are granted for a period of 5 years, renewable for periods of 1 year. Thereafter the tenement must either be converted to a mining lease or relinquished. After the third year of currency, the size of exploration licence areas must be reduced by 50% annually under the provisions of the Mining Act.

(2) Mining leases are granted for a term of 21 years and are renewable.

(3) Prospecting licences are issued for a 2 year term being renewable for 2 years.

(4) Mining tenements are as at December 1988.

Source: Department of Mines

(iv) Clay pits at Muchea (Midland Brick);

(v) Clay pits at Middle Swan (IBT Pty Ltd);

(vi) Clay pits at Upper Swan (Bristile Pty Ltd, IBT Pty Ltd, Midland Brick, Pilsey Investments).

A number of additional extractive industry sites such as gravel pits that are too small to be reliably located from the aerial photography may also be present. These sites would be identified during detailed route planning.

It might be assumed initially that active mining and electrical transmission are incompatible lands uses, as there are many potential sources of mutual interference. These include constraint of access, restriction to machinery movement near towers and conductors, and occlusion of the ore reserves beneath tower structures.

However, most of the active mining or extractive industry sites in the study area are quite small. It is therefore likely that these sites, or clusters of sites such as those at Redhill or Muchea, could be included in a transmission corridor. An acceptable deviation around active mining or ore reserves could likely be developed within the corridor.

The study area also contains large areas of land that are either undergoing exploration or are subject to exploration licence applications. In view of the large size of these licence areas and the relatively low probability of any particular location being found economically suitable to mine, exploration licence areas should not be considered a constraint to corridor or route identification.

3.10 HERITAGE PLACES

3.10.1 Architectural and Historical Places

Within the Study area there are a number of buildings and places listed by the National Trust. These are comparatively small buildings or sites, which can be taken into account at the route selection phase and do not impact at corridor selection level.

3.10.2 Aboriginal Sites

Discussions with the Aboriginal Sites Section of the WA Museum indicate that no comprehensive data about aboriginal site within the Study area is held.

Sites are generally small enough to avoid interference and hence the potential for aboriginal sites to constrain line transmission corridors is regarded as low.

At the time of route design it will be necessary to obtain detailed advice from the Museum, and subsequently to undertake surveys to identify any sites of ethnographic or archaeological significance.

3.11 RADIO COMMUNICATIONS

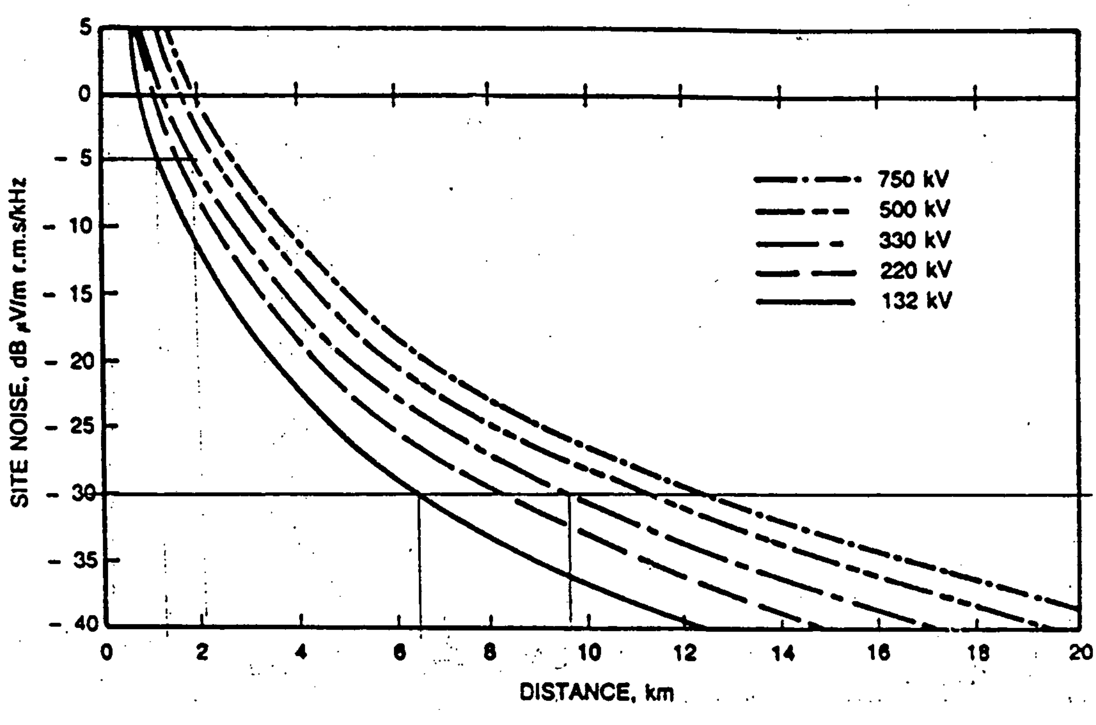
3.11.1 General

Radio communication facilities, particularly high frequency receiving facilities, are highly sensitive to a number of background noise factors, including high voltage transmission lines. The siting of Radio Communications Facilities is dealt with in a recent Australian Standard - AS 3516.1-1988. AS 3516.1 sets out guidelines for siting, but emphasises at the same time that:

> "the Standard is not intended as a substitute for consultation between the authority involved and concerned parties, but as a basis from which meaningful discussions may proceed. It should be emphasised that the Standard cannot specify the practical requirements at every site due to the wide variety in types of service intended, geographical and environmental situations and the interaction which may occur and for this reason the Standard should not be applied without reference to the parties concerned."

The Standard sets out three categories of HF long-distance receiving stations - A, B, and C - according to the primary purpose of the receiving system and in ascending order of level of tolerance to man-made noise. The Standard sets out generally acceptable levels of man-made noise for each category and defines appropriate separation distances from common sources of noise, including roads overhead and transmission lines.

FIGURE 4: SEPARATION DISTANCE FOR OVERHEAD POWER LINES ABOVE 100kV



Source: Australian Standard AS 3516.1 - 1988

The Standard specifies maximum levels of site noise of -30dB μ/m (rms/kHz) and -5dB μ/m (rms/kHz) for Category A and Category B facilities respectively.

The Standard specifies (Figure 1, p11) that within a certain distance (Zone A) of a receiving facility no sources of man-made noise should be present. For Category A and Category B facilities this distance is 1.8km and 0.2 km respectively from the site boundary. In Zones B and C (that is outside Zone A) the separation distance is specified according to the type of man-made noise, and is measured between the facility itself and the road or transmission line.

Figure 4, extracted from AS3516.1, gives separation distances for overhead power lines of various voltages within Zones B and C.

In terms of Category A and B facilities and the transmission lines proposed in this Study the crude separation distances can be tabulated as follows:

TABLE 3.11: SEPARATION DISTANCES FOR HF RECEIVING FACILITIES

Line Size	Category of Facility A	B
132kV	6.5km	1.15km
330kV	9.6km	2km

As can be readily be appreciated there is much greater significance in the distinction between category of facility than there is between transmission line sizes. The classification of the facility becomes of prime importance in considering how closely a transmission line might reasonably be constructed to a HF radio receiving facility. Since choice of category is simply empirically derived from commonly acceptable levels of man-made noise, in practice it might be reasonable to refer back to an acceptable noise level, and derive the appropriate distance from that.

Five other factors can be significant also:

- the point from which the separation distance is taken;
- localised factors affecting noise transmission;
- the type of transmission line equipment;
- the directionality of the receiving installation; and
- the extend to which the site is already degraded because of noise.

Reflecting on these factors it becomes apparent why the Standard sets out to offer guidance only, and stresses the need for consultation.

Recognising these factors AS3516.1 qualifies the specific separation distances:

"The distances shown in Figures 1 to 4 should be considered a basis for negotiation. In determining actual separation distances for particular sites, factors such as the following should be considered in a technical assessment jointly conducted by the affected authorities:

A. Required or existing site noise based on regular noise monitoring.
B. Level to which the intervening terrain attenuates the noise.
C. Presence of overhead power and telephone lines which could act as carriers of noise.
D. Performance characteristics of the antenna system.
E. Limit to which it is practicable for the communications operator to control sources of man-made noise in the near vicinity of the site.
F. Ability of receiving system to reject interference.
G. Degree of previous site degradation due to the location of noise and intereference sources.
H. Likely future growth of noise sources."

Radiocommunication facilities within the Study area, together with various separation distances, are shown on Map 8.

3.11.2 Overseas Telecommunications Commission Facility

The Overseas Telecommunications Commission (OTC) has a major communications facility located approximately 5km north of the SECWA Northern Terminal, at Cullacabardee. The facility includes:

- two separate satellite earth station operations;

- the control centre for the Australian end of the Australion/Indonesiona/Singapore (A.I.S.) cable and associated microwave facilities; and,

- high frequency radio operations between Australia and marine craft, including the 24-hour-a-day monitoring of maritime distress frequencies - the Safety of Life at Sea (S.O.L.A.S.) Service.

It is the third function which has most significance for this Study, since it involves reception of frequently-weak, long-distance, high-frequency radio signals, in what may be life-threatening situations.

SECWA has been corresponding with OTC since 1973 with respect to the corridor requirements for the major Northern Terminal switiching station. This switching station was energised at 132kV in 1965 and at 330kV in 1975. In 1973 OTC nominated a clearance between the facility and future transmission line(s) of 1.6km, based on the guideline recommendations of the Australian Inter-Departmental Telecommunications Advisory Committee. These guidelines were subsequently superseded by the Code of Practice for the Installation of Power, Telephone and Remote Control Cables near Ground Radio Stations - February 1977 (which specified recommended restrictions on overhead conductors up to a voltage of 132kV).

In correspondence dated May 1981 OTC quoted the requirement for a clearance of 1.6km for 132kV lines, and introduced for the first time a recommendation for 4km clearance for 330kV lines.

In April 1988, OTC quoted clearance requirements of 6km for 132kV lines and 9.5km for 330kV lines, based on the requirements for a Category A Receiving Station as outlined in the new Australian Standard AS 3516.1-1988, referred to in 3.11.1 above.

Over this time the OTC facility has been progressively upgraded, as has Northern Terminal. Both are currently proposing yet further expansion.

At the present time Northern Terminal has several 330kV transmission lines within 5-6 km of the receiving facilities at OTC. There are also three 132kV transmission lines within 1 to 2km of the receiving facilities. Thus the requirements for Category B facility are barely met at present, and those for a Category A facility are very substantially violated, as Map 8 illustrates.

Additionally, urban growth has theoretically forced an increase in background radio interference levels in the vicinity of the OTC facility, due to 22kV overhead distribution lines (which run to the OTC site boundary) as well as to increased road traffic and consequent ignition interference.

Finally, it should be noted that the OTC receiving antennae are directional and oriented north to northwest.

The situation poses a considerable dilemma in terms of assessing the level of constraint which the presence of the OTC facility realistically imposes on transmission lines out of Northern Terminal.

Recognising this difficulty, SECWA and OTC have agreed to undertake a range of actions directed towards identification and mitigation of radio interference effects:

- field surveys have been conducted in the vicinity of the OTC facility to establish existing levels of background interference and an ongoing monitoring program has been established;

- field surveys of other SECWA lines (not near OTC) have been conducted for reference purposes; and

- future transmission lines near OTC (in the proposed corridor) will be designed so as to minimise radio frequency interference.

It is understood that discussions may also have taken place between OTC and the Air Force Office regarding a possible co-siting - presumably at Pearce - of receiving facilities. From the pressures on OTC - not only from transmission lines but also encroaching urban development - such a move would be rational.

3.11.3 3TU (RAAF Pearce)

The Royal Australian Air Force operates a major radio receiving facility - 3TU- located about 5km west of the air base itself. 3TU has long been recognised by SECWA as a sensitive facility, and its status as a Category A facility is accepted without question.

As a Category A facility the zones of exclusion around 3TU would be 6.5km and 9.6km for 132kV and 330kV lines respectively. RAAF Pearce has requested a blanket 13km radius zone of exclusion around 3TU based on a 42m high 330kV line.

It should be noted that the existing Northern Terminal - Muchea 132kV wood pole line passes within 4km of 3TU, that is, inside the separation distance recommended by AS 3516.1.

Map 8 also shows the area of buffer zone around 3TU acquired by the Air Force Office.

This Study is proceeding on the basis that the AS 3516.1 separation distances should form the basis of transmission line location.

3.11.4 Caversham Facility (RAAF)

The RAAF also operates a radio communication facility at Caversham, on the former airfield. It has requested a 1.4 km zone of exclusion around the site. The technical basis of this request has not been given, and hence it is not possible to evaluate whether or not it is reasonable.

It should be noted that there are two existing 330kV lines just over 1km from the site boundary and a 132kV line within about 0.5km. However, the distance to the antennae is greater and the existing lines are understood not to create problems.

Caversham is also listed by the Civil Aviation Authority as a site for navigational aid and communication. Proposed installations such as transmission lines within 2km of such sites are required to be notified to the Civil Aviation Authority.

As noted in 3.6.3 above the Caversham site has been the subject of pressure from the Housing Industry Association to release the land for urban (residential) development.

3.11.5 RAAF Microwave Links

In addition to the HF radio receiving and transmitting installations RAAF operates microwave links between Caversham and Pearce, and Pearce and the Kalamunda Telecom Tower. A 200m radius clearance around these links is requested. The existing 132kV line to Northam intersects both these links, apparently without detriment, so it is assumed that the microwave links do not pose a constraint on further corridors.

3.12 AIRCRAFT MOVEMENT

3.12.1 RAAF Pearce Air Base

The RAAF Air Base at Pearce is one of the two busiest RAAF bases in Australia. It is also a major training base. Hence, its requirements for air safety - including clearance from transmission lines - are more stringent than might otherwise be the case.

Map 8 shows the clearance areas requested by RAAF Pearce in respect of:

- the Pearce aerodrome;
- the Gingin aerodrome;
- the bombing range; and
- a low flying area east of the base.

RAAF Pearce has advised that these assume 330kV transmission lines with 42m high towers.

The exclusion areas requested in respect of Gingin and Pearce are a radius of 16km, which the Base states could be reduced to 13km with a 30m tower height. They take no account of the actual flight approach and take-off paths and are acknowledged to be conservatively formulated.

It should be noted that three existing 132kV transmission lines and the proposed Pinjar Power Station all lie within the proposed areas of exclusion. Two of the lines - the Muchea-Eneabba and Yanchep-Muchea run east-west north of the bombing range and one - the Northern Terminal-Muchea line runs approximately north-south. RAAF Pearce are understood to have advised that this latter line should be removed altogether if it is proposed to upgrade it at any time.

The main runway at Pearce is aligned north-south and the second runway is aligned south-west to north-east. The bombing range (which is also an ejection area) has north-south approaches.

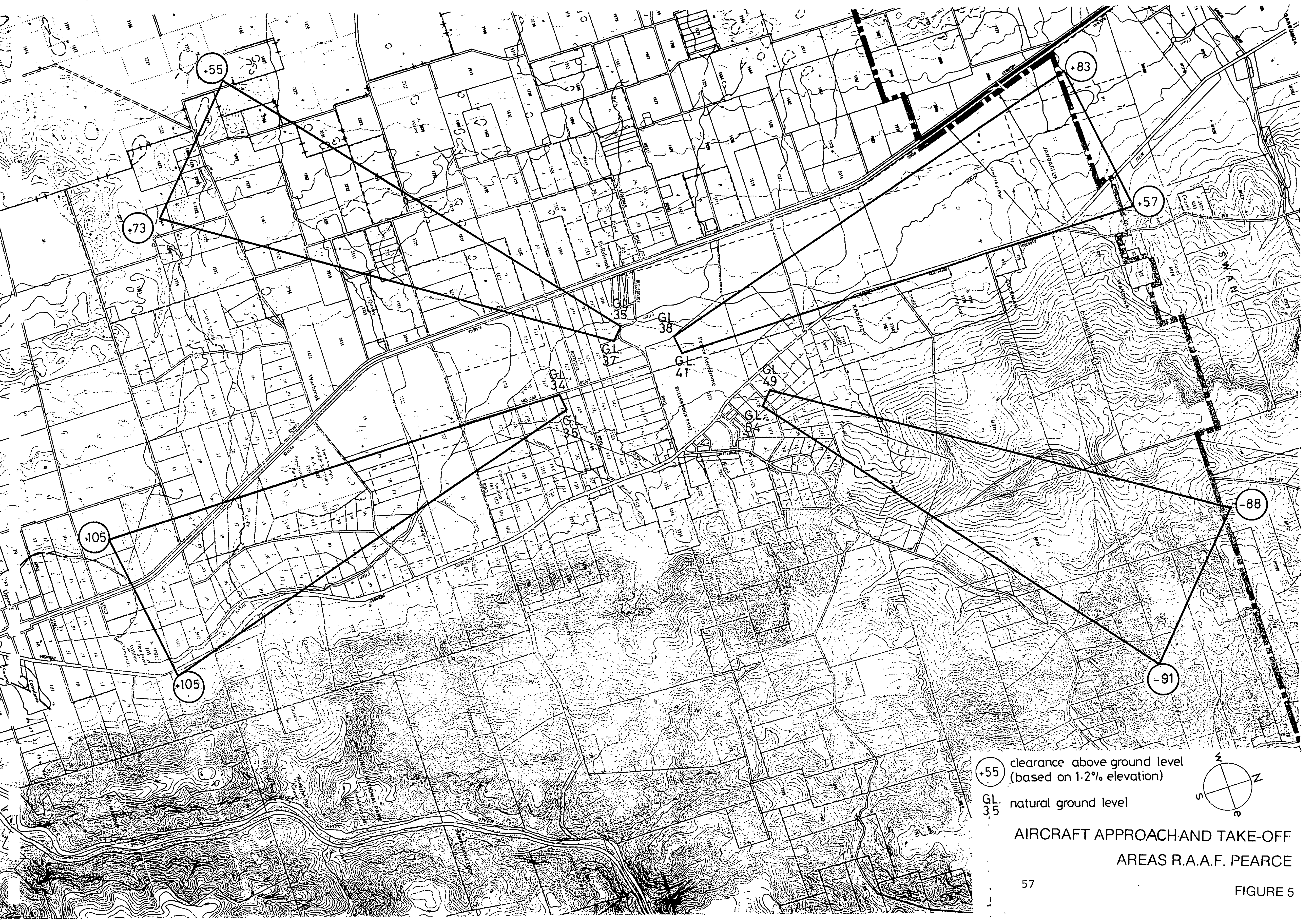
The Gingin runway is aligned approximately east-west.

The alignments of the runways suggests that a more precise, technically-based, assessment is possible. In the absence of RAAF-based technical criteria we have applied civil aviation standards as set out by the Civil Aviation Authority, Western Australia Region.

Calculations based on these criteria are shown at Figure 5. These indicate that the short N-E runway does not allow sufficient clearance for aircraft over the escarpment within the 7.5km defined area. In all other cases sufficient clearance exists outside the defined area to allow transmission lines.

It is not possible, on the information available, to estimate clearance areas in relation to the bombing range and ejection area.

In relation to Gingin aerodrome similar calculations have been prepared by Dames and Moore. These indicate that Gingin aerodrome



AIRCRAFT APPROACH AND TAKE-OFF AREAS R.A.A.F. PEARCE

FIGURE 5

take-off and approach areas should not impinge on the existing power lines or on the Study area generally.

Because the escarpment area is used as a low-flying training area for aircraft, and because of helicopter ceiling restrictions within 9km of Pearce, any proposed transmission lines on the scarp face east of Pearce would need to be examined closely to assess their acceptability.

3.12.2 State Forest No. 65 (Gnangara Pine Plantation)

As noted earlier, the efficient management of the Gnangara Pine Plantation depends on the extensive use of aircraft. For this purpose there are a number of aircraft landing strips within the State Forest. These are oriented both N-S and E-W, to take advantage of prevailing winds.

Any transmission line through the pine plantation is likely to result in the loss of one or more landing strips, either directly or by affecting take-off and landing areas.

The least impact would be caused by direct east-west routes across the plantation, or by skirting around its edges.

Again, it is noted that a 132kV line already exists within the plantation.

3.13 ELECTROMAGNETIC FIELD EFFECTS

There is some public and scientific controversy over the extent, if any, to which the health of individuals is affected by prolonged exposure (through residence, principally) to electric and magnetic fields surrounding transmission line conductors.

Various international bodies, notably the World Health Organisation, the National Radiation Protection Board of the UK, and other nations including the USSR and the USA, have adopted various maximum acceptable values of field strengths.

The Environmental Protection Authority of Western Australia commissioned a study of the subject from Scott and Furphy Pty. Ltd. Consulting Engineers. The study report "Review of High Voltage ELF Transmission Line Field and Human Health Effects" was published in 1987.

The Scott and Furphy study included measurements of fields within existing high voltage lines in Western Australia. These showed that the maximum electric and magnetic fields measured within easements were considerably lower than the recommended limiting levels. In the case of electric fields the maximum field strength measured at the boundary of an easement was only 10% of the maximum recommended value.

It is worth quoting the Scott and Furphy report Conclusion in full:

> "Whilst a link between ELF electric and magnetic fields and human health remains neither established nor otherwise, the WHO and IRPC have recommended conservative field values which are considered safe for various degrees of human exposure. A safety factor of about 10 has been adopted in setting these recommended maximum field strength values. Notwithstanding the above, an eminent Western Australian Medical Scientist has some reservations regarding the WHO approach to setting maximum ELF field values.
>
> The field values measured in and around SECWA ELF high voltage transmission lines and substations have indicated these to be well within the relevant international recommended limits.
>
> Whilst the possible link between ELF electric and magnetic fields and human health will doubtless be fully established (or discounted) in the future, it would appear that in the interim, field levels in Western Australian installations will not constitute a threat to public health."

The Public Environmental Report for the Proposed Harvey-Kwinana 330kV transmission line, prepared by Dames and Moore for SECWA in 1988, also explored the question of field effects. Their report refers to proposed new - and more conservative - limits to be set by WHO.

For the 330kV transmission line under investigation by Dames and Moore the highest magnetic field that could occur within the easement under emergency conditions would be less than 30% of the proposed new limit, and under normal conditions it would be less than 10%. The highest magnetic fields at the edges of the easement would be 2.5% of the limit.

The highest electric field within the easement would be 80% of the recommended limit, while at the edges it would be less than 10%.

It is important to note that these are levels within or at the edges of easements. Since neither dwellings nor activities involving a prolonged presence within an easement will be permitted any exposure levels to people should be negligible.

3.14 SEPARATION OF TRANSMISSION LINES

Where feasible, transmission lines should be well separated from one another, for line security reasons. Where transmission lines share a common easement there is an increased risk of more than one line being rendered inoperative in the case of hazards such as wildfire and lightning strike.

For this reason the Brief refers to a separation distance of between 1 and 3 kilometres.

The more stringent requirement since placed on location of transmission lines by OTC has, however, greatly reduced opportunities for separation.

Other than the question of line security at least two other factors need to be taken into account in deciding whether to separate transmission lines or combine them in a common easement. These are the impacts on land use and visual amenity respectively.

Two separate 330kV lines will require two easements of 60m width, as compared with a single easement of 110m width. The difference between the two in terms of gross area affected is negligible. However, in the case of forestry, and perhaps other land uses, transmission lines may not only result in loss of productive area but also affect efficient management of the land by carving it up into less than optimal parcels. In such cases it is better to combine transmission lines.

In terms of visual impact there are differences of opinion about whether it is best to combine or separate transmission lines. In part this may be because of the relatively subjective nature of the subject, but it may also be because the answer may depend on the nature of the land through which the transmission lines pass.

In open, flat terrain any transmission line will be highly visible. However, a single line of towers is likely to have significantly less impact than two lines of towers grouped together. The visual impact in fact may be much less than half (if it were possible to quantify it). In addition, however the towers are spaced, from any given viewpoint the regularity of the tower spacing will tend to vary, with neighbouring towers at times appearing closer and at time further apart. The result is likely to be more visually chaotic and more noticeable than if the lines were separated by a considerable distance. It is stressed that the separation must be sufficient to ensure that the lines are not seen to have a combined impact.

In well or heavily treed country the visual impact of two separate cleared easements will be much greater than of a single easement, not only for the obvious reason of a doubling of the loss of trees, but also the creation of two separate scars through the landscape. The effect will be accentuated in rugged or hilly terrain.

Several different landscape types are present in the Study area, including some typical of those referred to above.

Within State Forest 65 it will be desirable, from a forest management point of view, to minimise the number of easements crossing the pine plantation, bearing in mind also the 132kV transmission line which exists at present.

4. POTENTIAL CORRIDORS

4.1 GENERAL

As noted in 2.2.1 above the selection of alternative corridors is not an automatic process: it requires conscious choice and judgement.

The process of corridor selection is greatly assisted by the correct identification of constraints and an understanding of the tolerance of those constraints to the presence of transmission lines.

By their nature some constraints are absolute or are given absolute status in the fullest sense. In such cases the constraint area constitutes an absolute bar to the presence of transmission lines. These are important at the point of selection of potential corridors but of no significant interest thereafter.

Some constraints are absolute in the more limited sense that while the particular constraining attribute will either wholly escape or be wholly destroyed by the presence of transmission lines, its loss can ultimately be tolerated.

In most cases, however, constraining factors are relative, both to one another and in terms of degrees of loss, violation or cost. The relativities are important at both the stage of selection of potential corridors, and the stage of evaluating alternatives.

Where choices are heavily constrained, as they are in the present Study, possibly the most difficult aspect of corridor and route selection is determining the relative importance of vastly different factors, and making the necessary trade-off judgements.

It is appropriate to underline at this point that there are no realistic potential transmission line routes which would comply with the stated requirements of both OTC and RAAF Pearce. Even leaving aside the fact that Northern Terminal itself lies within the exclusion areas for OTC, the exclusion areas for OTC and RAAF Pearce overlap considerably. To avoid these it would be necessary for lines to be routed south of the North Perimeter Highway before finding an easterly or westerly path. Such options are not feasible.

Choice of potential corridors has, therefore, been conditioned by judgements about what may be acceptable to OTC and RAAF Pearce, in all the circumstances.

4.2 MAJOR DETERMINANTS

The selection of potential corridors has ultimately been determined by reference to four basic options for OTC, and to adoption of a particular rationale in relation to the requirements of RAAF Pearce.

The four options considered in relation to OTC, and their consequences for transmission line corridors, are:

(1) **Full acceptance of OTC as a category A facility,** (notwithstanding Northern Terminal's present violation of that status). This entails corridors taking the shortest possible path away from OTC, and skirting RAAF Pearce to the east.

(2) **Partial acceptance of OTC as a Category A facility,** in view of the proximity of Northern Terminal and existing transmission lines. This basically entails identifying corridors for one or both 330kV lines to pass between OTC and Pearce, with the maximum feasible separation from OTC.

(3) **Regard OTC as a Category B facility.** This was, of course, the original starting point for the Study. It entails finding corridors passing between OTC and Pearce, possibly quite close to OTC, for all three transmission lines.

(4) **Disregard the existence of OTC altogether,** that is, assume that it would be relocated.

The rationale adopted in respect of RAAF Pearce and its various facilities is:

(1) Full acceptance of 3TU as a Category A facility, with only negligible violation of its area of exclusion tolerated.

(2) Acceptance of Civil Aviation Authority standards, with a considerable safety margin, in relation to aircraft take-off and approach areas.

(3) In the absence of technical standards, no particular clearance around Caversham.

(4) In the absence of technical standards, a generally conservative approach to the low flying area around the bombing range.

(5) In the absence of technical standards and the apparent non-viability of take-off and approach across the scarp east of Pearce, no particular requirements for height limitations there.

In the case of items 3, 4 and 5 above, especially, it is expected that negotiations with the Air Force Office would occur in due course, if necessary.

Other major determinants of selection of potential corridors are set out in Section 3.6 of this report.

4.3 CORRIDOR OPTIONS

The various corridor options identified are shown on Map 10. For ease of description and subsequent evaluation each is divided into sectors, designated alphabetically.

The potential corridors are also grouped into Western and Eastern Corridors - those passing respectively west and east of RAAF Pearce.

A brief description of each corridor option and its rationale follows.

Corridors WI, WIA and WIB

Corridor WI is based on the assumption that OTC would tolerate an additional 132kV double circuit line alongside the existing Northern Terminal-Muchea 132kV line. It follows the path of that line around the OTC-SantaMaria site and then follows it into the Gnangara Pine Plantation for approximately 6km, before turning west across the pine plantation, towards its western edge, and keeping outside the 9.6km radius of exclusion from 3TU. At this point the corridor is wide enough to accommodate two well-separated transmission line easements, if desired. The corridor then turns north and along the east side of Lake Pinjar, remaining within State Forest. The corridor runs between Melaleuca Park and the smaller lakes of the EPA's M8 (System 6) area.

Corridor WIA is identical to WI except that the line would follow the existing transmission line for a further two to three kilometres before turning west.

Corridor WIB is essentially the same as WI but skirts to the west rather than the east of Lake Pinjar, again remaining essentially within State Forest 65, in this case the Pinjar Pine Plantation. The southern section of this part of Corridor IB is drawn sufficiently widely to locate a route either to the north or south of the Wanneroo Golf Course.

The convoluted alignment of the existing route makes this corridor suitable only for a 132kV line.

Corrisors W2, W2A and W2B

Corridor W2 assumes that paralleling the existing NT-Muchea 132kV line is not acceptable to OTC (especially in the case of a 330kV line), or to SECWA (as being too convoluted for lattice towers). A 330kV line could occur in this corridor if OTC were to vacate its site or to accept a Category B classification.

The line would utilise existing easements east along Marshall Road and north between Tonkin Highway and Beechboro Road. North of Kingsway Road the Corridor W2 options are essentially as for Corridor Wl, although there is sufficient scope between Kingsway and Gnangara Road to swing westwards, particularly if Tonkin Highway were to be extended in that direction and the line were to parallel it. In the section between Kingsway and Gnangara Road, the corridor takes in the western fringe of Whiteman Park.

Any line within the corridor would need to be routed east of the Cullacabardee settlement.

Corridors W3 and W3B

The W3 Corridor options are based on obtaining a 6.4km clearance from OTC in as short a distance as possible. If OTC then maintains a Category A classification these options would still technically be limited to a 132kV line. However, it would be reasonable to accept a 330kV line within this corridor.

W3 runs parallel to the existing easement along Marshall Road. It turns north in the vicinity of Lord Street, along the eastern fringe of Whiteman Park and the west side of RAAF Caversham, to the southern edge of the Gnangara Pine Plantation. The corridor then turns north-west through the plantation in the vicinity of Wetherall Road, to join the route described in Corridors W1 and W2.

Corridor W3B is identical to W3 except that it skirts around the west side of Lake Pinjar instead of the east.

There is no Corridor W3A - the sub-option to follow the NT-Muchea line makes no sense in this case.

Corridors W4 and W4B

Corridor W4 is based on the assumption that OTC is relocated or that it accepts limits on its site and a Category B classification. This is as direct a route as possible northwards out of Northern Terminal while avoiding residential development in the locality. From Woollcott Avenue north the corridor is the same as Corridor W2. A line within this corridor would need to be routed west of Cullacabardee settlement.

Corridor W4B incorporates the sub-option west of Lake Pinjar, as for corridors 1B, 2B and 3B.

Corridor W5

Corridor W5 is based on achieving a 9.6km clearance from OTC for as great a distance as possible.

As for Corridor W3 it parallels the existing easement along Marshall Road. It then turns north-northeast west of West Swan Road passing along the eastern fringe of RAAF Caversham and clear of West Swan Road. It passes to the west of The Vines and Belhus special rural areas then turns west through the Gnangara Pine Plantation to join Corridors W1 and W2 described above, whence its clearance from OTC is again reduced.

Corridors E6 and E6A

The eastern corridors are all based on the possibility that OTC may rigidly require adherence to the Category A facility separation distances, except of course to the extent to which Northern Terminal itself is within those distances.

Corridor E6 is the same as W5 between Northern Terminal and a location immediately west of The Vines special rural area. At this point it heads north-east, skirting the RAAF 9.6km exclusion area until it crosses Ellen Brook between Twin Swamps and Ellen Brook Wildlife Sanctuaries (M17 of EPA's System 6 Report). At the foothills of the Darling Scarp, just north of the Walyunga National Park entrance, the Corridor heads northwards, ascending the scarp face at a location on the southern part of Lot 7 Great Northern Highway (northwest end of Walyunga National Park). The climb up the Scarp is mostly hidden by a spur to the west of this area. This section of the corridor impinges by up to 1 kilometre on the 9.6km exclusion area from the RAAF 3TU receiving station. Once on the plateau the corridor skirts the eastern side of the existing Special Rural Zone north of Muchea. From Muchea the corridor parallels existing lines to the Pinjar site.

Corridor E6A follows the same direction as Corridor E6 with the exception that it remains on the plateau for some distance before descending the Scarp at a more northerly location.

Corridors E7 and E7A

The E7 Corridor options are in part based on the possibility that E6 is not acceptable to RAAF Pearce, or the Walyunga National Park or RAAF Caversham.

Corridor E7 takes a direction east along Marshall Road to the Swan River. The crossing of the river might follow either the existing 330kV Wundowie line, or another route immediately north of this. The corridor travels eastwards to the Scarp and thence heads northwards along the foothills to the Walyunga National Park. From this point to Pinjar, Corridor E7 is the same as Corridor E6, and E7A as E6A.

Corridors E8 and E8A

The E8 Corridor options are in part based on the possibility that in addition to objectives to E6, a foothills route may not be politically or otherwise acceptable.

Corridor E8 is identical to E7 from Northern Terminal to the base of the Scarp just north of Toodyay Road. At this point it ascends the Scarp to the South of Mt. Oakover and heads north-northeast across the Darling Plateau, passing well to the east of Walyunga National Park and the Brigadoon special rural development. The corridor crosses the Avon River northeast of Walyunga Lookout, close to the confluence of the Brockman and Avon Rivers, and turns north-east to join the route for Corridors E6 and E7 on to Pinjar. Corridor E8A corresponds to Corridors E6A and E7A.

5. CORRIDOR EVALUATION

5.1 METHOD

The method of evaluation adopted here involves both written discussion of alternatives and a numerically scored matrix.

The reasons for this are simple enough. Some factors are not easily quantified, and in other cases it is not appropriate to attempt to quantify them. Compliance with the separation distances set out in A5 3516 & 1 - 1988 is a good example. In the first place the separation distances will either be complied with or not - there is little scope for degrees of compliance. At the same time the standard itself stresses that the distances are guidelines to a number of technical and other factors.

Another reason is that the evaluation must take account of the complexity of the task. The study aims to identify not one but three corridors, for transmission lines of two different capacities. It must also take into account the desirability of separating transmission lines, and the acceptability of combining them. The written evaluation deals essentially with the advantages and disadvantages of each corridor. The numerical evaluation deals, in as objective a way as possible, with a comparison of the relative performance of each corridor against a series of criteria derived in turn from a set of objectives.

Each corridor has been analysed sector by sector in terms of the various factors. In the case of the numerical evaluation a score has been assigned to each sector based on a qualitative assessment together with a quantitative measure of the extent to which the factor occurs, generally related to the length of the sector. Inevitably, and appropriately, the length of a corridor has a significant influence on its score.

To assist the process a notional route has been prepared for each corridor. These are shown at Map 11.

5.2 OBJECTIVES AND CRITERIA FOR EVALUATION

5.2.1 Classification of Objectives

For clarity and to enable different biases to be applied to assessment, objectives and criteria for selection have been categorised according to differing emphasis of source. The categories and the relevant objectives are summarised as follows

SECWA Objectives

(i) Maximise reliability of operation
(ii) Minimise compensation, construction, maintenance and operating costs
(iii) Minimise political and community opposition

Economic Objectives

(iv) Minimise costs to community (see (ii))
(v) Minimise impact on economic use of land including residential, agricultural, recreation, extractive industry, forestry etc
(vi) Minimise impact on tourism industry (see (x))

Environmental Objectives

(vii) Minimise loss of native flora and fauna
(viii) Minimise impact on wetlands and other environmentally sensitive areas
(ix) Minimise risk of spread of dieback, soil erosion and increased salinity

Social Objectives

(x) Minimise impact on landscape/visual intrusion
(xi) Minimise impact on recreation (see (v))
(xii) Minimise impact on heritage
(xiii) Avoid interference to radiocommunications
(xiv) Minimise impact on aircraft movement

5.2.2 Criteria for Numerical Evaluation

Not all objectives are capable of being translated into a numerical evaluation.

As far as reasonable criteria have been derived from objectives and scored against potential corridors in an evaluation matrix. The distilled criteria for this purpose are:

SECWA Criteria
(1) Cost
(2) Reliability

Economic Criteria
(3) Land Use Impacts

Environmental Criteria
(4) Impact on native vegetation and environmentally sensitive areas

Social Criteria
(5) Landscape and visual impact

The derivation of the assessment of these criteria is set out below.

The other - non numerically-scaled - criteria are dealt with in the written evaluation.

5.2.3 Derivation of Values for Criteria

(1) Cost

Distance is the basic surrogate for cost, but must be qualified according to construction difficulty.

The cost of transmission lines in standard ground conditions is of the following order:

132kV D.C.	$130,000 per km
330kV S.C.	$185,000 per km
330kV D.C.	$315,000 per km

Under difficult foundation conditions costs could increase by around $100,000 per km. Heavy clearing and difficulty of access would substantially further increase these figures.

Each corridor has been evaluated according to its comparative length, with a factor applied to reflect difficulties of construction. Three broad engineering criteria were brought into the calculation of construction difficulty: foundation conditions; risk of inundation or erosion; and ease of alignment.

Foundation suitability is based on soil and slope factors. Dry sand on flat land is a very suitable foundation. Rocky surfaces, including duricrust and granite outcrops, are less suitable, due to the possible cost of blasting or excavation. Clay soils, particularly wet clays, are least suitable, due to risk of subsidence, slipping or swelling.

Ease of route alignment depends on topography. Flat, topographically featureless land is highly suitable. By comparison steeply sloping or deeply dissected land has been rated as least suitable due to the probable requirement for many route deviations.

For the purposes of the evaluation it has been assumed that maintenance costs are reflected in capital costs.

(2) Reliability

Each corridor has been scored in relation to the linear extent of exposure to potential bushfire hazard.

(3) Land Use Impacts

Each corridor has been scored in relation to the extent to which the corridor passes through areas of intense or valued land use, including urban (residential), intensive rural and rural-residential, pine forest, pasture, extractive industry and recreation and tourism areas. Each of these is assigned a comparative value depending on the extent to which a transmission line is likely to impact on either economic production or land value.

(4) Impact on Native Vegetation

The factors that require consideration are the floristic and structural characteristics of native vegetation; the conservation of native vegetation; and the degree of disturbance of vegetation.

The conservation value of native vegetation results from differences in species diversity, function as fauna habitat or representation in conservation reserves and national parks under varying conditions.

The degree of disturbance to native vegetation depends in part on the structural form of the vegetation. Transmission easements are cleared to remove all vegetation that has height greater than 1.5m. Therefore tall forest vegetation with little understorey will undergo greater structural disturbance from clearing than heath formations or low open woodland with a species rich understorey.

Consideration of these factors create some difficulties in comparing the relative acceptability of clearing vegetation of different structural form, floristic composition and condition. Traditional environmental management principles suggest that minimization of the reduction of species diversity should be considered paramount. However, this does not take account of the broader aspects of conservation value. The suitability analysis used in this investigation relies mostly on the length of transmission line route to be cleared and the known or apparent condition of the vegetation.

These factors were determined by analysis of colour aerial photographs at scale 1:25,000, by reference to existing technical literature describing the vegetation complexes that occur within the corridor sectors, and brief field inspections. Subjective assessment of the comparative value of vegetation types with regard to species diversity was also noted in the scoring process. It is assumed that any occurrences of gazetted rare or geographically restricted flora can be avoided by sensitive transmission route planning should these be identified in pre-construction vegetation and flora survey. Desk top investigation of the location of gazetted rare plant populations indicated that there is one such population within a corridor. The precise location of this population is known to the study team but is not identified here, for reasons of security.

(5) Environmentally Sensitive Areas

Each corridor was scored according to the extent to which System 6 recommendation areas and other environmentally sensitive areas are likely to be adversely affected. Each area was assigned a value and the linear extent of impact was measured together with that value.

(6) Landscape and Visual Impact

Utilising the values assigned to landscape units in Map 3, taken together with the length of corridor involved in each landscape unit, a comparative measure of impact was obtained for each corridor.

The values obtained take into account the following four factors, as discussed earlier in this report:

- the intrinsic quality of the landscape;
- the capacity of the landscape to visually absorb a line;
- the capacity of the landscape type to physically absorb a line; and
- the degree of visibility of a line in the landscape.

This method is seen as having advantages over those which rely only on visibility of the line. The same line with the same degree of visibility is less acceptable in a beautiful landscape than in a poor one.

Also some landscapes because of their topography and vegetation cover have a greater ability to absorb a line visually than others. A line may be fully exposed to view but have a low visual impact because it is seen against a backdrop of hillside or vegetation. The same line, the same distance from a viewpoint, could have a high visual impact if seen against the sky.

The physical impact of a line is not only created by towers but also by the amount of clearing necessary for the line and for a maintenance track. A flat, well drained, pastoral landscape, for example, suffers very little from construction or maintenance. A forest section, or one traversing wet country, or extremely broken terrain, results in permanent and severe scarring.

5.2.4 Scoring Method

In each case a score has initially been assigned to each corridor in respect of its performance against a particular criterion. In most cases, because impact is being measured, the poorer the performance the larger the score. For example, the highest cost corridor is the worst performer in relation to that factor.

The initial scores have then been converted to a score out of ten by inverting the values and assigning a score of 10 to the best performing corridor.

These scores are set out in Table 5.3A.

5.2.5 Numerical Weighting of Criteria

The comparative weight which is given to any given criterion is probably the most difficult judgement to be made in evaluating alternatives. In the numerical evaluation it is possible (indeed necessary) to expose a set of values in any given evaluation. For this reason four separate evaluation matrices have been prepared, to reflect both unweighted scores and different sets of values held by three different interest groups. The three assumed interest groups are:

(i) SECWA;
(ii) Environmental groups;
(iii) The Community as a whole.

The process is, of course, subjective. Nevertheless it serves a useful purpose in testing the sensitivity of alternatives to different sets of values.

5.3 EVALUATION OF ALTERNATIVE CORRIDORS

5.3.1 Numerical Evaluation

Tables 5.3A, 5.3B, 5.3C and 5.3D set out the results of the numerical evaluation. These show unweighted scores and scores weighted to reflect SECWA, environmental and community value-sets respectively.

We have adopted the convention that the higher the score the more acceptable the corridor.

TABLE 5.3A

EVALUATION MATRIX-UNWEIGHTED SCORES

		CORRIDOR OPTIONS																	
CRITERIA	WEIGHT	1	1A	1B	2	2A	2B	3	3B	4	4B	5	5B	6	6A	7	7A	8	8A
SECWA																			
Cost		10	9.7	8.8	9.7	9.5	8.8	8.2	7.5	10	9	7.4	6.9	5	4.9	4.6	4.5	3.5	3.4
Reliability		7	7	7	7	7	7	10	10	7	7	5	5	5	5	5	5	4	4
ECONOMIC																			
Land Use		5.9	5.8	4.5	10	9.6	6.5	8.1	5.7	6.8	5.0	6.4	4.8	4.7	4.7	4.1	4.1	4.1	4.1
ENVIRONMENTAL																			
Vegetation, Wetland etc		10	9.5	9.6	9.7	9.2	9.4	9.2	8.9	10	9.5	7.5	7.2	7.5	7.0	9.4	8.6	5.3	5.0
SOCIAL																			
Landscape		10	9.3	8.6	9.4	9.3	8.2	7.7	6.8	10	8.6	7.0	6.3	3.8	3.7	3.8	3.6	3.5	3.4
TOTALS		43	42	39	46	45	40	43	39	44	39	33	30	26	25	27	26	20	20

The unweighted scores give the following ranking:

Score 40-plus Corridors 2, 2A, 4, 1, 3, 1A, 2B
35-39 3B, 4B, 1B

All eastern options scored less than 30.

TABLE 5.3B

EVALUATION MATRIX-SECWA BIAS

CRITERIA	WEIGHT	CORRIDOR OPTIONS 1	1A	1B	2	2A	2B	3	3B	4	4B	5	5B	6	6A	7	7A	8	8A
SECWA																			
Cost	4	40	39	35	39	38	35	33	30	40	36	30	28	20	20	18	18	14	14
Reliability	4	28	28	28	28	28	28	40	40	28	28	20	20	20	20	20	20	16	16
ECONOMIC																			
Land Use	1	6	6	5	10	10	7	8	6	7	5	6	5	5	5	4	4	4	4
ENVIRONMENTAL																			
Vegetation, Wetland etc	2	20	19	19	19	18	18	18	18	20	19	15	14	15	14	19	17	11	10
SOCIAL																			
Landscape	3	30	28	26	28	28	25	23	20	30	26	21	19	11	11	11	11	11	10
TOTALS		124	120	113	124	121	113	122	114	125	114	92	86	71	70	72	70	56	54

Scores weighted to reflect a SECWA bias give the following ranking:

Score of 120-plus Corridors 4, 2, 1, 3, 2A, 1A
115-119 3B, 4B, 1B, 2B

All eastern options scored 72 or less.

TABLE 5.3C

EVALUATION MATRIX - ENVIRONMENTAL BIAS

CRITERIA	WEIGHT	CORRIDOR OPTIONS 1	1A	1B	2	2A	2B	3	3B	4	4B	5	5B	6	6A	7	7A	8	8A
SECWA																			
Cost	1	10	10	9	10	10	9	8	8	10	9	7	7	5	5	5	5	4	3
Reliability	1	7	7	7	7	7	7	10	10	7	7	5	5	5	5	5	5	4	4
ECONOMIC																			
Land Use	1	6	6	5	10	10	7	8	6	7	5	6	5	5	5	4	4	4	4
ENVIRONMENTAL																			
Vegetation, Wetland etc	5	50	48	48	48	46	47	46	45	50	48	38	36	38	35	47	43	27	25
SOCIAL																			
Landscape	3	30	28	26	28	28	25	23	20	30	26	21	19	11	11	11	11	11	11
TOTALS		103	99	95	103	101	95	95	89	104	95	77	72	64	61	72	68	50	47

Scores weighted to show an environmental bias give the following ranking:

Score	100-plus	Corridors 4, 2, 1, 2A
	95-99	1A, 1B, 2B, 3, 4B

No eastern option scored more than 72.

TABLE 5.3D

EVALUATION MATRIX - COMMUNITY BIAS

		CORRIDOR OPTIONS																	
CRITERIA	WEIGHT	1	1A	1B	2	2A	2B	3	3B	4	4B	5	5B	6	6A	7	7A	8	8A
SECWA																			
Cost	1	10	10	9	10	10	9	8	8	10	9	7	7	5	5	5	5	4	3
Reliability	1	7	7	7	7	7	7	10	10	7	7	5	5	5	5	5	5	4	4
ECONOMIC																			
Land Use	2	12	12	9	20	19	13	16	11	14	10	13	10	9	9	8	8	8	8
ENVIRONMENTAL																			
Vegetation, Wetland etc	3	30	29	29	29	28	28	28	28	30	29	23	22	23	21	28	26	16	15
SOCIAL																			
Landscape	5	50	46	43	47	47	41	39	34	50	43	35	32	19	19	19	18	18	17
TOTALS		109	104	47	113	111	98	101	91	111	98	83	76	61	59	65	62	50	47

The community value weighted scores produced the following ranking:

Score	100-plus	Corridors 2, 2A, 4
	100-109	1, 1A, 3

No eastern option scored more than 65.

Corridor W2 emerges from this process as a clear winner, with W4 a consistent second. Third ranked are W1 and W2A, followed by W3. However, it must be noted that in most cases comparatively little separates the top-ranked corridors.

There is a "watershed" at W5, which consistently scores below corridors W1 to W4, but also above all eastern corridors.

It must also be noted that W1 and W2A are not suitable for 330kV double-circuit lines.

5.3.2 Discussion of Alternatives

Corridor W1

At approximately 37.5km W1 is, with W2, almost the shortest and least costly corridor. Only W4 is shorter, by one kilometre. W1A and W1B are longer by 1 and 4.5 kilometres respectively.

W1 would only be suitable for a 132kV line. It is essentially a route rather than a corridor initially, as it shares an easement for several kilometres with the existing 132kV single-circuit wood pole transmission line. While this is understood to be feasible it may not be a great advantage because of the number of angles involved. The easement passes between two newly planned residential developments, in which steel lattice towers would be unwelcome.

In other respects W1 and its variations are identical to corridors W2 and W4, and their variations.

Corridor W2

Corridor W2 utilises the already agreed easement between Beechboro Road and Tonkin Highway. North of Gnangara Road it is initially totally within pine plantation. Its impacts on human settlements and land uses other than forestry are very low.

Depending on the selected route alignment, W2 might share a service corridor with the Tonkin Highway when the Highway extends to the north and northwest.

As with W1 and W4, W2 could also share an easement with the existing 132kV wood pole line north from Kingsway for up to 10.5 kilometres (W2A) or about 7.5 kilometres (W2). Again, as with W1 and W4, this corridor is only suitable for a 132 kv route because of its proximity to OTC, unless OTC either vacates its site or accepts a category B classification.

W2 extends over the western fringe of Whiteman Park and the eastern fringe of the Santa Maria/OTC land, which is currently under investigation for future urban development. Although a line would be fairly visible in the landscape the landscape itself is not outstanding, and the backdrop of trees in Whiteman Park would provide a reasonable degree of screening. The line could also be located within Whiteman Park, parallel to Beechboro Road. The only component of the Park facilities affected would be the International Shooting Complex. A line would fit comfortably between the complex and the road with a suitable buffer space for tree planting. However, a likely scenario is also an alignment parallel to Tonkin Highway, possibly sharing a service corridor. In that situation a substantial well-treed buffer would be desirable.

From north of Gnangara Road to the RAAF bombing range W2 is almost totally within pine plantation, which provides excellent visual screening. W2B, skirting the west side of Lake Pinjar, would also be inside the pine forest for most of its length. East of Jandabup Lake the corridor is wide enough to allow for separation of a kilometre or more for two separate 330kV lines if necessary. The major adverse impacts of W2, W2A and W2B would be loss of pine forest production.

The cost of a 330kV D.C. line in W2 might be of the order of $12m, with an extra $1m for W2B.

W2 remains outside the 9.6km separation distance from 3TU, but within the extensive separation area requested by RAAF Pearce. It would not need to approach closer than 2km to the site boundary of OTC, which should be acceptable for a 132kV line and, depending on technical factors, also for a 330kV line. The receiving facility at OTC is oriented in the opposite direction to the corridor.

Within W2 it would be possible to minimise impact on the pine plantation, by keeping to the western edge of the pine plantation from the vicinity of Jandabup Lake northwards. In the context of the need for three routes this advantage may be diluted if the other route or routes has to be separated by a kilometre or more.

Corridor W3

A major difference between W3 and W2 is that W3, skirting the east rather than the west side of Whiteman Park, is some 7km longer, and would cost some $2m extra, for a 330 kv D.C. line.

W3 would have a greater impact on human settlement. There is insufficient spare capacity in the existing easement along Marshall Road east of Beechboro Road, so a 330kV line would be located north of Marshall Road passing through a variety of agricultural uses, and turning north through rural-residential development west of Lord Street, and thence into Whiteman Park.

There may be some difficulty gaining acceptance of the potential impact on Whiteman Park and RAAF Caversham. The corridor encompasses the east fringe of the Park and the western edge of Caversham. The precise impact on Caversham is not known, although the corridor impinges on the requested area of exclusion.

A route within Whiteman Park from Harrow Street north to a point short of the main entrance to Whiteman Park would be relatively unobtrusive against the topography and tree background, if well separated from Lord Street. The line should avoid impacting on the entrance to the Park opposite Youledean Street, either by diverting across Lord Street and the corner of the Caversham site, and thence north, or deeper into the Park.

North of Youledean Road as far as Park Street the impact on the pasture land of either Whiteman Park or the land to the east of it would be acceptable. Assuming Lord Street were to be extended in future a suitable buffer area would be necessary.

North of Park Street to Gnangara Road the land west of Lord Street is in Whiteman Park. The landscape is not exceptional, and the scattered tree cover, with a more substantial backdrop of trees would modify the impact of a line set well back from Lord Street. In a metropolitan park dedicated to a range of recreational uses and with a variety of structures, including railway lines, the presence of a transmission line would not be incongruous, especially given the relatively unexceptional quality of the landscape within the corridor, and its use for grazing.

On the east side the land is developed with rural-residential lots, including some substantial houses. The landscape is relatively bare. An alignment to the rear of these properties (which front Lord Street) would be feasible, although exposed.

As for W2 most of the balance of W3 is within State forest. The corridor meets the Gnangara plantation in the vicinity of Lord Street. It would be easily possible to avoid any adverse impact on the two recreation areas in the vicinity, Gnangara Old Mill and Pine Drive Picnic area.

As for W2 the environmental impact of W3 is very low. Although some remnant wetland occurs within the corridor it would be easily possible to avoid any adverse impact.

Corridor W3 has the advantage of being substantially outside the 6.4km separation distance from OTC. Of necessity it is still within 9.6km of OTC, in order to maintain 9.6km separation from 3TU. In this respect it represents the optimum between OTC and 3TU. It should be acceptable to both.

Corridor W4

Corridor W4 is feasible for a 330kV line if OTC vacates its site, or if it accepts a Category B classification and is prepared to heavily compromise on separation distances.

W4 is included here for evaluation because it represents the most direct route out of Northern Terminal. As for W1 it would cut through future residential development north of Northern Terminal. It is one kilometre shorter than W1 and W2.

Although the corridor north of Woollcott Street is the same as for W2, in practice a line in W4 would probably take a more westerly alignment (i.e. closer to the OTC site) as far as the pine plantation. Thereafter the corridors are identical.

Corridor W5

Corridor W5 is approximately 49.5km long - about 12km longer, and perhaps $4m more expensive, than W2.

The corridor follows W3 east from Northern Terminal to a point south of RAAF Caversham, before skirting Caversham and passing well west of West Swan Road, along the western fringe of the Swan Valley.

Its principal advantage is that it achieves a 9.6km separation from OTC for much of its length, although this is of doubtful value, given existing intrusions within that separation distance.

Its principal disadvantages are its length - and hence cost - and its impact on the Swan Valley. Although not unduly obtrusive, as seen from West Swan Road or from within the Valley generally, it would have a marked impact on human rural-residential use of land in the Valley.

Once clear of the Swan Valley the impact of W5 is low. It passes through open agricultural land before entering the Gnangara pine plantation and thence to Pinjar, following the path taken by the other western corridors.

It would not be difficult to find a route to avoid areas of wetland and remnant native vegetation within the corridor.

The Eastern Corridors

The sole advantage possessed by the eastern corridors over the western corridors is that they take the shortest feasible route out of Northern Terminal to clear the 9.6km separation distance from OTC, and thereafter maintain it.

All pay a substantial penalty for this, in terms of cost, and environmental and other impacts.

The least costly of the eastern corridors would be about 50% more expensive than the most expensive of the western corridors, and about double the cost of W2. The most expensive eastern corridor would be about treble the cost of W2.

Corridor E6

At 61.5km E6 is the shortest of the eastern corridors, but about 7km longer than the longest of the western corridors.

In common with E5 it has a substantial part of its length through the fairly intensively developed land on the west fringe of the Swan Valley.

In this location the corridor's western edge coincides in part with the eastern edge of proposed future urban areas. Consequently a route should be feasible at or near the interface between rural-residential and urban development.

In the main E6 avoids serious conflict with other existing areas of rural-residential development although there is scattered development within the corridor, and the corridor passes through the eastern edge of a special rural development at Bullsbrook.

The impact of E6 on rural-residential land use is about double that of W2.

E6 crosses Ellen Brook at Upper Swan and the Avon River at a point 2km northeast of Walyunga National Park.

E6 has a comparatively low impact on areas of conservation value. It passes between the Ellen Brook and Twin Swamps nature reserves. It does, however, intrude into the northwest corner of Walyunga National Park, largely because no other location offers the possibility of climbing the scarp face relatively unobtrusively, taking advantage of the topography.

Environmental and visual impact on the plateau is lower than it might have been, due to the broken topography, and the fact that much of the land has been cleared and is utilised for grazing. Scattered tree cover provides screening.

Altogether about 30km of E6 is in cleared farmland. Hence the impact on economic land use is not as substantial as might have been expected of a corridor in the Darling Scarp and plateau.

Nevertheless a transmission line within E6 would be highly visible for much of its length.

A 12 kilometre section of the three eastern corridors immediately east of Pinjar Power Station would involve clearing of the native vegetation. Apart from the loss of the vegetation the visual impact would be significant, due to the topography and the limited height of the vegetation. Some idea of the impact could be gauged from the effect of the two existing 132kV wood pole lines in this corridor.

Much of corridors E6, E7 and E8 lies in close proximity - within 7 to 10 kilometres - of Pearce Air Base, and may come into conflict with the low-flying area designated east of the base. It is not possible to test the precise extent of conflict. The corridors pass through the substantial area of exclusion requested by RAAF Pearce, but no technical basis for the exclusion zone is available as yet.

The suboption E6A offers an alternative route for part of the corridor. Its impact is virtually the same.

Corridor E7

Corridor E7 has much in common with corridor E6, including all but about 12km of their length. E7 is about 2.5 kilometres longer. The major differences - and some similarities - derive from the fact that while E6 traverses the west side of the Swan Valley E7 passes along the east side, in the foothills of the Darling Scarp.

In addition to the crossings of the Avon River and Ellen Brook E7 involves crossing the Swan River (twice) and also Susannah Brook.

E7 passes through several kilometres more of rural-residential and intensively utilised rural land than E6. It cuts through the Brigadoon special rural subdivision at the southern end of Walyunga National Park before passing to the west of the special rural zone and the Park itself, prior to joining E6. Its impact on human settlement is thus higher.

The foothills area which E7 traverses is also one of the proposed urban expansion areas of the Preferred Metropolitan Strategy, and as such it is the subject of intense public debate, and considerable outcry from owners who would prefer it remained rural-residential. Either way, a 330kV transmission line would meet strong opposition from land owners who are more than ordinarily alert to perceived threats to the future of their land.

Corridor E8

Corridor E8 is the longest - 70km - and most costly of all options under consideration. It also presents a number of environmental and practical difficulties.

As with E6 and E7 this alternative involves crossing both the Swan and Avon Rivers, together with tributaries such as Susannah and Gidgegannup Brooks, and crossing the face of the Darling Scarp twice.

More than half of its length traverses the plateau. It involves considerable clearing of native vegetation.

The length of corridor E8 is a direct consequence of the need to find a route east of Walyunga National Park.

Because of the terrain this corridor involves significantly more areas which are prone to water erosion and/or excessive slopes, both involving additional costs.

A transmission line in this corridor would be highly obtrusive at certain locations in the landscape, both because of visibility of the line itself from recreational and regional roads, but also because of the extensive scarring of the landscape which would occur.

While E8 constitutes a feasible corridor if one has to be found across the plateau between Walyunga and Avon Valley National Parks, it is the least attractive of all corridors under consideration.

5.4 PREFERRED CORRIDORS

5.4.1 The 132kV Double Circuit Transmission Line

We recommend that corridor W2A be adopted for immediate development of a 132kV double circuit transmission line.

This recommendation is made on the assumptions that:

- the immediate need is for a 132kV double circuit line;
- the line will be carried on steel lattice towers; and
- it will be supplemented in due course by at least one and possibly two 330kV double circuit transmission lines between Northern Terminal and Pinjar.

The recommended route is set out in Section 6 and shown on Map 12.

5.4.2 Two 330kV Double Circuit Transmission Lines

We recommend that:

(i) corridor W2B be adopted for development of a 330kV double circuit transmission line and that appropriate negotiations take place as soon as possible with OTC, CALM and other interested parties; and

(ii) corridor W3 be provisionally adopted for development of a second 330kV double circuit transmission line and that appropriate consultations take place with the SPC, Air Force Office and other interested parties.

These recommendations are based on the assumptions that:

- two 330kV transmission lines will be required;
- OTC will remain on its present site, and that a 330kV line in corridor W2 will be acceptable to OTC;
- it is acceptable for the 132kV line and a 330kV line to share a common easement for a significant distance;
- it is not acceptable to SECWA for two 330kV transmission lines to share a common easement over long distances;
- it is not acceptable for 330kV transmission lines to cross one another;
- corridor W3 will be acceptable to the State Planning Commission in relation to Whiteman Park and to the Air Force Office in relation to RAAF Caversham.

Should it prove acceptable to SECWA to run the two 330kV lines in a common easement for a significant distance then the corridor diversion to the west of Lake Pinjar should be considered for possible deletion, that is corridor W2B could revert to W2.

Should it be decided that only one 330kV line is required the recommended corridor is W2.

Corridor W4 is not recommended for adoption as a possible 330kV transmission line corridor because of the impact it would have on proposals for residential development in the locality, and the unlikelihood of such a route being acceptable to OTC.

The recommended corridors are shown on Map 12.

6. THE RECOMMENDED 132kV ROUTE

The recommended 132kV route is shown on Map 12, together with the preferred corridors for two 330kV transmission lines.

The recommended route effectively commences in the previously proposed 200 metre easement between the Tonkin Highway extension and Beechboro Road.

Between Woolcott Avenue and Kingsway the precise alignment will be affected by the alignment of Tonkin Highway extension, which is likely to bear westerly at some point.

North of Kingsway the line joins the existing 132kV Northern Terminal-Muchea wood pole single circuit line and shares the same easement for some 10.5km to the point where the existing line turns north-northeast.

It appears possible, even likely, that in the longer term, after the integration of Pinjar Power Station into the network, this 132kV line may become redundant.

The new line continues in a straight line for up to 0.8km before bearing northwest, continuing through the pine forest to the southeast corner of the D'Orsogna piggery on Neaves Road.

The line then follows the southern boundary between the piggery and the pine forest, the pines providing an excellent backdrop to mask the view of the line from Neaves Road.

The line then continues west across farmland for a short distance before turning northwest again, crossing Neaves Road at an angle. The precise alignment at this point should be determined by the positioning of towers in the vicinity of Neaves Road.

After crossing Neaves Road the line takes a direct line through the pine plantation to a point where existing forestry roads meet. From here the line heads approximately due north for about 2 kilometres, following the forestry road to join Ziatus Street, which runs along the east side of Lake Pinjar. The easement alongside Ziatus Street should allow for a 330kV line as well as the 132kV line. The 132kV line should be on the near (road) side of the easement, and separated from the road by a substantial landscape buffer. The buffer area should contain native and pine trees, as appropriate to the adjacent landscape, designed to provide effective screening, as seen from the road and from Lake Pinjar itself.

About 7km south of the Pinjar site Ziatus Road takes an S-bend. The road may be re-aligned to eliminate the bend. If not careful consideration should be given to the transmission line route design, to avoid increased visual exposure.

From the northeastern corner of the Lake Pinjar reserve the line continues due north to the power station site.

APPENDIX 1

RARE FLORA AND FAUNA IN THE STUDY AREA

1.1 RARE FLORA

The presence of rare and high priority species of native flora is recorded by the Department of Conservation and Land Management. Because of the inherent danger in making public the locations of rare and endangered species it is CALM policy not to reveal or publish precise locations.

The following tables set out both gazetted and high priority species known to occur in the Northern Forest Region at November 1987.

TABLE A1.1: GAZETTED RARE FLORA SPECIES

Species	Flowering Period
Acacia anomala	Aug-Sept
Acacia aphylla	Aug-Sept
Caladenia arrecta	Aug-Sept
Caladenia dorriena	Sept-Oct
Caladenia gemmata var. ixoides	Sept-Oct
Caladenia integra	Sept-Oct
Darwinia acerosa	Sept-Oct
Darwinia apiculata	October
Daviesia microphylla	July-Aug
Duiris purdiei	Sept-Oct
Drakea jeanensis	Oct-Nov
Drosera occidentalis	Oct-Nov
Eucalyptus latens	June-Aug
Eucalyptus argutifolia	March-April
Grevillea cirsiifolia	Sept-Dec
Grevillea saccata	June-Aug
Hydrocotyle lemnoides	Sept-Oct
Lechenaultia laricina	Oct-Dec
Lechenaultia pulvinaris	Oct-Dec
Prychosema pusillum	Oct-Nov
Thelymitra stellata	Oct-Nov
Thomasia sp.	Sept-Oct
Wurmbea drummondii	June-July
Astrolasia grandiflora:	
North pop.	June-Aug
South pop.	July-Oct
Astrolasia nivea	Aug-Oct
Spirogardnera rubescens	Aug-Nov

Source: Department of Conservation and Land Management

The following Tables set out high priority species located within the northern Forest Region and considered for declaration as rare fauna but in need of urgent further survey.

TABLE A1.2 PRIORITY ONE SPECIES

(Known only from one or a few localities on lands under threat (eg. road verges, urban areas, active mineral leases.)

Species	Distribution in NFR	Flowering
Acacia anarthros		
Anthocercis gracilis	Mundaring Weir	September
	North Dandalup	
Asteridea gracilis	Gosnells	Sept-Oct
Diplolaena andrewsii	Swan View	Jul-Oct
Gastrolobium epachriodoides	Darling Scarp	September
Gonocarpus pithyoides	Yanchep	Oct-Nov
Hakea crassinervia	Bickley, York	July
Hemiandra linearis	Chidlow	-
Platysace eatoniae	? Wambyn	-
Stylidium utricularioides	Bullsbrook	Oct-Dec
	Death Adder Creek	
Thelymitra benthamiana	Gidgegannup	Oct-Nov
Thysanotus fastigiatus	Kalamunda, Roleystone	May-Dec

Source: Department of Conservation and Land Management

TABLE A1.3: PRIORITY TWO SPECIES

(Known from one or a few localities on land not under immediate threat.)

Species	Distribution in NFR	Flowering
Acacia subflexuosa (granite)	Bullsbrook	Aug-Oct
Astroloma foliosum	Ellis Brook Lesmurdie	
Calothamnus graniticus subspecies leptophyllus	Oakley Dam	June-Aug
Calytrix sylvanna	New Norcia-Bindoon	Aug-Oct
Darwinia pimelioides	John Forest NP	Oct Walyunga
Grevillea uniculata subspecies florida	North Bindoon	-
Helipterum pyrethrum	Bullsbrook	Oct
Lasiopetalum cardiophyllum	Bannister	Nov
Parsonsia diaphanophleba	Murray River, Coolup	May-June
Pimela rara	Mundaring	Jan-Feb
Pithocarpa achilleoides	Wooroloo, Bindoon	Jan-Apr
Platysace cirrosa	Wambyn	-
Stylidium aff repens	Boulder Rock Canning Weir	Dec
Stylidium rigidifolium	Gooseberry Hill, Pickering Brook	Oct-Nov
Tetratheca similis	Bindoon, Mt Dale area	Aug-Sept
Thysanotus arbuscula	Forrestfield Helena Valley	Nov-Dec
Trymalium urceolare	Bindoon-Toodyay	Sept-Oct
Verreauxia verreauxii	Dobaderry NR	Dec-Jan

Source: Department of Conservation and Land Management

TABLE A1.4: PRIORITY THREE SPECIES

Species	Distribution in NFR	Flowering
Aotus cordifolia	Red Hill, Gidgegannup Helena Valley, Byford	Aug-Dec
Dryandra polycephala	Bindoon	-
Eucalyptus foecunda	Lancelin	-
Jacksonia gracilis	Pinjarra	Jan-Feb
Lasiopetalum glabratum	York, Carmel Serpentine	Nov
Persoonia sulcata	John Forrest NP, Wongamine	-
Restio stenostachyus	Gingin	-
Scholtzia eatoniana	York	Nov-Dec
Senecio gilbertii	Bindoon, York	Sept-Oct
Tetiatheca pilifero	Two Rocks, Chidlow	Aug-Sept

Source: Department of Conservation and Land Management

1.2 RARE FAUNA

Table A2 sets out gazetted rare fauna species known to occur within the northern Forest Region, as at March 1987.

TABLE A2: GAZETTED RARE FAUNA SPECIES: NORTHERN FOREST REGION

Common Name	Scientific Name
Dell's Skink	Ctenotus delli
Western quoll or chuditch	Dasyurus geoffroii
Red-eared fire-tail finch	Emblema oculatum
Peregrine falcon	Falco peregrinus
Crested shrike-tit	Falcunculus frontatus
Lined burrowing skink	Lerista lineata
Numbat	Myrmecobius fasciatus
Carpet snake	Pythos spilotus
Freckled duck	Stictonetta naevosa
Black striped snake	Vermicella calonotus

Source: Department of Conservation and Land Management, March 1987

APPENDIX 2

TRANSMISSION LINE DESIGN PRINCIPLES

4. **Design principles and planning criteria**

(a) **Rolling wooded-agricultural land unit**
Coastal Plain: Ridge Hill Shelf
Eastern Agricultural Area (fig 1).

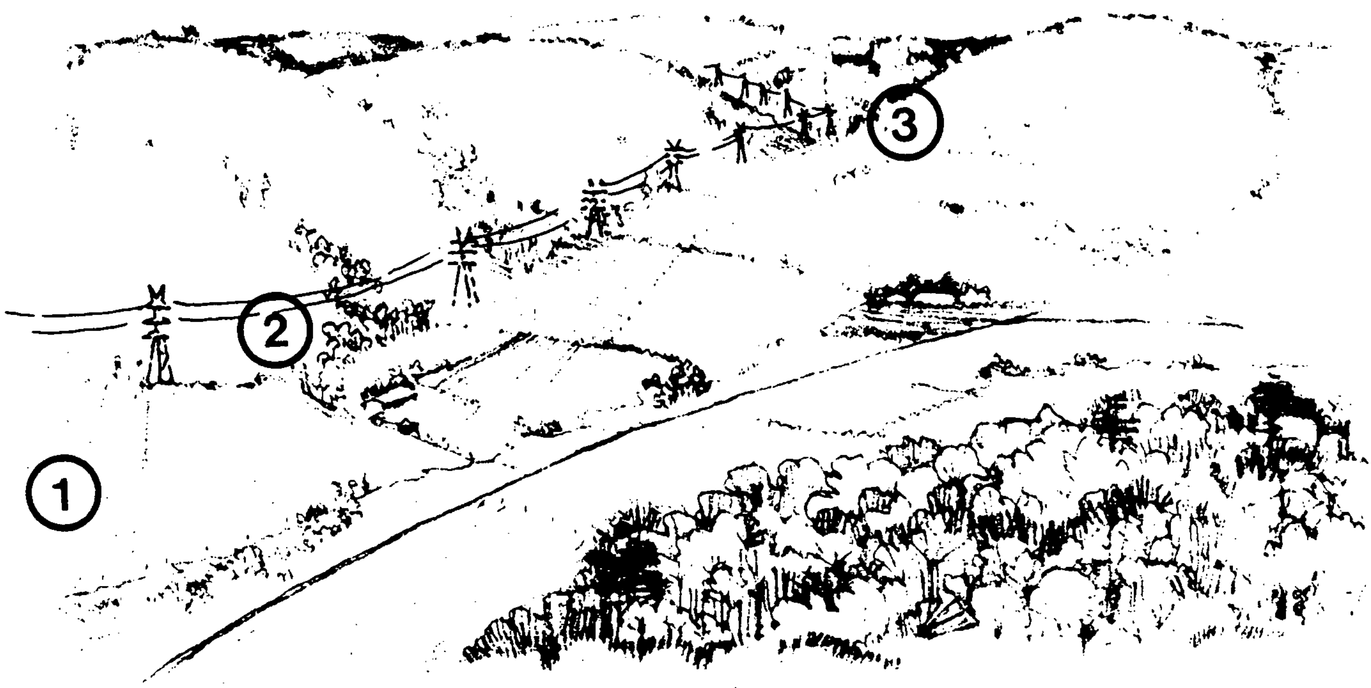


Fig. 1

Suitable alignment

1. The **border of a land unit** in rolling topography is a distinctive visual edge, large enough to accept a transmission easement provided that it respects and protects the character of each unit that forms the edge (wooded hills—cleared paddocks).
2. The lines should run **parallel to the contours** of the land and conform to the patterns of the topography, changing direction with the scale and **flow of topographic changes.** Natural lightning protection is offered by the hill folds to either side of a transmission line when located in a valley.
3. Where the lines cannot avoid cutting across major land use boundaries, the contrasting effect of **entry from paddocks (open) to forest (closed)** should be minimised, both by choice of alignment and by masking the point of entry with trees and shrubs.

(b) **Rolling wooded-agricultural land unit**
Coastal Plain: Ridge Hill Shelf
Eastern Agricultural Area (fig 2)

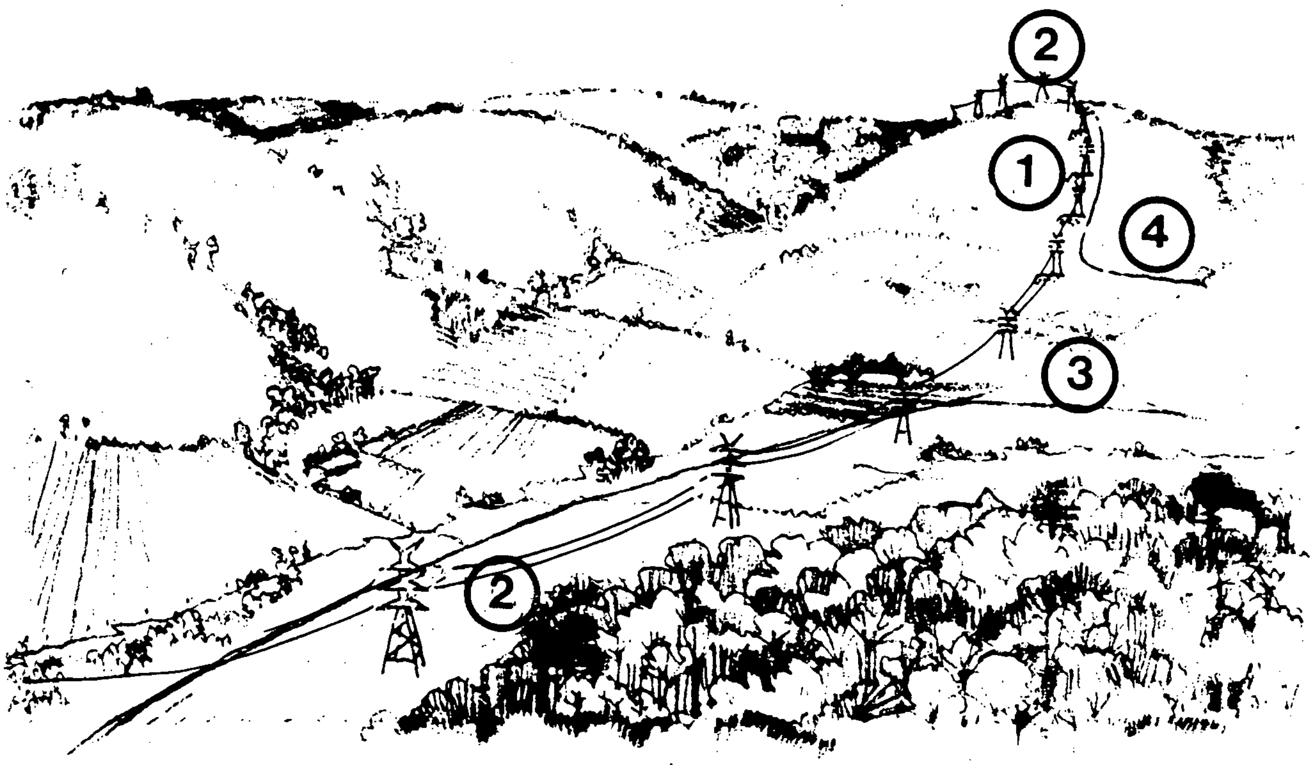


Fig. 2

Unsuitable alignment

1. Routes should avoid crossing hills at right angles to the contour, especially where easement is **centred on a hillcrest,** which results in a symmetrical arrangement that focuses attention upon the easement. Lines running against the grain of the landscape pattern become intrusive visual elements.
2. Towers should be placed below the crest of the hill or horizon line to reduce prominent **silhouette effects against the sky;** especially from a scenic viewpoint. A **centre alignment** in a valley draws attention to the easement—locate at edge of valley.
3. Keep easements away from **road intersections** which require open views for safety and high attention levels from motorists; reducing visual impact is very difficult under these conditions.
4. Access roads for construction and maintenance purposes focus attention on the easement; grading around tower bases compounds this visually raw effect. More sensitive road and tower base grading with gentle slopes planted with native grasses will help reduce this effect.

(c) **Flat open-agricultural land unit**
Coastal Plain: Pinjarra Plain and Bassendean Dune System (fig 3).

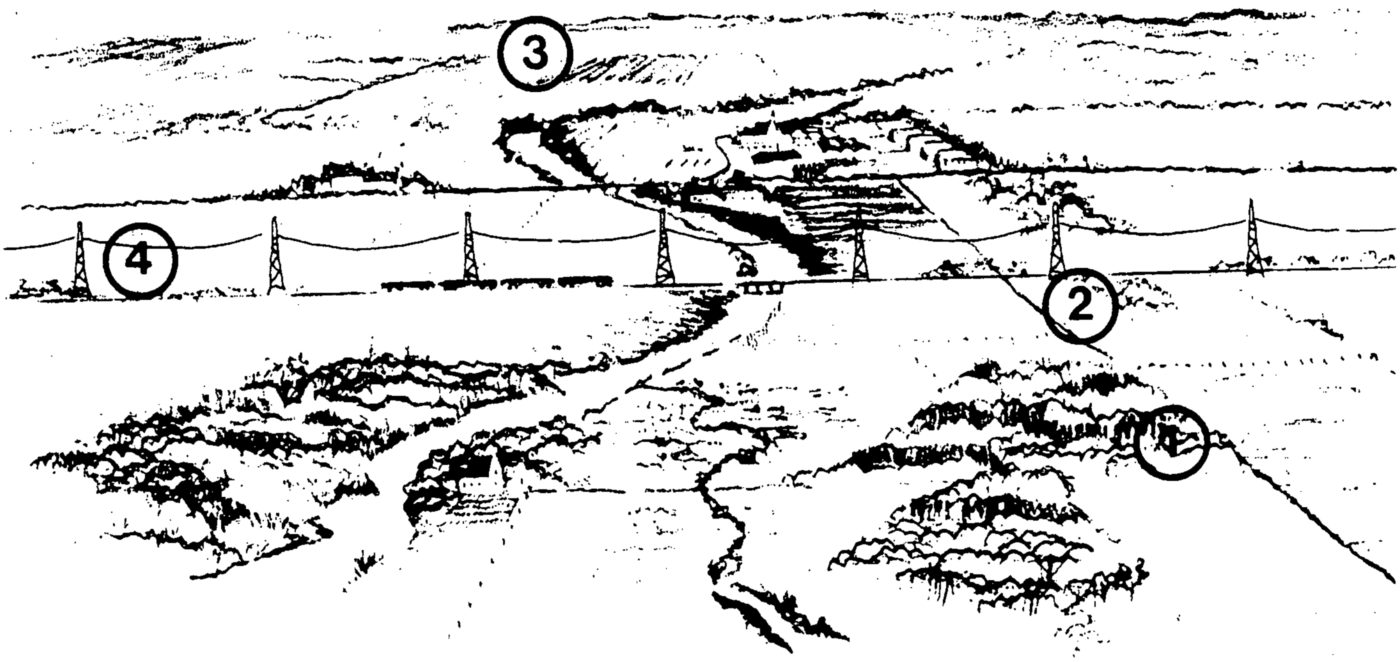


Fig. 3

Suitable alignment

1. In land units where **man's geometry** dominates, such as roadways, drains, paddocks, windbreaks and clearings, the route should parallel and complement the direction of these dominant forms. The man-influenced edge is a good background for the easement while providing easy access for maintenance.
2. The angle at which transmission lines **cross the highways** should be as near to perpendicular as possible, to permit maximum set-back of towers for low visibility from the highway. Long-span towers should be used if crossing mature roadside vegetation or scenic areas.
   Retain existing vegetation, where possible, to serve as a foreground screen or a background for the towers. The webwork of poles and wires is muted against the background of trunks and branches. Foreground screening should block out the view of the upper tower which is the most intrusive element.
3. The major communications corridor is influenced by both natural and man-made factors. Alignments must respect future patterns of growth (proposed urban expansion, freeway location, etc).
4. **Joint use of easement corridor** for various utilities (road, railroad, gas and electric) is often desirable because it minimises the visual impact that separate easements would produce.

(d) **Flat open-agricultural land unit**
Coastal Plain: Pinjarra Plain and Bassendean Dune System (fig 4).

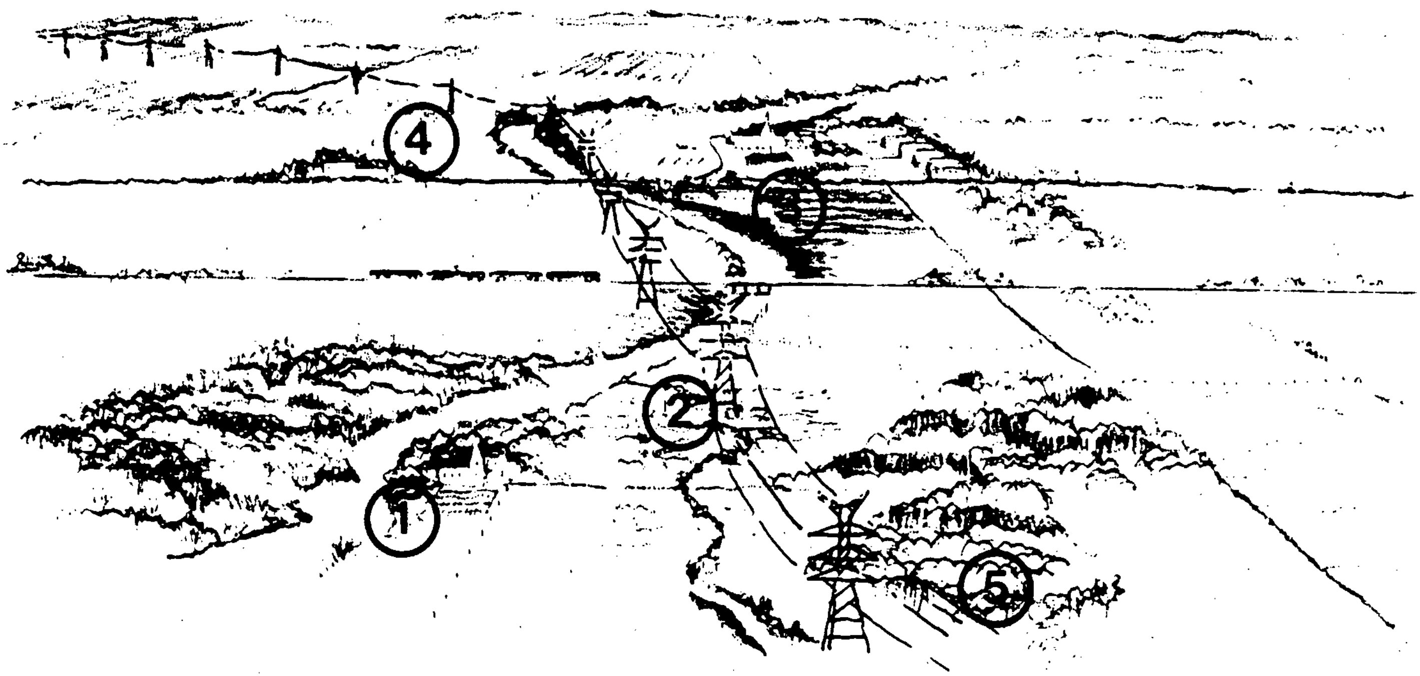


Fig. 4

Unsuitable alignment

1. Stream and river corridors are non-conforming features in this type of land unit, dominated by grid-iron geometry. Thus streams are important **visual edges** which cannot accept the straight alignment of the transmission easement, because the degree of contrast between the fluent natural form and the static easement is too great. Streams that have been straightened, deepened, and banked with levees are geometrical elements, exempt from the above comment.
2. **Landscape features** such as lakes, bogs and marshes should be avoided because of their recreation and scenic potential. The open and reflective nature of such features magnifies the presence of the lines and towers.
3. Avoid locating transmission lines and especially towers near **farm buildings and houses**, because the comparison between their relative size increases the visual impact of the easement.
4. The easement should not **bisect areas** that are suitable for expansion of urban land uses. An easement slicing through a cohesive land unit prevents harmonious expansion and creates friction between uses.
5. The easement that must pass through woodland should be cleared in such a manner that some natural **asymmetry** is maintained. The trees and clumps of bushes should appear to flow through and counter to the alignment of the easement. The land use can carry on beneath the lines without a break.

(e) **Rolling wooded land unit**
Darling Plateau (fig 5).

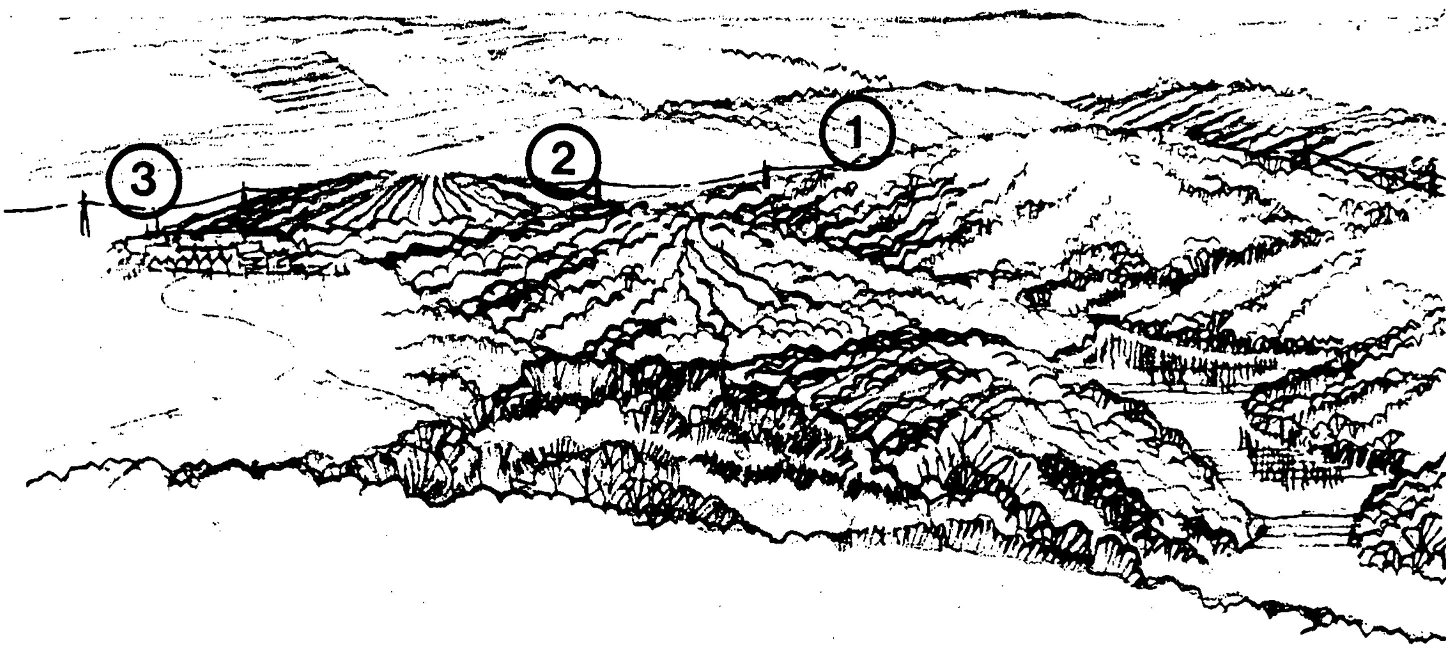


Fig. 5

Suitable alignment

1. *Phytophthora* generally spreads down rather than up hill, which suggests the routing of transmission lines at a low level through valleys to reduce the spread of infection.
2. The crossing of a stream below a dam will not disturb the forest in the water catchment, hence no increase in water pollution. The visual effect will be minimised because of the narrower stream valley and use of higher towers to carry the lines across the valley.
3. Alignment of the transmission lines must respect future patterns of industrial growth by by-passing lands with mining leases. The easement forms a suitable buffer between extractive and agricultural or forestry uses.

(f) **Rolling wooded land unit**
Darling Plateau (fig 6).

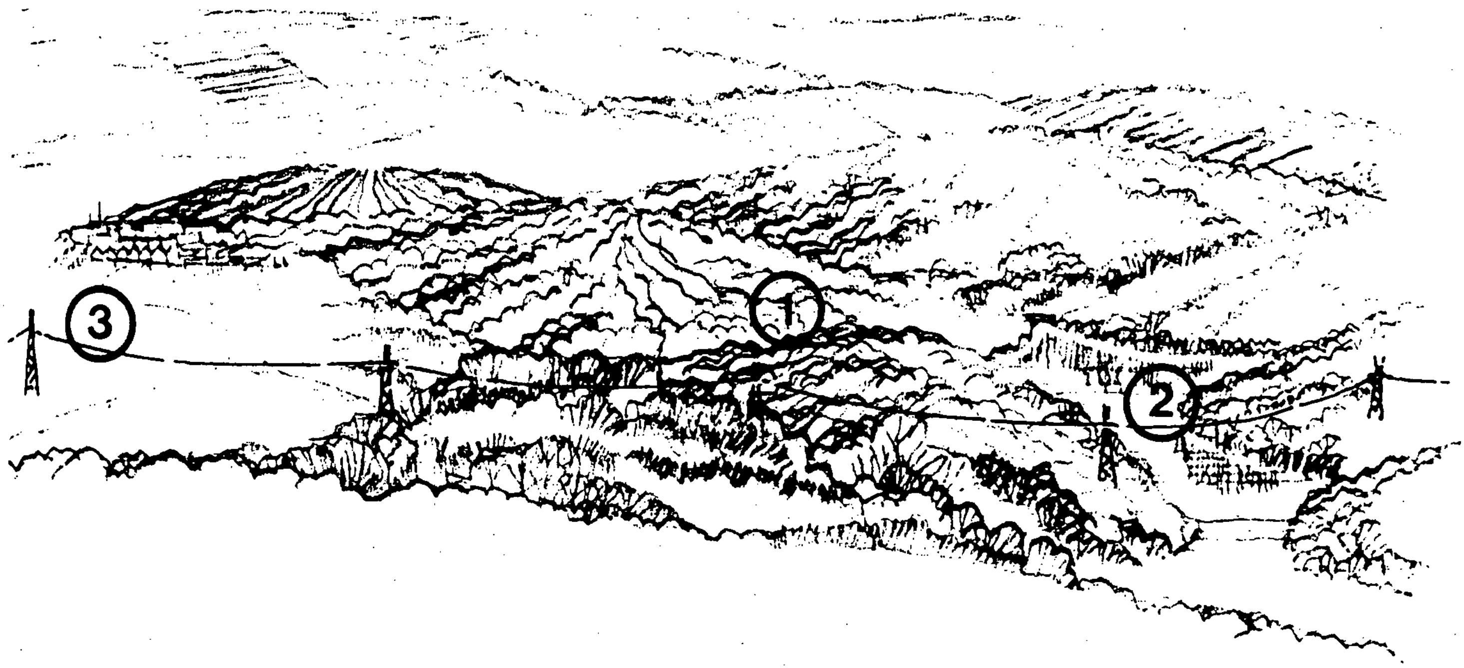


Fig. 6

Unsuitable alignment

1. The routing of a transmission line that runs perpendicular to the topographic pattern may increase the spread of *Phytophthora*.
2. The crossing of a stream above a dam can increase the water salinity because of forest clearing operations. The line will be more visible from passive recreation areas near the dam.
3. The bisection of land parcels under the same mining lease may prevent extraction of minerals within the easement area and cause operational hardships for extraction on either side of the easement.

Tower design and siting guidelines

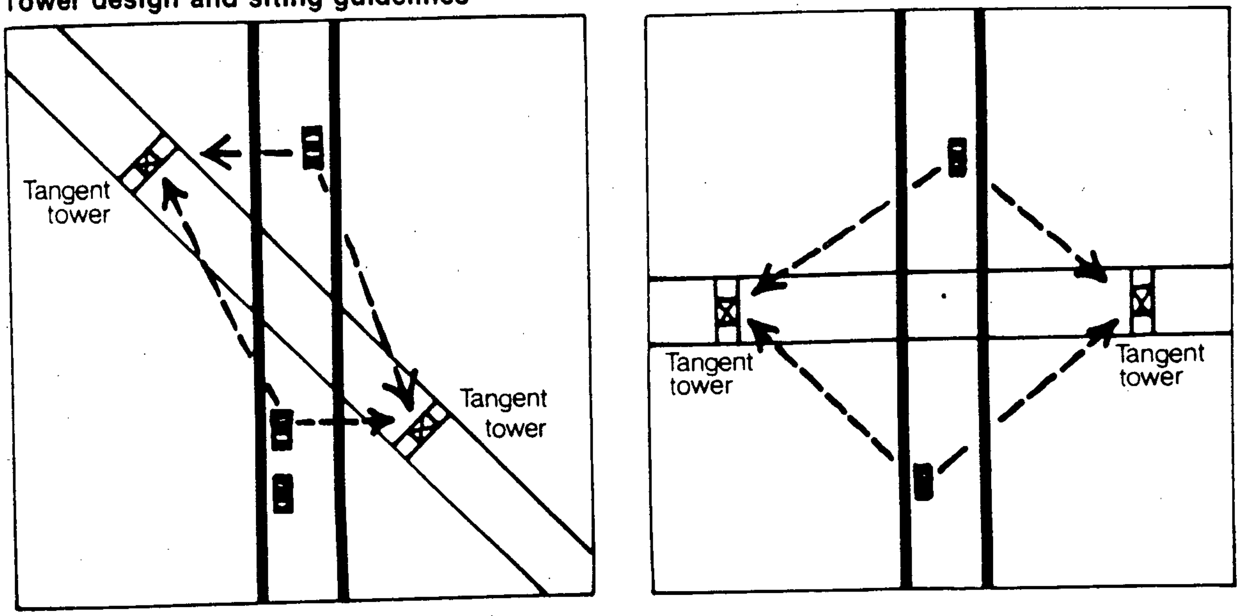


Fig. 7

A line crossing the road either at right angles or diagonally. Care should be taken to keep towers sited equally back from the road on both sides if possible. This removes the towers from dominance in the view and may well cause their being shielded by other structures or foliage. In addition, a more symmetric line of conductors will cross the road.

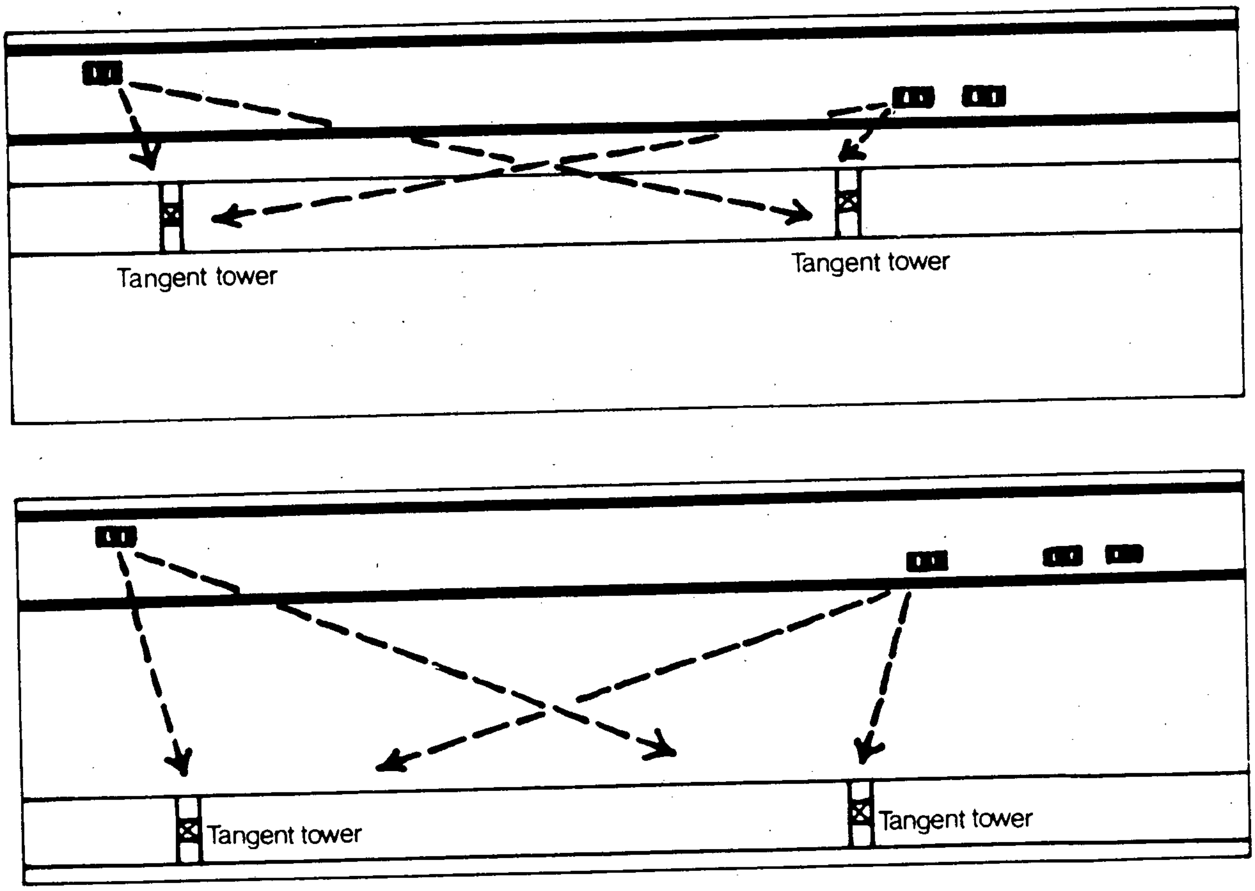


Fig. 8

Lines installed close to the road exaggerate tower spacing and conductor sag as viewer moves past them. Lines installed further from the road relieve exaggerated problems to the moving viewer.

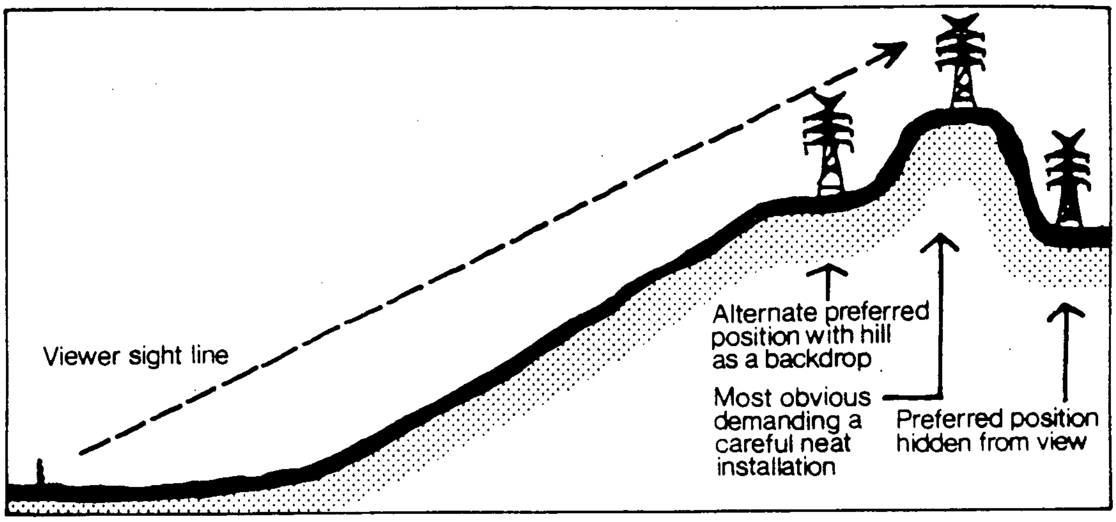


Fig. 9
Towers located above the viewer are often silhouetted against the sky.

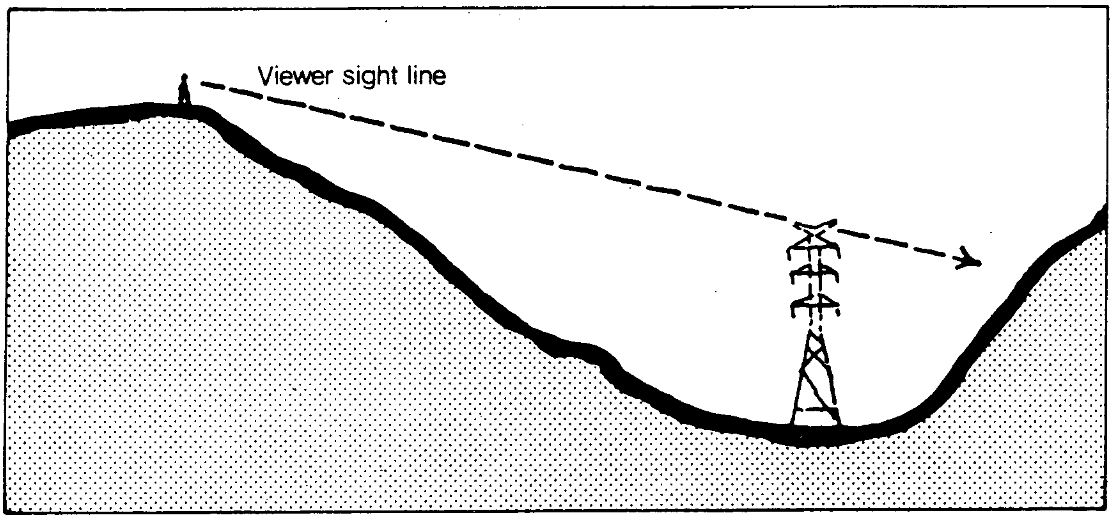


Fig. 10
Consider that the earth often forms a backdrop to the towers in a low installation helping conceal them if an appropriate colour is chosen. Sometimes lattice will also help if towers are distant from the viewer.

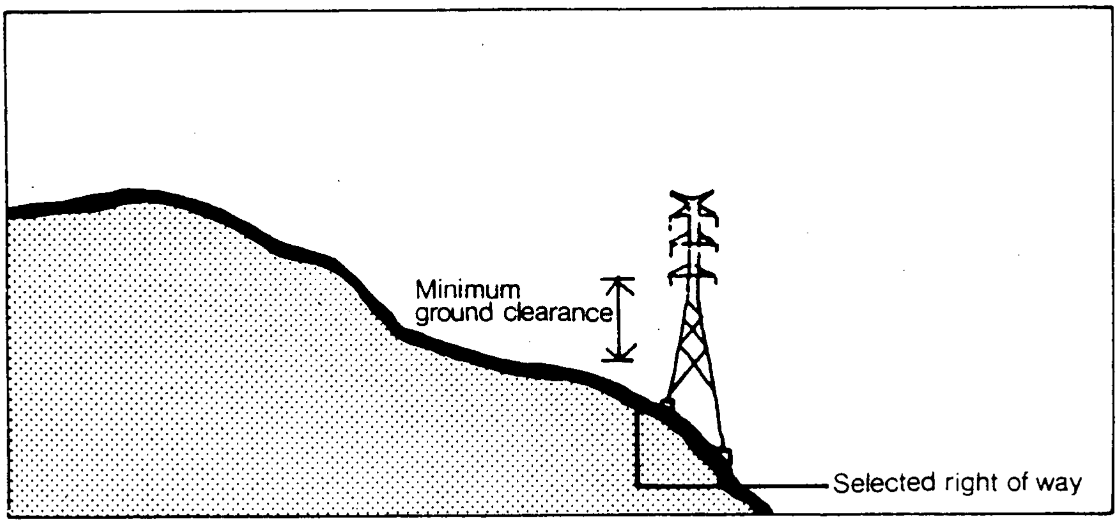


Fig. 11(a)
The right-of-way as selected leaves this tower with an undesirable differential in leg length in a high visibility situation.

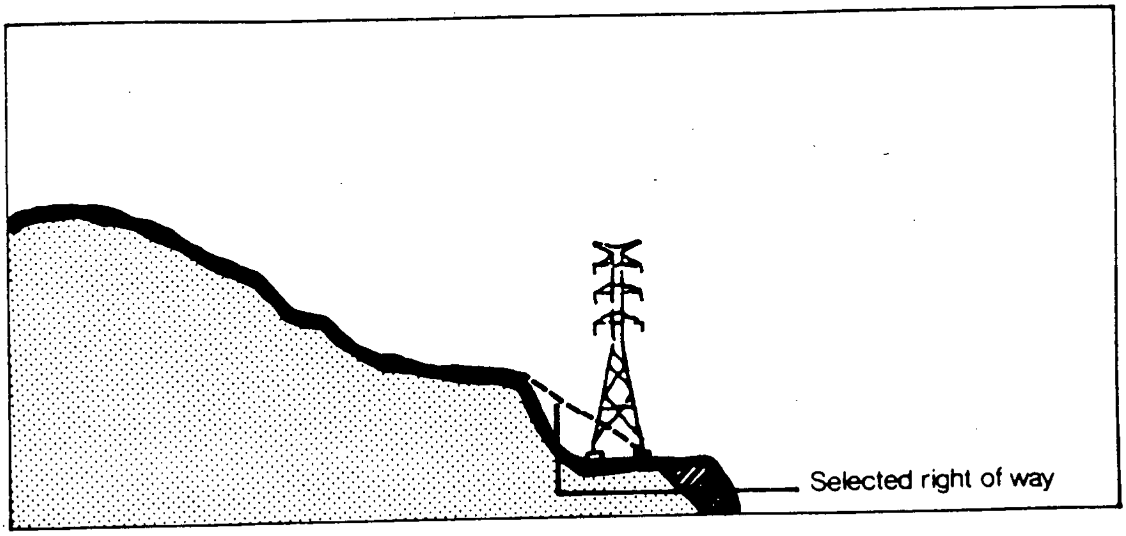


Fig. 11(b)
Cut and fill is not a good solution because the earth scars are often more noticeable than poor tower proportions.

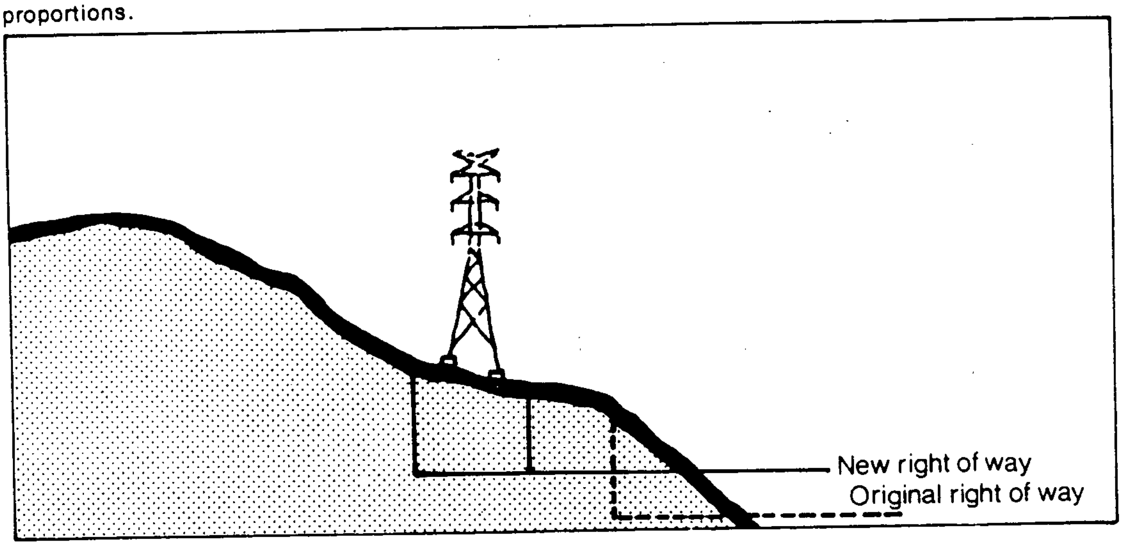


Fig. 11(c)
A preferred method would be to shift the right-of-way slightly, whenever possible, to find an improved site in its natural condition. This will entail close personal surveying of actual terrain. If this is not possible, then minor grading combined with modest unevenness of tower leg lengths should be studied for the best compromise.

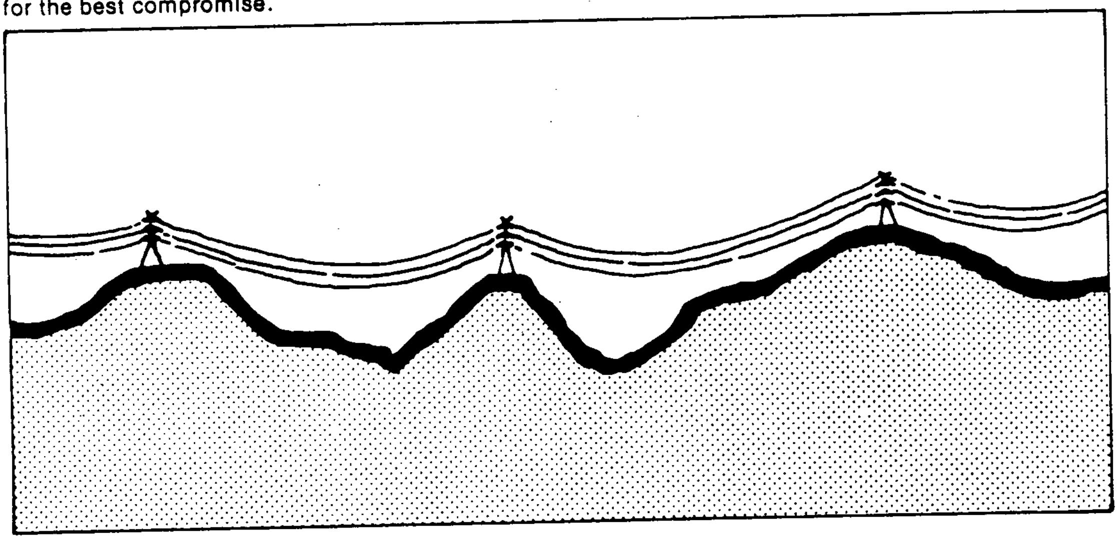


Fig. 12(a)
Long spans are possible because of taking advantage of the valleys between hilltops. This means that towers can be shorter and farther apart. These advantages must be weighed against some disadvantages.

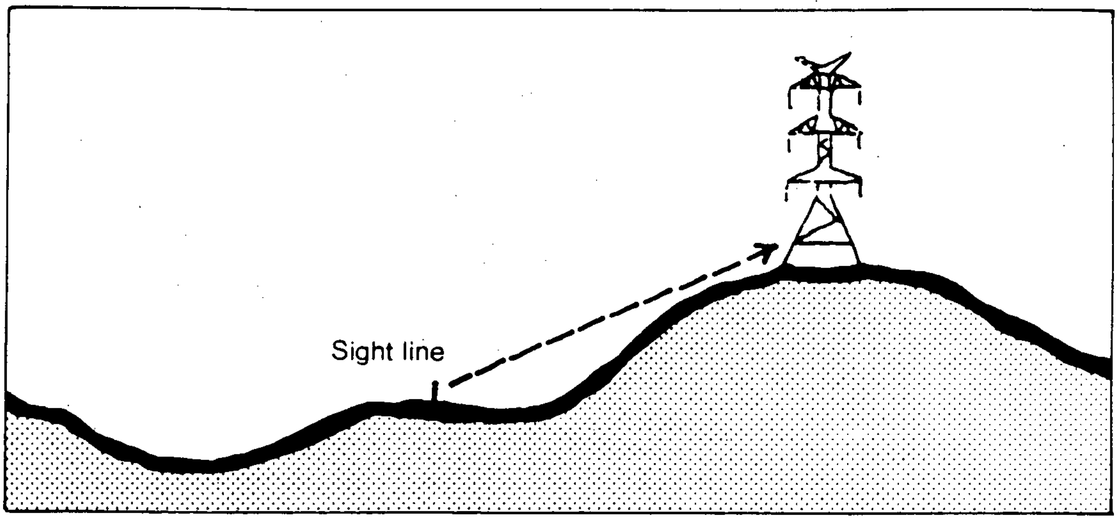


Fig. 12(b)
To complicate the situation, hilltops are often highly visible. An excessively short tower makes for poor proportions.

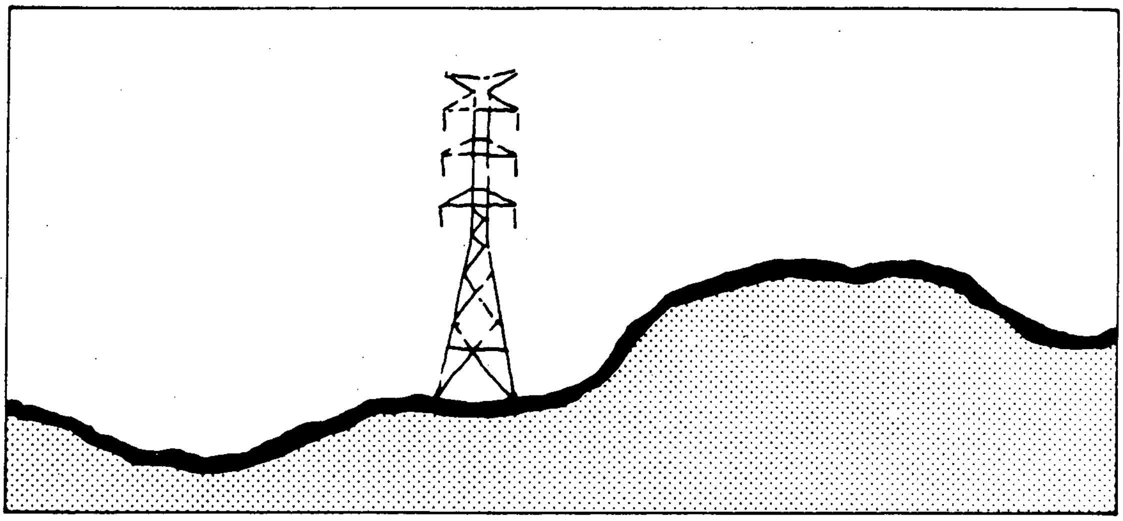


Fig. 12(c)
A better solution, whenever possible, is to locate the tower below hill crests to gain better proportions and as much concealment as possible.

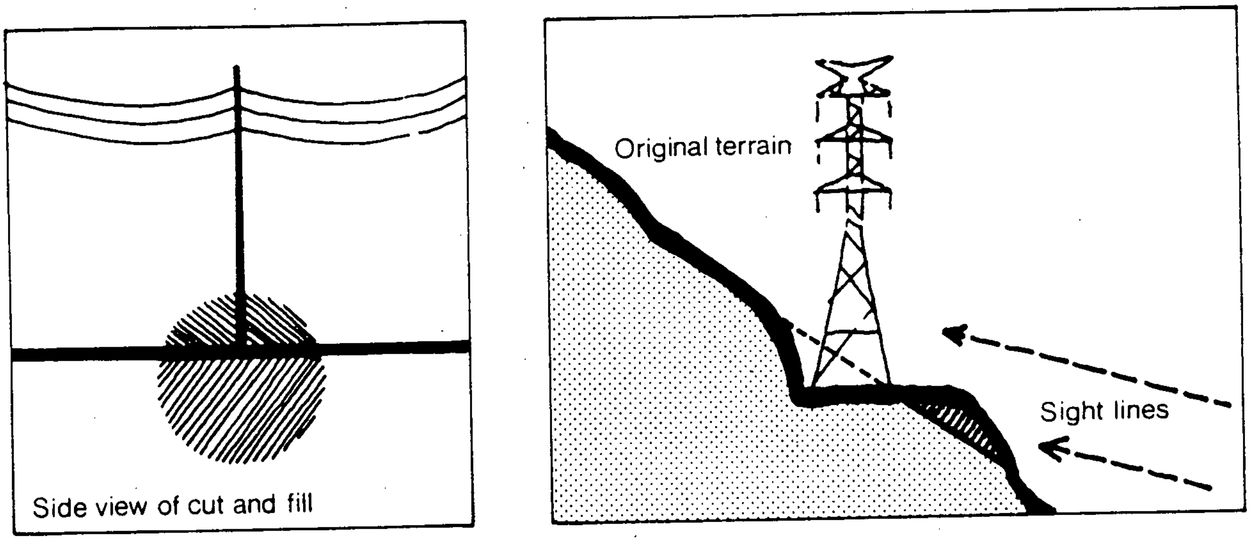


Fig. 13(a)

Typical cut and fill practice leaves both the cut and the fill areas as undesirable visual features. The fresh earth is usually a contrasting colour with the natural and a re-vegetation plan should be initiated. A better program would be careful site selection requiring no grading or carefully planned and executed grading.

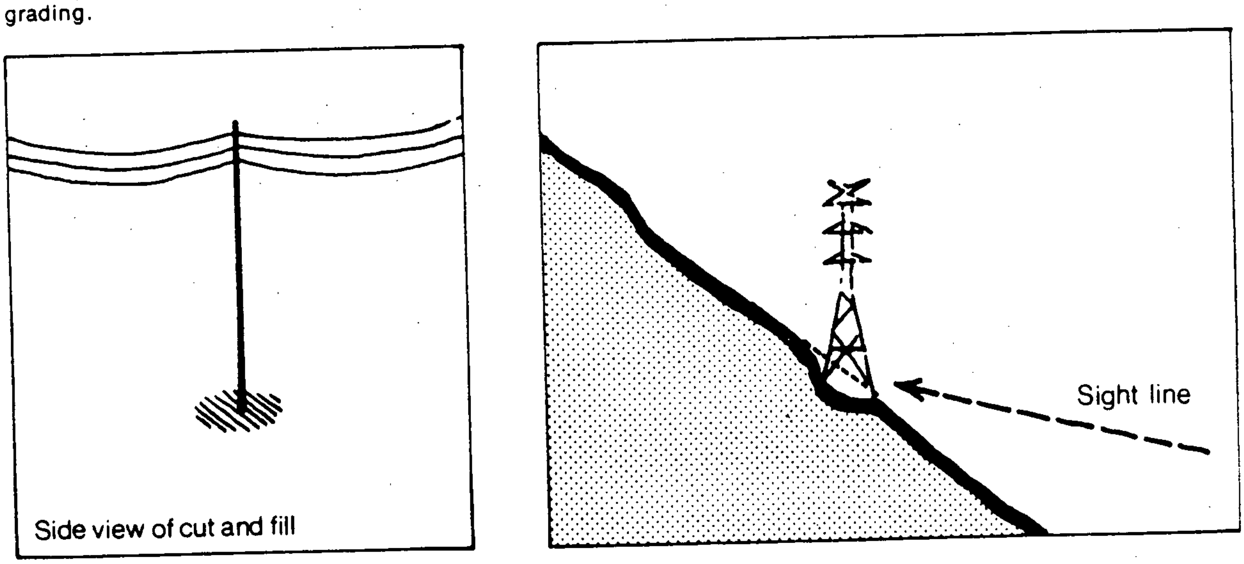
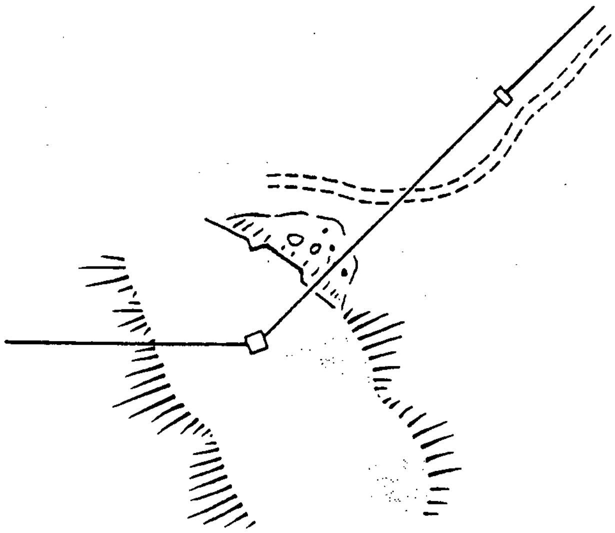


Fig. 13(b)

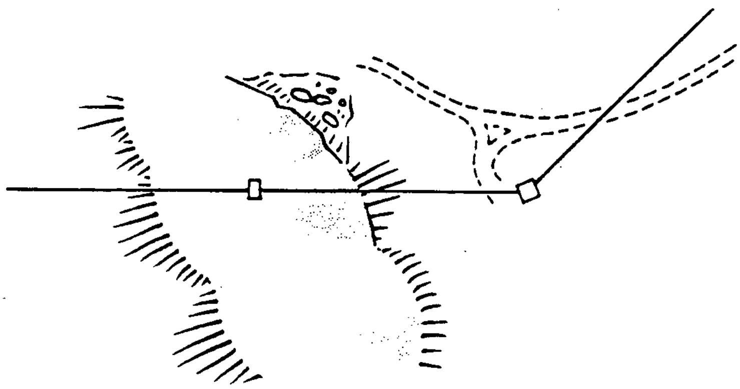
Modest cut with soil carried away. The base plane is angled slightly to parallel normal viewing angle resulting in an acceptable unequal leg length.

Source of Figures 7-13:—
Southern California Edison.
Design Guide: Aesthetic Guidelines for Electric Transmission. 1972.

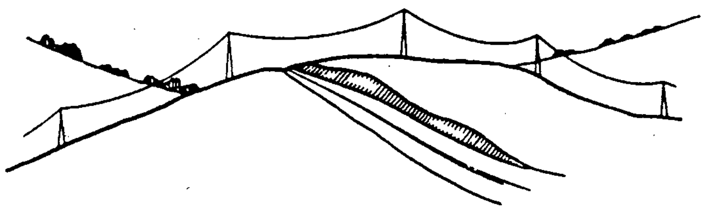
Some basic concepts :



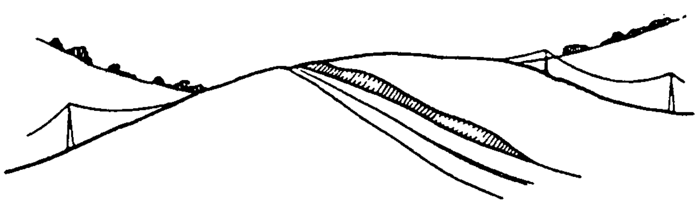
Avoid locating angle or tension towers on prominent ridges or ones with difficult access



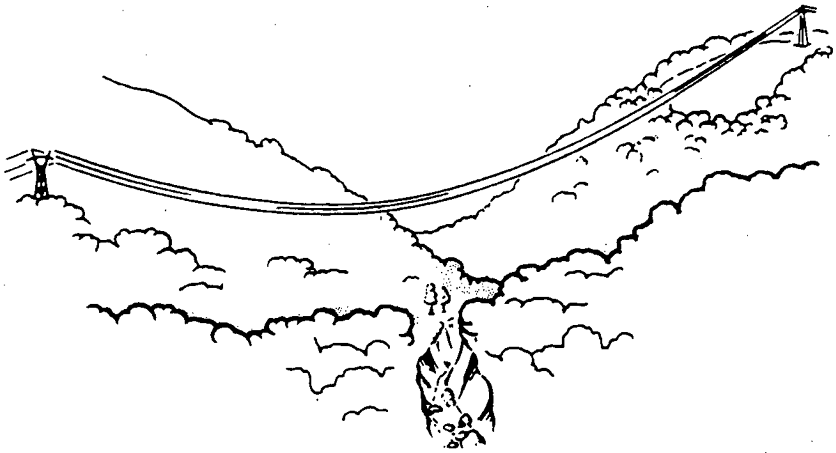
Locate heavy foundations where construction equipment has best access



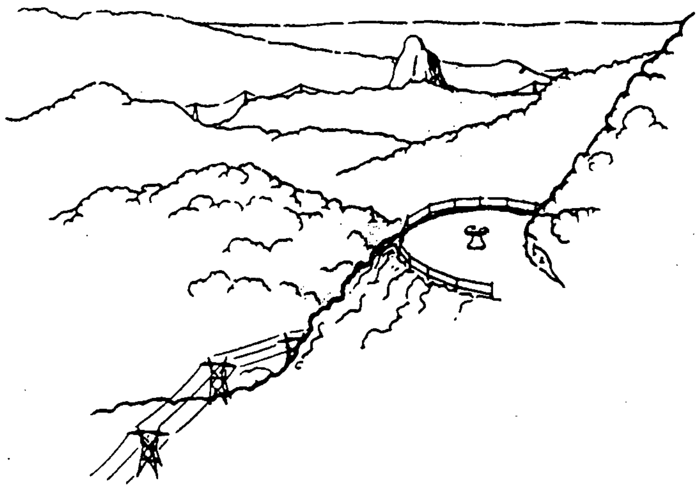
Avoid crossing at high points in the road



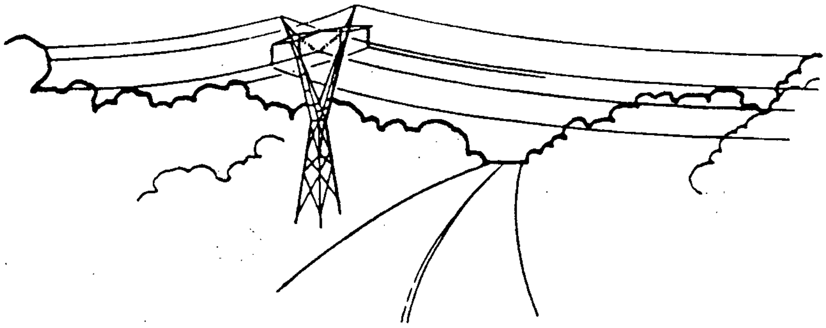
Cross at a dip



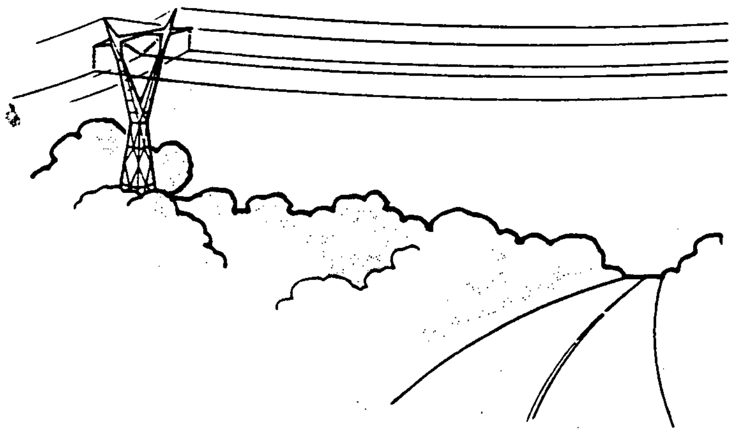
Span over deep narrow valleys minimising clearing



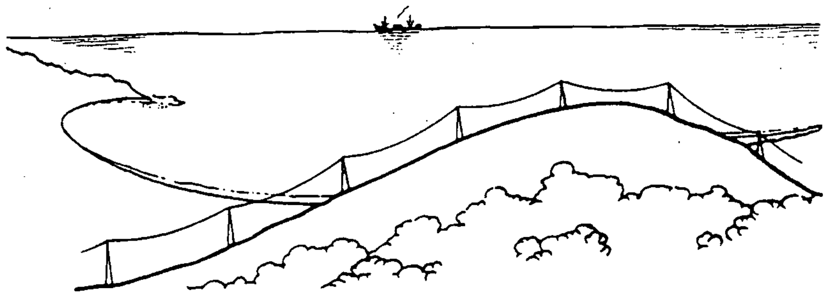
Hide lines from landscape viewing points by strategic placement and selective clearing



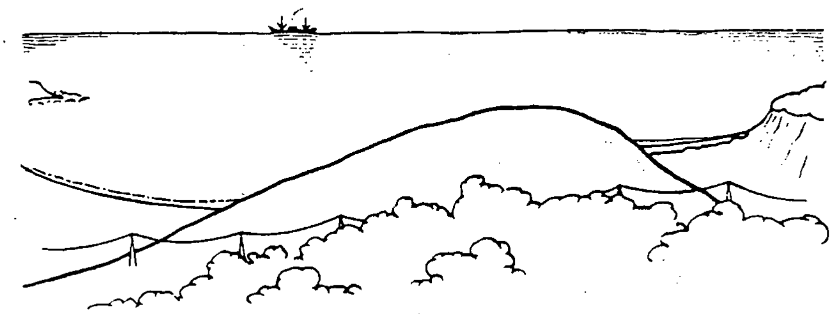
Avoid tower prominence at road crossings



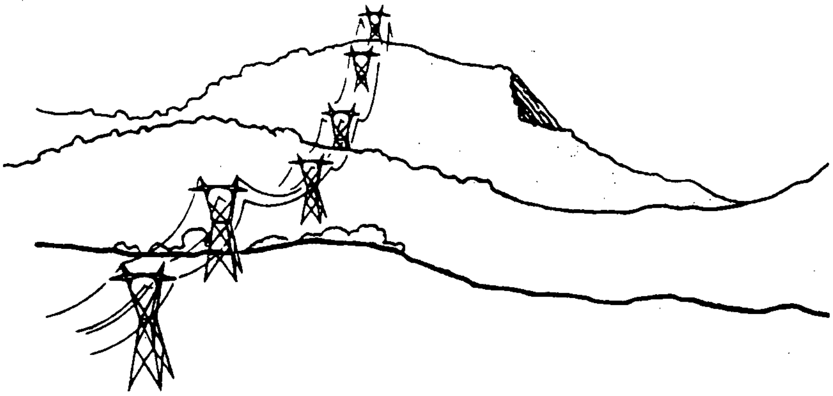
Set towers well back
Make use of natural screen



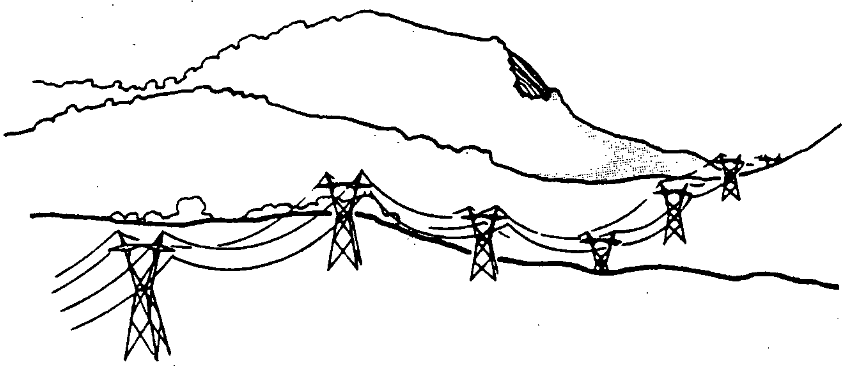
Avoid placing line against ocean background



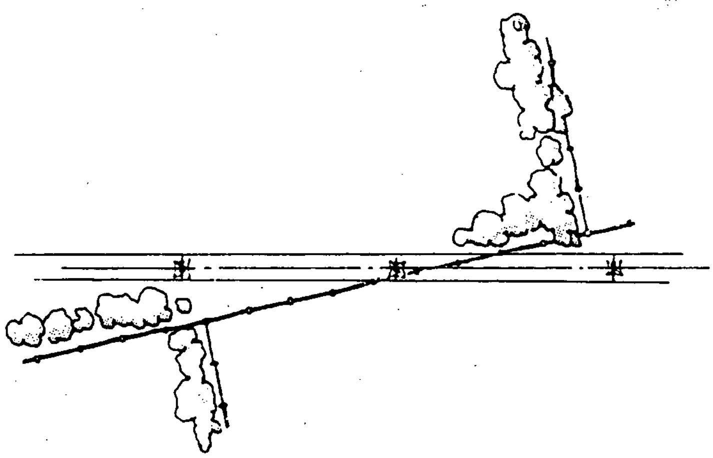
Use slopes or trees for background



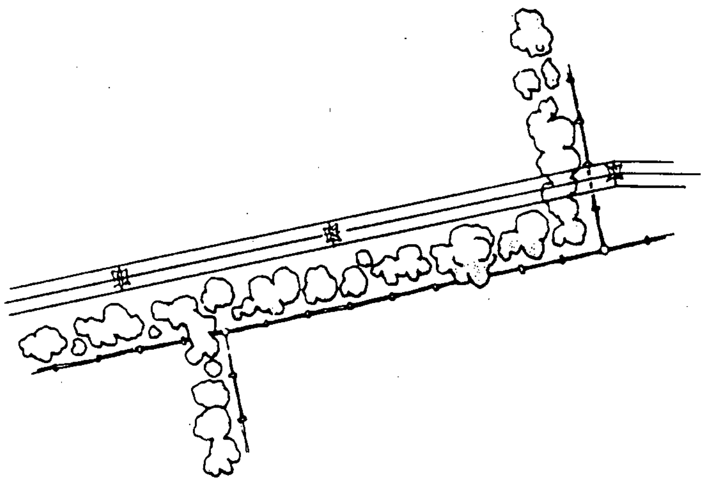
Avoid crossing at crests



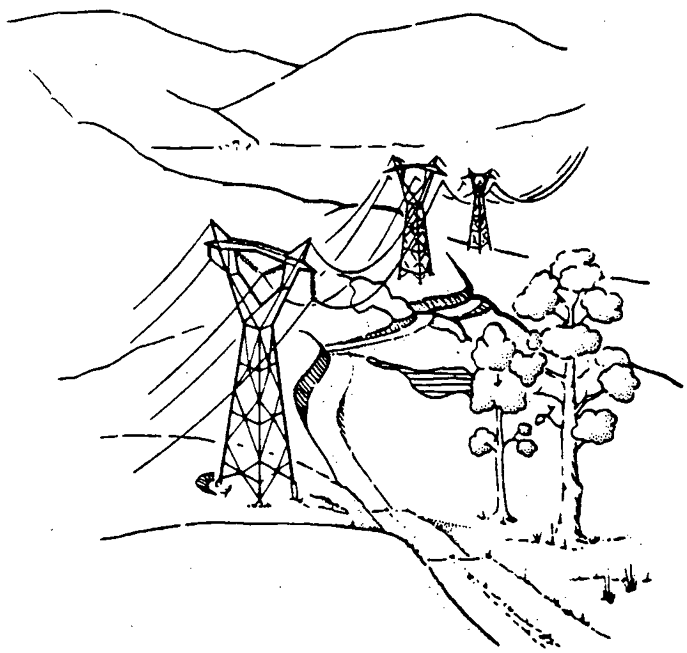
Cross at a saddle



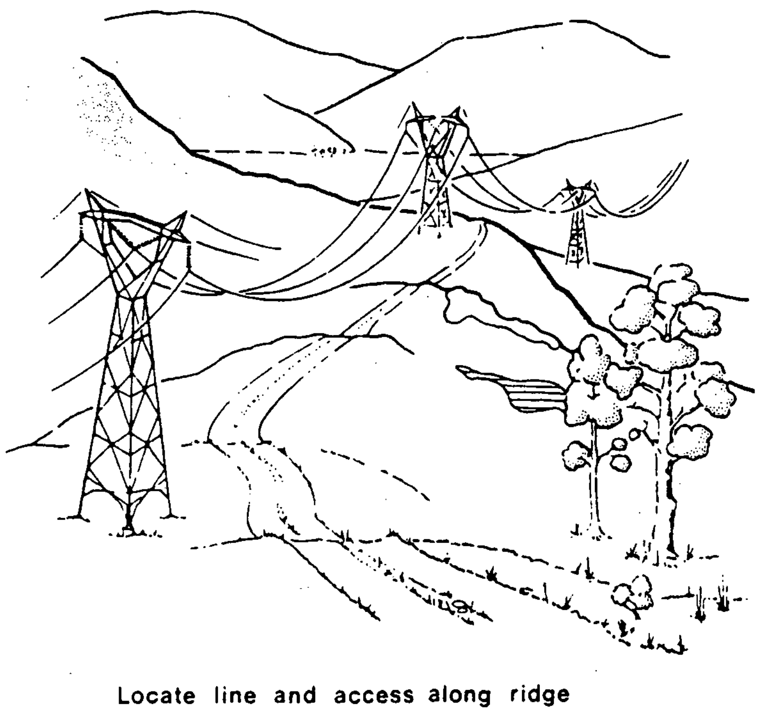
Do not destroy farm windbreaks or other screens



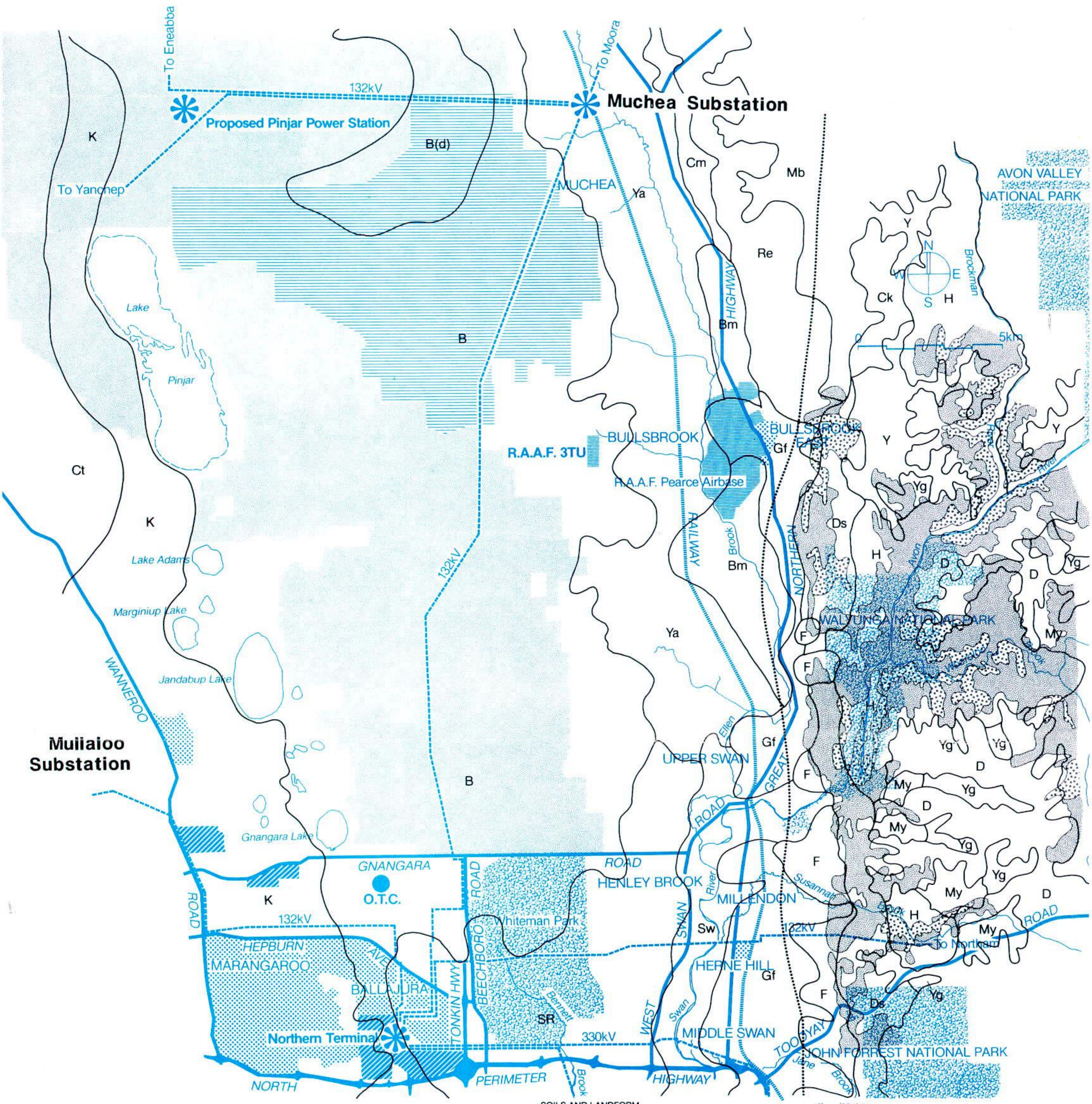
Increase tower height and string over timber



Avoid erosion of tower site and access, unnecessary earthworks and scarring of countryside



Locate line and access along ridge



Major Roads

Existing Major Power Lines

Existing Urban Zone (M.R.S.)

(1987)

Major Open Space (M.R.S.)

Industrial Areas (M.R.S.)

State Forest

Commonwealth Purposes

SLOPES — Information from Perth Metropolitan Region Environmental Geology series

Slopes 10° — 20°

Slopes 20° — 30°

SOILS AND LANDFORM
SWAN COASTAL PLAIN

AEOLIAN DEPOSITS

B Bassendean
Sand plains with low dunes and occasional swamps; iron or humus podzols; areas of complex steep dunes shown by B(d).

SR Southern River
Sand plain with low dunes and many intervening swamps; iron and humus podzols, peats and clays.

K Karrakatta
Undulating landscape with deep yellow sands over limestone

Fluviatile Deposits

Cm Coonambidgee
Gently sloping fringe to the Dandaragan Plateau; deep grey sands.

Gf Guildford
Flat plain with medium textured deposits; yellow duplex soils.

Sw Swan
Alluvial terraces with red earths and duplex soils.

Bm Beermullah
Poorly drained plain; saline and solonetzic soils, bog iron ore and some shallow sands over bog iron ore.

Ya Yanga
Poorly drained plain with grey sandy benches and intervening swamps.

Ridge Hill Shelf

F Forrestfield
Lateritised foothills of the Darling Scarp dominated by gravelly and sandy soils.

DARLING PLATEAU

LATERITIC UPLANDS

D Dwellingup
Gently undulating landscape with duricrust on ridges; sands and gravels in shallow depressions.

Y Yalanbee
Gently undulating landscape dominated by fine gravels, some duricrust on ridges.

Minor Valleys

Yg Yarragil
Valleys of the western part of the plateau, sandy gravels on the slopes; orange earths in swamp floors.

Ck Coolakin
Valleys of the eastern part of the plateau, sandy and gravelly duplex soils on slopes.

Major Valleys Combining Slopes and Floors

H Helena
Very deeply incised valleys with steep rocky slopes and some shallow red or yellow earths.

My Murray
Deeply incised valleys with red and yellow earths on slopes, narrow alluvial terraces.

Major Valley Slopes and Scarps

Ds Darling Scarp
Very steep slopes with shallow red and yellow earths and much rock outcrop.

DANDARAGAN PLATEAU

LATERITIC UPLANDS

Mb Mogumber
Gently undulating landscape; duricrust and gravels or crests and grey sands in broad shallow depressions.

Scarps

Re Reagan
Gently sloping scarp dominated by yellow grey sands; some duricrust and gravels.

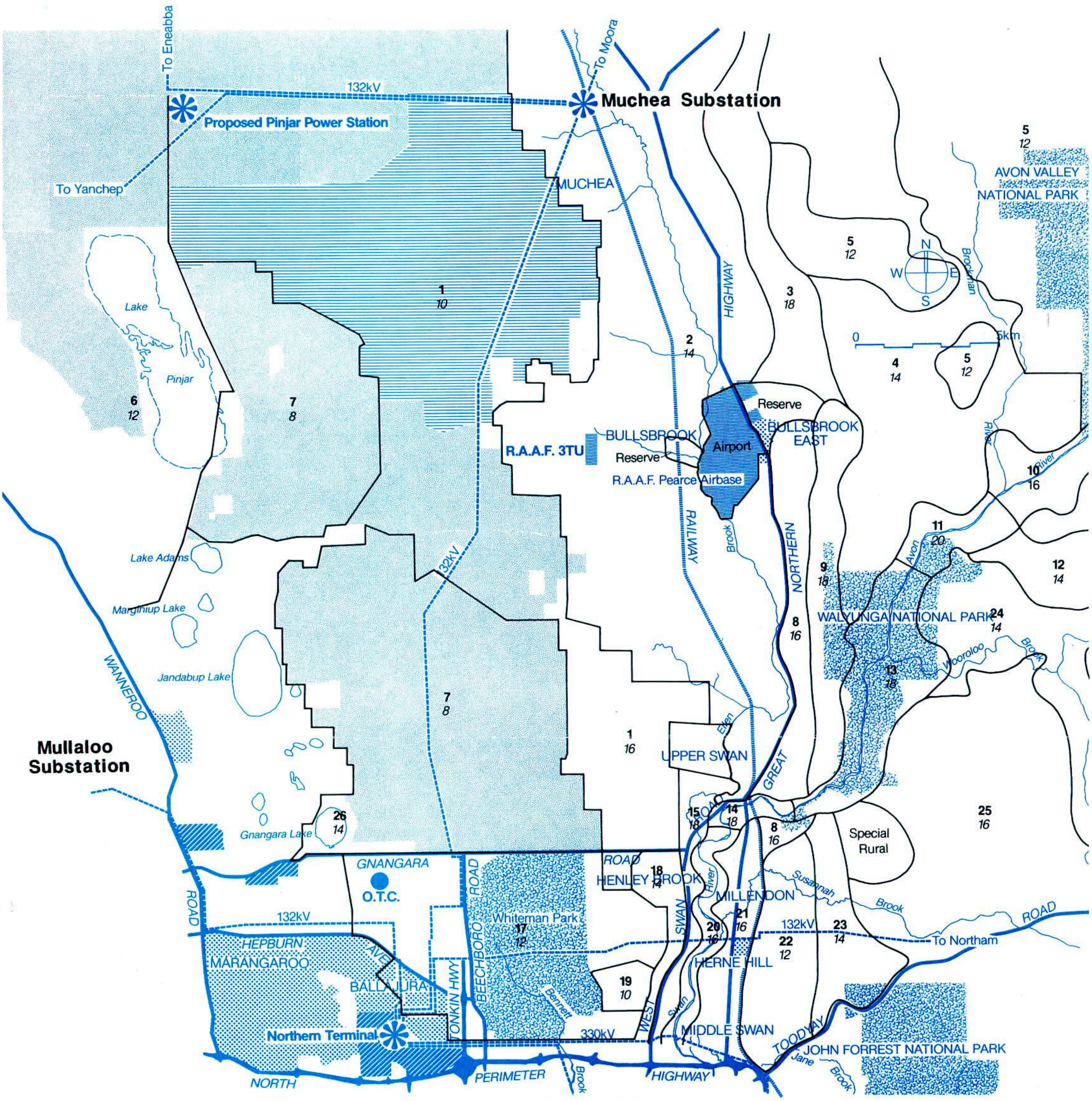
S.E.C.W.A. NORTHERN TERMINAL TO PINJAR TRANSMISSION LINE STUDY

K.A. ADAM & ASSOCIATES

December 1988

REGIONAL LANDFORMS AND SOILS

MAP 2



Legend	
Major Roads	State Forest
Existing Major Power Lines	Commonwealth Purposes
Existing Urban Zone (M.R.S.)	
Major Open Space (M.R.S.)	
Industrial Areas (M.R.S.)	

AREA DESCRIPTION

1 Cleared land, vegetation cover mixed.
2 Cleared rural land, largely clear with holdings of various sizes.
3 Escarpment north of Bullsbrook. Lower slopes cleared.
4 Variously cleared rural land on top of escarpment.
5 Uncleared native forest on top of escarpment.
6 Cleared, low lying land, thinly vegetated.
7 Pine plantation with dense cover.
8 Cleared land adjacent to highway at base of escarpment.
9 Escarpment south of Bullsbrook to Swan River. Lower slopes cleared.
10 Avon Gorge - low exposure.
11 Avon Gorge within viewshed of Walyunga lookout.
12 Cleared rural land, some tree cover along boundaries and road reserve.
13 Avon Gorge through Walyunga Park - high exposure.
14 Swan River Valley at Great Northern Highway crossing viewshed.
15 Cleared rural land between West Swan Road and Swan River.
16 Sand pits.
17 Semi cleared native vegetation (some regrowth).
18 Cleared land, some small holding and residential development.
19 Old Caversham airport - cleared, some regrowth, mainly derelict.
20 Swan River and margin vegetation.
21 Cleared land, mainly vineyards, between Swan River and Highway.
22 Mainly residential/special rural, quite dense development.
23 Escarpment Swan River to Toodyay Road.
24 Uncleared native forest.
25 Variously cleared land on top of escarpment.
26 Lake Gnangara and surrounding uncleared land.

LANDSCAPE QUALITY

18 - 20 Very High
14 - 16 High
10 - 12 Medium
0 - 8 Low

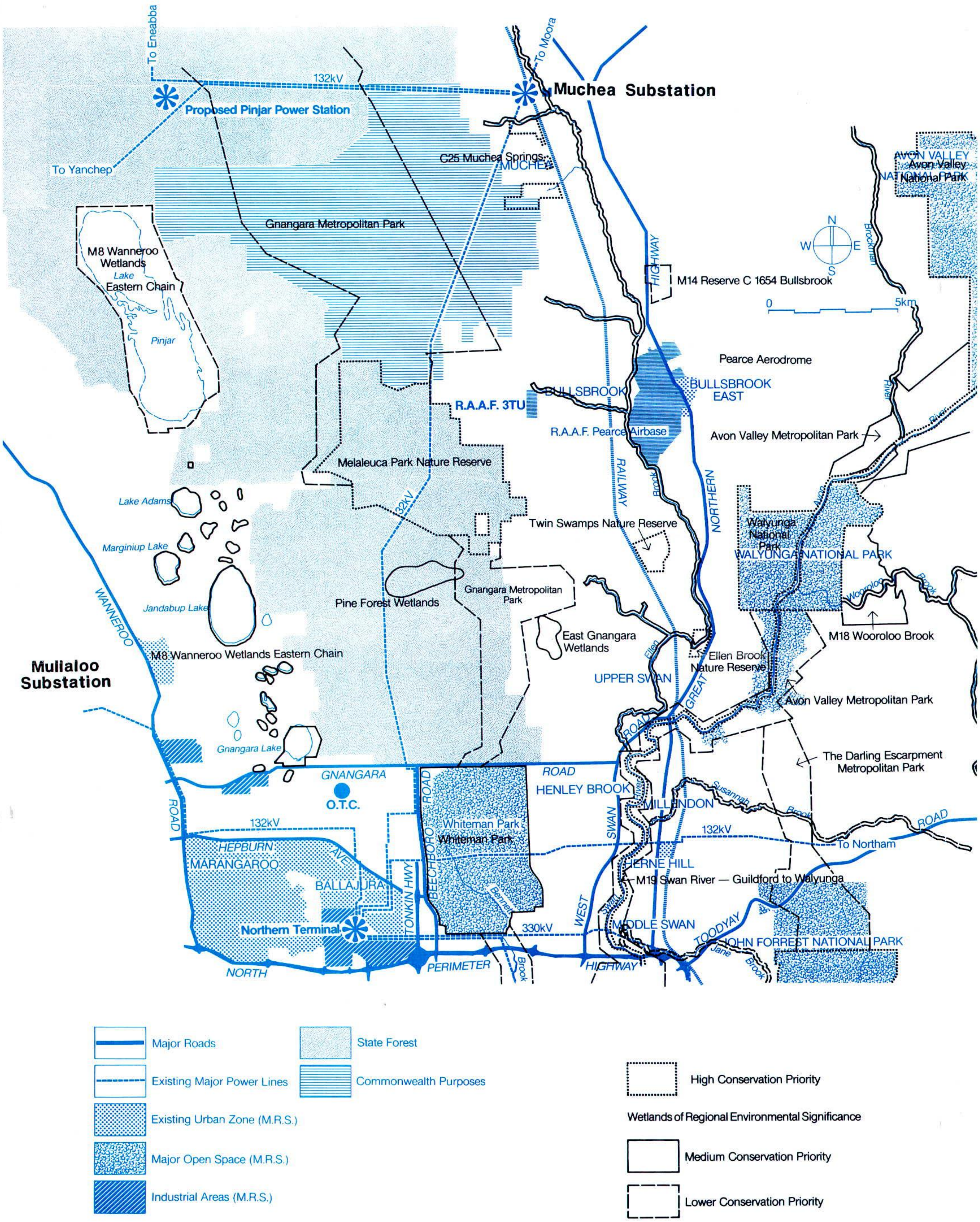
S.E.C.W.A. NORTHERN TERMINAL TO PINJAR TRANSMISSION LINE STUDY

K.A. ADAM & ASSOCIATES

December 1988

REGIONAL LANDSCAPES

MAP 3



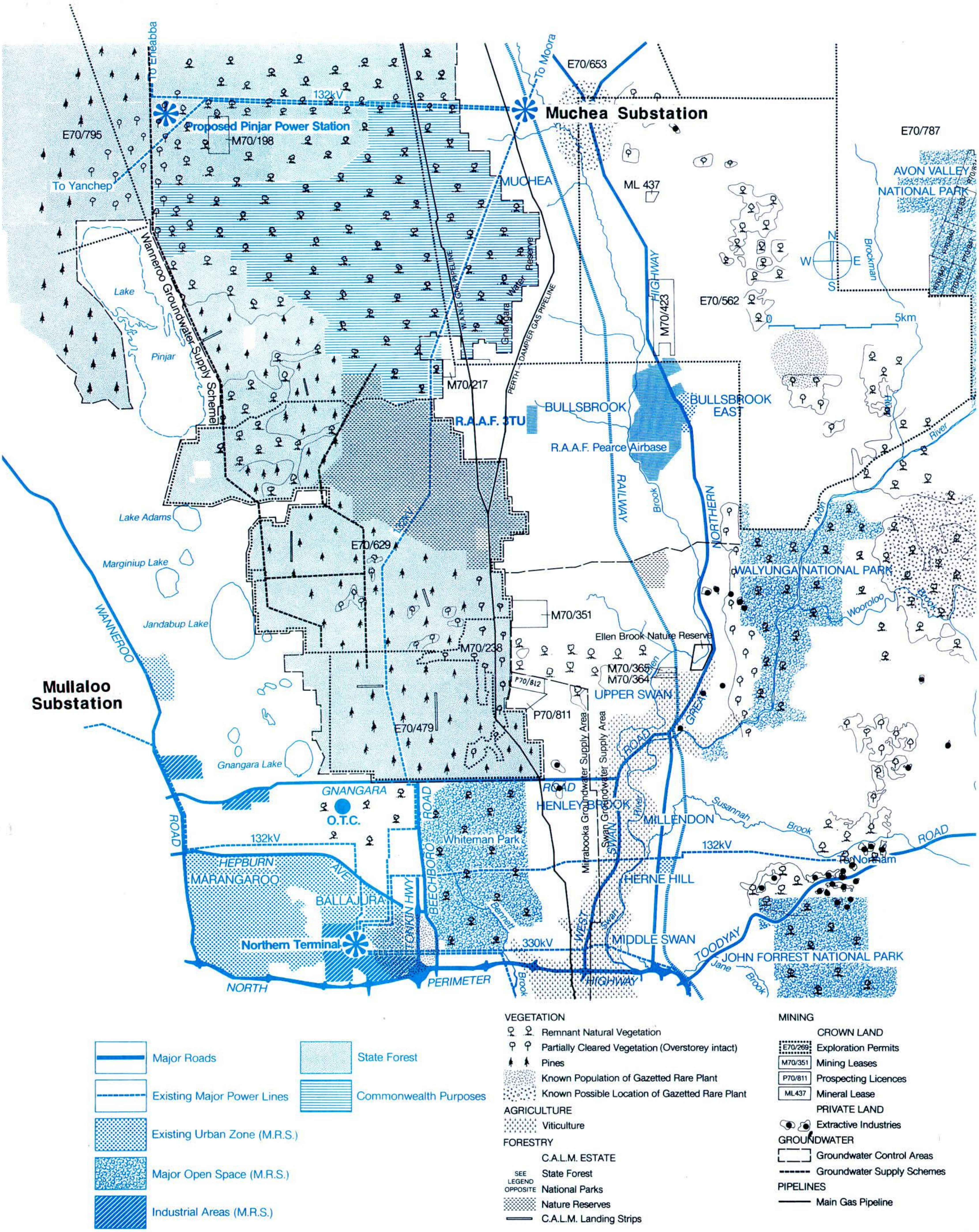
S.E.C.W.A. NORTHERN TERMINAL TO PINJAR TRANSMISSION LINE STUDY

K.A. ADAM & ASSOCIATES

December 1988

ECOLOGY AND CONSERVATION

MAP 4



S.E.C.W.A. NORTHERN TERMINAL TO PINJAR TRANSMISSION LINE STUDY

K.A. ADAM & ASSOCIATES

December 1988

VEGETATION, AGRICULTURE, FORESTRY AND MINING

MAP 5

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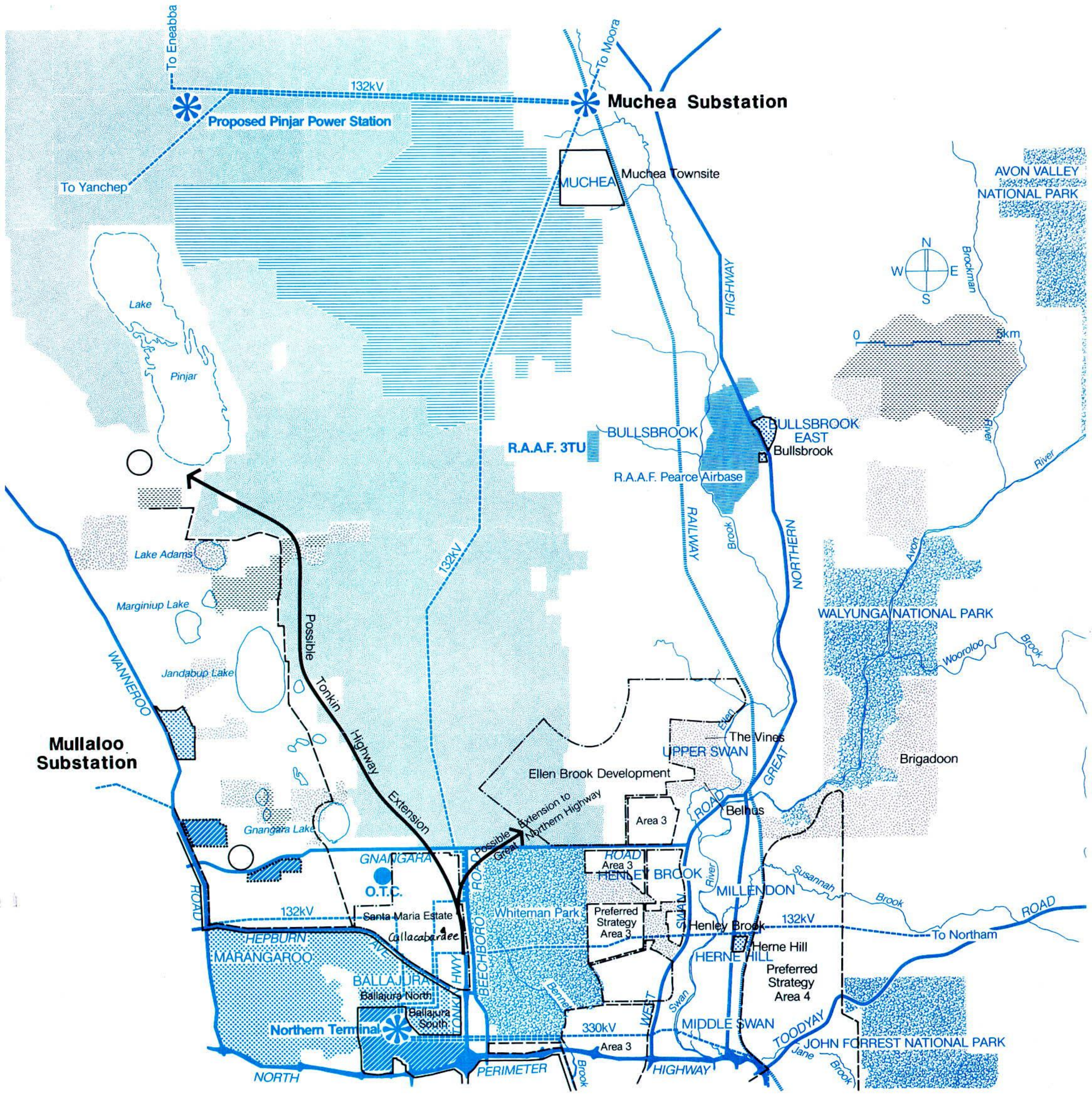


Legend	
Major Roads	State Forest
Existing Major Power Lines	Commonwealth Purposes
Existing Urban Zone (M.R.S.)	
Major Open Space (M.R.S.)	
Industrial Areas (M.R.S.)	

Existing Development
- Urban
- Industrial
- Rural Residential

Other Potential Development
- Urban
- Rural Residential

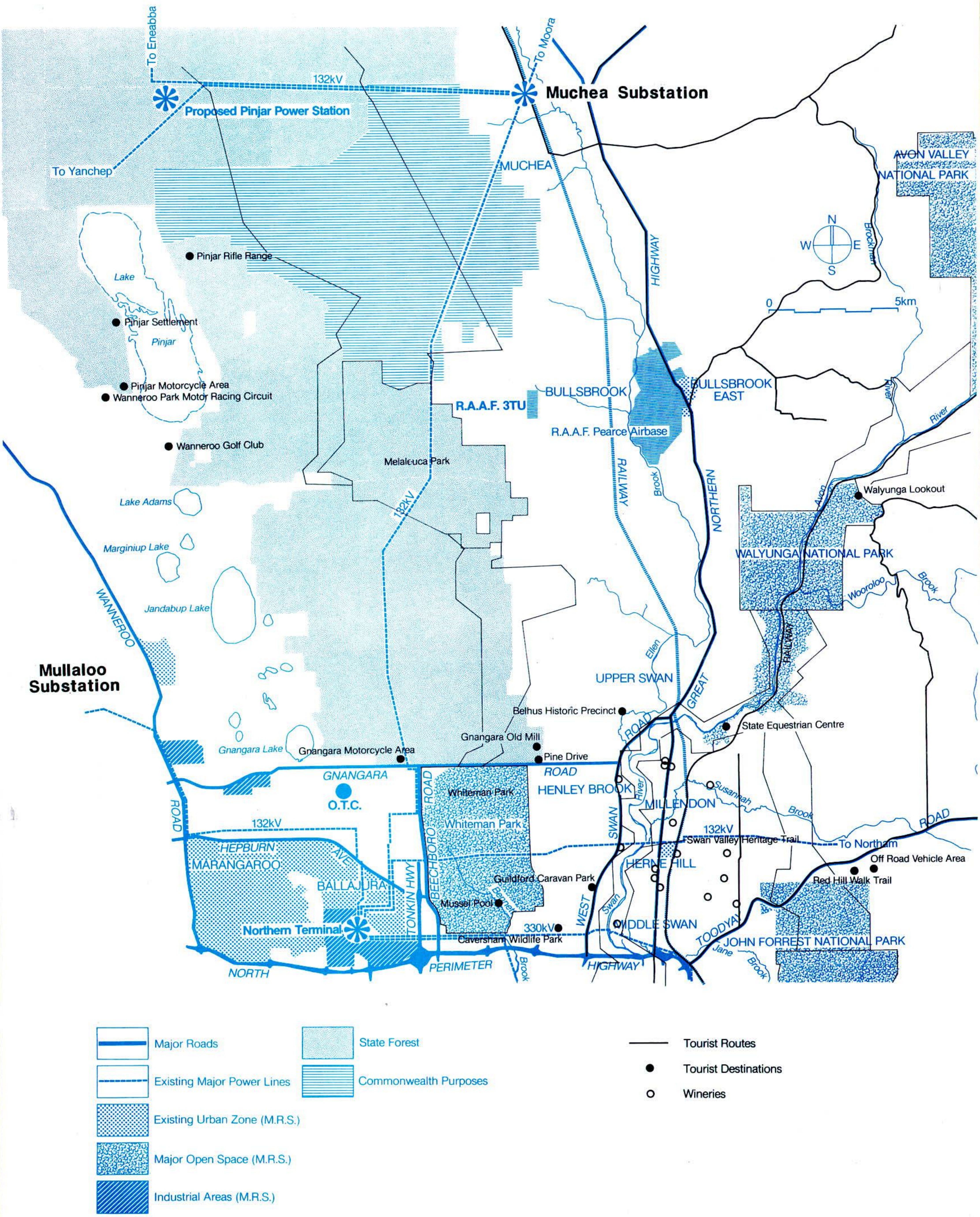
Preferred Strategy Proposals
- Proposed Future Urban Development Areas
- Major Industrial Area

S.E.C.W.A. NORTHERN TERMINAL TO PINJAR TRANSMISSION LINE STUDY

K.A. ADAM & ASSOCIATES December 1988

URBAN DEVELOPMENT

MAP 6



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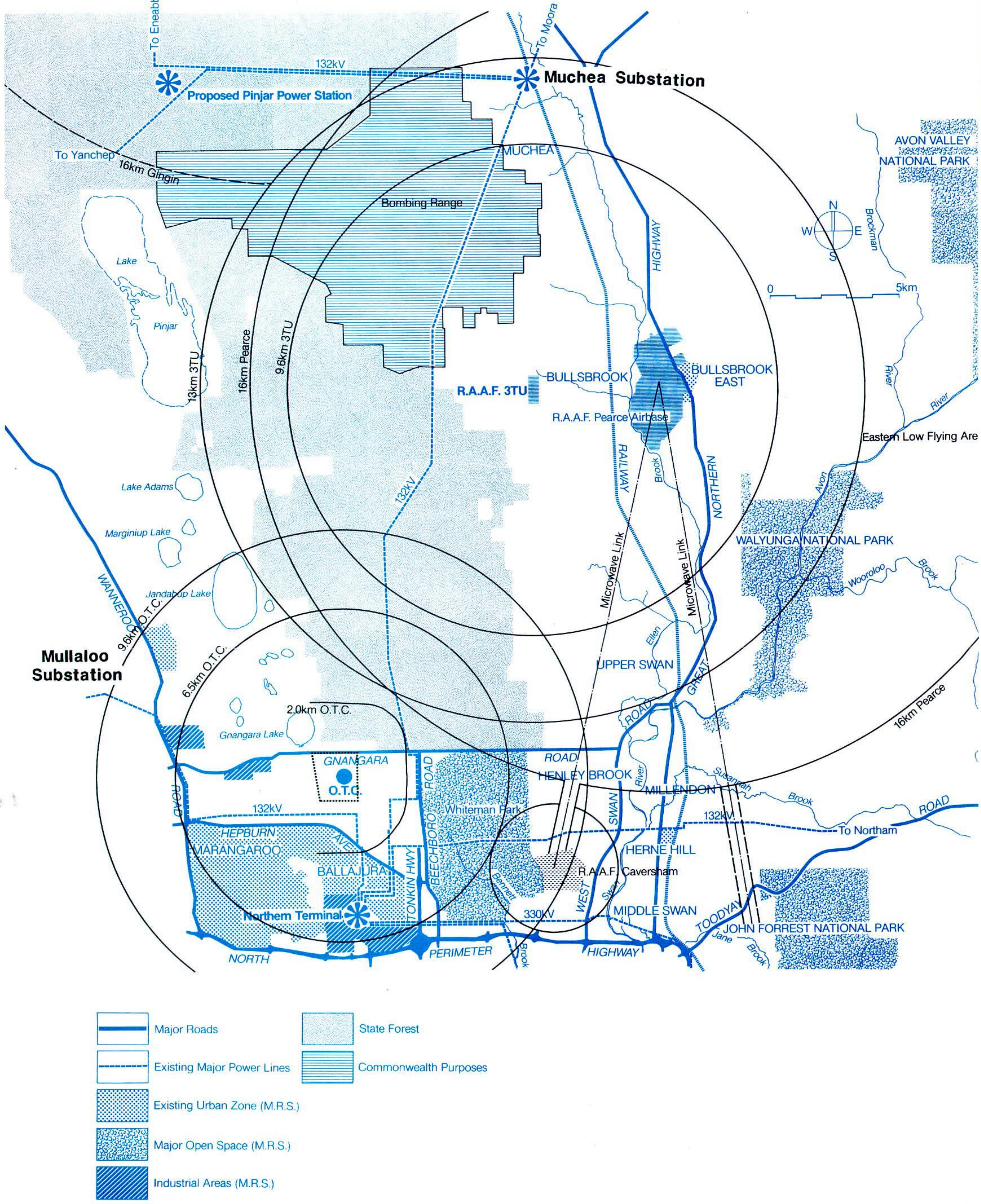
K.A. ADAM & ASSOCIATES December 1988

RECREATION AND TOURISM

MAP 7



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TRANSMISSION LINE STUDY

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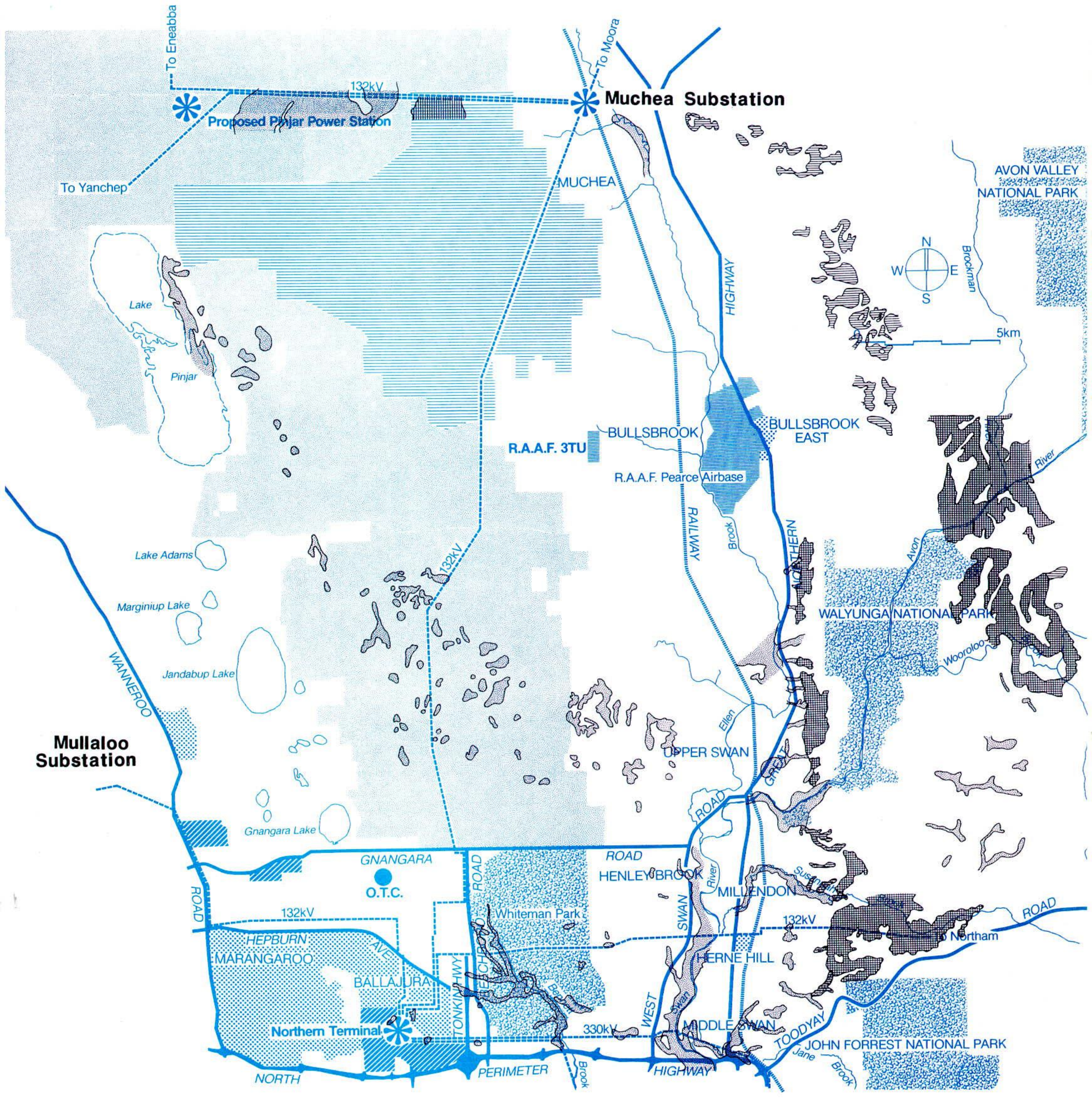
RADIOCOMMUNICATIONS AND
AIRCRAFT MOVEMENT

MAP 8



- Major Roads
- Existing Major Power Lines
- Existing Urban Zone (M.R.S.)
- Major Open Space (M.R.S.)
- Industrial Areas (M.R.S.)
- State Forest
- Commonwealth Purposes
- Water Erosion Risk
- Steep Slope Category
- Waterlogging/Inundation Risk

NOTE : Not comprehensive — applies only to Corridor Options, Map 10.

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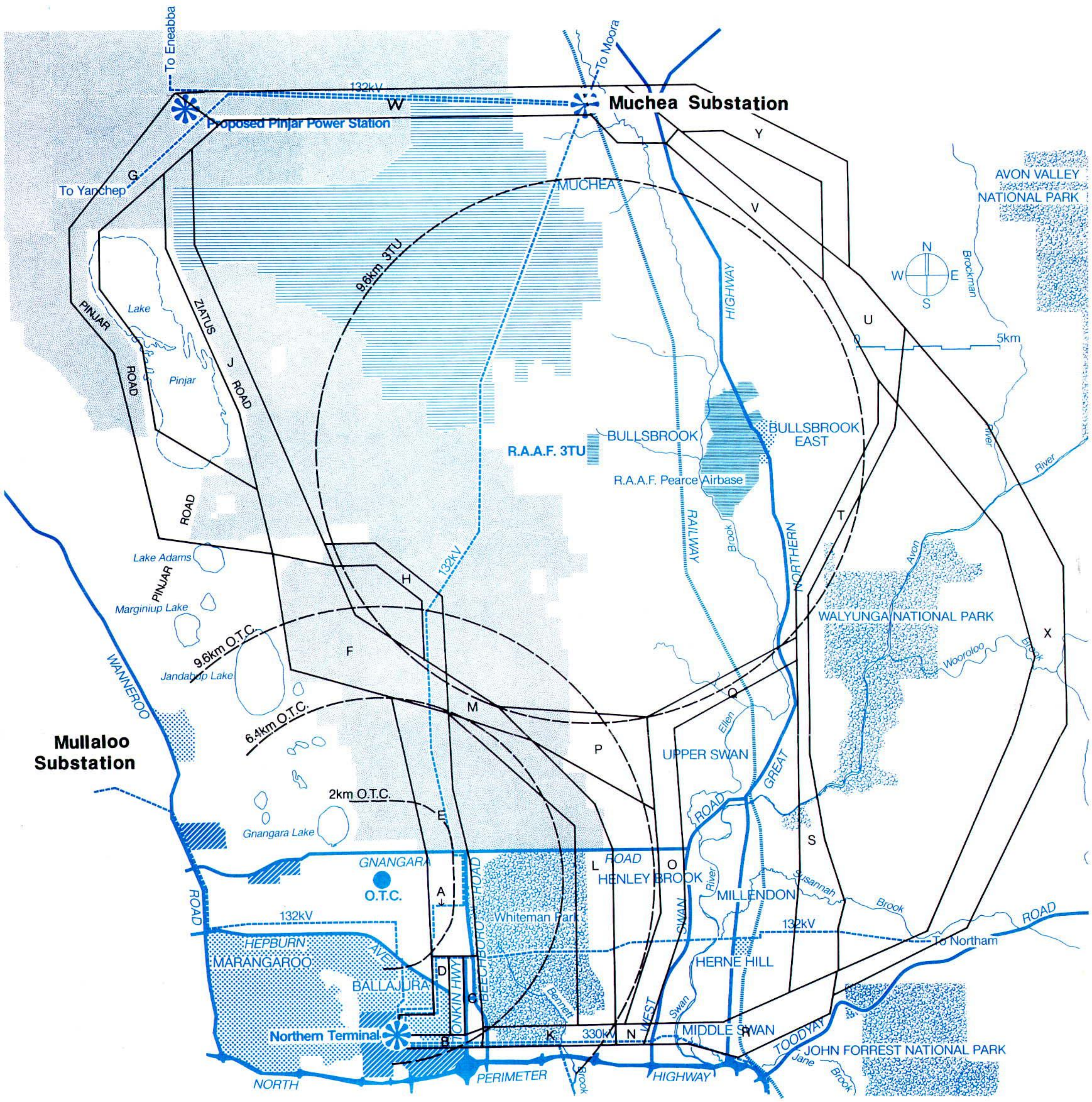
ENGINEERING CONSTRAINTS

MAP 9



- Major Roads
- Existing Major Power Lines
- Existing Urban Zone (M.R.S.)
- Major Open Space (M.R.S.)
- Industrial Areas (M.R.S.)
- State Forest
- Commonwealth Purposes

POTENTIAL CORRIDORS

Western Options

W1	AEFJ	37.4km
W1A	AEHJ	38.4
W1B	AEFG	41.9
W2	BCEFJ	37.5
W2A	BCEHJ	38.5
W2B	BCEFG	42.0
W3	BKLMFJ	44.5
W3B	BKLMFG	49.0
W4	DEFJ	36.5
W4B	DEFG	41.0
W5	BKNOPMFJ	49.5
W5B	BKNOPMFG	54.0

Eastern Options

E6	BKNOQTUVW	61.5km
E6A	BKNOQTUYW	63.0
E7	BKNRSTUVW	64.0
E7A	BKNRSTUYW	65.5
E8	BKNRXUVW	70.0
E8A	BKNRXUYW	71.5

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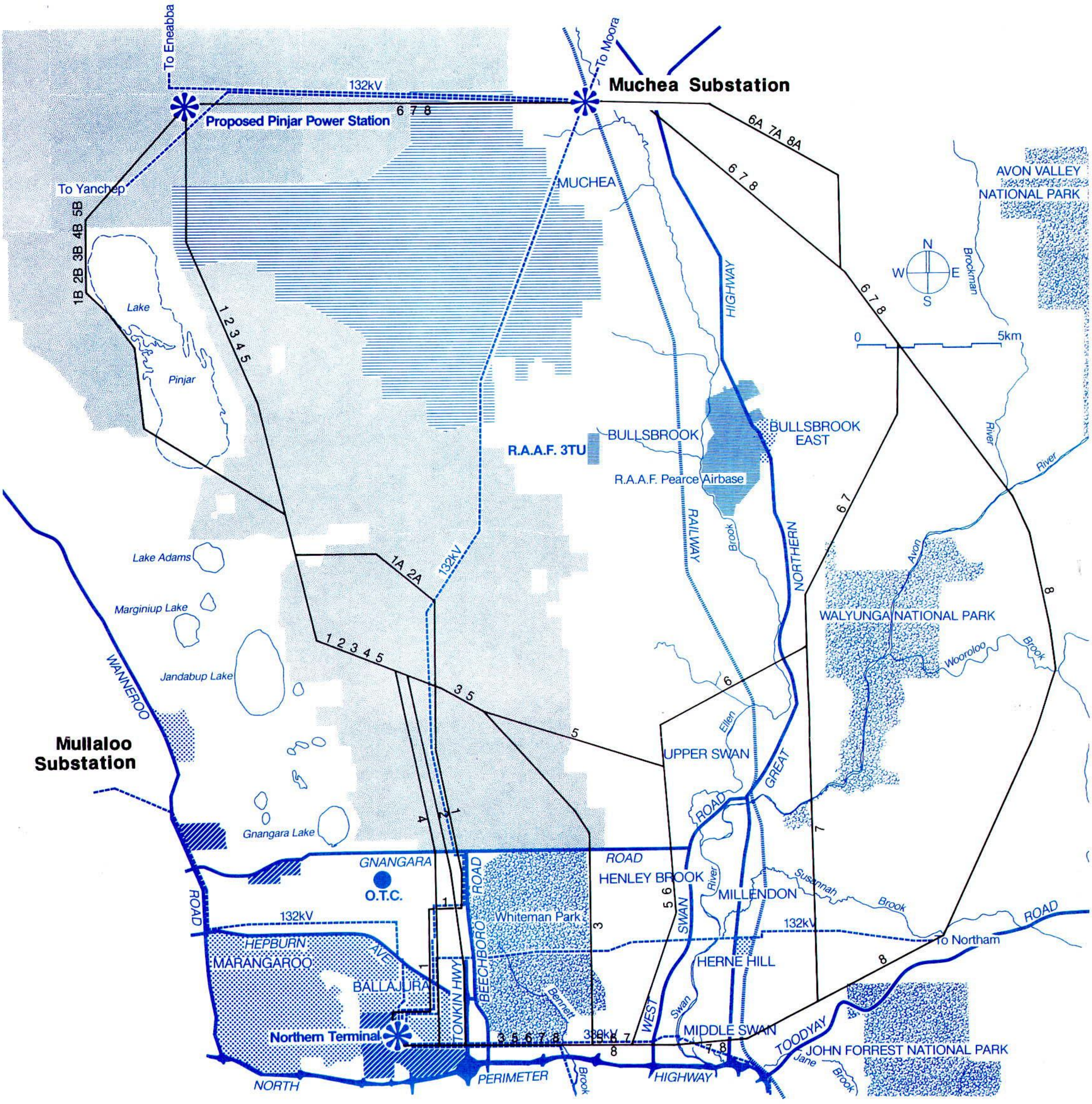
CORRIDOR OPTIONS

MAP 10



Major Roads	State Forest
Existing Major Power Lines	Commonwealth Purposes
Existing Urban Zone (M.R.S.)	
Major Open Space (M.R.S.)	
Industrial Areas (M.R.S.)	

Notional Potential Routes

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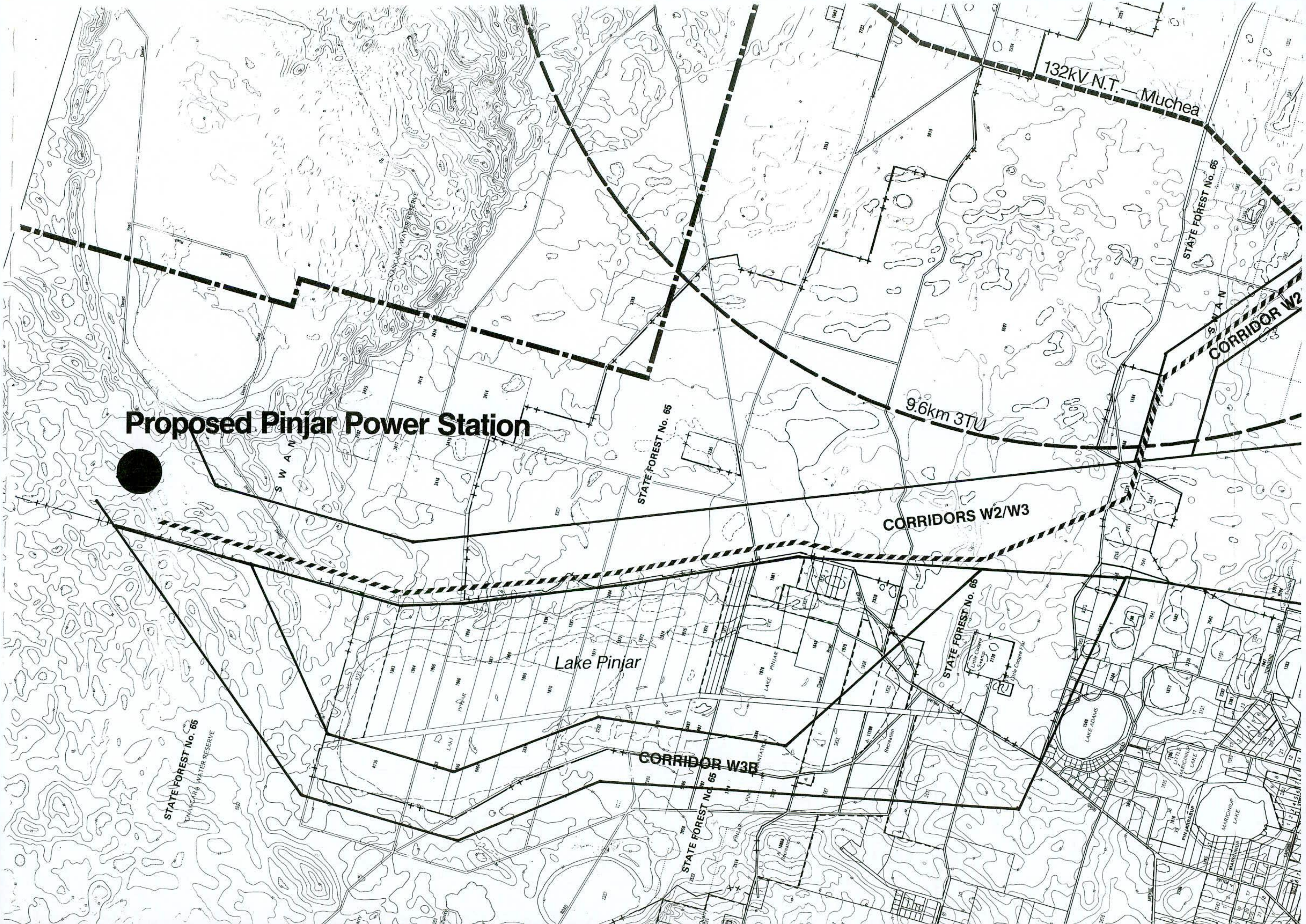
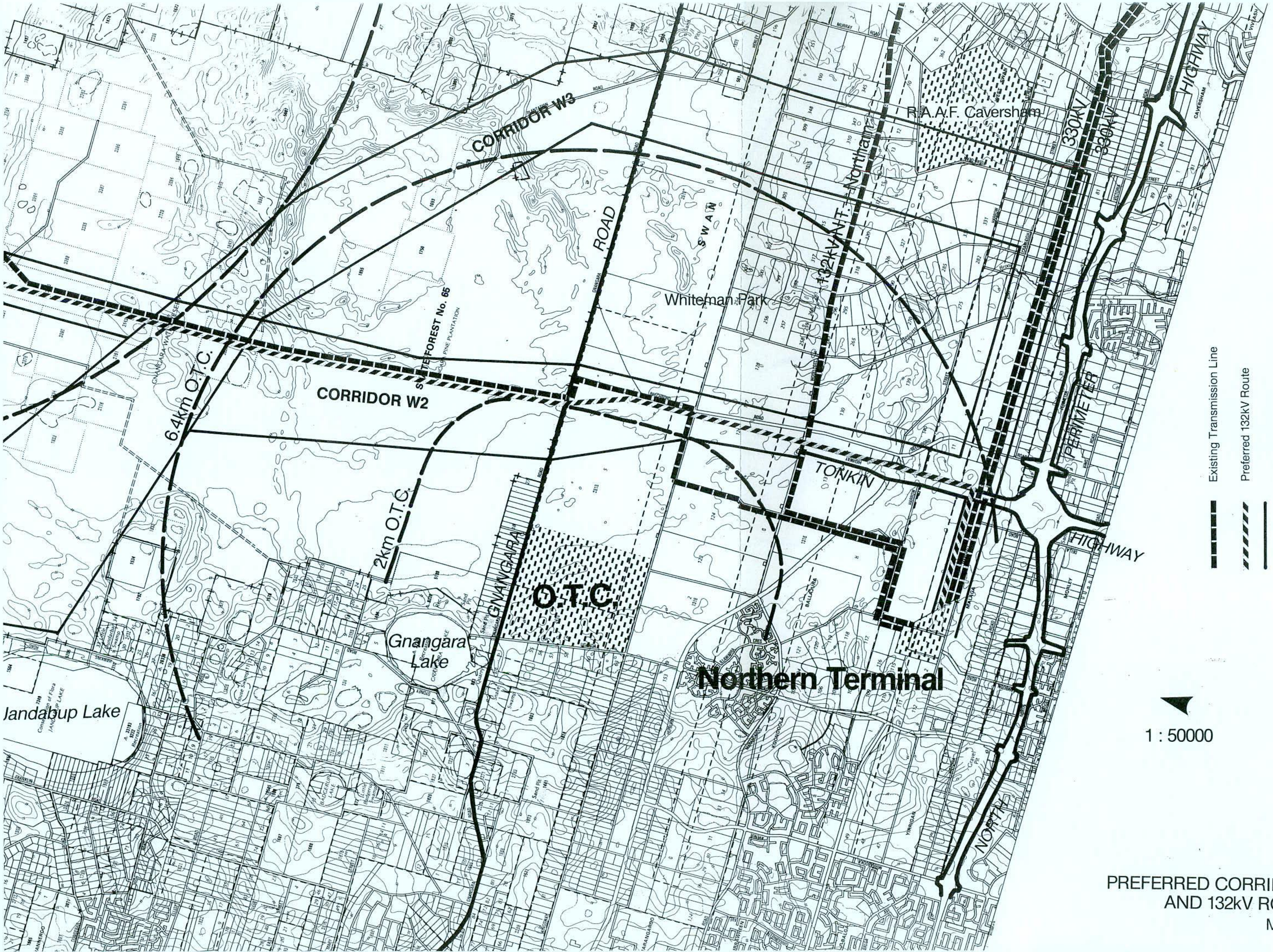
NOTIONAL ROUTES

MAP 11



Proposed Pinjar Power Station
132kV N.T. — Muchea
CORRIDOR W2
9.6km 3TU
CORRIDORS W2/W3
CORRIDOR W3B
Lake Pinjar
STATE FOREST No. 65
SWAN



PREFERRED CORRIDORS
AND 132kV ROUTE
MAP 12