ORIGIN AND DEVELOPMENT OF THE A.C.T. LAND SURVEYING SYSTEM

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Introduction

The land tenure and surveying system in the Australian Capital Territory has attracted some attention in recent years with the growth in importance of land use and survey co-ordination. It is interesing, therefore, to examine the history of the A.C.T. land tenure and the development of the land surveying system particularly against the background of rapid urban growth which has occurred in recent years.

Land Tenure

2. The Book of Leviticus in dealing with property redemption for the tribe of Levi says:

> "The land shall not be sold in perpetuity; for the land is mine, and, you are but aliens who have become my tenants. Therefore, in every part of the country that you occupy, you must permit the land to be redeemed.".

3. The Seat of Government (Administration) Act 1910-1972 takes a somewhat similar approach in Section 9 which states:

> "The Crown land shall not be sold or disposed of for any estate in freehold . . . ".

This clause, then, provides the legislative basis for the leasehold system in the Territory.

4. The question often asked is "why a leasehold system?". To find the answer one should examine the comments of Federal Parliamentarians in the early 1900s. However, the short answer would be that the leasehold system provides an effective control over land use, it limits the opportunity for speculation in land and ensures that appreciation in land values over the longer term will benefit the nation as a whole.

5. However, the Commonwealth did not acquire the freehold interest in all the land in the Territory at the time the area was ceded by New South Wales. Some 492 square miles of the 910 square mile territory remained under freehold title after acceptance by the Commonwealth. This area was mainly in the southern section of the Territory and therefore, not required immediately for urban development.

6. As Canberra itself developed, land has been progressively acquired for urban, institutional and recreational purposes. At the present time only ~~100~~ 70 square miles are held under freehold. Of the remainder, 393 square miles are held under leasehold for a variety of rural uses and 302 square miles remain as unleased Commonwealth land and used for purposes such as water storage, forestry, recreation, etc. The balance of 115 square miles comprises the Canberra City District.

7. The plan of Canberra was originally based on Walter Burley Griffin's design which catered for an expected population of 25,000 with provision for expansion up to 75,000. The city has been constructed substantially according to the broad outline of the original design but with the increase in population, not provided for in the Griffin plan, the City District has expanded beyond the limits of the original design.

8. Provision to vary the City plan is contained in the Seat of Government (Administration) Act 1910-1972 which requires gazettal of the "plan of layout of the City of Canberra". Before any modification can be made, whether it be an alteration of the original design or the addition of new features, the variation has to be approved by the Minister for the Interior and tabled in Parliament for a statutory period.

9. Land in the City District is leased for purposes such as residential, business, special uses, etc. Leases are granted for terms up to 99 years depending on the purpose of the lease. Residential leases are for 99 year terms. Because the land tenure system in the Territory is different from that in New South Wales there was a need to develop a new code of land tenure. This code has been developed under four leasing Ordinances:

City Area Leases Ordinance 1936-1971
Leases Ordinance 1918-1966
Leases (Special Purposes) Ordinance 1925-1971
Church Lands Leases Ordinance 1924-1966.

10. The code is not entirely radical and not traditional either.(1) However, despite criticisms and difficulties in adjustment to changing commercial and social requirements it has served the Territory well and can be said broadly to have achieved the aims of its originators.

History of the Territorial Survey System

11. The early history of the New South Wales Trigonometrical Survey is well documented.(2) Its original purpose is somewhat similar to that of the A.C.T. system of survey control. In early New South Wales, settlers took up land in isolated areas and no continuous survey could be made between grants; roads and public works were delayed due to the lack of maps which could not be prepared in the absence of a trigonometrical or control survey; the Sydney Gazette of the day commented, "A general survey is an indispensable requisite for the satisfactory location of grants, the division of the Colony and the construction of public works". The subsequent Trigonometrical Survey of New South Wales and the development of its surveying system through to integration is, in itself, an interesting study.

12. In the same way, the planning and development of a city such as Canberra demands a co-ordinated survey system if all aspects of development are to proceed in an orderly fashion. The design and construction of arterial road systems, water supply, residential and commercial development often occur in areas separated from existing development as each part of the pattern falls into place. The need for survey co-ordination and control was appreciated at the outset and, although the pattern of development has modified the survey system in the Territory over the years, the essential concept of a co-ordinated survey system remains. The development of the control system in the Territory is described elsewhere.(3) However, a brief account of its history is useful in a paper such as this.

13. The original Canberra plan provided for the initial development to take place in the Inner Canberra area. Subsequent expansion of the city has seen the development of satellite areas at Woden, Weston, Belconnen and Tuggeranong. The accompanying map at Annexure A shows the location of these and other areas planned for urban development.

14. Initially, the control for the city area consisted of a system of radial lines following the major city thoroughfares. This system was connected to the N.S.W. trigonometrical chain and was surveyed to a remarkable degree of accuracy by the early surveyors. It was re-surveyed during the 1950's and is still being used today as the basic control for the Inner Canberra area.

15. The system, however, suffered from two major defects. It was very effective where the plan was characterised by long straight major roads. As planning concepts changed with neighbourhood designing, and development became more influenced by topography, the pattern of main thoroughfares altered and the traditional broad straight avenues disappeared to be replaced by thoroughfares less suited to use as lines of control.

16. Additionally, the radial system did not necessarily provide control between the radial lines. As the city spread, the distance between radials increased and the co-ordination of surveys in isolated sections of the city became more difficult. As measuring techniques improved, some inconsistencies appeared due to propagation of small errors from the centre of the system towards the perimeter.

17. The spread of the city from the Inner Canberra area to the Woden Valley provided the opportunity to develop a system of survey control more suited to the changing concepts of urban development. This con-

sisted basically of a triangulated network with lines of approximately one mile. All angles were observed and selected lines measured with a geodimeter. Additional control marks were placed at intervals of 1,500-2,000 feet along the lines.

18. This system was an improvement on the original radial system but it too suffered from two defects. Firstly, it relied too heavily on angular measurement and tended to produce accumulated errors beyond the desired limits.(4) It also left areas towards the centre of each triangle without the control necessary for accurate co-ordination of construction and subdivision surveys.

19. It was then realised that future development of satellite areas should be preceded by an accurate system of major control broken down into a secondary system which in turn could be broken down a stage further to provide co-ordination for residential construction and subdivision surveys. These levels of control are referred to locally as:—

(a) major control;
(b) sectional control; and
(c) neighbourhood control or standard traversing.

The network of major control is illustrated in Annexure B.

The Present Control System

20. In the major control network, the stations have been carefully selected at intervals of approximately five to six miles, to give the best geometry economically attainable. Attention has also been given to the profiles of the lines to minimise the effects of atmospheric anomalies on observations of angles and distances. In this level of control, all angles and distances are measured and azimuth is controlled using La Place stations at about 10 mile intervals. Although angles and azimuths are observed on one night only and distances are observed from one end only, the final accuracy attained is 1:250,000. The azimuth can be computed between La Place stations using observed data and, without exception, the agreement is better than one second of arc.

21. Sectional control aims to break the major work down to a useable ½ mile interval. Attention is still given to the geometry to ensure a good "fix" of each point. Care is taken to ensure a large number of redundancies. Prior to the advent of the infra-red, short range E.D.M., this control was carried out using triangulation strengthened by E.D.M. traverses. Scale and azimuth were controlled primarily by integrating the sectional control net with a small figure from the major control network. An accuracy of 1:100,000 was achieved using this technique.

22. Now that precise, short range E.D.M. equipment is readily available, a system of trilateration strengthened by angular traverses is being used. The accuracy of this technique appears to be of the order of 1:150,000. I would hazard a guess that the increase in accuracy obtained by this method is derived from the use of infra-red equipment which is affected less by atmospheric changes than is visible light.

23. The alternative name for neighbourhood control, standard traversing, suggests the technique used here. For many years this work was carried out using a one-second theodolite and steel wire to run traverses between the sectional control marks. However, E.D.M. equipment is now being used with results comparable with steel chaining.

24. It is the intention of this exercise to fix a control mark within 100 feet of every intersection point and major tangent point in a neighbourhood or suburb. These control marks are placed some 15 feet behind the future property line so as to be safe during the construction of engineering services within a neighbourhood. They form the framework of the suburb on which every subsequent survey up to final subdivision rests. For this reason they are accurately traversed and the final result is in the order of 1:50,000.

25. As can be seen from the above description, a large amount of survey control is established in each area before any cadastral or engineering survey takes place. The benefits derived from this are apparent in the control of topographic surveys for planning purposes prior to development. They also appear at the stage of surveys for construction. Large contracts are let in this field for the construction of roads, kerbs, hydraulic services, etc. Speed and accuracy in set-out are essential and using the above system makes them both possible. Several survey parties can be working simultaneously in an area confident that where they meet there will be no hiatus. Errors in field work are detected quickly and easily rectified as the average distance between control marks is only 350 feet.

Adjustment to Australian Geodetic Datum

26. The survey of the major control commenced during the early 60's using Clarke's 1858 figure. In 1970 the network was re-adjusted using the Australian Geoid figure and the Mt. Stromlo co-ordinates obtained from the 1966 adjustment of the Australian Geodetic Survey. This adjustment of the major control was carried out as a free adjustment and did not adopt values of adjoining geodetic stations due to the differing standards of measurement between the Territorial control and the Australian Geodetic Survey.

27. The adjustment of the Territorial control to the Australian Geodetic Datum was examined during 1971. It was decided that if the Territorial system was to be adjusted to the Australian Geodetic Datum, further connections to the adjoining N.S.W. network should be measured using Model 8 Geodimeters and additional La Place stations observed. It was recognised that, if the standard accuracy of the major control was to be maintained over the Territory and environs, there would have to be a buffer zone between this area and that part of N.S.W. covered by the 1966 adjustment in which the discrepancies caused through the different standards could be adjusted.

28. A programme of observation, measurement and adjustment was drawn up and carried out jointly by the Survey Branch and the Division of National Mapping. All field work has now been completed and the re-adjustment of the major control is now (August 1972) in progress.

29. Similarly, the Territorial level network, which consists of loops of second and third order levels, has been adjusted and connected to the Australian Height Datum.

Use of the Transverse Mercator Projection

30. Historically, the Territorial survey system was based on rectangular co-ordinates. The re-adjustment of the major control and the conversion to metric units provided a good opportunity to review the suitability of the present system against the Territory's future needs and the trend to co-ordinated and integrated survey systems.

31. After a thorough investigation, it was decided to retain the existing Transverse Mercator projection with some modifications.

32. The following are the features of the projection:

Projection	: Transverse Mercator
Longitude of Origin	: Mt. Stromlo Trig. as determined by the 1966 A.G.D. Adjustment
Latitude of Origin	: 0° (the equator)
Unit of Length and Height	: Metre
False Origin for Co-ordinates	
Eastings	: 200,000 metres west of Mt. Stromlo Trig.
Northings	: 600,000 metres south of Mt. Stromlo Trig.
Scale Factor at Central Meridian	: 1.000086

33. The scale factor at the central meridian is a combination of the central scale factor of the projection (.99999) and the sea level factor of 1.000096 applied at the central meridian so that the level datum of the projection is raised to 610 metres (formerly 2,000 feet).

Summary

34. This, then, is the base on which the A.C.T. survey system rests. At the present time, all subdivisions in the Canberra City District are tied to the major control through the network of standard traverses and

secondary control. Other surveys for design and construction can also be connected to this control. It would seem that, on this basis, the city has a co-ordinated survey system of exceptionally high precision. However, much remains to be done before this state is reached.

35. As I have explained earlier, two control systems, namely, the radial and triangulation system, were used before the present overall system was conceived. In some respects we had worked from the part to the whole, at least in so far as the Inner Canberra and Woden areas were concerned.

36. The task which now remains is to tie these two areas to the major control. I say task because it is known that small errors propagated in both systems have generated co-ordinates which differ from those now obtained from the major control system. This, in spite of the fact that both systems derive from the same origin and datum. In the case of the Woden area, the integration of the existing co-ordinates with the new system can probably be achieved through recalculation and some re-measurement. In the Inner Canberra area, however, much re-measurement and re-observation is required firstly to upgrade the standard of the measurement of the existing control to that obtained using modern E.D.M. equipment. The control would then need to be re-computed and adjusted to the adjoining major control. A programme for the re-adjustment of control in both the Woden and Inner City areas is being examined at the moment.

37. Historically, whilst the A.C.T. land surveying system has always relied on a co-ordinated control, parcel corners are not usually defined by co-ordinates. In the original subdivision of urban sections, the street intersections are usually fixed by radiation from the standard traverse. The sections which are pre-computed are then subdivided using traditional surveys by metes and bounds and including connections to and comparisons of azimuth with adjoining surveys. Sufficient permanent and reference marks are placed to facilitate re-definition which, once again, is carried out using traditional principles such as monuments, measurements, etc. Apart from the pre-computing of subdivisions, which is possible with the present control, the surveying techniques and principles are much the same as those throughout Australia.

38. An alternative to the present method is the definition and re-definition of parcel corners by co-ordinates. Although some thought is being given to the matter, greater priority is being given to the question of establishment and survey of co-ordination marks after construction in order to simplify re-definition of section corners. Provision of survey co-ordination marks, averaging say two to three for each section, will also allow all subsequent surveys to be readily co-ordinated.

Influence of Urban Design and Land Administration

39. The sequence of urban design and development has had an important influence on the evolution of the survey control system. For instance, large scale topographical plans are required by the National Capital Development Commission for their planning and design studies. These plans must be on the same co-ordinate datum as subsequent development. It is therefore necessary that the major and secondary control systems be established ahead of the topographical survey in order to provide the co-ordinate datum and to facilitate the establishment of field control for photogrammetric mapping.

40. Similarly, the policy of constructing all engineering services in urban areas prior to building, means that subdivision is delayed until the bulk of site disturbance is over. The survey marks placed in the course of subdividing are therefore less subject to disturbance than commonly occurs in other areas. This is not to say that reference and permanent marks always remain; nevertheless, I suspect that they have a higher preservation rate than most areas of urban development.

41. Most importantly, the planning and development of the Territory commit the Commonwealth to a survey system which will provide co-ordination for every purpose from design and construction through to land administration.

42. The pattern of urban design and development has, therefore, been important in the evolution of the Territorial survey system. Has the leasehold system of land tenure had any fundamental influence on the survey system? Judged by the present methods the answer is no. As I have mentioned earlier, the principles of defining or re-defining land boundaries in the Territory are not significantly different from those which operate elsewhere in Australia. Under the present system, definition by co-ordinates could be readily introduced into the Territory if it is thought necessary. One could conclude that in Australia, at least, the survey systems are influenced less by the land tenure system than by other factors such as land values, traditional methods, available survey equipment and techniques, etc.

Conclusion

43. The survey system in the Territory is not put forward as the ultimate system for use in all circumstances. Nor do we pretend that it is a perfect system. Indeed, it suffers from some of the weaknesses of other systems. However, it does give a fundamental system of control and co-ordination without which the present rapid and ordered development of Canberra would not be possible. From this point of view the principles of the system are worth considering by any organisation confronted with similar problems.

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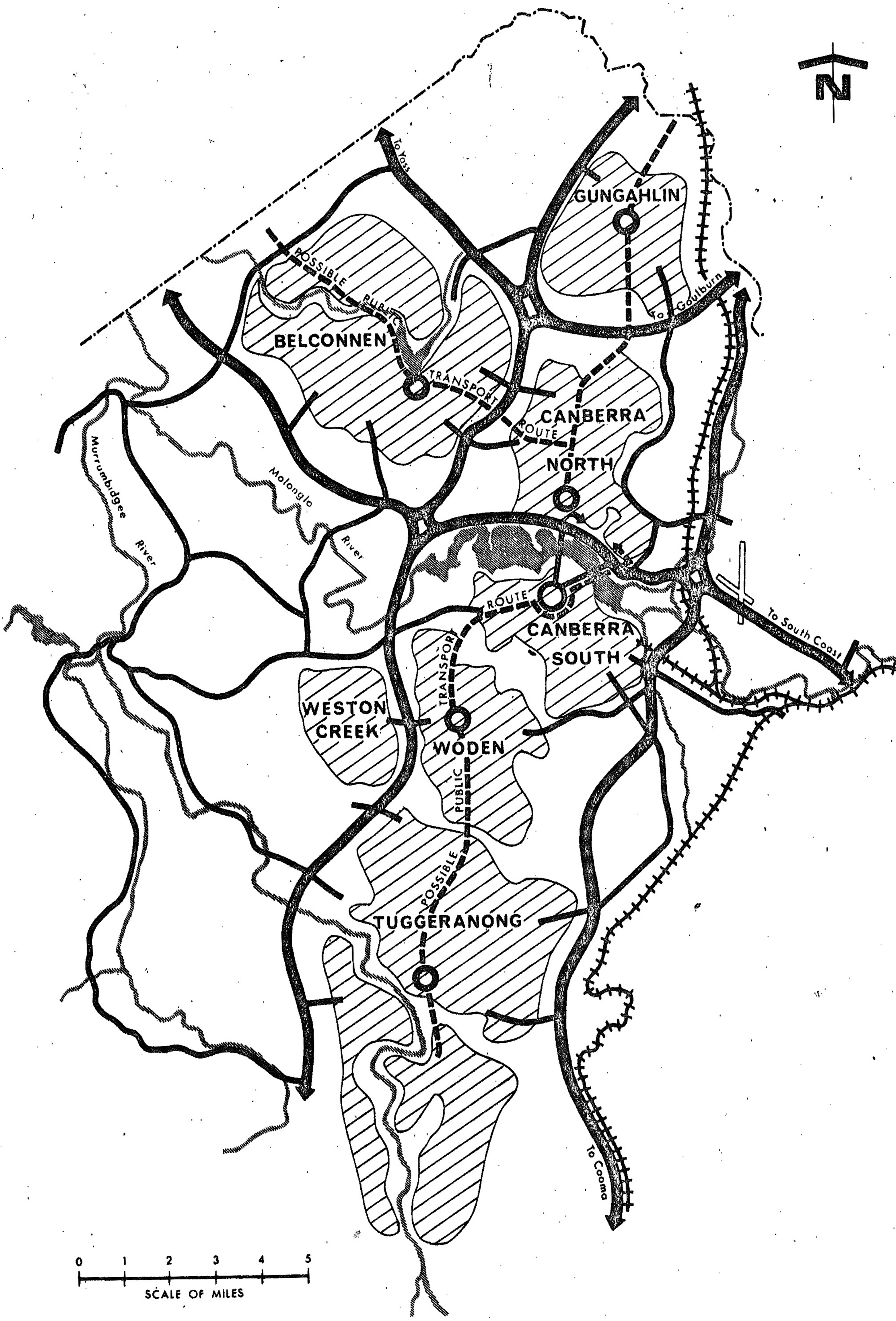
STRATEGY PLAN FOR METROPOLITAN GROWTH



AUSTRALIAN CAPITAL TERRITORY

HORIZONTAL CONTROL