MANUAL

of the

NEW SOUTH WALES INTEGRATED SURVEY GRID

NEW SOUTH WALES
DEPARTMENT OF LANDS,
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PREFACE

The introduction of the Integrated Survey Grid (I.S.G.), as the first comprehensive system of survey in this State, has not been without difficulty. The initial representations for the introduction of a co-ordinated statewide system commenced in the last century. Spasmodic attempts have been made throughout the years to introduce a proper system of survey. The Survey Co-ordination Act, 1949 was the first positive step towards the establishment of control surveys and connection to the Trigonometrical Survey. It is unfortunate that so little progress was made in implementing the provisions of this Act.

The first positive move towards the establishment of a modern and comprehensive system followed a request by the Institution of Surveyors, Australia, New South Wales Division at the instigation of the President, Mr I. C. Booth. With ministerial approval, a committee of investigation was established in 1968 to investigate and report on the introduction of an Integrated Survey System. The committee comprised the Registrar General and representatives of his Department, the chief or principal surveyors of twelve government departments and instrumentalities involved in surveying and representatives of the N.S.W. Division of the Institution and Universities of Sydney and New South Wales under the chairmanship of the Surveyor General. The committee was also assisted by numerous technical experts.

The committee undertook a detailed study, including investigation of overseas practices, particularly where similar changes had been introduced in recent years. Quite a number of the committee members had the benefit of experience in various survey systems in other countries. The committee reported to the Minister for Lands in July, 1969, and, in January, 1970, the Government approved the introduction of an Integrated Survey System and authorized the Surveyor General to commence the marking and control surveys and prepare draft legislation.

In November, 1971, the profession undertook the "Sydney Pilot Survey" in which a survey to establish some sixty-six control points, located in the commercial heart of Sydney, was undertaken by eighteen separate survey parties. This one-day exercise was designed to demonstrate the machinery and potential of integration. As the report indicated, it was successful in every way.

A recommendation for draft legislation was furnished to the Minister for Lands in April, 1972, and a copy of the draft provided to the Institution of Surveyors. Due to various representations, the Minister of Lands arranged for Sir John Overall to conduct a public inquiry to determine whether a more sophisticated system of survey was necessary and for report generally on the merits of the recommendations of the Investigation Committee.

Sir John Overall, in a report of August, 1974, recommended that the Integrated Survey System be introduced "forthwith" and that basic control be established in the urban and developing areas of the State in the first 5 years and in the other areas in the following 5 years.

A revised draft Bill has since been prepared on the lines recommended by Sir John Overall and it is hoped that it will be introduced in Parliament at an early date.

The Investigating Committee considered that the advantages to the State in establishing an Integrated System of survey can be summarized as:

(1) The establishment of one correlated system for all surveys.

(2) The system will provide a more positive basis for land titles and allow easier and less costly redefinition of these boundaries in the future.

(3) Abundant basic control for all mapping, surveys and compilation of cadastral maps and plans would be available.

(4) Adequate control for photogrammetric plotting at all scales.

(5) All data will be on one correlated system. This will greatly assist the collection of basic data for engineering, general investigation, design and planning. It will also avoid a considerable number of field surveys which are necessary at present to assemble this basic data.

(6) The system will establish adequate standards of accuracy for all types of survey.

(7) The system will provide control data in a form which can readily be converted to any unit of measurement.

(8) The system is most adaptable to electronic data processing, storage and plotting and is far superior to the existing method in this regard.

(9) More standard computation techniques will be possible and this will facilitate data processing and console services.

(10) The system will ensure the gradual accumulation of related survey data for the establishment of a technical data bank.

(11) Considerable savings in the cost of surveys will follow, particularly in:
  (a) normal property surveys,
  (b) prompt supply of existing data,
  (c) availability of control for mapping.

(12) The cost of the basic survey will be more than offset by the savings in the future.

The cost-benefit study published in Sir John Overall's report supports the latter claim.

So many people have been involved in these proposals, the compilation of mathematical tables, preparation, and review of this manual and generally in discussing and fostering integration, that it would be almost impossible to accurately record and acknowledge all efforts. There have been, of course, many outstanding contributions and it is felt that these are generally well known and already recognized.

The profession and the people of this State owe a great deal to the dedicated people responsible for introducing Integration.

Professor P. V. Angus-Leppan undertook the final editing of this manual, which is intended to explain all aspects of the Integration System now proposed for adoption and is designed for use by the practising surveyor and also the student.

L. N. FLETCHER,
Surveyor General
January, 1976

Sydney, N.S.W.

1. INTRODUCTION

1.1 *Integration*

The reasons for introducing an Integrated Survey system in New South Wales have been set out briefly in the preface. In establishing the system, one of the intentions has been to enable survey methods to be transposed into the new system with a minimum of change. There are three essential changes:

- surveys in Integrated Survey areas are based on control survey marks;
- projection corrections are applied to survey data to convert to projection data, before computation; and
- there is a new set of criteria for acceptable accuracy of survey data.

The corrections required are the *reduction to sea level*, the projection corrections: *scale correction*, the *arc-to-chord correction* and the *grid convergence*. In many surveys, perhaps the majority of cases, the corrections are negligibly small. Formulae for calculation of the corrections, with examples, are given in paragraphs 4.6 (sea level), 5.8 (scale correction), 5.5 (arc-to-chord) and 5.6 (grid convergence).

Most users of the Integrated Survey system will wish to have more detailed information on the system and its applications. This will enable them to make use of the positive advantages of working within a control survey system and applying co-ordinates in all computations. The *Manual* aims to fill the needs of these users. The requirement of surveys of high precision are specialized, and while the *Manual* provides full details on calculating the projection corrections to high precision, it does not deal with the methods of precise surveying.

Methods of calculation in the *Manual* are appropriate to programmable and non-programmable calculators of the pocket or desk-top types. Because the subject of electronic computing is specialized and subject to rapid changes, it is not covered in the *Manual*.

1.2 *Scope of the Manual*

The aims of this *Manual* are—

- to describe the co-ordinate system to be used for survey integration;
- to define standard symbols, terms and formulae for use in survey practice;
- to indicate methods of calculating projection corrections, which are convenient and appropriate for various orders of accuracy;
- to provide numerical examples for the standardisation and simplification of computations;
- to give examples of surveys based on co-ordinated survey control marks in an integrated system;
- to describe the accuracy standards introduced with survey integration and to indicate how they can be applied;
- to indicate methods for the determination of azimuth by astronomical methods;
- to describe the Australian Height Datum and indicate the reasons why it was chosen to supersede the State Standard Datum;
- to set out revised survey directions on determination of mean high water mark.

A section at the end of the *Manual* contains a glossary, the bibliography and annexures. The glossary is intended to provide simple descriptions of terms used in the *Manual* and in discussions on survey integration. These descriptions are not rigorous definitions.

Very few references are quoted in the *Manual*. However the bibliography provides a list of publications for further reading, including those referred to in the text. The bibliography is arranged according to the parts of the *Manual*. The annexures include tables and diagrams for easy determination of projection corrections, forms and tables for computation of coordinate transformations, and maps showing the levelling net and the integrated survey grid zones in New South Wales.

2. FIGURE OF THE EARTH AND GEODETIC DATUM

2.1 *Introduction*

The Australian National Spheroid (*ANS*) and *Australian Geodetic Datum* have previously been adopted for the computation of surveys in Australia. They are also adopted for the computation of Integrated Surveys in New South Wales.

2.2 *Australian Geodetic Datum.*

The *Australian Geodetic Datum* was defined by the 1966 Adjustment of first order triangulation of Australia, in which the fundamental station was the Johnstone Geodetic Origin.

In 1972, the first order network between Newcastle, Sydney, Wollongong and Canberra was extended towards the coast to include trigonometrical stations in the proclaimed Integration Survey areas. This network was readjusted retaining the 1966 values for the western peripheral stations. It is intended to retain the co-ordinates obtained in the 1966 adjustment and in the 1972 readjustment as noted above for the adjustment of second and lower order triangulation and traverse networks.

Any values obtained by future readjustment of first order triangulation and used in integrated surveys should be qualified by a statement of their source and used with the approval of the Surveyor-General only. No such statements are required for the 1966-1972 values.

2.3 *The Australian National Spheroid.*

The defining parameters of the Australian National Spheroid are:

Major semi-axis, $a = 6\,378\,160$ metres

Flattening, $f = 1/298.25$

Derived functions are:

Flattening, f	$= 0.00335\,28918\,69$
Minor semi-axis, $b = a(1 - f)$	$= 6\,356\,774.719$ metres
$e^2 = 2f - f^2 = (a^2 - b^2)/a^2$	$= 0.00669\,45418\,55$
$e'^2 = e^2 + e^4/(1 - e^2) = (a^2 - b^2)/b^2$	$= 0.00673\,96607\,96$
$c = a/(1 - e^2)^{\frac{1}{2}}$	$= 6\,399\,617.255$ metres.

For the computation of radii of curvature in latitude ϕ, where ρ is the radius of curvature in the meridian and ν is the radius of curvature in the prime vertical:

$$V^2 = 1 + e'^2 \cos^2 \phi = \nu/\rho$$

$$\rho = c/V^3; \quad \nu = c/V; \quad R = (\rho\nu)^{\frac{1}{2}} = c/V^2$$

The following values are useful:

sin 1″ = 0.00000 48481 36811 1
π = 3.14159 26536
1 radian = 57.29577 9513 degrees
= 3 437.74677 08 minutes
= 206 264.80625 seconds

Conversion factors:

1 yard = 0.9144 metres exactly
1 foot = 0.3048 metres exactly

2.4 *Integrated Survey Grid (I.S.G.)*

A Transverse Mercator Projection is used as the basis for the computation of co-ordinates on the Integrated Survey Grid.

Surveys are to be connected to the stations of the state survey control system. The Transverse Mercator co-ordinates of these stations are calculated from latitudes and longitudes on the Australian Geodetic Datum as defined in para 2.2.

The Integrated Survey Grid is defined as follows:

(1) The projection is the Transverse Mercator Projection.
(2) Zones are 2° wide with $\frac{1}{4}$° overlaps.
(3) The true origin of each zone is the intersection of the Central Meridian with the Equator.
(4) A central scale factor $k_0 = 0.99994$ is applied to co-ordinates on the projection.
(5) Easting, E is defined by adding 300 000 metres to the value of y measured from the central meridian.
(6) Northing, N is defined by adding 5 000 000 metres to the value of x measured from the equator. All values of x south of the equator are negative.
(7) The zones are numbered in relation to the 6° zones of the Australian Map Grid (A.M.G.). Each 6° zone is subdivided into three 2° sections, each of which is covered by one I.S.G. zone. The I.S.G. zone identification consists of two parts, the first part is the corresponding A.M.G. zone number, and the second part, separated by a slash, indicates the number of the subdivision, from 1 to 3, increasing eastwards. For example, the eastern sector of A.M.G. zone 55 (144°-150° E.) is covered by I.S.G. zone 55/3 which extends from 148°-150° E. and has central meridian 149° E. Details of I.S.G. zones are given in table I see annexure K.

TABLE I

Zones of the Integrated Survey Grid, New South Wales

I.S.G. Zone	Extent (excl. overlaps)	Central Meridian
54/2	140-142° E.	141° E.
54/3	142-144	143
55/1	144-146	145
55/2	146-148	147
55/3	148-150	149
56/1	150-152	151
56/2	152-154	153