THE BLACK–ALLAN LINE REVISITED

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ABSTRACT

The Black–Allan Line is the "straight line" section of the Victorian/New South Wales State border; from Cape Howe to the nearest source of the Murray River. Named in honour of the principal surveyors who marked it in 1870-72, the line was not officially proclaimed until 2006 and there is no explicit definition of the type of line set out. This paper examines possible candidates: geodesic; normal section; curve of alignment; great elliptic arc; and loxodrome. Original survey computations indicate that the Black-Allan Line is a normal section curve; which is confirmed by remarkable agreement with recently surveyed original marks.

BIOGRAPHIES OF AUTHORS

Rod Deakin is a lecturer in the School of Mathematical and Geospatial Sciences with pretensions to be known as a surveyor, Steven is a graduate of RMIT and much of this paper is based on his final year Major Project (2009) – he may be a surveyor one day. Bob Ross is a surveyor (recently retired) and in his 46 years with the Department of Lands (now the Office of Surveyor General, Victoria) surveyed all the marks mentioned in this paper. He re-built some, placed others and connected them all to the modern geodetic network. The first two authors are amateurs by comparison.

INTRODUCTION

In February 2006, after official publication in government gazettes, the Governors of Victoria and New South Wales; the Hon. John Landy AC MBE and Professor Marie Bashir AC CVO, met at Delegate River on the Victorian/New South Wales border to proclaim the Black–Allan Line as part of the border between the two states of Australia (Landy 2006; Bashir 2006).

This commemorative proclamation corrected an historical oversight, as this straight section of the Victorian/New South Wales border (marked on the ground in 1870-72) had never been officially acknowledged. In November 1873, a draft proclamation had been forwarded for consideration to the Secretary of Lands for New South Wales, by the Victorian Minister of Lands and Agriculture. But a legal defect; "supposed" by the Attorney-General of New South Wales, prevented its ratification and interest in the border line waned (Taylor, 2006, pp. 120-121).

The border line was marked by three Victorian geodetic surveyors: Alexander Black, Alexander Charles Allan and William Turton. After location of the terminal points of the line – one being a Spring defined as the most easterly source of the Murray River, and the other a stone pile on the coast at Cape Howe – the azimuth of a straight line was computed and a peg, known as Allan's Peg, placed on the west bank of the Delegate River. Historical records (Appendix A) show the distance from the Spring to Allan's Peg as 3058.92 chains which is roughly 1/3 of the total length shown of 8773.37 chains (8773 chains is approximately 176.5 km or 109.7 miles where 1 chain = 100 links = 66 feet = 20.1168 m and 80 chains = 1 mile = 1.609344 km).

Black and Allan commenced marking the line in April 1870 and finished in March 1872; Black marking the first third from the Spring to Allan's Peg and Allan marking the remaining two-thirds to the coast (Ellery, 1891, p. 20). Both Black and Allan were assisted by Turton who was involved on the survey from August 1870 to April 1871 (Benwell, 1991, p. 235).

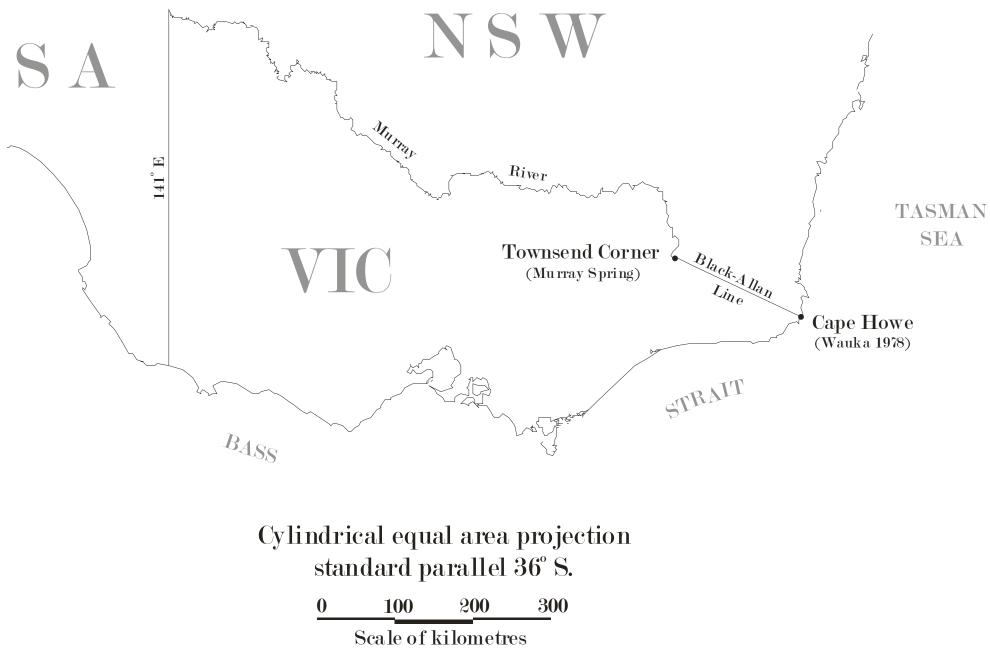

Figure 1: The Black–Allan Line, the straight section of the State Boundary between Victoria and New South Wales.

There are many references to the Black–Allan Line as *a straight line drawn from Cape Howe to the nearest source of the Murray River,* not the least being the British Act of Parliament that separated Victoria from New South Wales (see below); but precise definition of the line is lacking. What is a straight line? Is the Black-Allan Line a straight line drawn on a map? And if so; what is the map projection and what is the reference surface – sphere or ellipsoid? Or is the Black-Allan Line a curve on a reference surface? And if so; is it a plane curve or is it a geodesic – a curve having the shortest path length? Or is it some other curve with a useful property? This paper aims to answer these questions by an investigation of some of the original computations associated with the boundary line and also from official reports on the progress of the Geodetic Survey of Victoria around the time of the boundary line survey. In addition, a short historical section is provided.

A SHORT HISTORY OF THE BLACK–ALLAN LINE

Victoria was separated from New South Wales by a British Act of Parliament; The Australian Constitutions Act 1850, signed by Queen Victoria on 5 August 1850; which conferred on the colony a Constitution, and said in part:

> "... the Territories now comprised within the said District of *Port Phillip,* including the Town of *Melbourne,* and bounded on the North and North-east by a straight Line drawn from *Cape Howe* to the nearest Source of the River *Murray,* and thence by the Course of that River to the Eastern Boundary of the Colony of *South Australia,* shall be separated from the Colony of *New South Wales, ...*"
>
> (British Parliament 1850)

The New South Wales Parliament passed the necessary enabling legislation and separation took effect on 1 July 1851. Victoria was, by then, a wealthy region with a population of more than 70,000 and in that year gold was discovered at Clunes near Ballarat and subsequently at Bendigo. This was the beginning of one of the largest gold-rushes the world had seen and in the decade 1851-1860, 20 million ounces of gold was produced (approximately 622 tonnes); one third of world output, and the population increased dramatically to 540,000.

Surveying in the Port Phillip District of New South Wales began in September 1836 with the arrival of three Assistant Surveyors sent from Sydney by Governor Bourke. This was little over a year after the arrival in Port Phillip Bay of John Batman and other members of the *Port Phillip Association* in May 1835; and the establishment of the first settlement on the Yarra River by John Pascoe Fawkner who arrived aboard the *Enterprize* three months later (August 1835). In 1837, after an inspection by Governor Bourke, Robert Hoddle was appointed Surveyor-in-Charge of the Port Phillip District and the location and street layout of Melbourne was decided. And after Separation in 1851, Hoddle was appointed as Victoria's first Surveyor-General. Surveys in these early years were mainly concerned with land sales in districts near Melbourne, Geelong and Portland, although John Arrowsmith's 1853 *Map of the Province of Victoria,* showing the entire Colony and its major geographical features, has the caption "Principally Derived from the Surveys of Surveyor General Hoddle". Whilst this might overstate Hoddle's actual role in these surveys, it's a clear indication of his and other government surveyors roles in mapping a region comparable in size to the whole of Great Britain in a period of about fifteen years (Scurfield, 1995, p. 140).

In 1858 the Geodetic Survey of Victoria was initiated by Charles W. Ligar, Victoria's sixth Surveyor-General. This scheme partitioned the colony into *geographical divisions* whose boundaries were meridians and parallels of integral degrees; further subdivided into six-minute intervals, so that each geographical division contained 100 smaller *blocks*. The intention of the Geodetic Survey was to provide control for the preparation of plans and for the accurate subdivision of the Colony (Ligar 1859, 1860). The corners of these blocks were marked on the ground with square wooden posts and with stone cairns along some of the bloc boundaries.

These blocks formed the physical basis of the Parish subdivision, so the plan based thereon then recorded the status of land within the Parish. The Government Astronomer, Robert L. J. Ellery, was appointed as the Superintendent of the Geodetic Survey in July 1858 and soon thereafter chose a site on the Werribee plains for a geodetic base line. Measurement of a five-mile line (8 km) using three 10-foot iron rods (with the NSW 10-foot standard for comparison) began in early January 1860 and by June, the measurement was complete and the base line extended to nine miles (14.4 km) by triangulation (Benwell 1987). The Werribee Base was connected to the primary triangulation of a trigonometric survey that, by the mid 1860's, extended to the western border of the Colony (the Victorian/South Australian border having been marked by surveyors Henry Wade and Edward Riggs White in 1847-50), north to the Murray River and north-eastward into the mountain districts, and into south and east Gippsland. This primary triangulation supported the Geodetic Survey and by the late 1860's as the necessity arose for the marking of the north-eastern boundary between Victoria and New South Wales, the triangulation was pushed into New South Wales to include The Pilot, Kosciusko, Cape Howe and the mountains in the vicinity of the proposed boundary (Ellery 1891).

Sometime prior to 1869, Ellery met with the New South Wales Surveyor-General P. F. Adams on the coast at Cape Howe and after some discussion marked a spot they named Conference Point, agreeing that if the Boundary line to be run from the source of the Murray struck the coast within 5 chains (approximately 100 m) of Conference Point it would be acceptable to both Victoria and New South Wales. And at the end of 1869, geodetic surveyor Alexander Black reported on his investigations of the source of the Murray River; recommending that one of the springs he had found near a hill he called Forest Hill (on a spur of The Pilot) should be accepted as the source of the Murray nearest Cape Howe (Chappel 1996 p. 92, 1974 p. 44). These springs – discovered as the source of the Murray River by surveyor Thomas Scott Townsend in 1846 – and the western end of the Black-Allan Line are now officially known as Indi Springs and Townsend Corner (VICNAMES).

The terminal points of the boundary line, having been identified and marked, were connected to the triangulation network and the azimuth of the line determined. The boundary line was marked by surveyors Black and Allan, with the assistance of Turton; Black marking the western third of the line, from the Spring to Allan's Peg, and Allan marking the remaining two-thirds to the coast (the eastern end).

The western end is particularly steep and difficult country and the line crosses the Snowy River and passes near the summit of Mt Tingaringy. Black marked the line with substantial rock cairns on intersecting ridges and on the eastern bank of the Snowy River and it's likely that some of these were fixed from the triangulation network rather than running the line directly. Black's field computing book shows "Hills" lettered *A* to *H* as instrument points of a small triangulation network covering this section of the boundary line[1].

[1] *A* was on Forest Hill near the No. 1 Border Cairn, *B* is on the Berrima Range near No. 2 Cairn and *G* is near No. 8 Cairn on Mt. Tingaringy. Hills *E* and *G* have been found on the ground and connected by survey; their coordinates are in the Victorian State Government Survey Mark Enquiry System (SMES) (Ross 2005).

The eastern end of the line crosses slightly less difficult country and Allan's border marks were not as substantial as Black's; often wooden pegs and trenches and some stone cairns along the line[2]. Allan's field notes indicate little or no marking of the last 10 kilometres of the line to the coast.

Ellery (1891, p. 20) in describing the boundary survey writes;

> "... and in April, 1870, Messrs. Black and Allan commenced running, clearing, and marking the boundary line and finished in March 1872, Mr. Allan taking the line from Mr. Black at Bendoc and producing it to Cape Howe, where it struck the coast within 16.8 inches[3] of the marked terminal, completing a piece of survey work which for difficulties and for the requirement of skill, energy, and endurance, as well as for the accuracy attained I believe has never been surpassed. It is interesting to note here that the result attained goes to show the remarkable psecision(sic) of the elements of the figures of the earth given by Col. Clarke in his last work, which were used in determining the true direction of this line."

It should be noted here that as Allan neared the end of his work at the coast his survey line produced passed nearby the original terminal mark Conference Point agreed upon by Ellery and Adams at their meeting on the coast sometime prior to 1869. Allan marked the terminal point of his line at the coast with a rock cairn now known as Wauka. In 1967 the rock cairn with centre pipe was found by surveyors of the Department of Lands and Survey, Victoria and the Trigonometric Station Summary Sheet records that the cairn was rebuilt in 1919 by E.H. Lees with the centre pipe over a glass bottle allegedly placed by the original border survey. There is also a notation that the Trig coordinates do not coincide with those of Conference Point Trig of the original border survey which is noted as being 180 metres west. The access diagram sketch for Wauka (DLS Vic., Angle Book 342, 23-Jul-1967) shows Conference Point west of Wauka and on the NSW side of the border line. In 1978, shifting sands on the coast had covered the rock cairn and a concrete pillar was erected over the old centre pipe by surveyors of the NSW Department of Lands & Survey. This concrete pillar is known as Wauka 1978.

Many of Black's original border cairns remain and some have been rebuilt over original marks using newly cut timber and original stone material; and several of Allan's marks have been replaced by concrete pillars. For the analysis that follows, 15 border marks (including the terminal points) are used and the coordinates [latitudes and longitudes related to the Geocentric Datum of Australia 1994 (GDA94)] were obtained from the Victorian State Government Survey Mark Enquiry System (SMES) and are shown in Table 1 below.

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[2] Stone cairns of Allan's have been found at Delegate River, Mt Tennyson, Bondi Range, on the right bank of the Genoa River, on a spur of Mt Merragunegin, and on a spur above Wroxham near the Catematsu Fire Track. A Cairn at Mt Buckle and an earth mound near Mt Carlyle have been found and replaced by concrete pillars (Ross 2005).

[3] This was unfortunately wrong. Ellery writing in *Victoria and its Metropolis, Past and Present, Vol. II,* 1888 states that the offset was 16.8 feet. This is supported by network adjustments and computations using original observations. Also, Allan used a feet chain so that one would have expected the offset to be expressed in feet (Ross 2010).

NAME	GDA94		PARISH	ORDER
	LATITUDE	LONGITUDE		
Murray Spring⋆⋆	-36°47′49.2232″	148°11′48.3333″	Enano PM 15	2 (GPS)
Border Cairn No. 1	-36°47′55.8918″	148°12′04.5953″	Enano PM 16	2 (GPS)
Border Cairn No. 4	-36°51′40.4560″	148°21′14.7330″		3 (Radiation)
Border Cairn No. 5	-36°53′24.1963″	148°25′29.7546″		3 (Triangulation)
Border Cairn No. 8	-36°59′35.426″	148°40′47.113″	Boorpuk PM 2	5 (Transformed)
Border Cairn No. 9	-37°02′27.3332″	148°47′54.3630″	Cabanandra PM 22	2 (GPS)
Tennyson Cairn (NSW)	-37°10′30.6976″	149°08′04.3680″		5 (Radiation)
Bondi Range Cairn	-37°12′13.0075″	149°12′22.1394″	Kowat PM 29	3 (Triangulation)
Fiddlers Green Cairn⋆	-37°12′51.7495″	149°13′59.9063″	Kowat PM 28	3 (Triangulation)
Hotspur Ridge Cairn⋆	-37°13′23.8992″	149°15′21.1013″	Kowat PM 30	3 (Traverse)
Cann Track Cairn⋆	-37°13′41.7457″	149°16′06.1992″	Kowat PM 26	3 (Traverse)
Buckle 1962 (NSW) Cairn	-37°21′20.4569″	149°35′31.5395″		0 (Triangulation)
Carlyle	-37°27′59.1316″	149°52′34.3490″	Gabo PM 1	0 (Triangulation)
Allan Pillar (NSW) ⋆	-37°30′11.4860″	149°58′15.9723″	Gabo	0 (Triangulation)
Wauka 1978	-37°30′18.0674″	149°58′32.9932″	Gabo PM 4	0 (Triangulation)

Table 1: Coordinates of Black–Allan Line State Border Marks

The reference ellipsoid for GDA94 is the Geodetic Reference Ellipsoid 1980 (GRS80), semi-major axis a = 6378137 metres, flattening f = 1/298.257222101.

Note 1. The Border marks Fiddlers Green, Hotspur Ridge and Cann Track, while utilising Allan’s naming, were in fact placed directly on line between Bondi Range (original sub-surface mark found) and Mt Buckle (concrete pillar). These marks (minor cairns with concrete centre poles) were placed by the Office of Surveyor General Victoria (circa 2007) at the request of *VicRoads.* Original marks were searched for but not found (Ross 2010).

Note 2. In 1978, Allan Pillar was placed on line between Wauka 1978 and Carlyle as an auxiliary mark to Wauka (Ross 2010).

⋆ Border Marks are not original or are not replacing original marks found.

⋆⋆ Steel pipe placed in Spring by RMIT survey group in December 1984.

WHAT WAS (OR IS) THE “STRAIGHT LINE”?

The Australian Constitutions Act 1850, separating Victoria from New South Wales describes what we now call the Black–Allan Line as: “a straight line drawn from Cape Howe to the nearest source of the River Murray”. There are three words here that could lead to several different lines; *straight, drawn* and *nearest.*

Firstly, considering *drawn* and *straight,* we could easily imagine marking two points on a sheet of paper and *drawing* a line between them with a ruler. This line would also be *straight* and the sheet of paper (a plane reference surface) could be considered as a map projection. So the border line could be a straight line drawn on a map projection. But we could also draw a line between two points on another reference surface; say a sphere or an ellipsoid. Would this be straight? Yes, if was a plane curve[4]; but there are an infinite number of planes containing the terminal points of the line, so there needs to be some definition of the "correct" plane. On a sphere, if the intersecting plane contained the terminal points and the centre of the sphere, the curve would be an arc of a great circle and the distance between the points would be the shortest distance. On an ellipsoid, if the intersecting plane contained the terminal points and the centre of the ellipsoid, the curve would be an arc of a great elliptic and the distance between the points would not be the shortest distance. Again, for an ellipsoid, if the intersecting plane contained the terminal points and the normal to the surface at one of the terminal points, the curve would be an arc of a normal section curve and the distance between the points would not be the shortest. In general, on an ellipsoid, there are two normal section curves between two points on the surface; one created by the plane containing the normal at one end and the other curve created by the plane containing the normal at the other end of the line. These two normal section curves coincide if both points are on the equator, or both points lie on the same meridian.

Secondly, consider *nearest,* which could be taken to mean the line between Cape Howe and the nearest source of the Murray River having the shortest path length. On a sphere, a great circle arc between Cape Howe and the nearest source of the Murray is a straight line having the shortest length. On an ellipsoid there will be two normal section curves joining Cape Howe and the nearest source of the Murray and both will have different lengths (in theory) and both will be longer than the geodesic[5] (the path of shortest length). But the geodesic is a curve on the ellipsoid having both curvature and torsion (twist) and couldn't be considered as a straight line.

So, depending on our interpretation, we could have as candidates for the "straight line"

(i) a line drawn on a map projection,
(ii) a great circle arc on a sphere,
(iii) a normal section on an ellipsoid, or
(iv) a geodesic on an ellipsoid

We can discount the first two candidates as there is a clear (but indirect) reference to an ellipsoid by Ellery (1891, p.20) where he says in reference to the border survey:

> "It is interesting to note here that the result attained goes to show the remarkable psecision(sic) of the elements of the figures of the earth given by Col. Clarke in his last work, which were used in determining the true direction of this line."

This reference is to Alexander Ross Clarke, a Colonel of the Royal Engineers and the pre-eminent British geodesist of the era. Clarke derived the geometric parameters of three different earth ellipsoids known as Clarke's ellipsoids of 1858, 1866 and 1880 and he is the author of *Geodesy* (Clarke 1880). Also, Black's field book that he used for surveys in the period 1860's–1870's contains a page listing the elements of Airy's 1830

[4] A plane curve between two points on a surface is the line of intersection of the surface and a plane containing the two points.

[5] A curve drawn on a surface so that its osculating plane at any point on the surface contains the normal to the surface is a geodesic. It follows that the principal normal at any point on the curve is the normal to the surface and the geodesic is the shortest distance between two points on a surface.

ellipsoid[6]. So we may conclude that an ellipsoid was used as a reference surface. But there is no specific reference as to which ellipsoid may have been used in any of the border line computations we have seen or other documents showing measurements or descriptions of the line.

Computations we have seen in Thornhill's[7] computation book (Thornhill 1870) indicate that the boundary line adopted was the arc of a normal section curve where the normal section plane contained the Spring No.1[8], the normal to the ellipsoid passing through Spring No.1 and the other terminal at Conference Point. These computations include a determination of the latitude difference between Spring No.1 and Conference Point using Puissant's formula[9] (Thornhill 1870, p.13) and computation of latitude and longitude of Conference Point given the azimuth and distance from Spring No.1 using Clarke's long-line formula (Thornhill 1870, p.14). Both formula assume a normal section plane between the terminal points and from Thornhill (1870, p.26) on a page headed *Conference Point from No.1 Station* are the words:

Azimuth finally adopted = $\alpha = 116^{\circ}\ 57'\ 59.68''$

that accords with the azimuth of the boundary line shown in the document *Description of the Line forming part of the Boundary between Victoria and New South Wales* (see Appendix A). We could conclude that the normal section contained the normal at the Spring No.1. But what was the ellipsoid used?

WHAT WAS THE ELLIPSOID USED?

There is no specific reference to the ellipsoid that Thornhill (or others) used in boundary line computations we have seen. But, perhaps we may be able to make an inspired guess if we compare some computed values.

From *The Description of the Line …* shown in Appendix A the latitudes and longitudes of the terminal points of the boundary line are:

Spring No.1:	$\phi = 37^{\circ}\ 47'\ 56.901''$ S	Conference Point:	$\phi = 37^{\circ}\ 30'\ 25.593''$ S
	$\lambda = 148^{\circ}\ 11'\ 57.752''$ E		$\lambda = 149^{\circ}\ 58'\ 42.436''$ E

normal section azimuth, Spring No.1 to Conference Point: $\alpha =$ S $63^{\circ}\ 01'\ 50.58''$ E
which is a quadrant azimuth equal to the forward azimuth $\alpha = 116^{\circ}\ 58'\ 09.42''$

normal section azimuth at Conference Point: $\alpha =$ S $64^{\circ}\ 06'\ 18.64''$ E
which is a quadrant azimuth equal to the reverse azimuth $\alpha = 295^{\circ}\ 53'\ 41.36''$

the length of the line s = 8773.37 chains = 579042.42 feet.

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[6] Sir George Biddell Airy (1801-92), the English Astronomer Royal (1835-81) and President of the Royal Society (1871-73) whose scientific investigations included geodesy and map projections.

[7] William Thornhill was a geodetic surveyor engaged in marking the boundary line and as a geodetic computor. Reference to Thornhill is made in a document shown in Appendix A and headed *Description of the Line forming part of the Boundary between Victoria and New South Wales.*

[8] Black identified a number of springs that are the source of the Murray River in the vicinity of Forest Hill. Spring No.1 is the most easterly and the closest to Cape Howe and in this paper is also called Murray Spring. A steel pipe was placed in this spring by RMIT survey group in December 1984.

[9] Puissant , *Traité de Géodésie,* 3rd ed., vol 1, 1842, p.327.

Three ellipsoids are candidates, Airy 1830, Clarke 1858 and Clarke 1866 (Clarke's 1880 ellipsoid, determined after the boundary marked, is not considered as a candidate). The defining parameters of these ellipsoids are:

Airy 1830 ellipsoid: a = 20,923,713 feet (values from Black's field book)
b = 20,853,810 feet

Clarke 1858 ellipsoid: a = 20,926,348 feet
b = 20,855,233 feet

Clarke 1866 ellipsoid: a = 20,926,062 feet
b = 20,855,121 feet

a and b are the semi-major and semi-minor axes of the ellipsoid respectively and the ellipsoid flattening $f = \frac{a-b}{a}$ and eccentricity $e = \sqrt{f(2-f)}$.

The values for Clarke's ellipsoids are from Clarke (1880) but were published in scientific articles prior to the border survey.

A computer program[10] was written to compute the forward and reverse azimuths and the arc length of the normal section between the Spring No.1 and Conference Point and the results for the three ellipsoids as reference surfaces are:

	NORMAL SECTION		
	FORWARD AZIMUTH	**REVERSE AZIMUTH**	**DISTANCE**
"Description of the line…"	116º 58' 09.42"	295º 53' 41.36"	579,042.42 ft
Airy's 1830 ellipsoid	116º 58' 12.63" (+3.21")	295º 53' 44.27" (+2.91")	578,980.39 ft (-62.03 ft)
Clarke's 1858 ellipsoid	116º 58' 06.59" (-2.83")	295º 53' 38.22" (-3.14")	579,057.01 ft (+14.59 ft)
Clarke's 1866 ellipsoid	116º 58' 07.46" (-1.96")	295º 53' 39.09" (-2.27")	579,048.56 ft (+6.14 ft)

Table 2: Normal section azimuths and distances on three ellipsoids compared with the values in the *Description of the line…* shown in Appendix A.

The forward azimuth is the azimuth of the normal section Spring No.1 to Conference Point and this normal section plane contains the normal to the ellipsoid at the Spring. The reverse azimuth is the azimuth of the normal section plane measured at Conference Point back to the Spring No.1.

Inspection of the differences shown in Table 2 indicate that the ellipsoid used was probably Clarke's 1866 ellipsoid.

[10] Matlab programs *nsection_direct.m* and *nsection_inverse.m* were written for this exercise. The direct case is: given the latitude and longitude of P1 and the normal section azimuth and distance; compute the latitude and longitude of P2. The inverse case is: given the latitudes and longitudes of P1 and P2; compute the distance and forward and reverse azimuths of the normal section.

HOW CLOSE ARE THE "PRESENT" BORDER MARKS TO THE NORMAL SECTION CURVE?

Here we would like to show how close the State Border Marks shown in Table 1 are to the normal section curve between the terminal marks that are Murray Spring (Spring No.1 identified by Black and used in the previous section, but with GDA94 coordinates) and Wauka 1978 (which is not Conference Point of the last section and Appendix A). We will use the GDA94 coordinates in Table 1 and the computed normal section azimuths and distances shown in Table 3

NAME	Normal Section P1(Murray Spring) to P2		
	FORWARD AZIMUTH	DISTANCE	REVERSE AZIMUTH
Murray Spring			
Border Cairn No. 1	117°01′07.043299″	452.532022	297°00′57.302447″
Border Cairn No. 4	116°58′14.802908″	15742.035939	296°52′35.285455″
Border Cairn No. 5	116°58′14.591382″	22821.298458	296°50′02.040485″
Border Cairn No. 8	116°58′09.659338″	48242.260517	296°40′45.774513″
Border Cairn No. 9	116°58′11.177734″	60058.821565	296°36′30.065798″
Tennyson Cairn (NSW)	116°58′13.205443″	93444.239085	296°24′22.071209″
Bondi Range Cairn	116°58′13.548762″	100541.270965	296°21′46.604125″
Fiddlers Green Cairn	116°58′13.615086″	103231.612462	296°20′47.548450″
Hotspur Ridge Cairn	116°58′13.671959″	105465.350298	296°19′58.493641″
Cann Track Cairn	116°58′13.684304″	106705.796633	296°19′31.223678″
Buckle 1962 (NSW) Cairn	116°58′14.714181″	138703.341687	296°07′46.199193″
Carlyle	116°58′14.219285″	166698.340403	295°57′24.317187″
Allan Pillar (NSW)	116°58′14.249636″	176030.550699	295°53′56.452425″
Wauka 1978	116°58′14.173757″	176495.243760	295°53′46.013949″

TABLE 3: Normal Section Azimuths and Distances from Murray Spring

The forward azimuth is the azimuth of the normal section P1 (Murray Spring) to P2 (Border Mark "*x*") and this normal section plane contains the normal to the ellipsoid at P1 (Murray Spring).

The reverse azimuth is the azimuth of the normal section plane P1-P2 measured at station 2.

Now using the azimuth of the normal section P1 (Murray Spring) to P2 (Wauka 1978) of 116°58′14.173757″ as the Border Line (see the last line of Table 3), normal section distances were computed for points P2 near each Border Mark, such that the longitudes of these points were identical with the Border Mark values in Table 1. These computed distances and the normal section azimuth 116°58′14.173757″ to each point P2 were used to compute latitudes of each point P2 which were either north or south of the Border Mark. The latitude differences (angular quantities) along meridians passing through each Border Mark were then converted into linear distances to give the relationship between the Border Line and the Border Marks. These results are shown in Table 4 below.

NAME	GDA94 ELLIPSOID VALUES			
	LATITUDE	$d\phi$	ρ	$dm = \rho \times d\phi$
Murray Spring	-36°47′49.223200″			
near Border Cairn No. 1	-36°47′55.877996″	-0.013804″	6358334.751	-0.425 m
near Border Cairn No. 4	-36°51′40.454254″	-0.001746″	6358401.620	-0.054 m
near Border Cairn No. 5	-36°53′24.194620″	-0.001680″	6358432.525	-0.052 m
near Border Cairn No. 8	-36°59′35.464332″	+0.038332″	6358543.202	+1.182 m
near Border Cairn No. 9	-37°02′27.364850″	+0.031650″	6358594.486	+0.976 m
near Tennyson Cairn (NSW)	-37°10′30.713487″	+0.015887″	6358738.821	+0.490 m
near Bondi Range Cairn	-37°12′13.018529″	+0.011029″	6358769.395	+0.340 m
near Fiddlers Green Cairn	-37°12′51.759621″	+0.010121″	6358780.976	+0.312 m
near Hotspur Ridge Cairn	-37°13′23.908486″	+0.009286″	6358790.587	+0.286 m
near Cann Track Cairn	-37°13′41.754863″	+0.009163″	6358795.922	+0.282 m
near Buckle 1962 (NSW) Cairn	-37°21′20.443771″	+0.013129″	6358933.146	-0.405 m
near Carlyle	-37°27′59.130273″	-0.001327″	6359052.559	-0.041 m
near Allan Pillar (NSW)	-37°30′11.483665″	-0.002335″	6359092.229	-0.072 m
Wauka 1978	-37°30′18.067400″			

TABLE 4: Latitudes of intersections of the Border Line with meridians of Border Marks and distances *dm* of Border Marks from the Border Line along meridians.

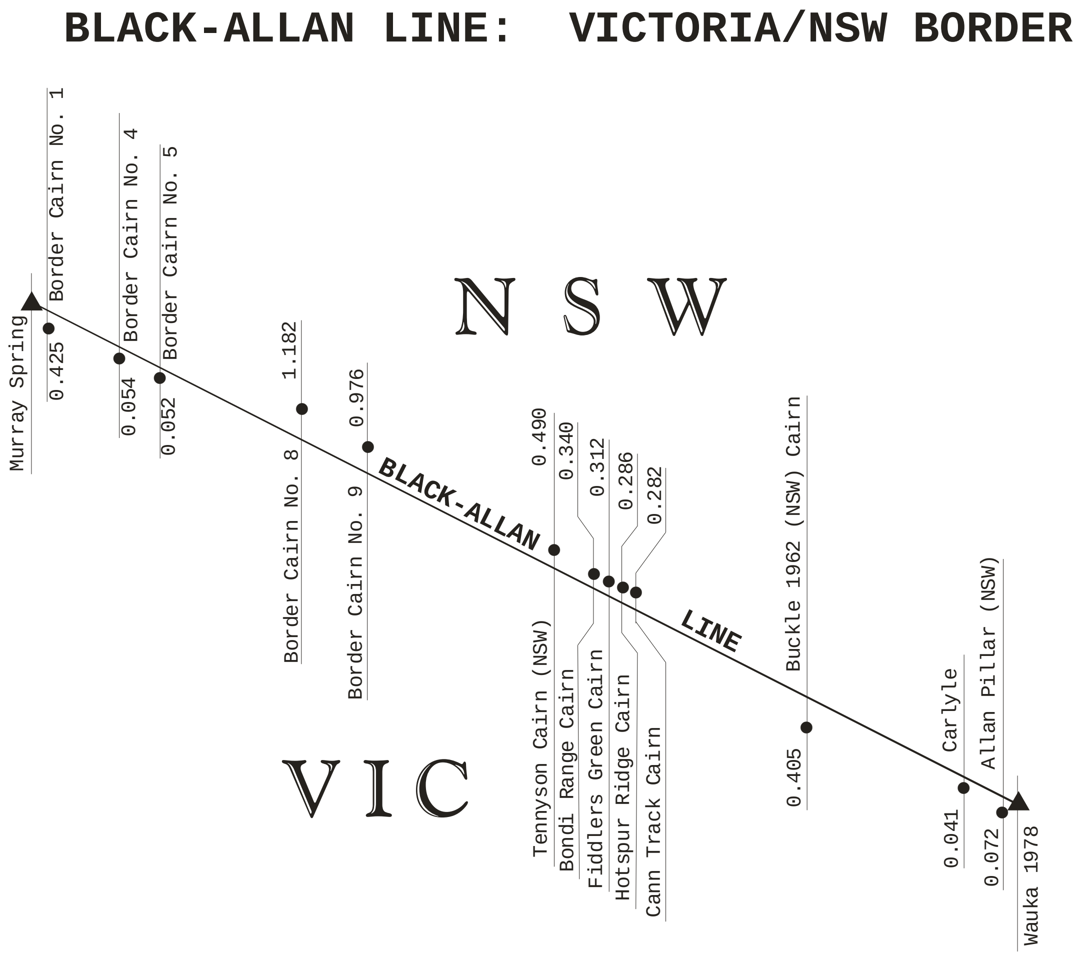
The difference in latitude between P2 (on the meridian north or south of each Border Mark) and the Border Mark is shown as $\pm d\varphi$. If $d\varphi$ is negative, the Border Mark is south of the Border Line.

The column headed ρ contains meridian radius of curvature of the reference ellipsoid (in metres) and $\rho = a\left(1-e^2\right)\left(1-e^2\sin^2\phi\right)^{-3/2}$

The column headed $dm = \rho \times d\varphi$ is a distance along the meridian passing through the Border Mark. If *dm* is negative, the Border Mark is south of the Border Line.

The “offsets” of the Border Marks from the Border Line (the Black-Allan Line) are shown schematically in Figure 2 and even though some of the Border Marks are not original (or not replacing original marks found, see Table 1) they are remarkably close to the assumed line marked on the ground given the era and the rugged terrain. In particular Border Cairns No.4 and No.5 on the Snowy Range and the eastern bank of the Snowy River respectively and approximately 15.7 and 22.8 km from the Spring. It’s probable that Black placed these cairns on the line using his local trigonometric network and the offsets (both 0.05 m) are vindication of his surveying skills. Similarly Allan’s Carlyle; 0.04 m off the line after traversing approximately 105.2 km. from Allan’s peg; although there were check–perpendiculars[11] to Delegate Hill (a short distance from Allan’s peg), Mt Tennyson and other trigonometric stations near the boundary line.

[11] These were computed distances along lines perpendicular to the boundary line and passing through nearby trigonometric stations. They were used as a means of controlling the direction of the line as it was produced forward with the theodolite in the field.



The Black-Allan Line is a normal section curve on the reference ellipsoid between P1 (Murray Spring) and P2 (Wauka 1978). This curve is the intersection of the normal section plane and the ellipsoid, and the normal section contains P1, the normal to the ellipsoid at P1, and P2.

The GDA94 coordinates of Murray Spring and Wauka 1978 are:
Murray Spring: ϕ -37°47′49.2232″ λ 148°11′48.3333″
Wauka 1978: ϕ -37°30′18.0674″ λ 149°58′32.9932″

The normal section azimuth and distance are:
116°58′14.173757″ 176495.243760 m.

Figure 2: Schematic diagram showing the relationships between the State Border Marks and the Black-Allan Line assumed to be a normal section

WHAT ABOUT THE “OTHER” NORMAL SECTION

In general, there are two normal section curves joining two points on an ellipsoid. For the border we are assuming the Black-Allan line is a normal section from Murray Spring to Wauka 1978 and this section contains the normal through the Spring. The “other” normal section curve, Wauka 1978 to Murray Spring, contains the normal through Wauka and will lie to the south of the Black-Allan line.

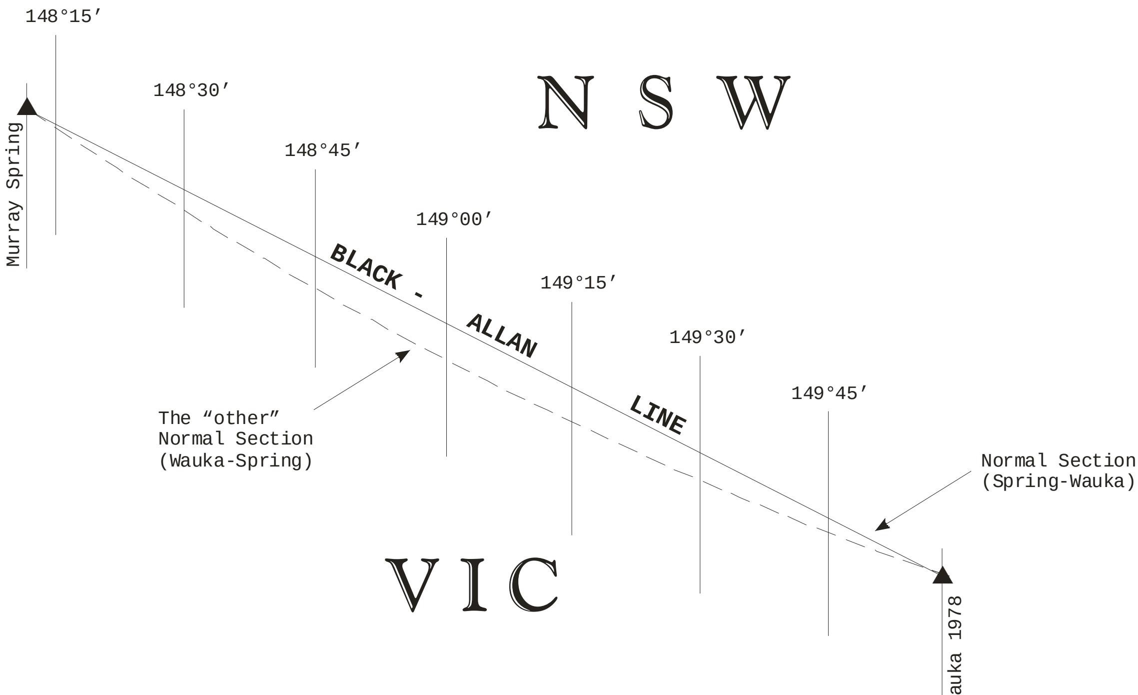
The difference between the two normal sections, measured along the meridian 149º 00' E is 0.032 m. The other normal section curve is shown schematically in Figure 3 below

BLACK-ALLAN LINE: VICTORIA/NSW BORDER

The Black-Allan Line is a normal section curve on the reference ellipsoid between P1 (Murray Spring) and P2 (Wauka 1978). This curve is the intersection of the normal section plane and the ellipsoid, and the normal section contains P1, the normal to the ellipsoid at P1, and P2.

The GDA94 coordinates of Murray Spring and Wauka 1978 are:
Murray Spring: ϕ -37°47′49.2232″ λ 148°11′48.3333″
Wauka 1978: ϕ -37°30′18.0674″ λ 149°58′32.9932″

The normal section azimuth and distance are:
116°58′14.173757″ 176495.243760 m.



The “other” normal section Wauka 1978 to Murray Spring contains the normal to the ellipsoid at Wauka and is shown plotted at an exaggerated scale with respect to the Border Line.

The “other” normal section azimuth and distance are:
295°53′46.013949″ 176495.243760 m.

At longitude 149°00′E. the other normal section is 0.032 m south of the Border Line.

Figure 3

OTHER CURVES OF INTEREST

As we mentioned earlier, a candidate for the border line could have been a *geodesic* which is a unique curve having the shortest path length. This doesn't really satisfy the criteria; "a straight line drawn from Cape Howe to the nearest source of the Murray River" as the geodesic is not a plane curve but we will consider it.

Another curve of interest is a *curve of alignment*[12] and similarly to the geodesic it is a curve on an ellipsoid having both curvature and torsion but is slightly longer (theoretically) than the geodesic. A curve of alignment is of interest here as it may well have been set out in the border survey. It is probable that Black fixed some of the major cairns 1, 2, 3, etc. (that are generally on major ranges crossing the boundary) from a local trigonometric scheme and then placed minor cairns on lower intervening ridges. These minor cairns were more than likely positioned by erecting sighting vanes at the major cairns, then clearing sections of the minor ridges in-between and marking the line there by "middling in" with the theodolite. If there were several of these minor ridges between the major ranges then the minor cairns would lie on a curve of alignment. So Black's section of the line could have been a series of curves of alignment resulting from the practical surveying solution to marking sections of the line. This is only supposition of course as there is little or no information remaining describing the actual survey operations. Also, we are supposing that the *vertical,* defined by the carefully levelled theodolite (in correct adjustment), is coincident with the ellipsoid normal. In mountainous terrain this may not be so.

We could also consider a *loxodrome*[13] as a useful and practical border line. Consider a "compass" that showed true bearings (related to the direction of the meridian) rather than the usual magnetic bearings. If we walked (on the ellipsoid) a line of constant true bearing then we would be walking along a loxodrome.

Finally, we could consider a *great elliptic arc*[14] as a plane curve where the intersecting plane contained Murray Spring, Wauka 1978 and the centre of the ellipsoid.

Each of these curves has been determined for the terminal points Murray Spring and Wauka 1978 and related to the Black-Allan Line (the normal section). Tabulated results are shown in Table 5.

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[12] A curve on the ellipsoid between terminal points that is the locus of a point P on the surface that moves so that the normal section plane at P contains the terminal points.

[13] A loxodrome is a curve on a u,v parametric surface that cuts each *u-curve* or each *v-curve* at a constant angle. For a spherical earth where the u-curves are parallels of latitude and the v-curves are meridians of longitude, a loxodrome (that was not a parallel or a meridian) would cut each meridian at a constant angle. Such a curve would spiral around the surface terminating at a pole. Mercator's projection (of the sphere) has the unique property that loxodromes are projected as straight lines.

[14] A plane curve created by intersecting the ellipsoid with a plane containing the terminal points and the centre of the ellipsoid. The trajectory of a ballistic missile lies in a plane containing the earth's centre of mass which would intersect the ellipsoid creating a great elliptic.

NAME	GDA94 ELLIPSOID VALUES				
	LATITUDE	**LONGITUDE**	**dφ**	**ρ**	**dm = ρ×dφ**
Murray Spring	-36°47′49.223200″	148°11′48.333300″			
A	-36°49′07.598047″ N -36°49′07.598090″ G -36°49′07.598051″ CoA -36°49′07.590584″ GEA -36°49′05.849245″ Lox	148°15′00.000000″	-00′00.000043″ -00′00.000004″ +00′00.007463″ +00′01.748802″	6358356.102	-0.0013 -0.0001 +0.2301 +53.9089
B	-36°55′13.876510″ N -36°55′13.876745″ G -36°55′13.876614″ CoA -36°55′13.840305″ GEA -36°55′05.371035″ Lox	148°30′00.000000″	-00′00.000235″ -00′00.000104″ +00′00.036205″ +00′08.505475″	6358465.209	-0.0072 . .-0.0032 +1.1161 +262.1958
C	-37°01′17.289080″ N -37°01′17.289478″ G -37°01′17.289366″ CoA -37°01′17.234433″ GEA -37°01′04.418599″ Lox	148°45′00.000000″	-00′00.000398″ -00′00.000286″ +00′00.054647″ +00′12.870481″	6358573.577	-0.0123 -0.0088 +1.6846 +396.7613
D	-37°07′17.845554″ N -37°07′17.846060″ G -37°07′17.846030″ CoA -37°07′17.782643″ GEA -37°07′02.991484″ Lox	149°00′00.000000″	-00′00.000506″ -00′00.000476″ +00′00.062911″ +00′14.854070″	6358681.204	-0.0156 -0.0147 +1.9394 +457.9177
E	-37°13′15.555723″ N -37°13′15.556262″ G -37°13′15.556326″ CoA -37°13′15.494607″ GEA -37°13′01.089240″ Lox	149°15′00.000000″	-00′00.000539″ -00′00.000603″ +00′00.061116″ +00′14.466483″	6358788.089	-0.0166 -0.0186 +1.8841 +459.9767
F	-37°19′10.429372″ N -37°19′10.429845″ G -37°19′10.429972″ CoA -37°19′10.379991″ GEA -37°18′58.711427″ Lox	149°30′00.000000″	-00′00.000473″ -00′00.000600″ +00′00.049381″ +00′11.717945″	6358894.232	-0.0146 -0.0185 +1.5224 +361.2501
G	-37°25′02.476276″ N -37°25′02.476564″ G -37°25′02.476677″ CoA -37°25′02.448453″ GEA -37°24′55.857608″ Lox	149°45′00.000000″	-00′00.000288″ -00′00.000401″ +00′00.027823″ +00′06.618668″	6358999.632	-0.0089 -0.0124 +0.8578 +204.0489
Wauka 1978	-37°30′18.067400″	149°58′32.993200″			

TABLE 9: Points where curves cut meridians of A, B, C, etc. at 0°15′ intervals of longitude along Border Line

N = normal section, G = geodesic, CoA = curve of alignment,
GEA = great elliptic arc, Lox = loxodrome.

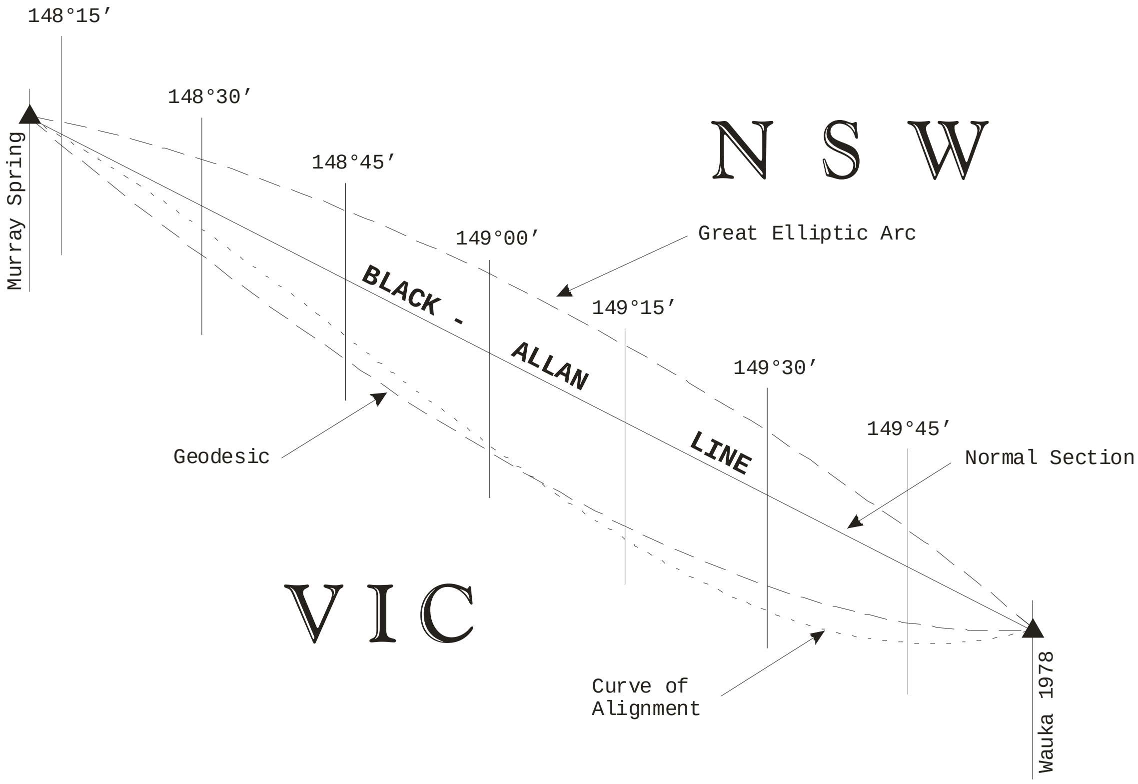
A schematic diagram, using the tabulated values above, showing the *geodesic, curve of alignment* and *great elliptic arc* with respect to the Black-Allan Line (normal section) is shown in Figure 4. The loxodrome is not shown on Figure 4 but it is a curve on the north side of the Border Line, similar to the great elliptic arc but more concave with respect to the Black-Allan Line.

BLACK-ALLAN LINE: VICTORIA/NSW BORDER

The Black-Allan Line is a normal section curve on the reference ellipsoid between P1 (Murray Spring) and P2 (Wauka 1978). This curve is the intersection of the normal section plane and the ellipsoid, and the normal section contains P1, the normal to the ellipsoid at P1, and P2.

The GDA94 coordinates of Murray Spring and Wauka 1978 are:
Murray Spring: ϕ -37°47′49.2232″ λ 148°11′48.3333″
Wauka 1978: ϕ -37°30′18.0674″ λ 149°58′32.9932″

The normal section azimuth and distance are:
116°58′14.173757″ 176495.243760 m.



The Geodesic, Curve of Alignment and Great Elliptic Arc are shown plotted at an exaggerated scale with respect to the Border Line (normal section).
At longitude 149°00′E. the Geodesic is 0.016 m south of the Border Line and the Curve of Alignment is 0.015 m south. The Great Elliptic Arc is 1.939 m north.
At longitude 149°30′E. the Geodesic is 0.015 m south of the Border Line and the Curve of Alignment is 0.019 m south. The Great Elliptic Arc is 1.522 m north.

The Geodesic azimuth and distance are:
116°58′14.219146″ 176495.243758 m

Figure 4: A schematic diagram showing the relationships between the geodesic, curve of alignment, great elliptic arc and the Black-Allan Line (normal section).

CONCLUSION

The history of the Black-Allan Line is reasonably well known to Victorian and New South Wales surveyors and even some non-surveyors have heard of the "straight line" from the Murray to the coast and been interested enough to delve into the history, organise a bushwalk and search for some of the border marks. As surveyors, our interest is more inclined towards the practical problems involved in turning a definition of a State Border into a series of marks defining the line on the ground; and of course the problems of achievable accuracy with the equipment at hand. But there are some of us (the authors in particular) who sometimes ponder the nature of the words "straight line" and "nearest" and what they might encompass when applied to a State Border. I doubt that anything we have discussed here would sow a seed of doubt in a practical surveyor; but a lawyer with a bent towards obfuscation (perhaps with the idea of prolonging his appearance at a healthy daily rate) might manage a bit of confusion. For example: What was the actual line marked and where is the definition? Was the line a normal section curve and if so which curve was marked? Why didn't you mark the shortest path? But of course all this is moot since the Commemorative Proclamation published in the Victorian Government Gazette (No. S 49, 16-Feb-2006) says in part:

> "… the Black–Allan Line is the demarked boundary between New South Wales and Victoria from Cape Howe to the nearest source of the Murray River as described respectively in the Plan of "Trig: Survey No. 11 Sheets 1–5" held in the Plan Room, Department of Lands, Sydney, New South Wales and Plans "BL1A, BL2A–8A" held in the Central Plan Office, Department of Sustainability and Environment, Melbourne, Victoria."

So, the border line is defined by the marks on the ground, placed in the course of the border survey 1870-72. A very practical definition and there's no need to worry about what curve or ellipsoid may have been used at the time. If you're worried where the boundary is between existing marks then it's simply a matter of setting out a straight line between those marks found on the ground. Oops, we just said "setting out a straight line".

For those readers interested in the possible candidates for the straight line, we hope we have provided an interesting analysis and some results that may be of practical benefit. At least you may now know a little more about curves on an ellipsoid.

In addition, we hope that our analysis has shown that the original survey was very, very good, which we have often read and can now confirm with the relationships between the existing Border Marks and the Black-Allan Line as a normal section given in Table 4 and shown in Figure 2.

Thank you for your attention.

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APPENDIX A: DESCRIPTION OF THE LINE

Figures A1 to A5 are scanned images of A3-photocopies of original documents in the Office of Surveyor General, Victoria. They were obtained in 1985. The four pages (Figures A1 to A4) containing the *Description of the line* were stapled to a larger page (Figure A5) containing a diagram of the border line and the principal marks along the line. Portions of this larger sheet can be seen around the edge of the images of the smaller sheets.

It is possible that these documents are themselves first drafts or working originals of documents that formed part of the draft proclamation of November 1873.

On the first page following *The Description of the line forming part of the Boundary between Victoria and New South Wales* are the words:

> Commencing at a Spring in latitude 36° 47' 56.901" S and longitude 148° 11' 57.752" E (the latitude of the Melbourne Observatory being taken as 37° 49' 53.397" S and its longitude 144° 58' 40.903" E) which Spring is the source of the River Murray nearest to Cape Howe: thence bearing S 63° 01' 50.58" E to a point on Forest Hill called Station No 1 marked by a pile of stones 9 feet high having a pole in the centre beneath which at a depth of three feet below the surface of the ground is a stone marked on the upper side thus A | B / 18 | 70 the centre being a hole one inch in diameter and six inches deep which indicates a point on the line 22.50 chains from the spring. This point is at a distance of 420.04 chains and bears N 30° 43' 08.03" E from the trig: station on the Cobboros and 248.85 chains and bears S 4° 50' 00.79" W from the trig: station on the Pilot. The pile is square at base and built diagonally on the line. At each side of the line at this point is a large gum tree marked on the side facing the pile the one on the south side thus and that on the ↑ NSW 70 south side thus Thence bearing ↑ V 70 S 63° 02' 00.32" E the same straight line passes over the Berrima Range …

On the fourth page the description continues

> ... a continuation of the same straight line to the trig: station on Mt Carlyle: thence S 64° 02' 40.30" E a continuation of the same straight line to a point on the Coast at Cape Howe marked by a conical pile of stones 10 feet in diameter at base and 9 feet high with marked centre stone distant 8773.37 chains from the spring and situated in latitude 37° 30' 25.593" S and longitude 149° 58' 42.436" E : thence a continuation of the same straight line bearing S 64° 06' 18.64" E to a point at sea distant one league from high water mark at Cape Howe.

Figure A5 is a diagram of the border line headed:

Correct Azimuth of the Boundary line
from different points as shown
computed from their respective
Latitudes & Longitudes

It shows the azimuth at border marks numbered 1 (Forest Hill), 2 (Berrima Range), 3, 4 (Suggan Buggan Range), 5 (Snowy River), 6, 7, 8 (Mt Tingaringy), 8/2 and 9 between the Spring and Allan's Peg on the west side of the Delegate River. And the azimuth at Allan's Peg, Foot of Delegate perpendicular, Mt. Tennyson, Mt Buckle, Mt Carlyle and the Stone Pile on Coast.

The distance from the Spring to Allan's Peg is noted as 3058.92 chains (see A3) which is approximately 1/3 of the total length of 8773.37 chains.

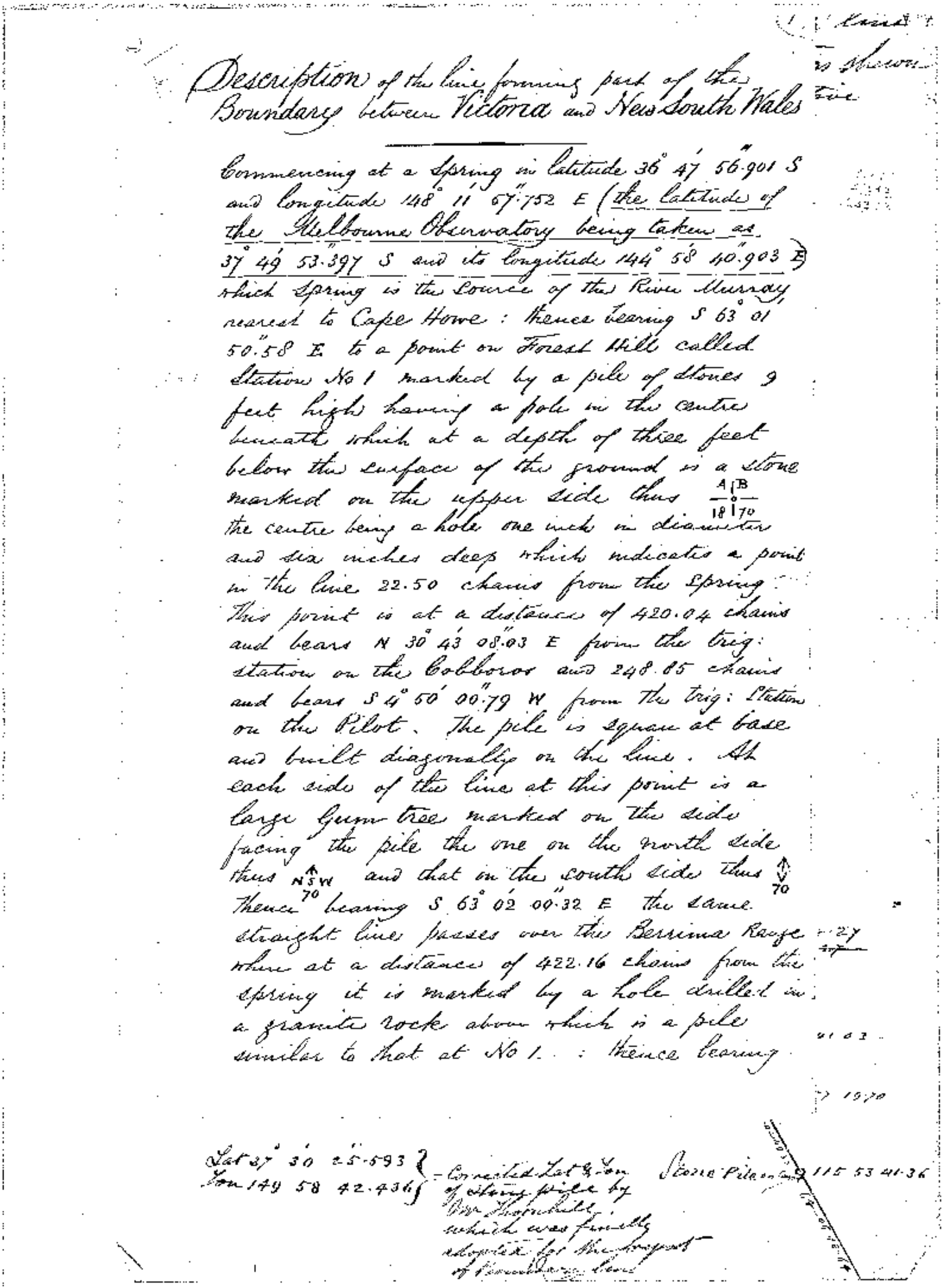
Geodetic surveyors Alexander Black and Alexander Charles Allan commenced marking the boundary line in April 1870 and finished in March 1872; Black marking the first third of the line from the Spring to Allan's Peg and Allan marking the remaining two-thirds to the coast (Ellery, 1891, p. 20). Both Black and Allan received assistance from geodetic surveyor William Turton who was involved in the survey from August 1870 to April 1871 (Benwell, 1991, p. 235).

At the bottom of Figure A5, by the Stone Pile on Coast, are the words

Lat 37° 30′ 25.593″ }
Lon 149° 58′ 42.436″ } = *Corrected Lat & Lon*
of stone pile by
Mr Thornhill
which was finally
adopted for the report
of Boundary line

William Thornhill was a geodetic surveyor engaged in marking the boundary line as well as computations of the positions of points on the line.

A careful inspection of the *Description of the line* reveals that there are minor changes to some of the bearings of the line, and the latitude and longitude of the Stone Pile on Coast (original seconds crossed out with corrections written above).



Description of the line forming part of the Boundary between Victoria and New South Wales

Commencing at a Spring in latitude 36° 47′ 56.901″ S and longitude 148° 11′ 57.752″ E (the latitude of the Melbourne Observatory being taken as 37° 49′ 53.397″ S and its longitude 144° 58′ 40.903″ E) which Spring is the source of the River Murray nearest to Cape Howe: thence bearing S 63° 01′ 50.58″ E to a point on Forest Hill called Station No 1 marked by a pile of stones 9 feet high having a pole in the centre beneath which at a depth of three feet below the surface of the ground is a stone marked on the upper side thus A|B 18|70 the centre being a hole one inch in diameter and six inches deep which indicates a point in the line 22.50 chains from the Spring. This point is at a distance of 420.04 chains and bears N 30° 43′ 08.03″ E from the trig: station on the Cobboros and 248.85 chains and bears S 4° 50′ 00.79″ W from the trig: Station on the Pilot. The pile is square at base and built diagonally on the line. At each side of the line at this point is a large Gum tree marked on the side facing the pile the one on the north side thus NSW 70 and that on the south side thus V 70. Thence bearing S 63° 02′ 09.32″ E the same straight line passes over the Berrima Range where at a distance of 422.16 chains from the spring it is marked by a hole drilled in a granite rock above which is a pile similar to that at No 1. : thence bearing

Lat 37° 30′ 25.593 } Lon 149 58 42.436 } – Corrected Lat & Lon of Stone pile by Mr Thornhill which was finally adopted for the purpose of Boundary line

Stone Pile 115 53 41.36

Figure A1: Page 1 of Description of the line

S 63° 04' ~~49.67~~ 53.61 E a continuation of the same straight line to a point on the first range east of the Ingeegoodbee Creek at a distance of 645.93 chains from the spring where the mark is a stake driven two feet in the ground above which is a round pile of stones 8 feet high: thence bearing S 63° 06' ~~26.82~~ 30.776 E a continuation of the same straight line to a mark on the Luggan Buggan Range which is a hole in a stone two feet below the surface of the ground above which is a pile similar to that at No 1. 782.61 chains from the spring: thence bearing S 63° 07' ~~26.20~~ 30.414 E a continuation of the same straight line to a similar mark and pile on the east bank of the Snowy River 1134.46 chains from the spring: thence bearing S 63° 09' ~~59.24~~ 62.415 E to a similar mark and pile on the range east of the Snowy River 1656.19 chains from the spring: thence (63 13 60.66) a continuation of the same straight line to the first range west of McKeachie's Creek 1978.59 chains from the spring where the mark is a hole drilled six inches deep in the solid rock beneath a pile similar to that at No 1. thence S 63° 16' ~~7.10~~ 11.113 E a continuation of the same straight line to a similar mark and pile on the Tingi Ringi Range 2398.12 chains from the spring leaving the trig: station on the summit of Tingi Ringi to the right 27.759 chains from the line: thence S 63° 19' ~~10.64~~ 14.040 E a continuation of the same straight line to a point marked by a stake driven two feet in the ground

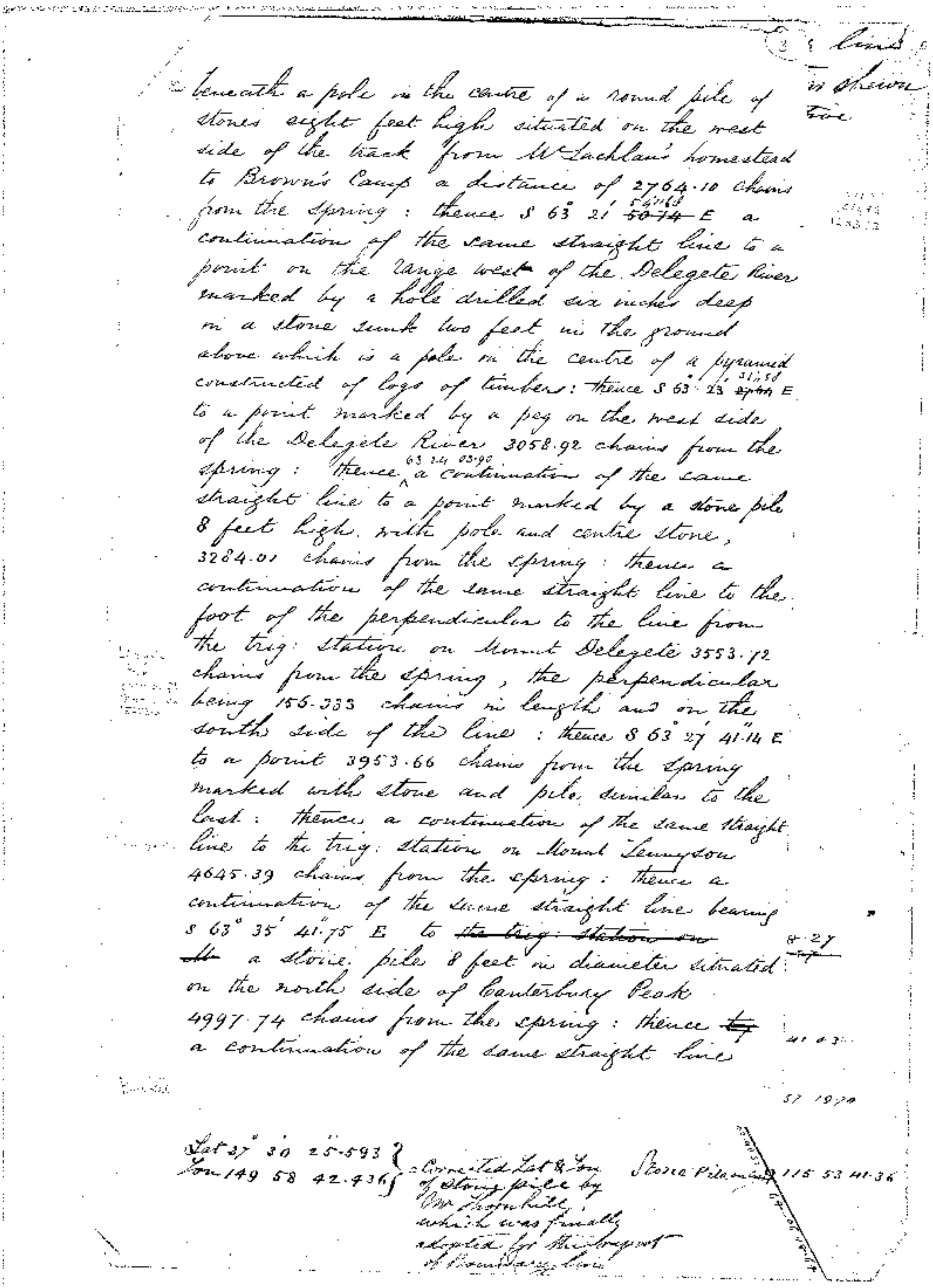
line as shown

8.27

Lat 37° 30' 25.593
Lon 149 58 42.436 } = Corrected Lat & Lon of stony pile by Mr [illegible] which was finally adopted for the purpose of Boundary line

Stone Pile 115 53 41.36

Figure A2: Page 2 of Description of the line



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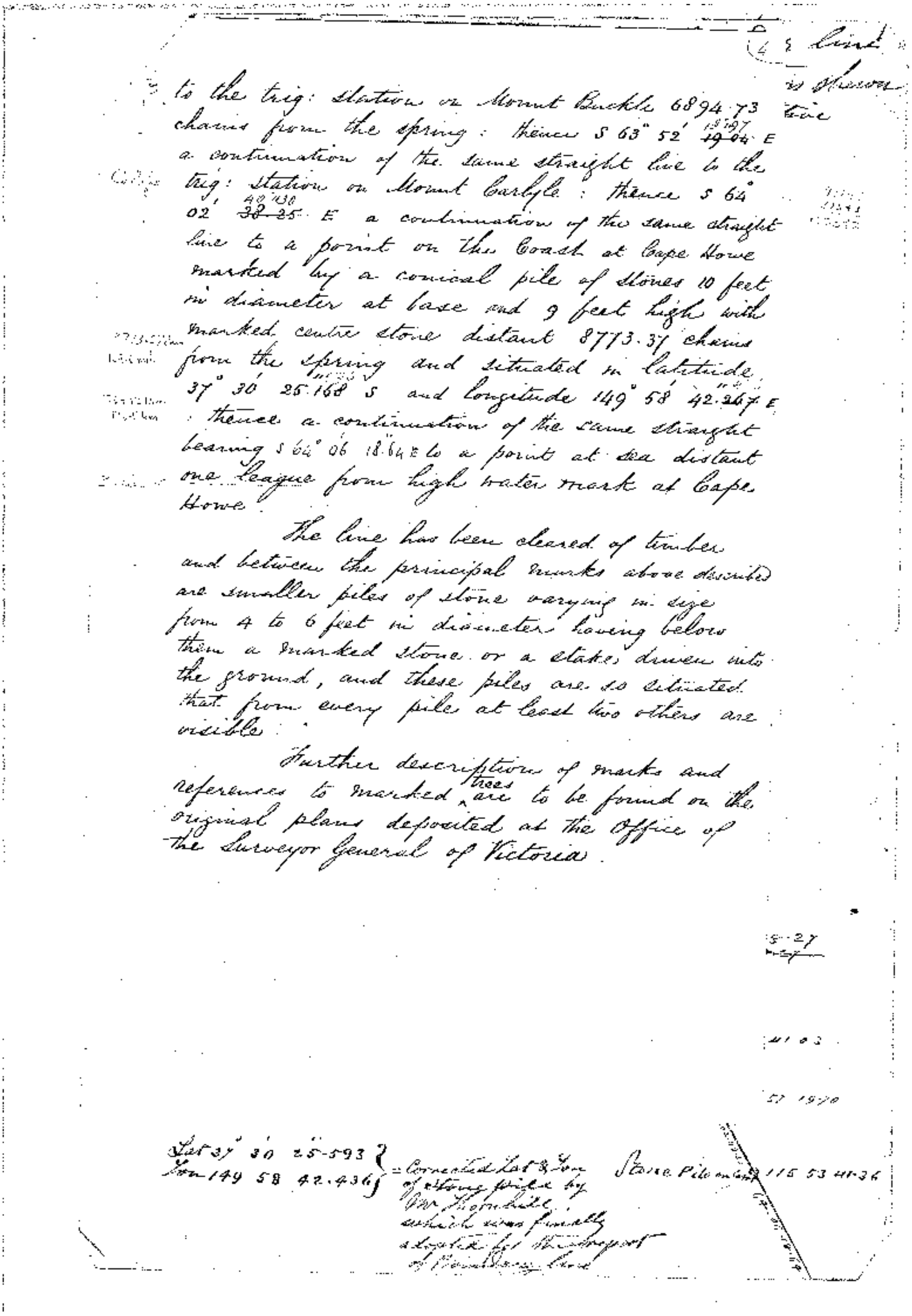
beneath a pole in the centre of a round pile of stones eight feet high situated on the west side of the track from McLachlan's homestead to Brown's Camp a distance of 2764.10 chains from the spring : thence S 63° 21' ~~50.74~~ 54.60 E a continuation of the same straight line to a point on the range west of the Delegete River marked by a hole drilled six inches deep in a stone sunk two feet in the ground above which is a pole in the centre of a pyramid constructed of logs of timbers : thence S 63° 23' ~~29.44~~ 31.58 E to a point marked by a peg on the west side of the Delegete River 3058.92 chains from the spring : thence (63 24 03.90) a continuation of the same straight line to a point marked by a stone pile 8 feet high with pole and centre stone, 3284.01 chains from the spring : thence a continuation of the same straight line to the foot of the perpendicular to the line from the trig: station on Mount Delegete 3553.72 chains from the spring, the perpendicular being 155.333 chains in length and on the south side of the line : thence S 63° 27' 41.14" E to a point 3953.66 chains from the spring marked with stone and pile similar to the last : thence a continuation of the same straight line to the trig: station on Mount Tennyson 4645.39 chains from the spring : thence a continuation of the same straight line bearing S 63° 35' 41.75" E to ~~the trig: station on the~~ a stone pile 8 feet in diameter situated on the north side of Canterbury Peak 4997.74 chains from the spring : thence ~~to~~ a continuation of the same straight line

Lat 37° 30' 25.593"
Lon 149 58 42.436 } = Corrected Lat & Lon of Stone pile by Mr Thornhill, which was finally adopted for the purpose of Boundary line

Stone Pile ... 115 53 41.36

Figure A3: Page 3 of Description of the line



is shown line

to the trig: station on Mount Buckle 6894.73 chains from the spring: thence S 63° 52' 19.97 E a continuation of the same straight line to the trig: station on Mount Carlyle: thence S 64° 02' 40.30 E a continuation of the same straight line to a point on the Coast at Cape Howe marked by a conical pile of stones 10 feet in diameter at base and 9 feet high with marked centre stone distant 8773.37 chains from the spring and situated in latitude 37° 30' 25.168" S and longitude 149° 58' 42.267" E : thence a continuation of the same straight bearing S 64° 06' 18.64" E to a point at sea distant one league from high water mark at Cape Howe.

The line has been cleared of timber and between the principal marks above described are smaller piles of stone varying in size from 4 to 6 feet in diameter having below them a marked stone or a stake driven into the ground, and these piles are so situated that from every pile at least two others are visible.

Further descriptions of marks and references to marked trees are to be found on the original plans deposited at the Office of the Surveyor General of Victoria.

Lat 37° 30' 25.593 }
Lon 149 58 42.436 } = Corrected Lat & Long of stone pile by Mr Thornhill, which was finally adopted for the purpose of Boundary line

Stone Pile ... 115 53 41.36

Figure A4: Page 4 of Description of the line

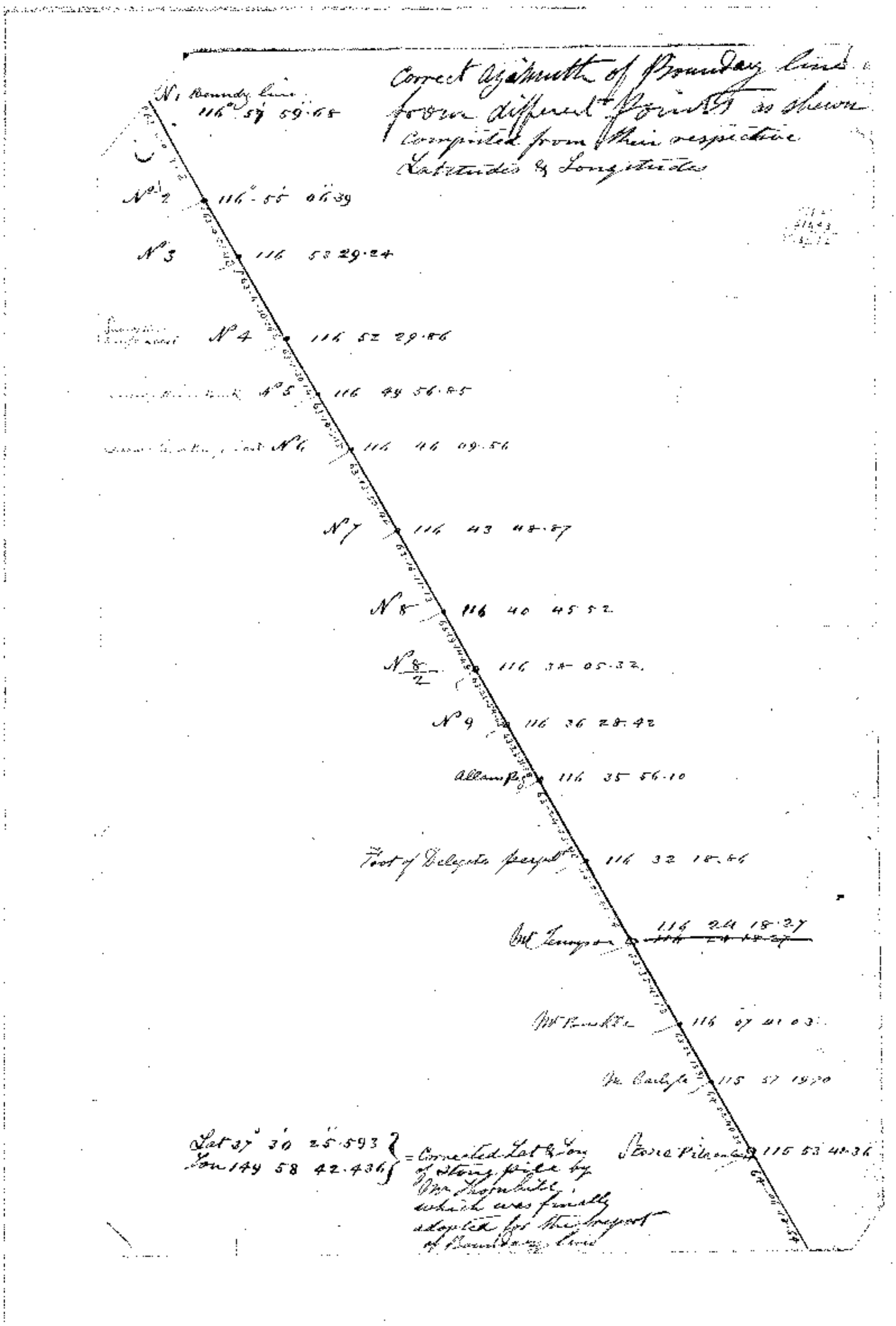


Figure A5: Diagram of the line