Coordinates and Mathematical Evidence

Minor Adjustments to the Hierarchy or Radical Change in Practice?

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Chair Land Tenure and Cadastral systems

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University of Calgary

Saskatechewan Land Surveyors Association Seminar

On-Line 30 November 2020

The Debate: Mathematics, Monuments and Hierarchy of Evidence

- Hierarchy of Evidence (first introduced **McPherson v Cameron** 7 N.S.R. 208 N.S. C.A., 1868)
  - Natural Boundaries
  - Original Monuments
  - Fences and Other Possessory Evidence
  - Plan data: Measurements Quoted by the Original Surveyor;
    - we can treat coordinates as derivatives of measurements.

Is this hierarchy still relevant; especially the bottom two items?

Structure

- Policy and practice in 3 countries
- Coordinates on Survey plans. Examples from my own work.
- Questions and policy tensions relating to coordinates and mathematical evidence.
- Law cases and policy from 19th and 20th century South Africa – absurdities that can arise when altering the hierarchy
- Case studies from my own work. Coordinates as useful evidence when re-establishing doubtful boundaries.
- Policy and practice suggestions
- Discussion

South Australia / Australian Capital Territory (ACT)

- S. Aus. proposal in 1990’s:- to lodge a survey with the Surveyor General and then fix the coordinate as the final position.
- In the case of re-establishing a lost monument, after due process, and all evidence considered, the curtain falls and the coordinate cannot be changed, even if fresh evidence emerges. [2]
- Does not appear to have been implemented.
- Much focus on Cost - Benefit Analysis in proposal
- I have found no evidence of consultation / workshops with public.
- Similar proposal in ACT appears to have been rejected. [2]

Switzerland

- In terms of Swiss Civil Code, boundaries depicted graphically on a cadastral plan take precedence over marks on the ground unless the plan is shown to be wrong.
- Monuments may be replaced if not in accord with a correct plan. [2]

Austria

- Introduced numerical/coordinate based cadastre in 1968.
- A coordinate could become the primary evidence of the position of a boundary polygon apex if all surrounding owners sign a consent form. I.e. coordinate is superior to original monument.
- Coordinates referenced to geodetic control.
- Coordinates adjusted if readjustment of geodetic control.
- Fewer than 12% of the parcels covering 2% of the land area are on this system [3]
  - “general public reluctant to accept coordinates as dominant evidence”
  - Greater acceptance in urban areas (One interview!)

43

LEASEHOLD DGM.

SIDES	Metres	ANGLES OF DIRECTION		CO-ORDINATES Y System Lo19 °	X
		Constants		∓ 0, 00	+3 700 000, 00
A B	3, 36	222 51 50	A	+ 51 850, 13	+ 78 293, 87
B C	1, 32	129 40 10	B	+ 51 847, 84	+ 78 291, 41
C D	5, 01	221 30 10	C	+ 51 848, 86	+ 78 290, 56
D E	8, 85	311 33 10	D	+ 51 845, 53	+ 78 286, 81
E F	3, 12	41 37 50	E	+ 51 838, 91	+ 78 292, 68
F G	1, 20	128 36 50	F	+ 51 840, 99	+ 78 295, 01
G H	5, 10	41 36 00	G	+ 51 841, 93	+ 78 294, 26
H A	6, 39	131 12 00	H	+ 51 845, 31	+ 78 298, 08
	8K36		⊕	+ 51 841, 58	+ 78 171, 62
	7K36		⊕	+ 51 677, 86	+ 78 102, 04

S.G. No.

5219-94

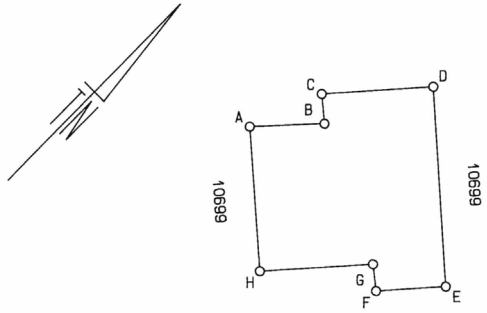
Approved

Surveyor-General

Descriptions of Beacons

B Wall Corner

All other beacons are: 12 mm Iron Peg



Scale 1: 200

The figure A B C D E F G H

represents 63 Square Metres of land, being

a lease area (No. 81) over Erf 10699 Fish Hoek

situate in the Municipality of Fish Hoek
Administrative District of Cape Province of Cape of Good Hope
Surveyed in April - May 1994
by me

PLS 0029 M.B. Barry Professional Land Surveyor

This diagram is annexed to	The original diagram is	File No. S/7782/6
No. dated i.f.o. Registrar of Deeds	No 1117/1927 annexed to Deed of Grant No. 1928- -24	S.R. No. E 1717/94 Comp. AHNH-1333 (M2639) DED. PLAN 1117/1927

5219/94

LEASEHOLD DGM.

	SIDES Metres	ANGLES OF DIRECTION		CO-ORDINATES Y	System Lo 19° X
		Constant		+ 0,00	+ 3700 000,00
AB	198,04	199 05 10	A	+ 45 007,00	+ 64 626,95
BC	24,28	200 32 20	B	+ 44 942,24	+ 64 439,80
CD	24,28	203 23 50	C	+ 44 933,72	+ 64 417,06
DE	24,28	206 16 50	D	+ 44 924,08	+ 64 394,78
EF	24,28	209 09 40	E	+ 44 913,33	+ 64 373,01
FG	24,28	212 02 20	F	+ 44 901,50	+ 64 351,80
GH	24,28	214 55 10	G	+ 44 888,62	+ 64 331,22
HJ	24,27	217 47 10	H	+ 44 874,72	+ 64 311,31
JK	24,28	221 51 40	J	+ 44 859,85	+ 64 292,13
KL	24,25	224 43 00	K	+ 44 843,65	+ 64 274,05
LM	24,22	227 36 40	L	+ 44 826,59	+ 64 256,82
MN	24,20	230 30 00	M	+ 44 808,70	+ 64 240,49
NO	24,17	233 20 40	N	+ 44 790,03	+ 64 225,10
OP	26,08	236 15 20	O	+ 44 770,64	+ 64 210,67
PQ	112,36	239 22 00	P	+ 44 748,95	+ 64 196,18
QR	35,33	293 19 40	Q	+ 44 652,27	+ 64 138,93
RS	77,52	347 14 40	R	+ 44 619,83	+ 64 152,92
ST	138,41	346 42 10	S	+ 44 602,71	+ 64 228,53
TU	54,74	77 00 50	T	+ 44 570,88	+ 64 363,23
UV	68,01	347 00 50	U	+ 44 624,22	+ 64 375,53
VW	20,47	245 42 10	V	+ 44 608,94	+ 64 441,80
WX	32,48	347 00 50	W	+ 44 590,28	+ 64 433,38
XY	30,00	257 51 10	X	+ 44 582,98	+ 64 465,03
YZ	7,01	212 25 20	Y	+ 44 553,65	+ 64 458,72
ZA'	507,00	346 59 30	Z	+ 44 549,89	+ 64 452,80
A'B'	358,18	84 00 00	A'	+ 44 435,77	+ 64 946,79
B'C'	65,08	65 43 10	B'	+ 44 791,99	+ 64 984,23
C'D'	95,50	155 43 10	C'	+ 44 851,31	+ 65 010,99
D'E'	46,94	175 39 00	D'	+ 44 890,58	+ 64 923,94
E'A	274,46	155 43 10	E'	+ 44 894,14	+ 64 877,13
		9 Q 18		+ 44 671,59	+ 63 880,72
		4 Q 19		+ 45 235,28	+ 64 134,63

Description of Beacons

U 100mm wooden fence post
All others are 12mm round iron pegs

The figure ABCDEFGHJKLMNOPQRSTUVWXYZA'B'C'D'E'

represents 31,2046 hectares of land, being

Erf 2712 Ottery comprising (1) and (2) as shown on the opposite page

situate in at Ottery in the Municipality of Cape Town Administrative District

of Cape Province of Cape of Good Hope.

Surveyed in February 1986

by me,

Land Surveyor

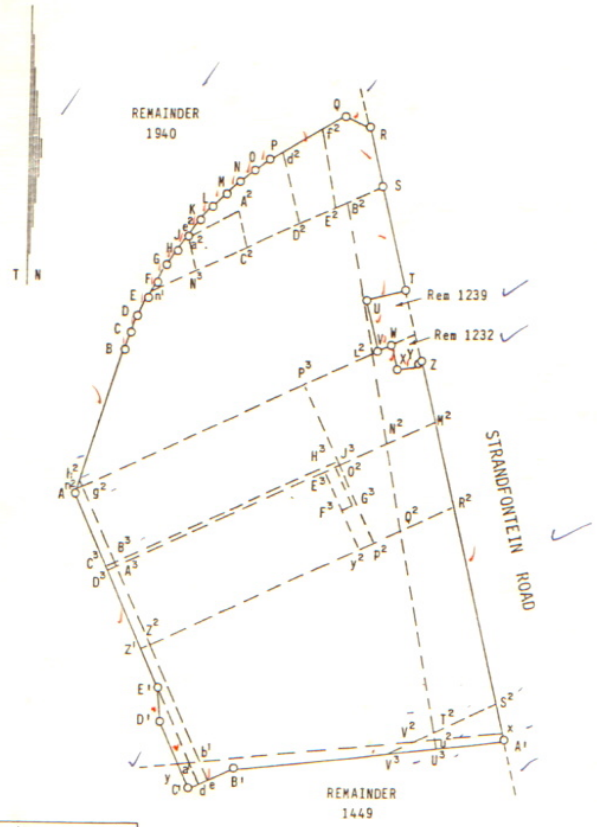
This diagram is annexed to	The original diagram~~s~~ are as quoted on the opposite page	File No. S/5908/34 S/5908/19
No.	No. annexed to	S.R. No. E 1145/86
dated	Transfer/Grant	Comp. AHNC-2144(M1691); AHNC-2153(M1692); AHNC-2142(M1685); AHNC-2151(M1686); AHNC-2123(M1680) AHNC-2114(M1679)
i.f.o.	No.	
Registrar of Deeds		

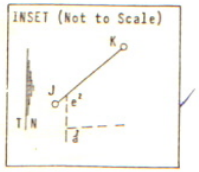
1. The figure ABCDEFGHJKLMNOPQRSTUVWXYZxyD'E' represents Erf 2711 Ottery vide Dgm.No.3692|86 D/T
2. The figure yxA'B'C' represents Erf 2710 Ottery vide Dgm. No.3691/86 D/T

S.G. No. 3693-86

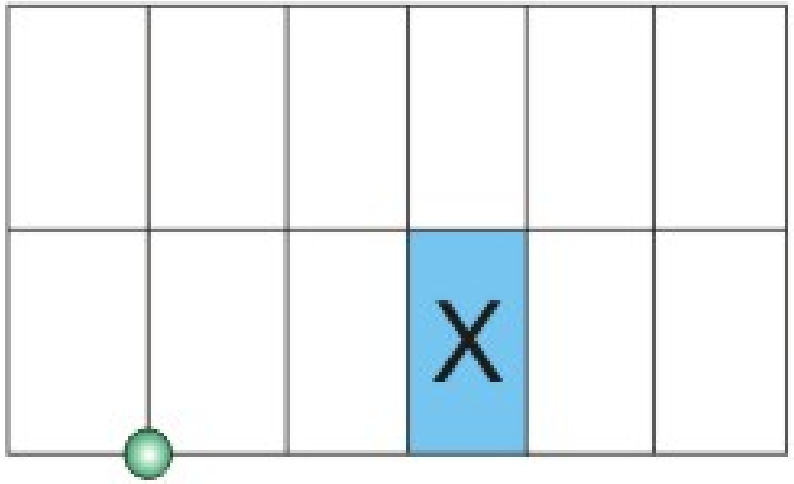
Approved

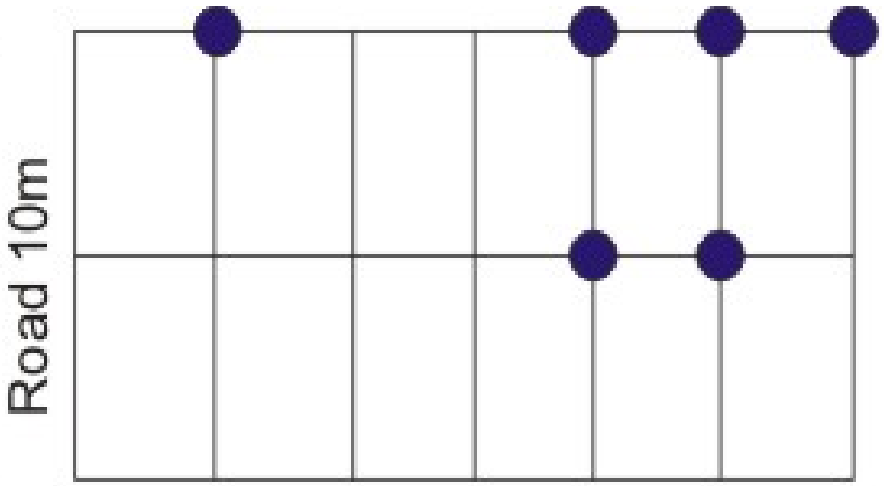
Surveyor-General

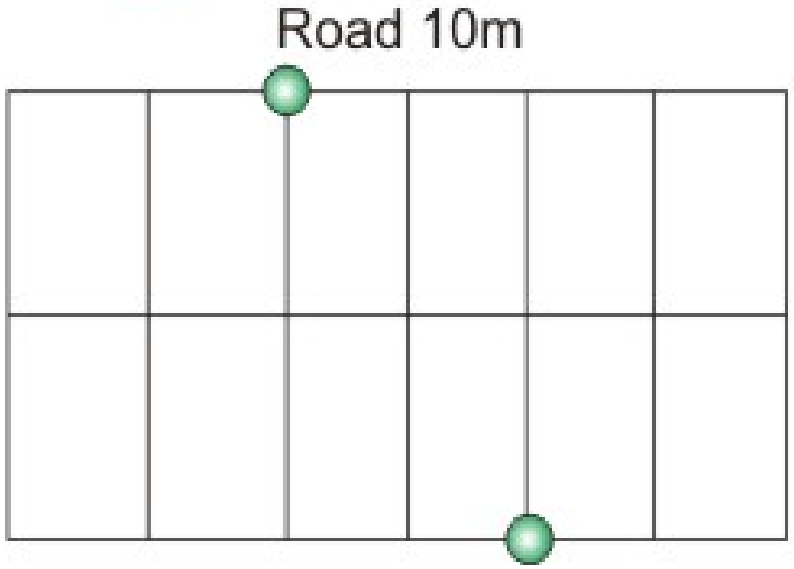




Scale: 1/6000



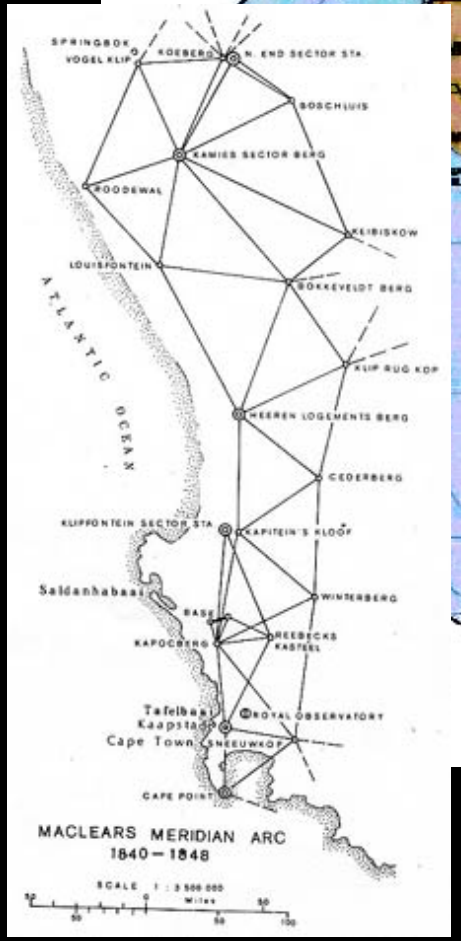


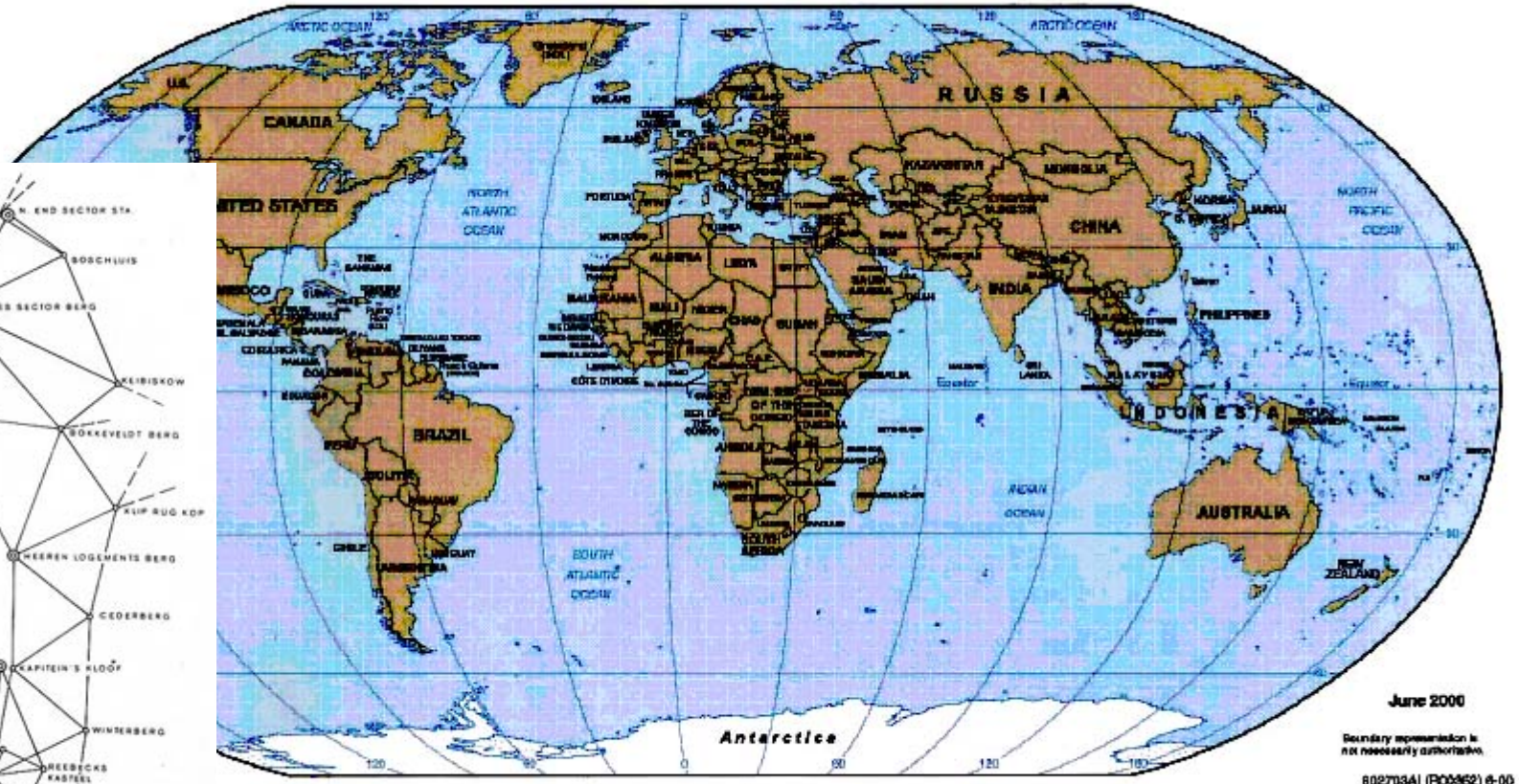


Survey 1

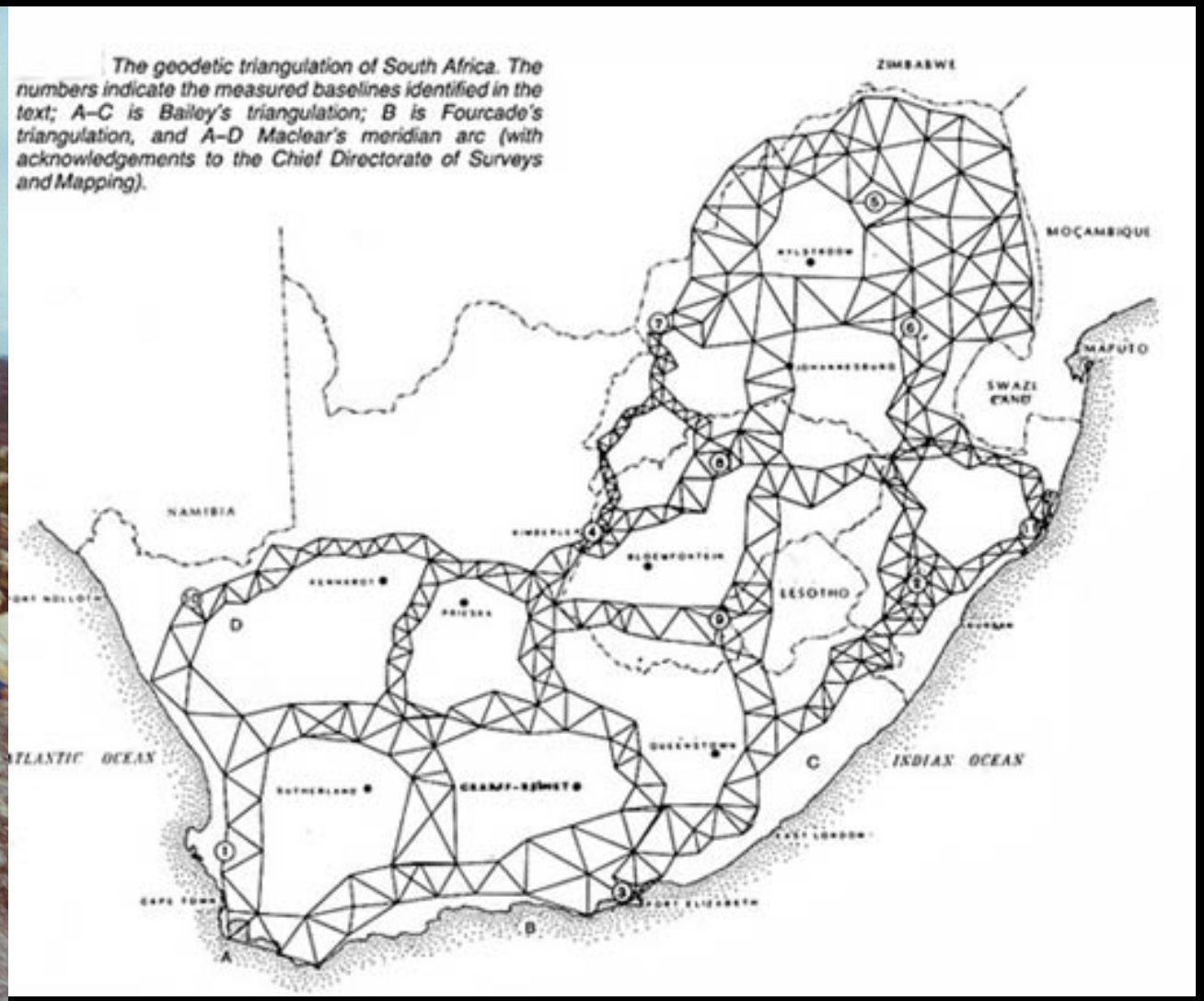
Survey 2

Task : locate and replace monuments of X.
Surveys 1,2 ... on coords.


SPRINGBOK
VOGEL KLIP
KOEBERG
N. END SECTOR STA.
BOSCHLUIS
KAMIES SECTOR BERG
ROODEWAL
KEIBISKOW
LOUISFONTEIN
BOKKEVELDT BERG
KLIP RUG KOP
HEEREN LOGEMENTS BERG
CEDERBERG
KLIPFONTEIN SECTOR STA.
KAPITEIN'S KLOOF
WINTERBERG
Saldanhabaai
BASE
KAPOCBERG
REEBECKS KASTEEL
Tafelbaai
ROYAL OBSERVATORY
Kaapstad
Cape Town
SNEEUWKOP
CAPE POINT
ATLANTIC OCEAN
MACLEARS MERIDIAN ARC
1840 – 1848
SCALE 1 : 3 500 000
Miles


ARCTIC OCEAN
RUSSIA
CANADA
UNITED STATES
NORTH ATLANTIC OCEAN
NORTH PACIFIC OCEAN
CHINA
INDIA
PHILIPPINES
INDONESIA
BRAZIL
AUSTRALIA
NEW ZEALAND
INDIAN OCEAN
SOUTH ATLANTIC OCEAN
Antarctica
June 2000
Boundary representation is not necessarily authoritative.
802703AI (R00862) 6-00

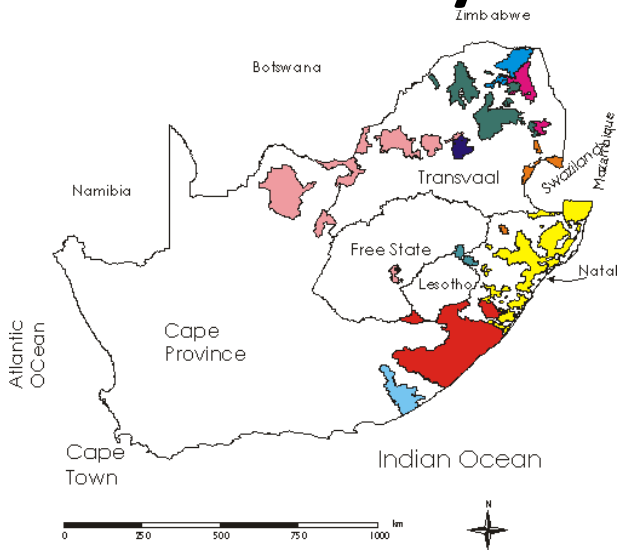
Geodetic Survey and Geodesy

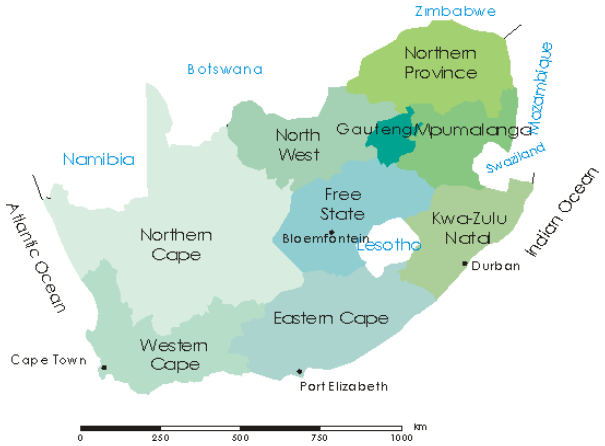


The geodetic triangulation of South Africa. The numbers indicate the measured baselines identified in the text; A–C is Bailey's triangulation; B is Fourcade's triangulation, and A–D Maclear's meridian arc (with acknowledgements to the Chief Directorate of Surveys and Mapping).

South African Cadastral Surveys

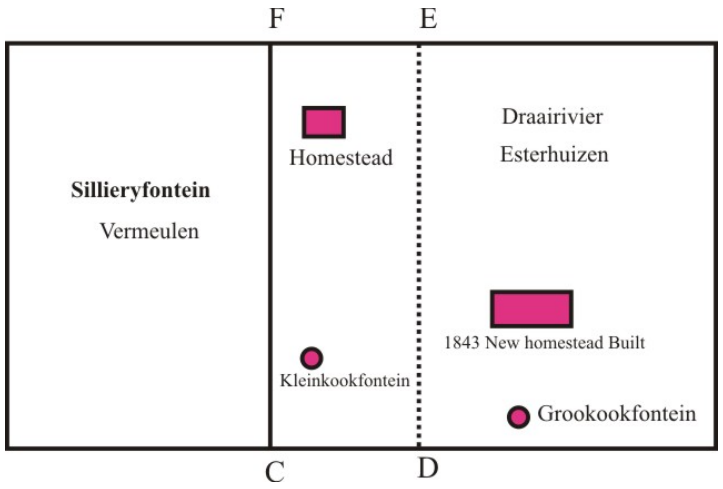
- Used coordinate systems since 1833 on various local, regional and national systems
- Multitude of boundary cases in late 19th century and early 20th century
- Land Survey Act of 1927 (replaced by 1997 Act) and national mapping system – compulsory use of coordinates on national grid in rural areas soon followed after complete coverage by tertiary trig beacons.
- Local coordinate systems prior to this
- Regulation whereby Surveyor General could assign an official coordinate to a point and all surveyors would be compelled to use that coordinate thereafter introduced in 1962 but abolished in 1990's.
- All surveys, urban and rural, have had to be tied to geodetic control and coordinated since early 1990's.
- Major advantages to integrated survey systems; I don't recall litigation over fixed boundary positions since 1930's.
- But ... Some 19th century laws and policy which defy logic.





Cape of Good Hope: Esterhuizen's Executrix v Vermeulen 1867-8

- 1830 two farms surveyed and beacons placed at C and F.
- 1838 farms sold "according to diagram"
- Upon resurvey, diagrams showed beacons should be at E and D; Esterhuizen abandoned his house and moved to new homestead.
- 1858 Cape Land Beacons Act recognised original monuments as taking precedence and case came to court. Set the foundation for rules for arbitrators (i.e. weighting evidence) in use today.
- Court held that boundary was on line C-F, where the original monuments were.

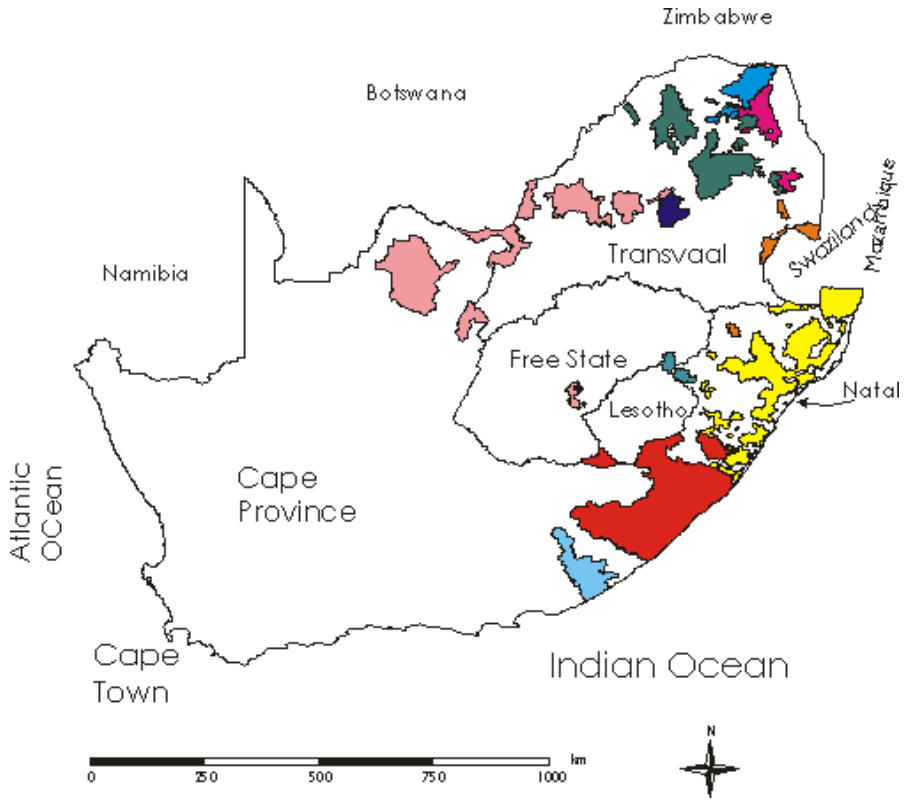


Rules for Arbitrators Land Survey Acts

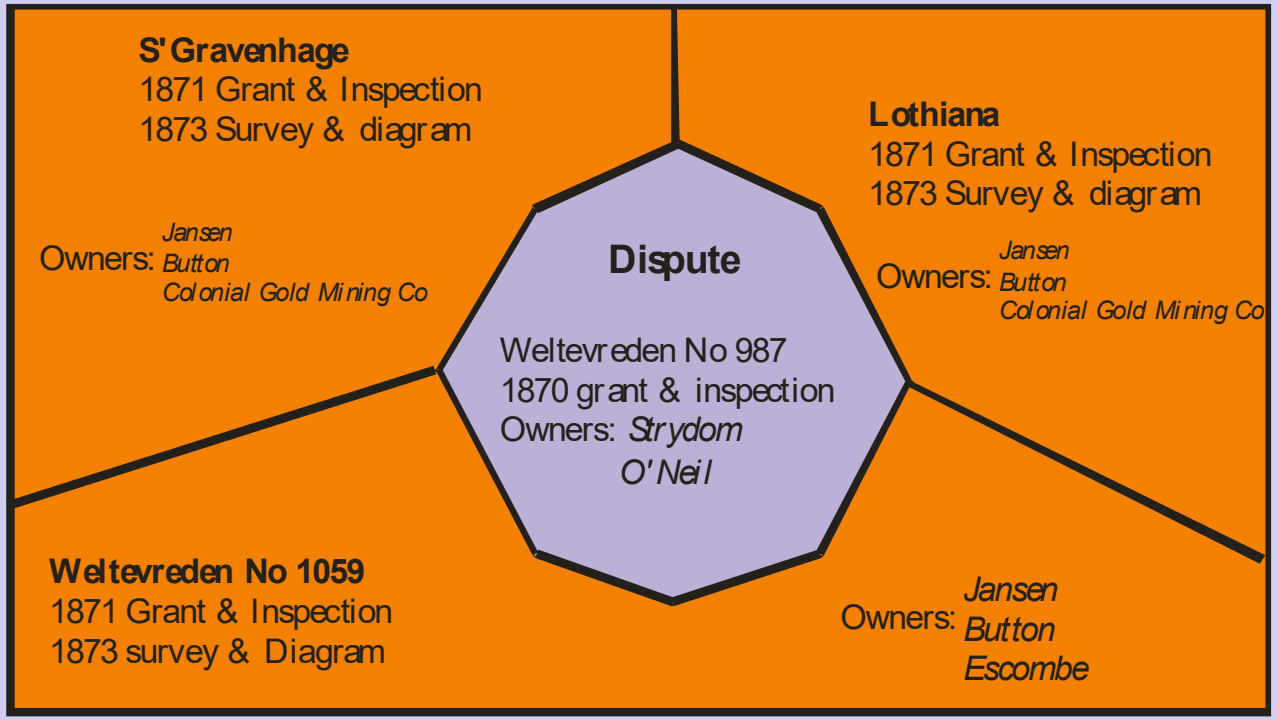
1. Original monuments / beacons
2. Well ascertained beacons recognised by all parties for 30 years or more.
3. Overlaps? Older grant prevails.
4. Diagrams to be rectified if incorrect.

Mathematics above All: Transvaal

- Transvaal Republic 1870 Act – document signed by State President is unimpeachable (indefeasible).
- An earlier act of 1864 had established the monuments should be constructed by grantees and these would be the primary evidence
- The 1870 Act probably did not intend to make survey plans / diagrams unimpeachable; that was perhaps an unintended consequence.



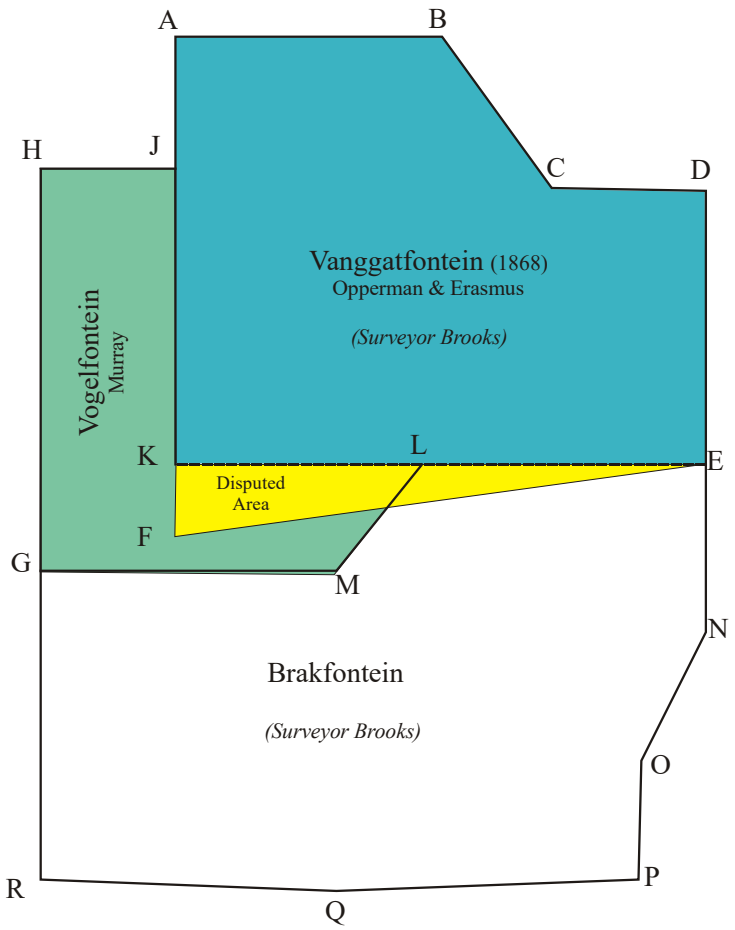
O'Neil vs Colonial Gold Mining Company & Escombe 1885



Conceptual sketch: not a representation of geometry of farm boundaries

Murray v Opperman 1904: Transvaal

- Vanggatfontein and Brakfontein surveyed by Brookes in 1868.
- All surrounding owners attended survey and agreed to large stone cairn at K as a monument.
- Brooks mistakenly depicted a working station at F as the monument on his survey diagram instead of K.
- Court held that due procedure had been followed and therefore graphical and mathematical evidence on diagram was unimpeachable and boundary monument was at F, even though all the surrounding owners had accepted the cairn at K as the monument.

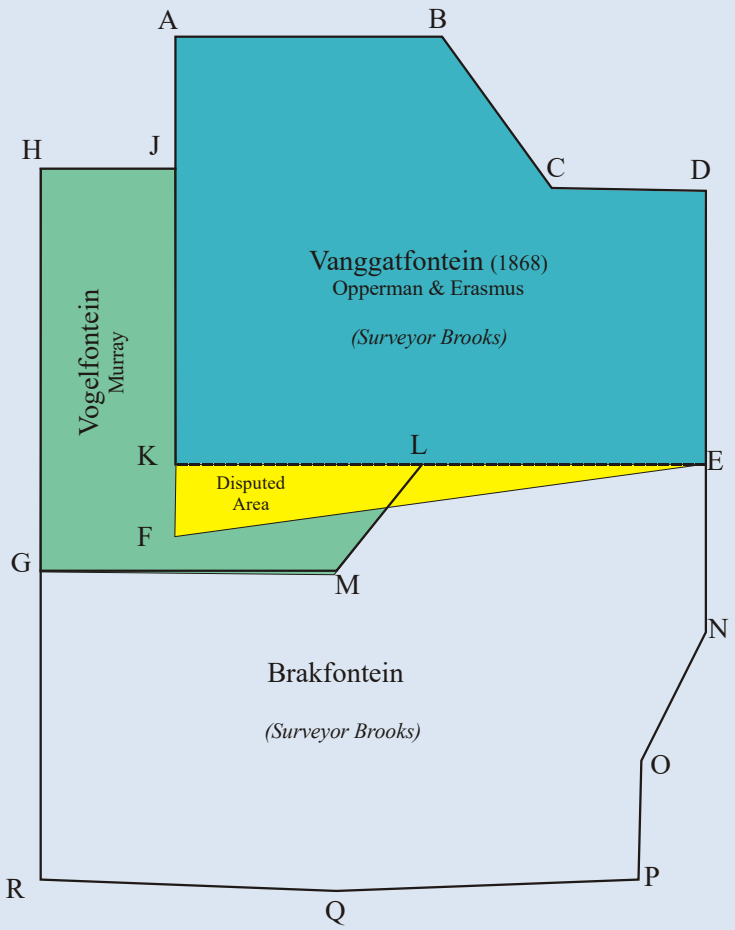


Murray v Opperman 1904: Transvaal

- The surrounding owners could have had the diagram rectified if the owners of Vanggatfontein had agreed to this.
- They didn't!
- The case reputedly had a major influence on surveyors thinking.

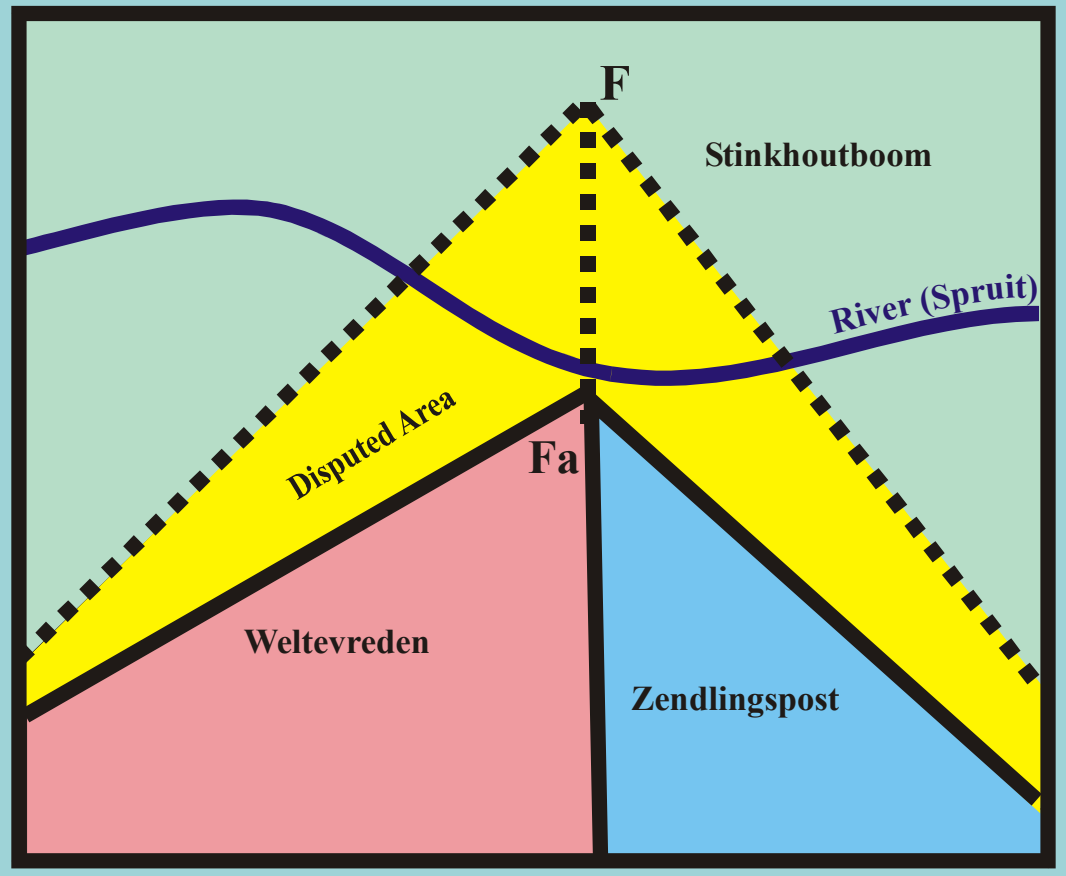
- Compare this case with Swiss and Austrian policies?

- What do we do in the case of an indefeasible coordinate at F – rather than at K - and another one at L?



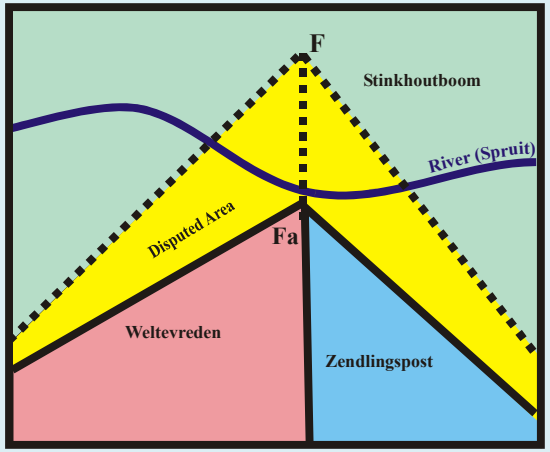
African & European Investment Co. v Warren 1924

- Three farms surveyed in 1895 and northern beacon of farms Zendlingpost and Weltevreden shown to be at Fa, south of the river.
- Original beacon was at Fa and it still existed south of the river as shown on the diagram.
- Resurvey based on mathematical evidence placed it at F. Plaintiffs claimed yellow disputed area.



African & European Investment Co. v Warren 1924

- Court held for Warren; beacon should be at Fa as mathematical evidence contradicted pictorial evidence which indicated the intent of the grantor. Picture showed the topological relationships.

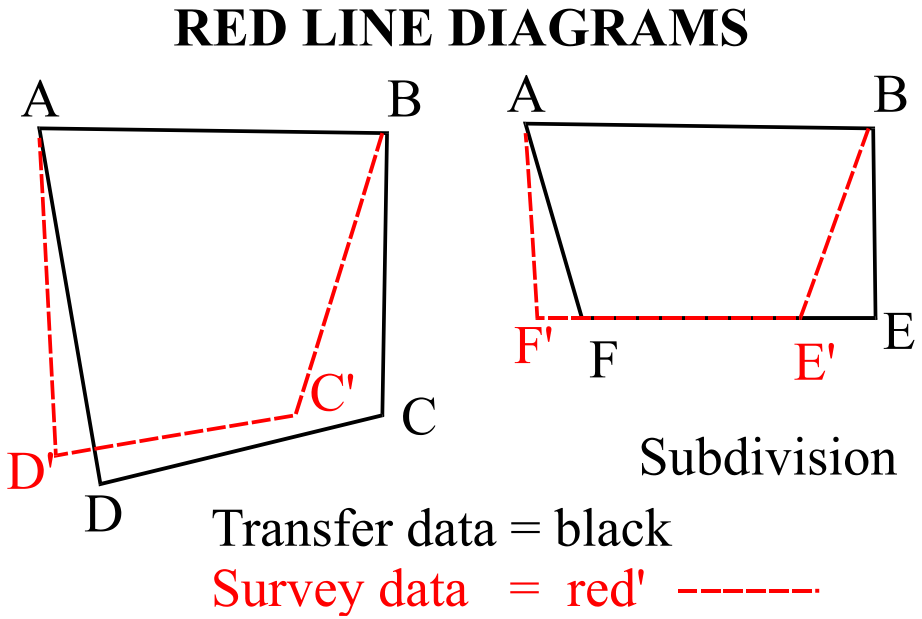


De Villiers J.A.:" ...in the case of a document which contradicts itself, the impossible conclusion is reached that the same beacon of the three farms is at one and the same time at one point, and at another 180 yards away. No document is wholly unimpeachable otherwise it would be possible for two confirmed unimpeachable documents to represent the same piece of ground and yet purport to be diagrams of different pieces of ground..... There are limits of what the legislation can decree, that limit being determined by the impossible."

What do these 3 cases tell us about coordinates, indefeasible boundaries and topological relationships in determining boundary positions?

Simons Town 1795 grant and 1886 subdivision with road allowance

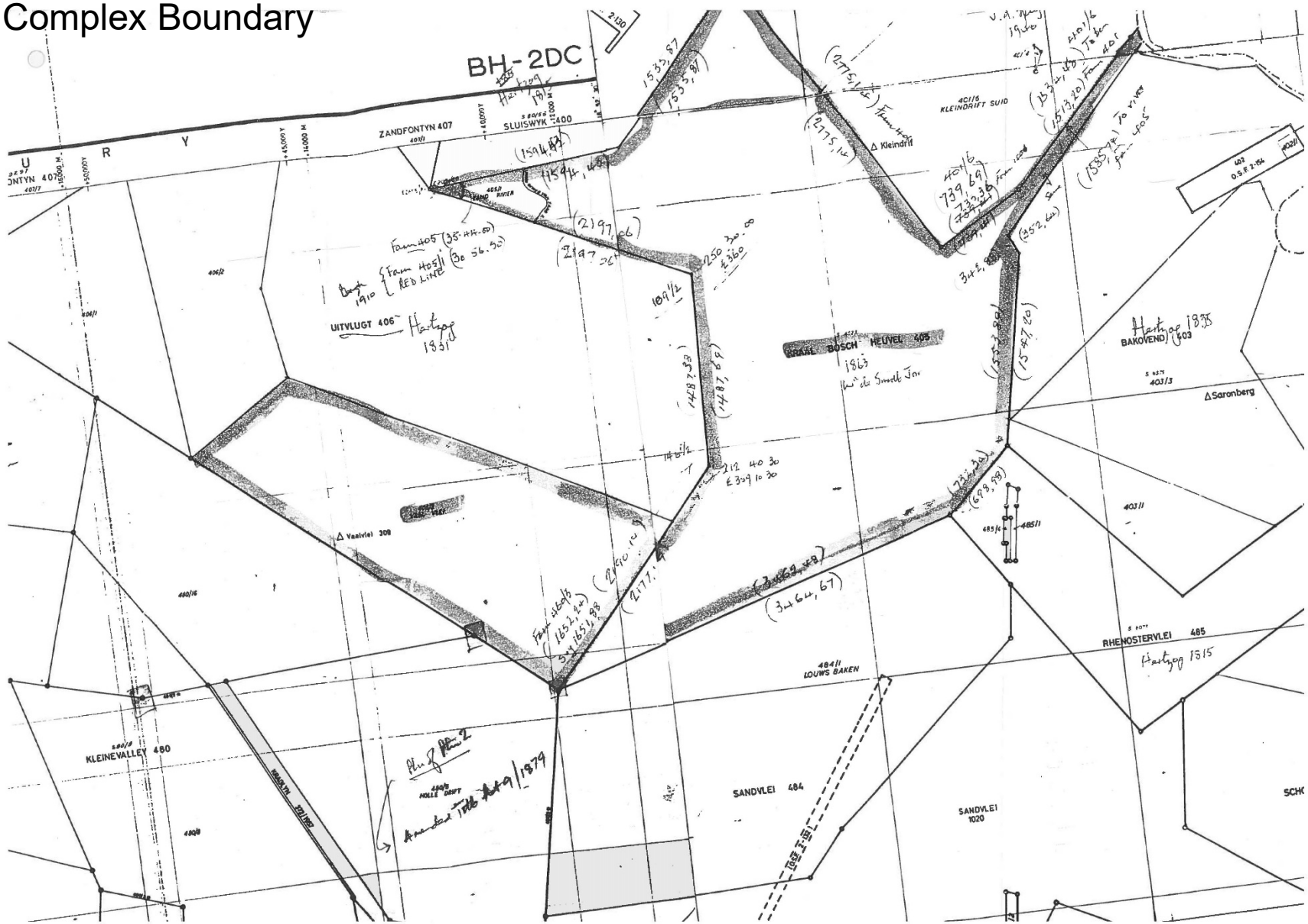
Cape of Good Hope: Red Line Diagrams by Cape Government Notice 229/1879



- Poor compromise for amended title. If black data was incorrect, surveyor put the "correct" red lines in the survey plan, but registration done on black line data. Notion that you could not change a registered document.
- Red line / black line data carried forward to subdivisions.
- "Very incorrect surveyors" didn't bother to create red lines; just made their data fit the black data (I've only come across one such case – discussed later).

Moorreesburg: 1863 Survey and older adjacent ones

Complex Boundary



Moorreesburg

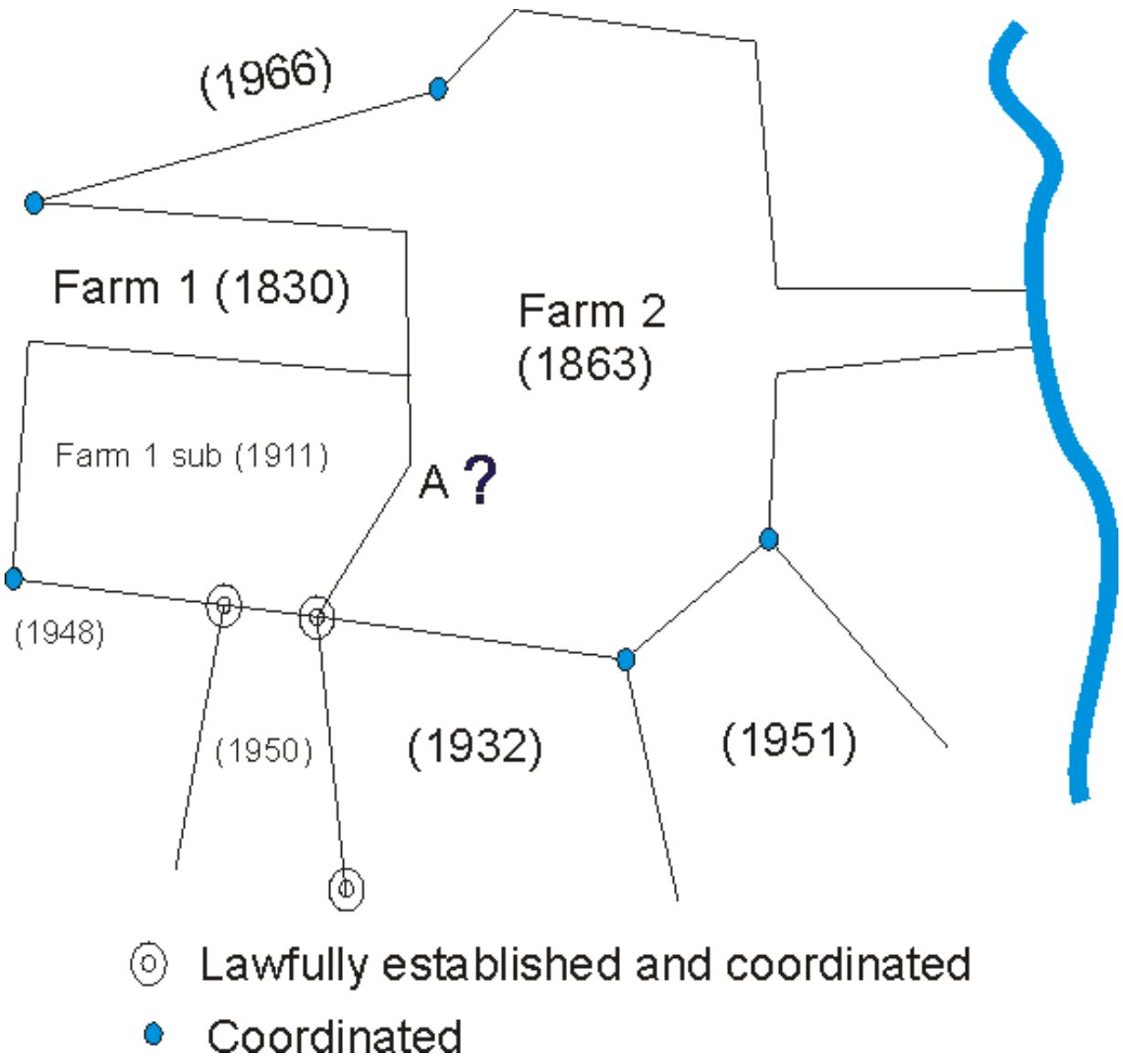
Challenges

Position of A out by 200m, but rest of 1863 survey compares well with more recent surveys

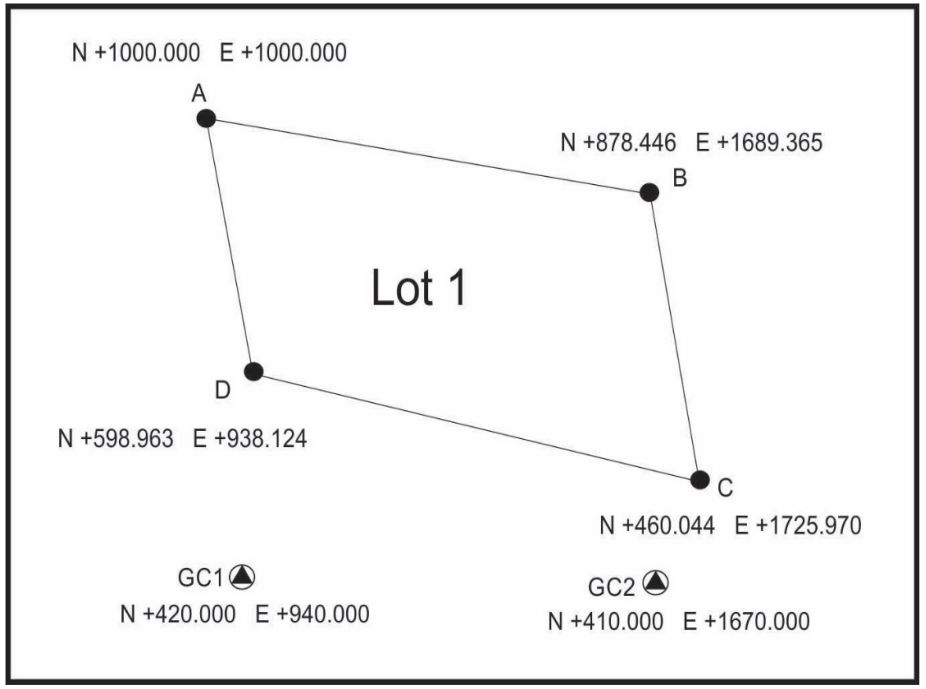
Red line data on 1911 survey provided a clue.

Coordinates of line in 1948 survey “out” by 40cm over 2km; now what?

Lawfully established monument off line and my reconstructed coordinate different to original coordinate



Re-establish B – Monuments A, C and D found



Plan Data

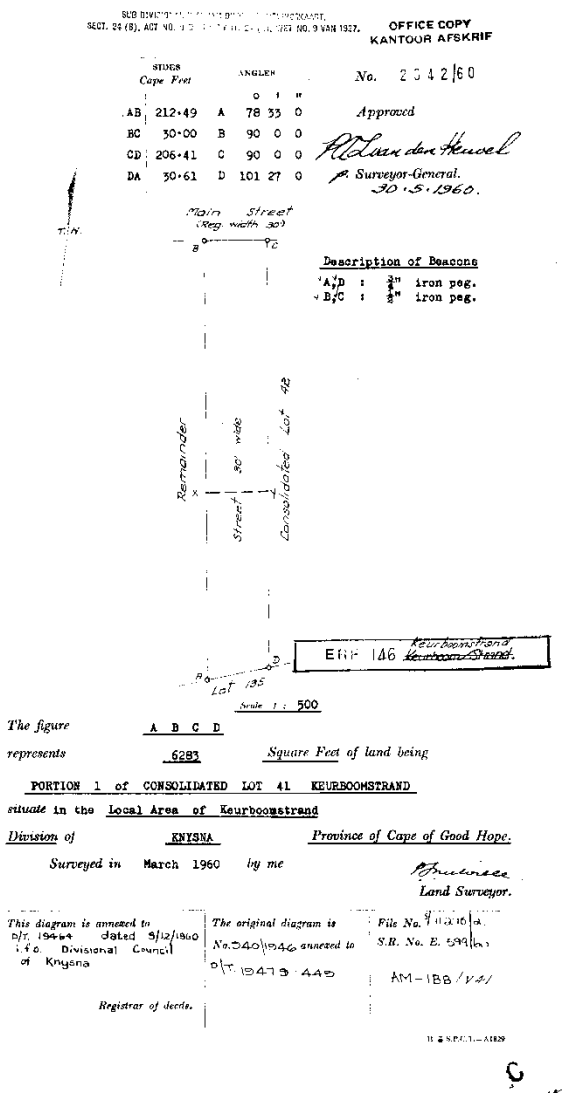
Coordinate Comparison of Monuments A, C & D			
		Northings	Eastings
Original Survey (year) Plan #	A	1000.000	1000.000
Current Survey (Year)	Afound	999.9800	1000.030
	Δ	+0.020	+0.030
Original Survey (year) Plan #	C	460.044	1275.970
Current Survey (Year)	Cfound	460.059	1275.995
	Δ	+0.015	+0.025
Original Survey (year) Plan #	D	598.963	938.124
Current Survey (Year)	Dfound	460.059	1275.990
	Δ	+0.025	+0.035
Mean Shift to be applied to the coordinates of B.	Δ	+0.020	+0.030
Original Survey (year) Plan #	B	878.446	1689.365
Correction	Δ	+0.020	+0.030
Replacement Value for B	BNew	878.466	1689.395

Survey Plan /Diagram Case: Urban Survey 1960: No Coordinates

- Urban surveys required coordinates from late 1960's if in reasonable range of a TSM / trig beacon.
- Plan on right has no coordinates.
- Draw original survey and see if surveyor did tie to trig or TSM's – (see next slide for general practice)
- If so, similarity transformation using old and new geodetic control points and transform coordinates of boundary monuments in the original survey.
- Use these to search for original monuments.
- If none found, search wider until reasonable original monument evidence found.

Reconstruct positions based on mathematical evidence. Then further search for evidence of originals and replace. Reconstructed positions should be close to fence posts; otherwise do further investigation.

If no coordinates, search for monuments near fence posts and survey fence posts. Adopt objects that tie in well with mathematical data on diagram.



SUB DIVISION ... SECT. 24 (8), ACT NO. ... SECT NO. 9 VAN 1927.

OFFICE COPY
KANTOOR AFSKRIF

No. 2342/60

	SIDES Cape Feet		ANGLES ° ' "
AB	212·49	A	78 33 0
BC	30·00	B	90 0 0
CD	206·41	C	90 0 0
DA	30·61	D	101 27 0

Approved

P. Surveyor-General.
30·5·1960.

Main Street (Reg. width 30')

Description of Beacons
A/D : ¾" iron peg.
B/C : ¾" iron peg.

Remainder
30' wide Street
Consolidated Lot 42

ERF 146 Keurboomstrand ~~Keurboom Strand~~

Lot 135

Scale 1 : 500

The figure A B C D represents 6283 Square Feet of land being

PORTION 1 of CONSOLIDATED LOT 41 KEURBOOMSTRAND

situate in the Local Area of Keurboomstrand

Division of KNYSNA Province of Cape of Good Hope.

Surveyed in March 1960 by me

Land Surveyor.

This diagram is annexed to D/T. 19464 dated 5/12/1960 i.f.o. Divisional Council of Knysna

Registrar of deeds.

The original diagram is No. 540/1946 annexed to D/T. 19479 · 445

File No. 9/1.2.16/2.
S.R. No. E. 599/(m)
AM-1BB/V41

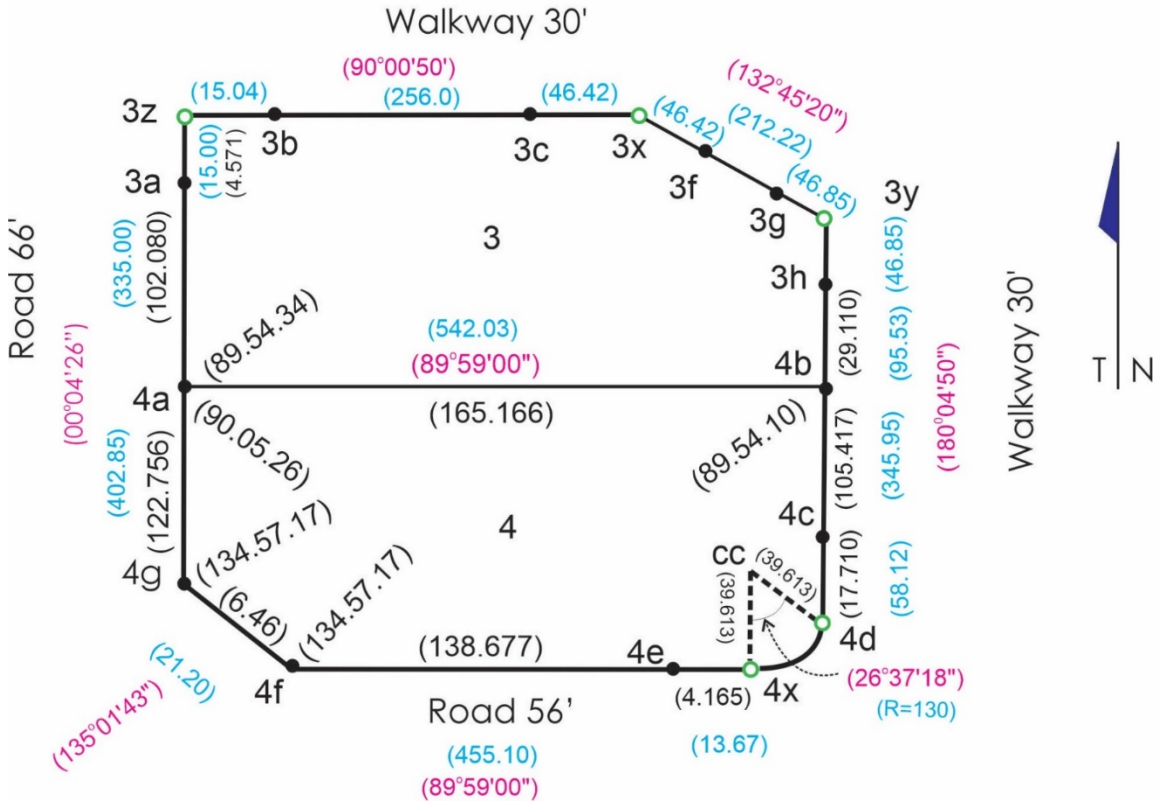
Data Comparison

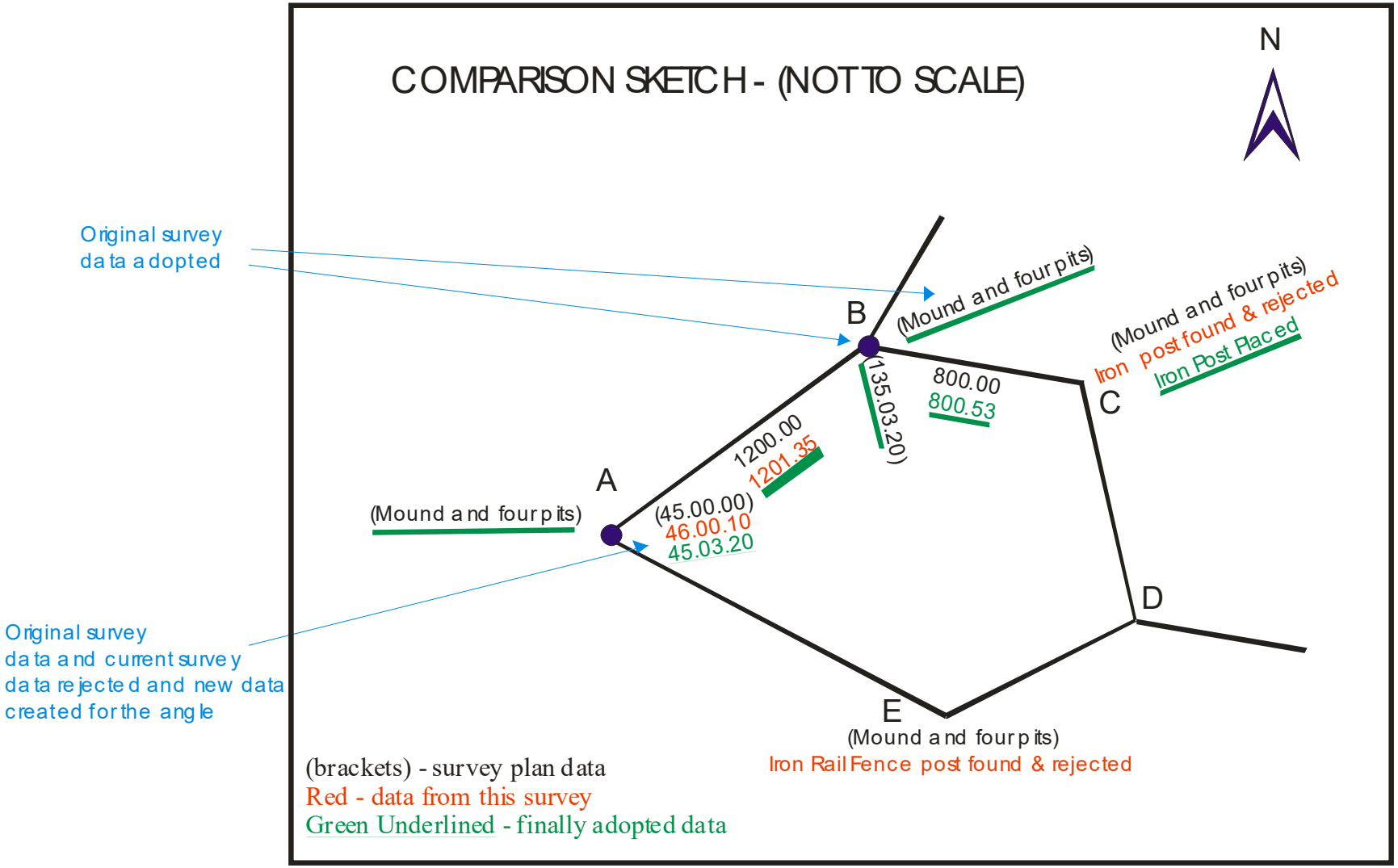
Preliminary Comparision sketch - not for distibution

Plan data - Ground distances in Feet - (blue in brackets) - not necessary on sketch
Plan data - bearings in d.m.s (crimson in brackets) - not necessary on sketch

Plan data - Grid distances in metres and angles - (black in brackets)
- combined factor 0.3048 x 0.999973 = 0.304717708

All monuments - (statutory iron posts)

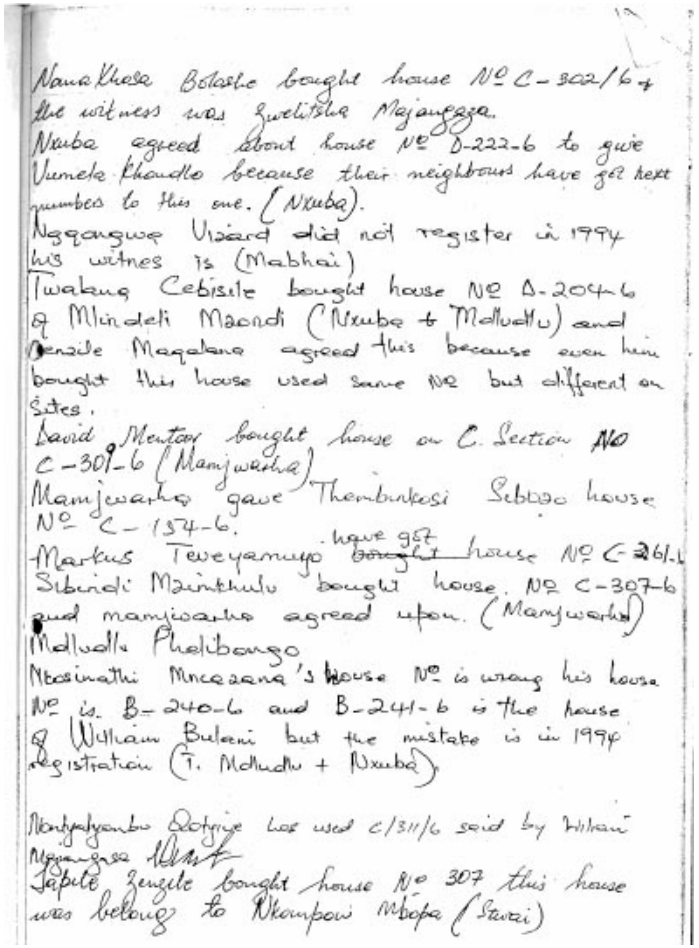




Visualise
Explore
Model

Sample of Parts of a Comparison Sketch

Policy decisions: Go and get your feet dirty!



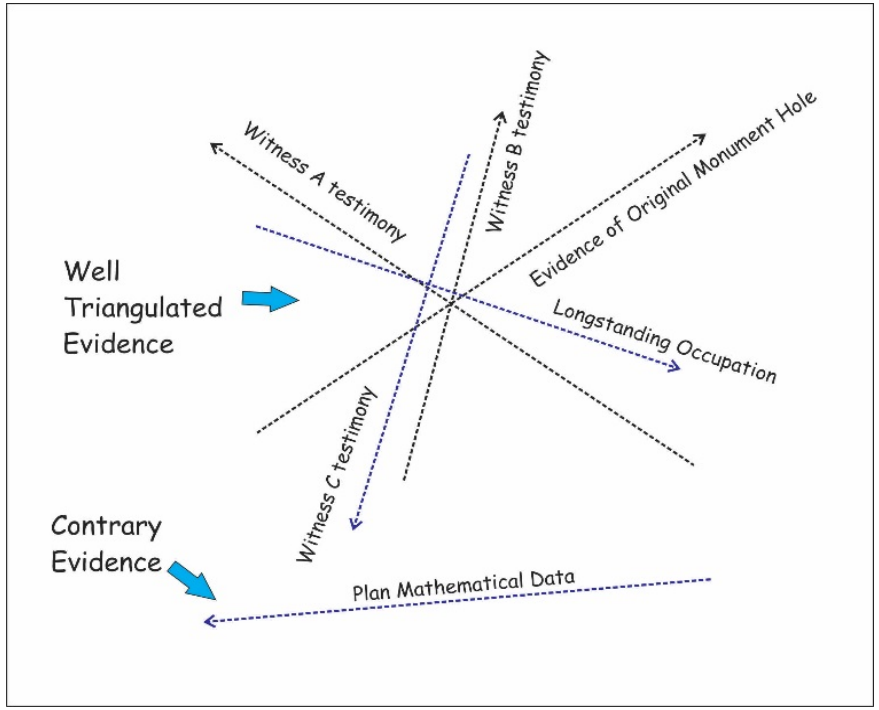
Nana Khala Bolaba bought house Nº C-302/6 + the witness was Zwelitsha Majangaza.
Nxuba agreed about house Nº D-222-6 to give Vumela Khandlo because their neighbours have got next numbers to this one. (Nxuba).
Ngqangwe Vizard did not register in 1994 his witnes is (Mabhai)
Twabang Cebisile bought house Nº D-204-6 & Mlindeli Maondi (Nxuba + Mdluelu) and Denzile Magalana agreed this because even him bought this house used same Nº but different on sites.
David Mentor bought house on C. Section Nº C-307-6 (Manjwarha)
Manjwarha gave Thembinkosi Sebiao house Nº C-134-6.
Markus Teveyamuyo ~~bought~~ have got house Nº C-261-6
Sibindi Mzinthulu bought house Nº C-307-6 and manjwarha agreed upon. (Manjwarha)
Mdluelu Phelibongo
Mbosinathi Mncezana's house Nº is wrong his house Nº is B-240-6 and B-241-6 is the house of William Bulani but the mistake is in 1994 registration (T. Mdludu + Nxuba)

Nontyalyambu Qotyiso has used C/311/6 said by William Ngangwe
Japile Zenzile bought house Nº 307 this house was belong to Nkompow Mbopa (Stwai)

Re-establishment: Suggestions

- Retain the hierarchy, but apply appropriate weights to the evidence.
- Caution against coordinates being absolute
- Major advantages to having coordinates on plans
- If a modern plan, accept the plan data but do enough do prove it wrong. Evidence should triangulate.
  - Check the plan for consistency before you start a survey.
  - Do not accept coordinates uncritically. Do proper plan checking.
- Understand the expected precision of a particular survey
- Link coordinated surveys to geodetic control if possible – adjust coordinate values if geodetic control values have changed

Well Triangulated Data / Evidence

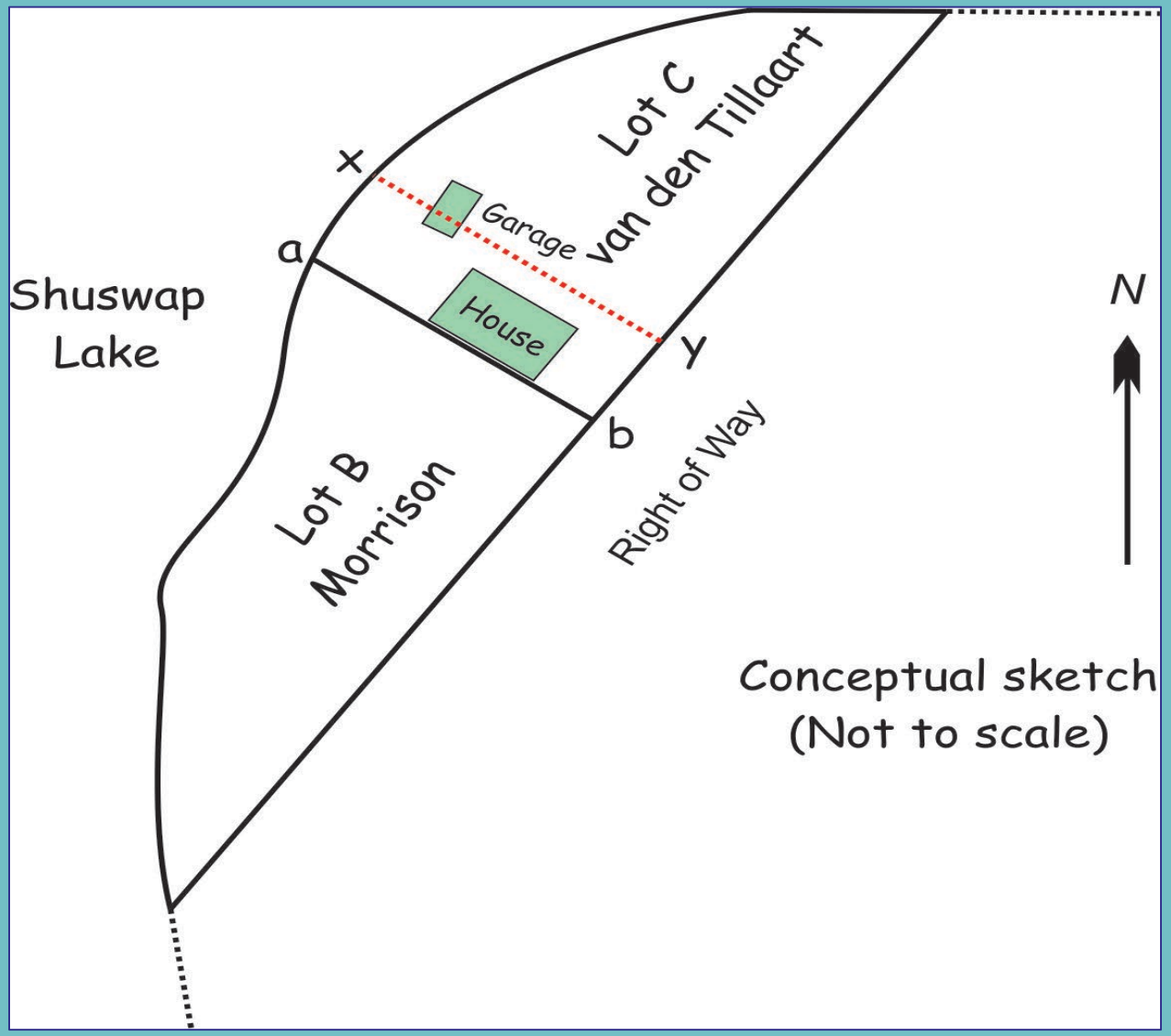


Questions: Do we move coordinates above original monuments in the hierarchy or merely place greater emphasis on weighting of evidence?

Hierarchy assumes all items of evidence are equally persuasive and therefore carry equal weight in forming a judgement / opinion. In reality we seek what social scientists refer to as triangulation (concept originates in surveying) – different items and classes of evidence together provide a conclusive or at least persuasive indication of the area in which a lost monument falls and we weight evidence items according to their quality / reliability to estimate the most probable position.

Zone of uncertainty is a key, but often forgotten concept especially when coordinates are used as evidence.

Morrison v van den Tillaart 2012



Questions / Discussion

- If we have a delayed posting plan where corners are initially defined by coordinates. When times comes to post the corners, the surveyor mistakenly places a post out of position. Then what?