

Surrey Calibration Baseline 1999 Provisional Values

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Baseline Site

The Surrey baseline is a stable baseline due to careful site selection and construction. It is built on well-drained gravel with well-constructed piers. The profile is flat and all piers are linear and intervisible.

There is abundant vegetation in the area, requiring frequent clearing. Radio transmissions interfere with automated meteorological sensor readings during measurements.

The baseline is on the grounds of the Surrey Nursery and Seed Orchards. The six piers have a north-south orientation, with pier 1 the most southerly one. A seventh pier (GCM #192740), which is offset with the baseline and is part of the Surrey basenet, was also tied in during the 1994 measurements as a one time only event. Offset pier 7 is only visible with piers 1, 2 and 3. In 1999, only the six pier linear baseline was measured.

See Appendix A for a plan and profile view of the baseline.

Measurements

The 1999 measurements of this baseline were made by Hennessey from July 15-17 using the ME5000 (serial number 357061). See Table 1 for the measurement history on this baseline.

In 1994, horizontal angles were measured with a Wild T-3 theodolite between piers 1, 2 and 3 on the baseline and offset pier 7 (basenet pier GCM #192740).

Table 1: Measurement history

Date	Observer	Instrument	Serial Number
June 6-9/1989	Lafrance	Geomensor CR204	013
Aug. 2-4/1990	Lafrance	Mekometer ME5000	357061
July 15-20/1994	Hennessey	Mekometer ME5000	357061
July 15-17/1999	Hennessey	Mekometer ME5000	357061

Each baseline measurement for a year consists of at least three double (forward and backward) distance measurements between all intervisible piers using the Mekometer ME5000 EDM instrument; except the Geomensor CR204 in 1989.

NGBL Calibration

The scale bias for the ME5000 was determined from two independent calibration surveys on the National Geodetic Baseline (NGBL). The constant bias from the NGBL was used as a gross check on the value determined from the Surrey baseline adjustment. The average scale bias from the two NGBL calibrations was applied to all distance observations. See Table 2 for the 1999 NGBL biases.

Table 2: ME5000 biases derived from 1999 NGBL measurements

Date	Measurement Sets	Constant Bias Value \pm Std.Dev. (mm)	Scale Bias Value \pm Std.Dev. (ppm)
May 25-27	3	-0.4 ± 0.1	$+0.20 \pm 0.20$
August 18-21	3	-0.3 ± 0.1	$+0.16 \pm 0.14$
Average		-0.4 ± 0.1	$+0.18 \pm 0.17$

Baseline Adjustment

The 1999 Surrey baseline measurements were processed with the baseline adjustment program CALIB (version 1.1, May 95). Interpier distances and a constant instrument bias were estimated. A minimally constrained adjustment was made with pier 1 fixed. An a priori standard deviation of 0.1 mm + 0.5 ppm was used for all ME5000 distances, and 0.1 mm for the centering errors. The results of the 1989, 1990, 1994 and 1999 adjustments are summarized in Appendix B. For the adjustment and analysis of the measurements done prior to 1999, the reader is referred to the reports issued for those years.

The constant bias from the 1999 CALIB adjustment was -0.3 ± 0.1 mm, which is consistent with the estimate obtained from the NGBL calibration (see Table 2). The variance factor for the adjustment was 1.253, which passes the Chi-square test. All residuals passed the Chi-square goodness-of-fit test for normal distribution. All tests were performed at the 95% confidence level.

Comparison with Previous Epochs

The results of the 1989, 1990, 1994 and 1999 adjustments were compared to check for any scale differences and pier movements between epochs. The analysis were performed with the baseline comparison program LINCOMP (version 1.3, May 95). The reader is referred to the reports issued for 1989, 1990 and 1994 for details of those measurements.

Pier Movement Analysis

The pier movement analysis performed by program LINCOMP uses the “least absolute sum” (L1-norm) solution. Piers that are identified as having statistically significant coordinate differences are removed from the analysis by renaming them. The process is iterated until no outliers remain. For the comparisons between the 1989, 1990 and 1994 epochs, all baseline piers were stable. LINCOMP did not detect any pier movements.

For the comparison between 1994 and 1999 epochs, the pier in Table 3 was found to have moved. The coordinate differences are estimated from a combined CALIB adjustment (least squares, L2-norm) of the epochs.

Table 3: Pier movement on the Surrey baseline

Comparison		Pier	Coordinate Differences	
From	To		Value \pm Std.Dev. (mm)	95% Confidence Interval (mm)
1994	1999	4	-0.5 ± 0.2	-0.9 to -0.1

Scale Difference Analysis

Any scale difference between epochs is estimated with program LINCOMP using the least squares (L2-norm) solution with suspected pier movements removed. The estimated scale differences between epochs are given in Table 4.

Table 4: Scale difference between epochs

Comparison		Piers Used	Scale Change	
From	To		Value \pm Std.Dev. (ppm)	95% Confidence Interval (ppm)
1989	1990	1,2,3,4,5,6	-0.08 ± 0.37	-0.81 to +0.65
1990	1994	1,2,3,4,5,6	$+0.54 \pm 0.36$	-0.17 to +1.25
1994	1999	1,2,3,5,6	$+1.26 \pm 0.37$	+0.54 to +1.98

The estimated scale difference is statistically significant at the 95% confidence level between the 1994 and 1999 epochs. The large standard deviation and confidence interval reflect the fact that the scale difference estimate is primarily based on the longer (less precise) distances.

Provisional Distances

Due to the unreliable pier movement detection, only Provisional Distances for the Surrey baseline are given in Appendix C and are based on the 1999 measurements. This table gives the adjusted interpier slope distances, estimated standard deviations and elevation differences. The distances are only reliable for the epoch of the survey.

Recommendations

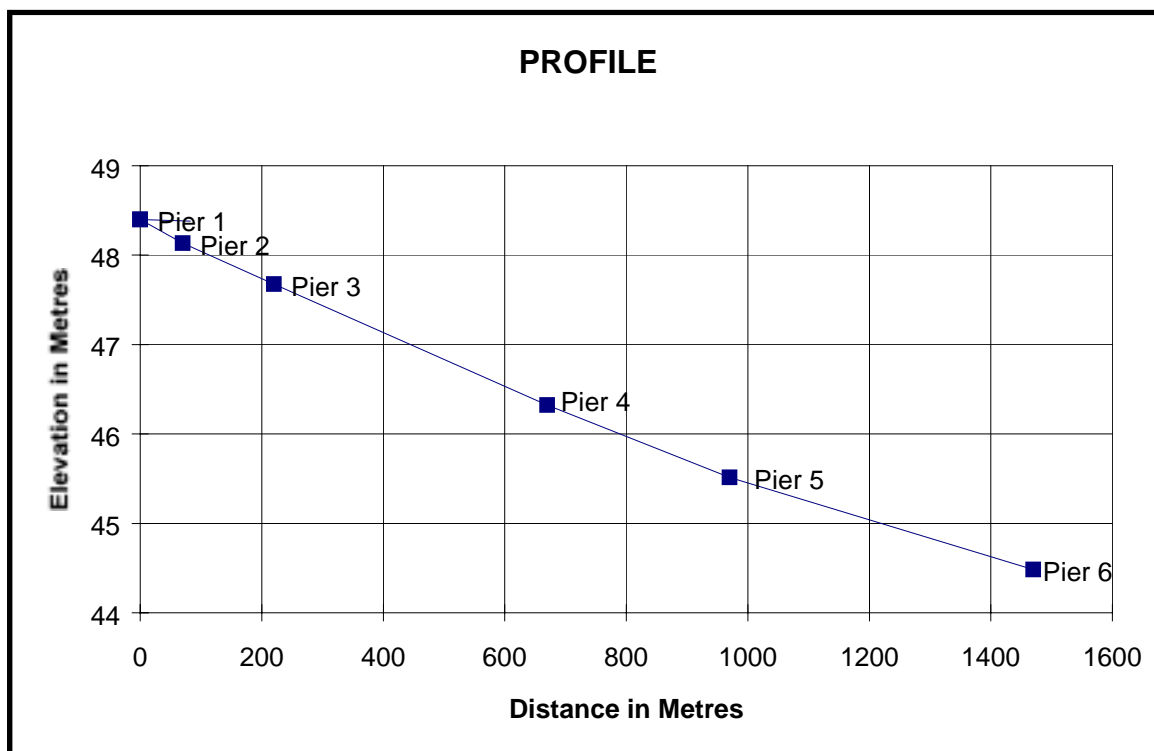
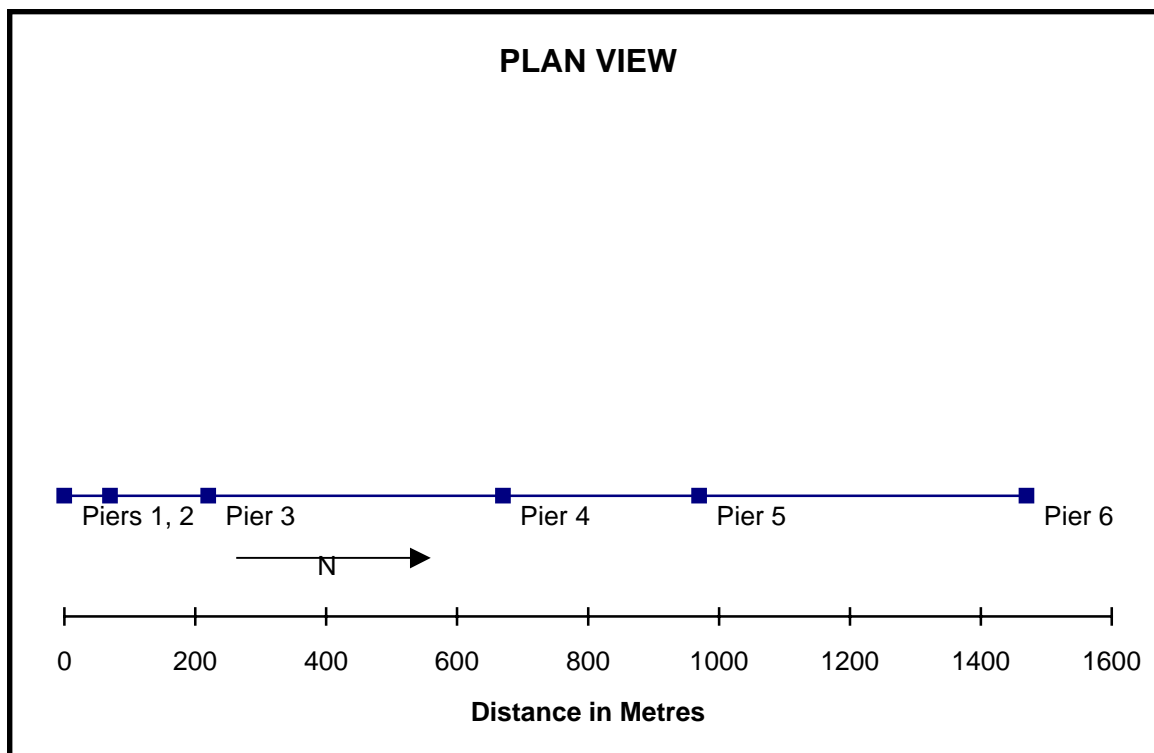
From our analyses for the Surrey baseline, there appears to be two options available to interpret the actual pier movements. Option 1 has pier 4 moving with a large scale change from the 1994 to 1999 epoch. Option 2 has piers 5 and 6 moving but LINCOMP (L1-norm) solution cannot reliably identify them.

Since we are not 100 % sure which option is the correct analysis, the 1999 distances are issued as only provisional values and we are recommending a remeasurement for the 2000 field program. With three stable piers 1, 2 and 3 and minor movement (about -0.5 mm) at pier 4, there is adequate redundancy to derive reliable constant and scale biases.

Hennessey
March 2000

SURREY BASELINE

APPENDIX A



CALIB LEAST SQUARES ADJUSTMENT SUMMARY**APPENDIX B**BASELINE NAME: **SURREY, BRITISH COLUMBIA**

Epoch Dates	Degrees of Freedom	Variance Factor	Statistical Tests		Derived Constant mm ±	Input Scale ppm ± S.D.	Comments
			V.F.	G.O.F.			
Jun.6-9 1989	116	0.756	Fail	Pass	+2.0 ± 0.1	+0.9 ± 0.3	No outliers
Aug.2-4 1990	84	1.096	Pass	Pass	-0.2 ± 0.1	-0.4 ± 0.2	1 outlier kept
July15-20 1994	87	1.471	Fail	Pass	-0.1 ± 0.1	-0.5 ± 0.2	No outliers
July 15-17 1999	84	1.253	Pass	Pass	-0.3 ± 0.1	+0.2 ± 0.2	Np outliers

LEGEND: V.F. - Variance Factor Test
G.O.F. - Goodness of Fit Test

NOTE: All statistical and outlier tests performed with a 95% Confidence Level.

1999 PROVISIONAL BASELINE DISTANCES**APPENDIX C**

BASELINE NAME: SURREY, BRITISH COLUMBIA

Calib Version 1.1
2000

1999 Epoch

March 2,

Geodetic Survey Division, Geomatics Canada

From Pier	To Pier	Elevation Difference Metres (m)	Slope Distance Metres (m)	Std Dev (mm)
1	2	-0.265	70.0004	0.1
	3	-0.722	220.0003	0.1
	4	-2.075	670.0136	0.2
	5	-2.883	970.0082	0.2
	6	-3.916	1469.9917	0.4
2	1	0.265	70.0004	0.1
	3	-0.457	149.9999	0.1
	4	-1.810	600.0133	0.2
	5	-2.618	900.0078	0.2
	6	-3.651	1399.9913	0.3
3	1	0.722	220.0003	0.1
	2	0.457	149.9999	0.1
	4	-1.353	450.0133	0.1
	5	-2.161	750.0079	0.2
	6	-3.194	1249.9914	0.3
4	1	2.075	670.0136	0.2
	2	1.810	600.0133	0.2
	3	1.353	450.0133	0.1
	5	-0.808	299.9946	0.1
	6	-1.841	799.9781	0.2
5	1	2.883	970.0082	0.2
	2	2.618	900.0078	0.2
	3	2.161	750.0079	0.2
	4	0.808	299.9946	0.1
	6	-1.033	499.9836	0.1
6	1	3.916	1469.9917	0.4
	2	3.651	1399.9913	0.3
	3	3.194	1249.9914	0.3
	4	1.841	799.9781	0.2
	5	1.033	499.9836	0.1

Note: There has been a minor movement of about -0.5 mm at pier 4 between 1994 and 1999.