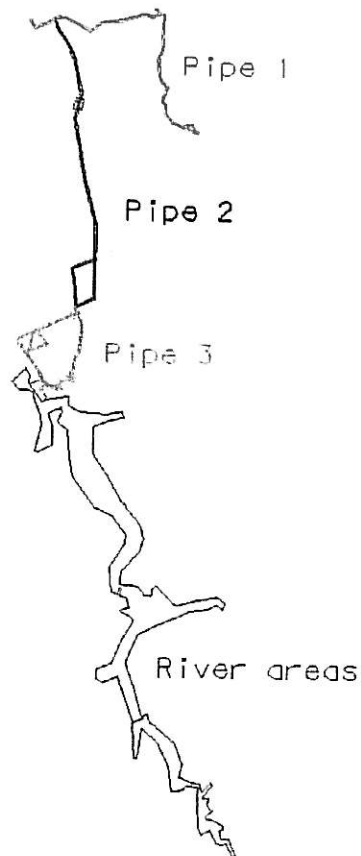


**SOUTHERN MAPPING
COMPANY**

LIDAR SURVEY REPORT

**MOKOLO & CROCODILE (WEST) WATER AUGMENTATION
PROJECT**



SURVEY: Mokolo & Crocodile (West) Water Augmentation Project.

DATE: 14 - 24 July 2009.

CLIENT: Aurecon, Kwezi V3 & Vela VKE.

INTRODUCTION:

Southern Mapping Company had been contracted by Aurecon, Kwezi V3 & Vela VKE to produce a topographical LIDAR survey of the Mokolo & Crocodile (west) Water Augmentation Project, stretching from the Hartebeestpoort dam, near Brits, to the Mokolo dam, near Lephalale, in the Limpopo Province. The project is divided into four sections, Pipe 1, Pipe 2, Pipe 3 and the River Areas, as shown above.

The topographical survey was carried out using an aircraft mounted LIDAR system that scanned the ground below with a 70 kHz laser resulting in a dense Digital Terrain Model (DTM) of the ground surface and objects above the ground. Digital colour images were also taken from the aircraft to produce colour orthophotos of the area.

The survey was flown at a height of about 1000m above ground level and an image pixel size of 10cm was obtained.

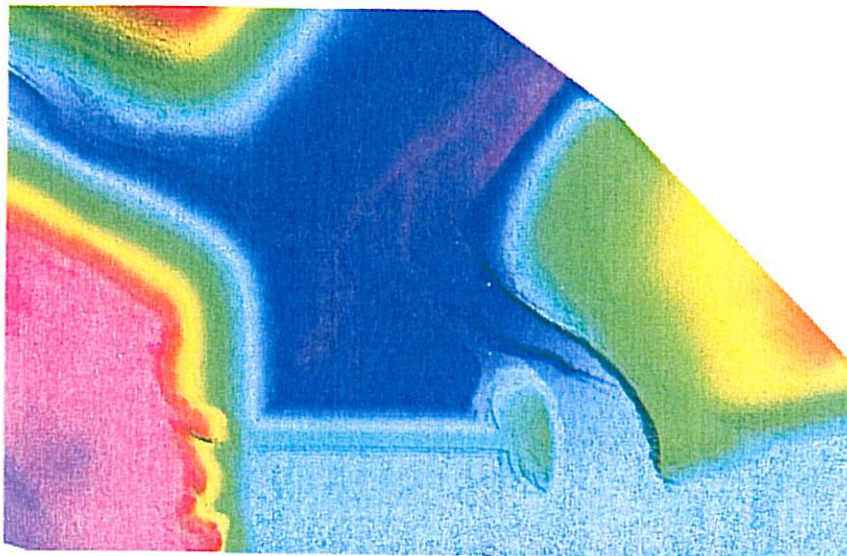
EQUIPMENT USED:

Aircraft: Cessna Grand Caravan aircraft.

Laser Scanner: Optech ALTM 3100 EA (up to 100 000 ranges per second)

Camera: Rollei AIC with a 64 mega-pixel Lightphase digital CCD.

GPS: Topcon and Trimble dual frequency receivers.



BASE STATIONS:

A GPS survey was carried out by SMC to produce control points for the base station positions. These points aided in checking the integrity of the Lidar survey and were also used as control for the additional beacons along the pipeline routes. They are based on point A4809 which is the datum for the Eskom Coal 3 project.

The network calculation is shown in annexure A.

The co-ordinates of the calculated base points are:

NAME	Latitude	Longitude	Ellip Ht.
SMCAA0922010	-23 52 44.35419	27 37 53.79575	974.5723
SMCAA0922079	-24 17 26.95091	27 26 58.37767	1035.6875
SMCAA0922126	-24 36 16.19383	27 20 17.21282	1023.0849
SMCAA0922167	-24 53 08.81525	27 31 40.62734	958.0332
SMCAA0922264	-25 15 36.46704	27 33 00.90507	1004.3884
A4809	-23 51 27.79913	27 24 00.65649	994.2534 DATUM
BRITS(trignet)	-25 38 08.71948	27 46 35.78846	1166.9564
ERAS(trignet)	-23 41 12.01000	27 41 45.91299	868.6714
Raloka	-25 32 35.96191	27 42 36.63695	1101.4313

LASER POINT PROCESSING:

For the purpose of processing the laser points, the Geographical (LLH, ellipsoidal) co-ordinates of the base stations were used. This is necessary as GPS works in the WGS84 datum with ellipsoidal heights.

The trajectory for each flight was post processed using *Waypoint DGPS* software, which combines the 1 Hz GPS readings with the 200Hz inertial measurement system (IMU) readings, and outputs a smoothed "best estimated" trajectory for the laser scanner and camera positions.

After this, the laser points were processed into raw ENH points, using Optech's Realm Survey Suite. The output was in the Hartebeesthoek94, WG27 projection with ellipsoidal heights. Annexure C gives more details of Realm.

A "1st run" automatic classification was carried out on the raw laser points using TerraSolid's TerraScan software to separate the laser points into ground hits and non-ground hits. This results in $\pm 80\%$ correct classification. After this, a manual classification is done over the area to edit the points that were incorrectly classified in the automatic classification. Annexure D gives more details of Terrascan.

The points were also thinned into "key-points". Key-points are a data set with the redundant points removed and contain only the points needed to define the ground surface without losing the accuracy of the surface. This is done to make the data set more manageable.

The point elevations along the pipeline routes were transformed from ellipsoidal to orthometric using the custom geoidal model as described below.

The point elevations in the river areas were transformed using the Southern Africa Quasi geoidal model and adjusted to the overlapping control points where available.



TRANSFORMATIONS & SURVEY SYSTEM:

The Lidar survey was calculated on the Hartebeesthoek94 datum and Lo27E projection with ellipsoidal heights.

Horizontal Transformation.

No horizontal transformation was necessary as the data is to be delivered in this system.

Vertical Transformation.

Because GPS works in the ellipsoidal elevation system, the initial output of the laser points was in ellipsoidal elevations.

To transform the ellipsoidal elevations to orthometric elevations along the pipeline routes, a custom geoidal model was produced from points that were both surveyed with GPS and leveled, to determine the geoidal height differences. They were connected to the base station survey.

This GPS and level survey was done by a private company, MHP Geomatics. Their report and data files are supplied with the handover data in hardcopy and digital format.

The final points that were used in the geoidal model determination are listed below:

Pt. ID.	Y	X	Z(Ellips)	(Ortho)	dZ.
A09220001	-72039.778	2651737.579	1021.376	1003.604	-17.771
A09220002	-70338.512	2651186.722	1113.778	1096.064	-17.714
A09220003	-68989.929	2651887.880	1116.146	1098.414	-17.731
A09220004	-67230.195	2651047.655	1056.495	1038.818	-17.677
A09220005	-66436.122	2650686.661	1034.665	1016.997	-17.668
A09220006	-65026.456	2649243.000	1018.918	1001.296	-17.622
A09220007	-64155.370	2647781.965	994.354	976.786	-17.568
A09220008	-64211.688	2645849.045	985.415	967.904	-17.511
A09220009	-63620.294	2643851.374	1021.212	1003.783	-17.430
A09220010	-64328.282	2642029.142	974.568	957.158	-17.409
A09220011	-64606.372	2640945.897	986.128	968.729	-17.399
A09220012	-63122.468	2639757.116	1026.324	1008.996	-17.328
A09220013	-62601.563	2637779.461	927.986	910.740	-17.246
A09220014	-62374.416	2635954.430	923.523	906.343	-17.179
A09220015	-62131.505	2634091.546	960.906	943.789	-17.117
A09220016	-62487.754	2632497.701	944.426	927.354	-17.072
A09220017	-63189.783	2630731.217	915.580	898.577	-17.003
A09220018	-63327.988	2628805.124	930.361	913.434	-16.926
A09220019	-63255.668	2626883.356	903.875	887.016	-16.859
A09220020	-63332.484	2624847.306	878.078	861.276	-16.802
A09220021	-63546.668	2622860.110	889.344	872.630	-16.714
A0922021A	-63769.804	2621517.603	881.824	865.146	-16.679

A09220022	-62966.635	2620844.960	881.636	864.977	-16.659
A09220023	-60877.350	2619141.994	891.937	875.342	-16.595
A09220024	-61170.232	2621666.523	892.652	875.969	-16.683
A09220025	-59479.308	2622286.402	906.117	889.419	-16.699
A09220026	-59799.512	2622336.251	904.304	887.641	-16.663
A09220027	-58128.258	2623305.318	912.177	895.405	-16.771
A09220028	-56251.799	2623879.609	925.967	909.265	-16.702
A09220029	-55419.397	2624214.233	929.911	913.205	-16.707
A0922029A	-55581.893	2622940.448	922.915	906.241	-16.674
A09220030	-53580.967	2623070.634	931.337	914.671	-16.665
A09220031	-51610.738	2623074.563	935.091	918.432	-16.659
A09220032	-49624.366	2623273.293	931.995	915.329	-16.667
A0922032A	-47624.476	2623445.477	938.940	922.277	-16.663
A09220033	-46221.091	2624234.158	949.798	933.131	-16.666
A09220034	-45356.507	2624880.543	961.031	944.340	-16.691
A09220035	-43799.417	2625944.270	966.762	950.044	-16.717
A09220036	-42234.543	2625178.602	951.827	935.148	-16.679
A09220037	-40789.064	2624394.670	947.161	930.505	-16.656
A09220038	-38816.543	2623283.139	944.586	927.978	-16.608
A09220039	-36830.085	2622164.025	932.274	915.735	-16.539
A09220040	-34930.600	2622484.181	929.134	912.601	-16.533
A09220041	-33255.071	2623359.288	933.826	917.270	-16.555
A09220042	-31513.643	2624078.802	936.019	919.454	-16.565
A09220043	-29705.399	2624826.500	941.122	924.548	-16.574
A09220044	-27240.655	2622573.069	927.346	910.866	-16.479
A09220045	-28306.080	2624462.010	939.745	923.215	-16.530
A09220046	-34035.618	2622632.522	932.002	915.436	-16.566
A09220047	-34721.966	2624432.945	939.849	923.238	-16.612
A09220048	-35484.800	2626066.424	947.909	931.243	-16.666
A09220049	-36367.300	2627503.814	956.722	940.038	-16.683
A09220050	-37296.600	2629016.144	962.699	945.954	-16.745
A09220051	-38100.836	2630526.670	974.078	957.290	-16.788
A09220052	-38850.791	2632244.384	987.622	970.761	-16.861
A09220053	-39619.511	2634027.523	992.067	975.175	-16.892
A09220054	-39865.046	2635889.735	995.037	978.101	-16.936
A09220056	-41376.086	2642613.232	1024.281	1007.223	-17.057
A09220057	-41143.582	2643611.552	1033.240	1016.164	-17.076
A09220058	-40696.876	2645598.953	1035.917	1018.830	-17.087
A09220059	-40260.747	2647525.829	1029.867	1012.774	-17.093
A09220060	-39840.527	2649408.140	1010.867	993.778	-17.089
A09220061	-40083.019	2651345.223	1004.966	987.849	-17.117
A09220062	-40413.038	2653279.106	998.001	980.843	-17.158
A09220063	-40753.721	2655246.361	980.899	963.695	-17.204
A09220064	-41079.776	2657136.394	956.367	939.138	-17.229
A09220065	-41407.659	2659084.863	966.759	949.501	-17.259
A09220066	-41741.660	2661060.358	966.339	949.020	-17.318
A09220067	-42090.153	2663045.922	959.358	941.995	-17.363
A09220068	-42423.538	2664995.636	940.012	922.587	-17.425
A09220069	-42896.105	2666938.495	972.030	954.543	-17.487
A09220070	-43388.166	2668884.884	970.865	953.314	-17.552

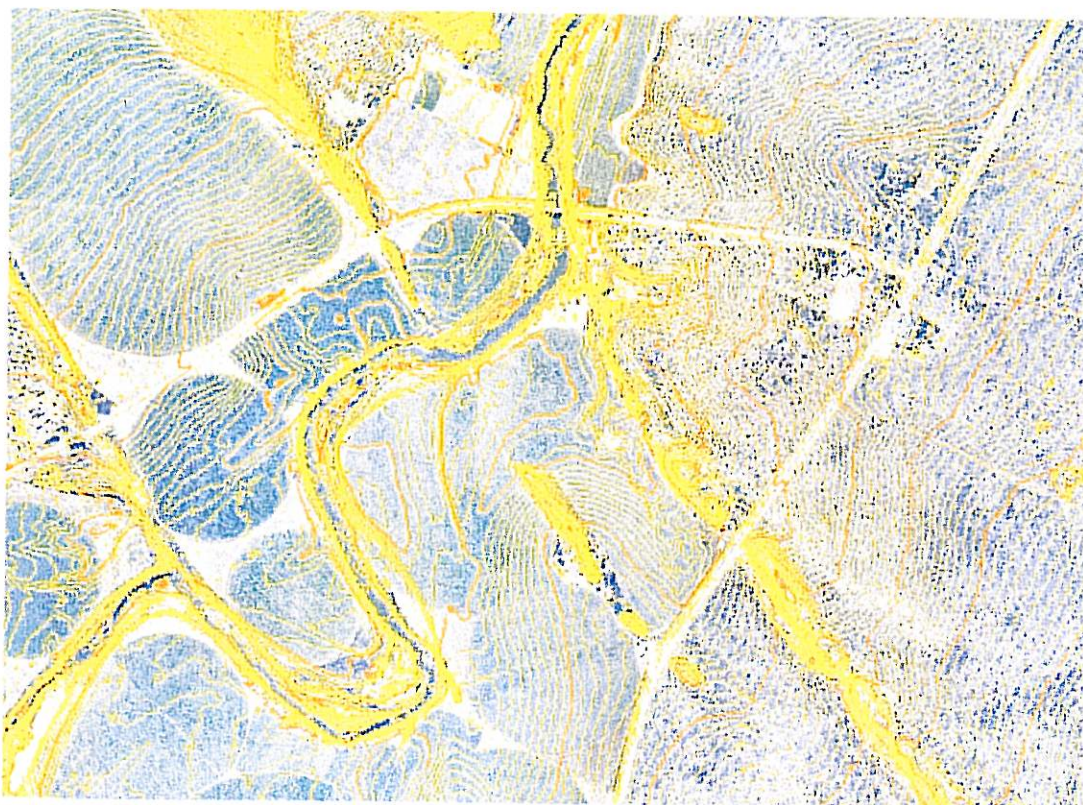
A09220071	-43912.648	2670919.483	967.856	950.238	-17.617
A09220072	-44414.378	2672865.317	987.363	969.684	-17.679
A09220073	-44924.858	2674843.419	995.117	977.371	-17.746
A09220074	-45424.247	2676777.731	998.684	980.868	-17.816
A09220075	-45701.712	2678737.364	1006.075	988.202	-17.874
A09220076	-45689.394	2680742.265	1011.212	993.310	-17.902
A09220077	-45672.879	2682660.636	1020.294	1002.331	-17.963
A09220078	-45653.064	2684672.881	1030.394	1012.347	-18.047
A0922078A	-45634.524	2686699.964	1038.149	1020.007	-18.142
A09220079	-45639.377	2687573.623	1035.667	1017.526	-18.142
A09220080	-45606.226	2689648.766	1030.744	1012.530	-18.214
A09220081	-45587.501	2691670.933	1038.536	1020.250	-18.286
A09220082	-45566.713	2693673.937	1052.987	1034.620	-18.367
A09220083	-45548.960	2695629.482	1057.008	1038.580	-18.428
A09220084	-45532.287	2697763.687	1058.579	1040.060	-18.519
A09220085	-44308.035	2698751.636	1070.305	1051.790	-18.515
A09220086	-42378.166	2699633.610	1094.900	1076.440	-18.460
A09220088	-40654.126	2700407.550	1094.399	1075.970	-18.429
A09220089	-41266.495	2702420.232	1119.038	1100.503	-18.535
A09220090	-39395.870	2702898.007	1136.525	1118.065	-18.460
A09220091	-38407.277	2703541.585	1104.083	1085.615	-18.468
A09220092	-36423.735	2704384.662	1071.058	1052.662	-18.396
A09220093	-34503.158	2705275.135	1041.757	1023.392	-18.364
A09220094	-32846.645	2706032.699	1021.730	1003.389	-18.340
A09220095	-31573.816	2706615.006	1007.496	989.164	-18.332
A09220096	-30234.960	2707329.199	995.110	976.795	-18.315
A09220097	-31483.432	2708763.584	1005.929	987.490	-18.439
A09220099	-25073.577	2709812.394	955.531	937.232	-18.299
A09220100	-26006.708	2711162.069	951.238	932.867	-18.371
A09220101	-27427.448	2713169.529	957.834	939.335	-18.498
A09220102	-28471.850	2714615.660	961.271	942.651	-18.620
A09220103	-29777.234	2716399.931	969.958	951.191	-18.766
A09220104	-30853.938	2717896.259	975.797	956.898	-18.899
A09220105	-29645.158	2718437.672	960.107	941.196	-18.911
A09220106	-27771.194	2718843.427	932.784	913.907	-18.877
A09220107	-25975.184	2719365.481	918.546	899.713	-18.833
A09220108	-23773.759	2720322.489	922.988	904.130	-18.858
A09220109	-25526.116	2720949.637	916.309	897.385	-18.924
A09220110	-26897.473	2722208.900	919.530	900.483	-19.047
A09220111	-28677.574	2722889.345	926.879	907.738	-19.141
A09220112	-30363.657	2724101.522	922.773	903.506	-19.266
A09220113	-31596.452	2725329.118	927.198	907.809	-19.389
A09220114	-31706.643	2726881.096	961.129	941.673	-19.456
A09220115	-31702.392	2728821.028	931.053	911.482	-19.570
A09220116	-32408.318	2730544.157	932.580	912.882	-19.698
A09220117	-32768.666	2731162.899	930.378	910.657	-19.721
A09220118	-33700.544	2730777.579	941.207	921.477	-19.730
A09220119	-35026.472	2730439.200	954.928	935.197	-19.731
A09220120	-37248.632	2729808.882	935.937	916.190	-19.746
A09220121	-38431.175	2728165.774	928.530	908.845	-19.684

A09220122	-38077.672	2726051.101	930.740	911.164	-19.576
A09220123	-39463.337	2724432.201	951.812	932.261	-19.551
A09220126	-34241.284	2722286.566	1023.065	1003.809	-19.256
A09220127	-32658.295	2721001.488	996.387	977.245	-19.143
A09220128	-31603.716	2719732.969	975.225	956.183	-19.041
A09220129	-32930.718	2732865.306	931.815	911.998	-19.818
A09220130	-33024.542	2735035.468	934.193	914.256	-19.937
A09220131	-33041.080	2736688.400	946.995	926.974	-20.021
A09220141	-43825.677	2737133.476	937.843	917.684	-20.159
A09220142	-44229.595	2735173.535	933.588	913.514	-20.074
A09220143	-44355.941	2733247.960	933.698	913.691	-20.007
A09220144	-44419.725	2731267.895	934.418	914.501	-19.917
A09220145	-44497.733	2729254.410	944.860	925.014	-19.846
A09220146	-42169.261	2729013.002	942.049	922.250	-19.799
A09220147	-40195.456	2728327.246	931.641	911.915	-19.726
A09220148	-45696.924	2729134.875	945.311	925.423	-19.888
A09220149	-47163.536	2730080.799	936.514	916.588	-19.926
A09220150	-47522.133	2731321.335	940.245	920.257	-19.989
A09220157	-43396.964	2739031.186	940.264	920.021	-20.243
A09220158	-40453.834	2698162.424	1097.862	1079.530	-18.332
A09220159	-40271.015	2696112.114	1090.672	1072.408	-18.265
A09220160	-40087.415	2694051.866	1080.205	1062.009	-18.196
A09220161	-39833.998	2692155.490	1068.302	1050.182	-18.120
A09220162	-39289.044	2690175.781	1053.215	1035.183	-18.032
A09220163	-40653.097	2689621.690	1055.366	1037.321	-18.045
A09220164	-42304.389	2688947.886	1060.735	1042.660	-18.076
A09220165	-44242.166	2688157.415	1041.470	1023.348	-18.122
A09220172	-32758.081	2710233.025	1021.757	1003.201	-18.556
A09220173	-33263.011	2710838.991	1033.843	1015.233	-18.610
A09220174	-31312.612	2711618.293	1001.335	982.768	-18.567
A09220175	-29219.381	2712453.068	974.512	955.989	-18.523
A09220176	-36467.809	2722355.764	1013.992	994.663	-19.330
A09220180	-39836.482	2719876.374	1013.559	994.240	-19.319
A09220181	-39841.281	2718582.023	1042.082	1022.825	-19.257
A09220182	-40414.860	2716743.624	1086.881	1067.687	-19.194
A09220183	-40618.308	2714753.548	1151.164	1132.038	-19.126
A09220184	-41426.514	2713379.888	1100.267	1081.163	-19.105
A09220185	-41946.888	2711494.768	1089.507	1070.499	-19.008
A09220186	-42154.969	2709499.021	1086.575	1067.665	-18.910
A09220187	-42407.385	2707514.289	1103.848	1085.034	-18.814
A09220188	-42338.014	2705814.645	1118.742	1100.012	-18.730
A09220189	-41986.233	2703922.063	1115.846	1097.215	-18.631
A09220212	-57245.915	2778158.195	970.130	948.092	-22.037
MKDW2	-73283.434	2653074.815	895.236	877.403	-17.833
SMCA084101	-36423.362	2636050.390	1000.751	983.889	-16.862
SMCA084803	-28151.854	2622787.661	930.602	914.097	-16.505
SMCA084804	-35400.869	2620448.030	924.395	907.860	-16.535
SMCA084805	-43068.830	2622964.189	946.238	929.605	-16.633
SMCA084806	-50757.343	2623175.646	931.054	914.387	-16.667
SMCA084809	-40764.132	2639587.920	994.253	977.281	-16.972

SMCA092001 -73217.005 2653177.620 895.036 877.220 -17.816

All points are 12mm steel pegs in concrete except MKDW2, which is an iron standard.

Photographs of all the points are in the REPORT directory with an index spreadsheet.



After transforming the laser points from ellipsoidal heights to orthometric heights using the custom geoidal separation model, they were compared to the control points and their mis-closures are listed below.

Comparison of leveled points to ground laser points (WG27, Orthometric)

PIPE 1

Number	Easting	Northing	Known Z	Laser Z	Dz
A09220001	72039.778	-2651737.579	1003.604	1003.710	+0.106
A09220002	70338.512	-2651186.722	1096.064	1095.920	-0.144
A09220003	68989.929	-2651887.880	1098.414	1098.490	+0.076
A09220004	67230.195	-2651047.655	1038.818	1038.780	-0.038
A09220005	66436.122	-2650686.661	1016.997	1017.030	+0.033
A09220006	65026.456	-2649243.000	1001.296	1001.200	-0.096
A09220007	64155.370	-2647781.965	976.786	976.880	+0.094
A09220009	63620.294	-2643851.374	1003.783	1003.790	+0.007
A09220010	64328.282	-2642029.142	957.158	957.100	-0.058

A09220011	64606.372	-2640945.897	968.729	968.650	-0.079
A09220012	63122.468	-2639757.116	1008.996	1009.040	+0.044
A09220013	62601.563	-2637779.461	910.740	910.630	-0.110
A09220014	62374.416	-2635954.430	906.343	906.260	-0.083
A09220015	62131.505	-2634091.546	943.789	943.700	-0.089
A09220016	62487.754	-2632497.701	927.354	927.340	-0.014
A09220017	63189.783	-2630731.217	898.577	898.530	-0.047
A09220018	63327.988	-2628805.124	913.434	913.380	-0.054
A09220019	63255.668	-2626883.356	887.016	887.040	+0.024
A09220020	63332.484	-2624847.306	861.276	861.270	-0.006
A09220021	63546.668	-2622860.110	872.630	872.700	+0.070
A0922021A	63769.804	-2621517.603	865.146	865.180	+0.034
A09220022	62966.635	-2620844.960	864.977	864.990	+0.013
A09220024	61170.232	-2621666.523	875.969	876.010	+0.041
A09220030	53580.967	-2623070.634	914.671	914.800	+0.129
A09220031	51610.738	-2623074.563	918.432	918.390	-0.042
A09220032	49624.366	-2623273.293	915.329	915.450	+0.121
A0922032A	47624.476	-2623445.477	922.277	922.310	+0.033
A09220033	46221.091	-2624234.158	933.131	933.170	+0.039
A09220034	45356.507	-2624880.543	944.340	944.350	+0.010
A09220035	43799.417	-2625944.270	950.044	950.000	-0.044
A09220036	42234.543	-2625178.602	935.148	935.240	+0.092
A09220037	40789.064	-2624394.670	930.505	930.590	+0.085
A09220038	38816.543	-2623283.139	927.978	927.960	-0.018
A09220039	36830.085	-2622164.025	915.735	915.780	+0.045
A09220040	34930.600	-2622484.181	912.601	912.660	+0.059
A09220041	33255.071	-2623359.288	917.270	917.320	+0.050
A09220042	31513.643	-2624078.802	919.454	919.640	+0.186
A09220043	29705.399	-2624826.500	924.548	924.640	+0.092
A09220045	28306.080	-2624462.010	923.215	923.310	+0.095
A09220046	34035.618	-2622632.522	915.436	915.450	+0.014
MKDW2	73283.434	-2653074.815	877.403	877.520	+0.117
SMCA084803	28151.854	-2622787.661	914.097	914.220	+0.123
SMCA084806	50757.343	-2623175.646	914.387	914.580	+0.193
SMCA092001	73217.005	-2653177.620	877.220	877.350	+0.130
Average dz		+0.008			
Minimum dz		-0.144			
Maximum dz		+0.193			
Average magnitude		0.070			
Root mean square		0.084			
Std deviation		0.080			

Note: Co-ordinate signs have been swapped for CAD purposes.

PIPE 2

Number	Easting	Northing	Known Z	Laser Z	Dz
A09220046	34035.618	-2622632.522	915.436	915.350	-0.086
A09220047	34721.966	-2624432.945	923.238	923.190	-0.048
A09220048	35484.800	-2626066.424	931.243	931.240	-0.003
A09220049	36367.300	-2627503.814	940.038	940.070	+0.032
A09220050	37296.600	-2629016.144	945.954	945.950	-0.004
A09220051	38100.836	-2630526.670	957.290	957.260	-0.030
A09220052	38850.791	-2632244.384	970.761	970.660	-0.101
A09220053	39619.511	-2634027.523	975.175	975.090	-0.085
A09220054	39865.046	-2635889.735	978.101	977.970	-0.131
A09220056	41376.086	-2642613.232	1007.223	1007.240	+0.017
A09220057	41143.582	-2643611.552	1016.164	1016.260	+0.096
A09220058	40696.876	-2645598.953	1018.830	1018.820	-0.010
A09220059	40260.747	-2647525.829	1012.774	1012.770	-0.004
A09220060	39840.527	-2649408.140	993.778	993.810	+0.032
A09220061	40083.019	-2651345.223	987.849	987.820	-0.029
A09220062	40413.038	-2653279.106	980.843	980.770	-0.073
A09220063	40753.721	-2655246.361	963.695	963.700	+0.005
A09220064	41079.776	-2657136.394	939.138	939.100	-0.038
A09220065	41407.659	-2659084.863	949.501	949.540	+0.039
A09220066	41741.660	-2661060.358	949.020	949.040	+0.020
A09220067	42090.153	-2663045.922	941.995	941.970	-0.025
A09220068	42423.538	-2664995.636	922.587	922.600	+0.013
A09220069	42896.105	-2666938.495	954.543	954.390	-0.153
A09220070	43388.166	-2668884.884	953.314	953.280	-0.034
A09220071	43912.648	-2670919.483	950.238	950.190	-0.048
A09220072	44414.378	-2672865.317	969.684	969.590	-0.094
A09220073	44924.858	-2674843.419	977.371	977.380	+0.009
A09220074	45424.247	-2676777.731	980.868	980.880	+0.012
A09220075	45701.712	-2678737.364	988.202	988.230	+0.028
A09220076	45689.394	-2680742.265	993.310	993.370	+0.060
A09220077	45672.879	-2682660.636	1002.331	1002.380	+0.049
A09220078	45653.064	-2684672.881	1012.347	1012.370	+0.023
A0922078A	45634.524	-2686699.964	1020.007	1019.970	-0.037
A09220079	45639.377	-2687573.623	1017.526	1017.590	+0.064
A09220079	45639.377	-2687573.623	1017.526	1017.590	+0.064
A09220080	45606.226	-2689648.766	1012.530	1012.650	+0.120
A09220081	45587.501	-2691670.933	1020.250	1020.300	+0.050
A09220082	45566.713	-2693673.937	1034.620	1034.670	+0.050
A09220083	45548.960	-2695629.482	1038.580	1038.690	+0.110
A09220084	45532.287	-2697763.687	1040.060	1040.140	+0.080
A09220085	44308.035	-2698751.636	1051.790	1051.810	+0.020
A09220086	42378.166	-2699633.610	1076.440	1076.510	+0.070
A09220088	40654.126	-2700407.550	1075.970	1075.920	-0.050

A09220089	41266.495	-2702420.232	1100.503	1100.480	-0.023
A09220090	39395.870	-2702898.007	1118.065	1118.230	+0.165
A09220158	40453.834	-2698162.424	1079.530	1079.540	+0.010
A09220159	40271.015	-2696112.114	1072.408	1072.350	-0.058
A09220160	40087.415	-2694051.866	1062.009	1061.940	-0.069
A09220161	39833.998	-2692155.490	1050.182	1050.210	+0.028
A09220162	39289.044	-2690175.781	1035.183	1035.090	-0.093
A09220164	42304.389	-2688947.886	1042.660	1042.680	+0.020
A09220165	44242.166	-2688157.415	1023.348	1023.420	+0.072
A09220189	41986.233	-2703922.063	1097.215	1097.290	+0.075
SMCA084809	40764.132	-2639587.920	977.281	977.200	-0.081

Average dz	+0.000
Minimum dz	-0.153
Maximum dz	+0.165
Average magnitude	0.053
Root mean square	0.065
Std deviation	0.066

Note: Co-ordinate signs have been swapped for CAD purposes.

PIPE 3

Number	Easting	Northing	Known Z	Laser Z	Dz
A09220088	40654.126	-2700407.550	1075.970	1075.890	-0.080
A09220089	41266.495	-2702420.232	1100.503	1100.450	-0.053
A09220090	39395.870	-2702898.007	1118.065	1118.200	+0.135
A09220091	38407.277	-2703541.585	1085.615	1085.630	+0.015
A09220093	34503.158	-2705275.135	1023.392	1023.290	-0.102
A09220094	32846.645	-2706032.699	1003.389	1003.340	-0.049
A09220095	31573.816	-2706615.006	989.164	989.020	-0.144
A09220096	30234.960	-2707329.199	976.795	976.970	+0.175
A09220097	31483.432	-2708763.584	987.490	987.620	+0.130
A09220099	25073.577	-2709812.394	937.232	937.140	-0.092
A09220100	26006.708	-2711162.069	932.867	932.910	+0.043
A09220101	27427.448	-2713169.529	939.335	939.280	-0.055
A09220102	28471.850	-2714615.660	942.651	942.630	-0.021
A09220103	29777.234	-2716399.931	951.191	951.170	-0.021
A09220104	30853.938	-2717896.259	956.898	956.880	-0.018
A09220112	30363.657	-2724101.522	903.506	903.390	-0.116
A09220126	34241.284	-2722286.566	1003.809	1003.680	-0.129
A09220127	32658.295	-2721001.488	977.245	977.330	+0.085
A09220128	31603.716	-2719732.969	956.183	956.160	-0.023
A09220172	32758.081	-2710233.025	1003.201	1003.130	-0.071
A09220173	33263.011	-2710838.991	1015.233	1015.230	-0.003

A09220174	31312.612	-2711618.293	982.768	982.910	+0.142
A09220175	29219.381	-2712453.068	955.989	955.910	-0.079
A09220176	36467.809	-2722355.764	994.663	994.770	+0.107
A09220180	39836.482	-2719876.374	994.240	994.210	-0.030
A09220181	39841.281	-2718582.023	1022.825	1022.700	-0.125
A09220182	40414.860	-2716743.624	1067.687	1067.880	+0.193
A09220183	40618.308	-2714753.548	1132.038	1132.060	+0.022
A09220184	41426.514	-2713379.888	1081.163	1081.260	+0.097
A09220185	41946.888	-2711494.768	1070.499	1070.500	+0.001
A09220186	42154.969	-2709499.021	1067.665	1067.720	+0.055
A09220187	42407.385	-2707514.289	1085.034	1085.100	+0.066
A09220188	42338.014	-2705814.645	1100.012	1100.110	+0.098
A09220189	41986.233	-2703922.063	1097.215	1097.260	+0.045

Average dz	+0.006
Minimum dz	-0.144
Maximum dz	+0.193
Average magnitude	0.077
Root mean square	0.092
Std deviation	0.093

Note: Co-ordinate signs have been swapped for CAD purposes.

RIVER AREA

Number	Easting	Northing	Known Z	Laser Z	Dz
A09220104	30853.938	-2717896.259	956.898	956.820	-0.078
A09220105	29645.158	-2718437.672	941.196	941.090	-0.106
A09220107	25975.184	-2719365.481	899.713	899.580	-0.133
A09220109	25526.116	-2720949.637	897.385	897.330	-0.055
A09220110	26897.473	-2722208.900	900.483	900.550	+0.067
A09220111	28677.574	-2722889.345	907.738	907.820	+0.082
A09220112	30363.657	-2724101.522	903.506	903.420	-0.086
A09220113	31596.452	-2725329.118	907.809	907.770	-0.039
A09220114	31706.643	-2726881.096	941.673	941.790	+0.117
A09220115	31702.392	-2728821.028	911.482	911.540	+0.058
A09220116	32408.318	-2730544.157	912.882	912.820	-0.062
A09220117	32768.666	-2731162.899	910.657	910.620	-0.037
A09220118	33700.544	-2730777.579	921.477	921.450	-0.027
A09220120	37248.632	-2729808.882	916.190	916.270	+0.080
A09220121	38431.175	-2728165.774	908.845	908.930	+0.085
A09220122	38077.672	-2726051.101	911.164	911.130	-0.034
A09220126	34241.284	-2722286.566	1003.809	1003.710	-0.099
A09220127	32658.295	-2721001.488	977.245	977.330	+0.085
A09220128	31603.716	-2719732.969	956.183	956.140	-0.043
A09220129	32930.718	-2732865.306	911.998	912.050	+0.052

A09220130	33024.542	-2735035.468	914.256	914.220	-0.036
A09220131	33041.080	-2736688.400	926.974	926.980	+0.006
A09220141	43825.677	-2737133.476	917.684	917.620	-0.064
A09220142	44229.595	-2735173.535	913.514	913.560	+0.046
A09220144	44419.725	-2731267.895	914.501	914.450	-0.051
A09220145	44497.733	-2729254.410	925.014	925.080	+0.066
A09220146	42169.261	-2729013.002	922.250	922.190	-0.060
A09220147	40195.456	-2728327.246	911.915	911.910	-0.005
A09220149	47163.536	-2730080.799	916.588	916.630	+0.042
A09220150	47522.133	-2731321.335	920.257	920.200	-0.057
A09220157	43396.964	-2739031.186	920.021	919.980	-0.041
A09220212	57245.915	-2778158.195	948.092	948.120	+0.028
SMCA0922126	34241.288	-2722286.528	1003.748	1003.710	-0.038
SMCA0922167	53346.462	-2753505.439	937.115	937.070	-0.045
SMCA0922264	55430.951	-2794983.581	981.807	981.870	+0.063
Raloka	71375.098	-2826432.550	1077.777	1077.830	+0.053

Average dz	-0.007
Minimum dz	-0.133
Maximum dz	+0.117
Average magnitude	0.059
Root mean square	0.065
Std deviation	0.066

Note: Co-ordinate signs have been swapped for CAD purposes.



The final control point co-ordinates are listed in ANNEXURE B below.

IMAGES:

The raw images were ortho-rectified using TerraSolid's TerraPhoto software. This software combines the camera position (trajectory), aircraft attitudes (roll, pitch & heading), camera calibration and digital terrain model of the ground surface to accurately position and rectify the individual raw images into orthophoto tiles. The maximum size of the tile depends on the pixel size of the image and the computer hardware available. The tiles were output with a pixel size of 10cm in ECW format. Annexure E gives more details for TerraPhoto.



DELIVERABLES:

Three portable hard drives containing:

IMAGE TILES: 24 bit color, ortho-rectified image tiles in ECW compressed format with a 10cm pixel resolution. World files have also been generated for each image.

LASER POINTS: Easting, Northing and Orthometric height points in comma delimited ASCII format classified into ground & non-ground points. The laser points have also been broken up into smaller blocks to make them more manageable.

CAD FILES: Microstation DGN and Autocad DWG & DXF files containing an index plan showing the point blocks and 10cm pixel image positions for each section of the project.

0.5m contours have also been produced for each point block.

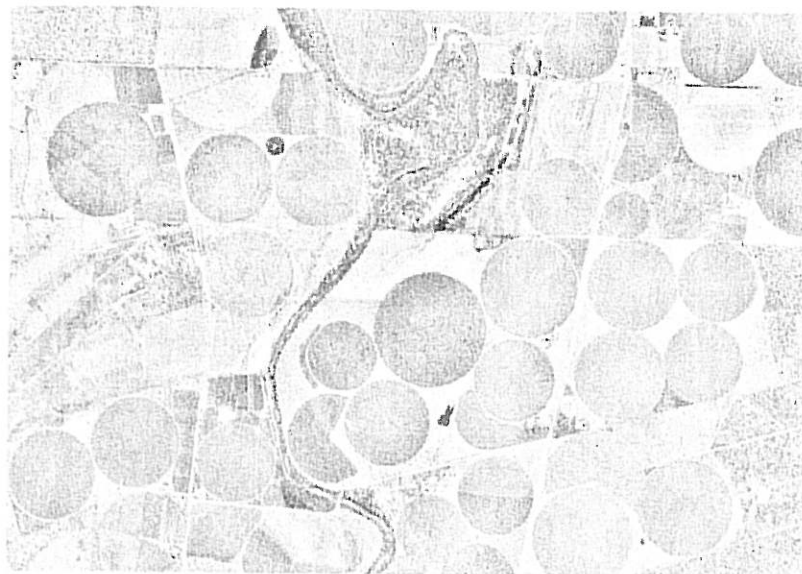
STEREO IMAGES: A set of printed stereo images for the Mokolo Dam-Matimba and Witklip(R510)-Rooipan sections of the pipe line are supplied. These and the remainder of the stereo images are also supplied in digital format along with a CAD index file.

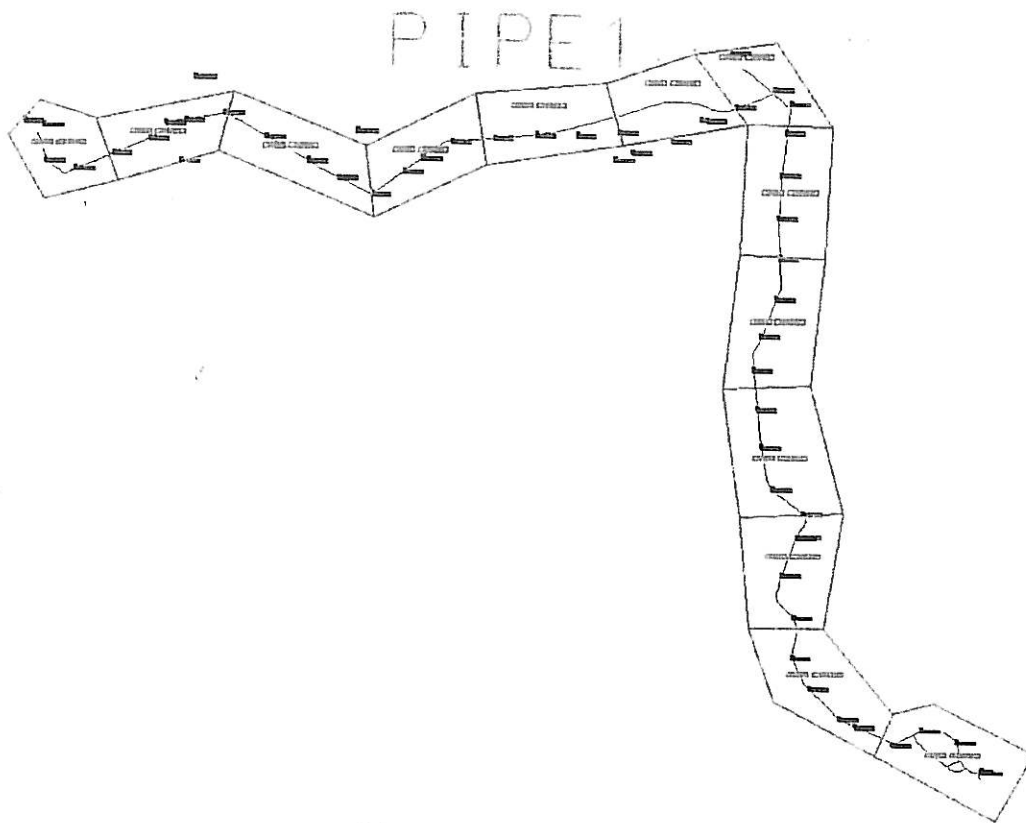
Final Project - Lidar survey report.

Levelling survey report.

Note: All the data is referenced to the Hartebeesthoek 94 datum, Gauss conform Lo27 projection with orthometric heights transformed using the custom geoidal model along the pipe line routes, and the Southern African Quasi geoidal model for the river areas.

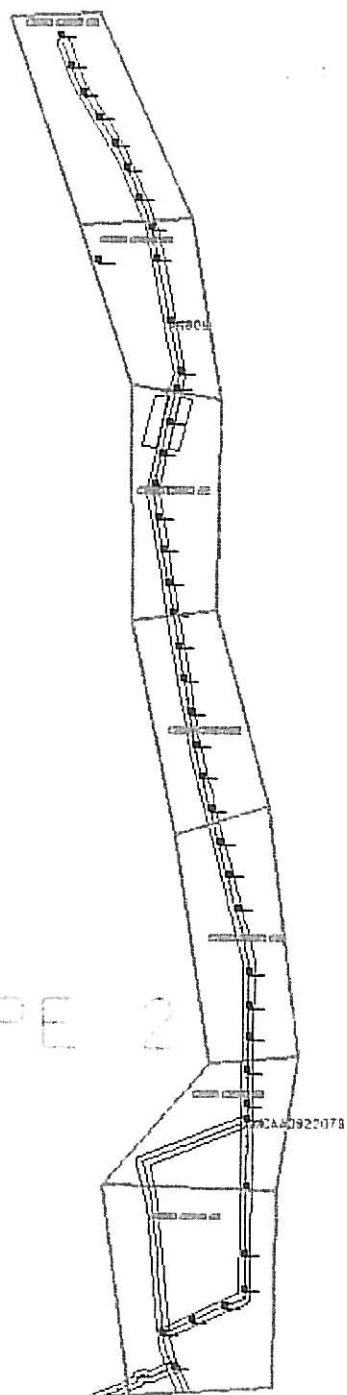
The signs of the co-ordinates have been swapped for CAD purposes.



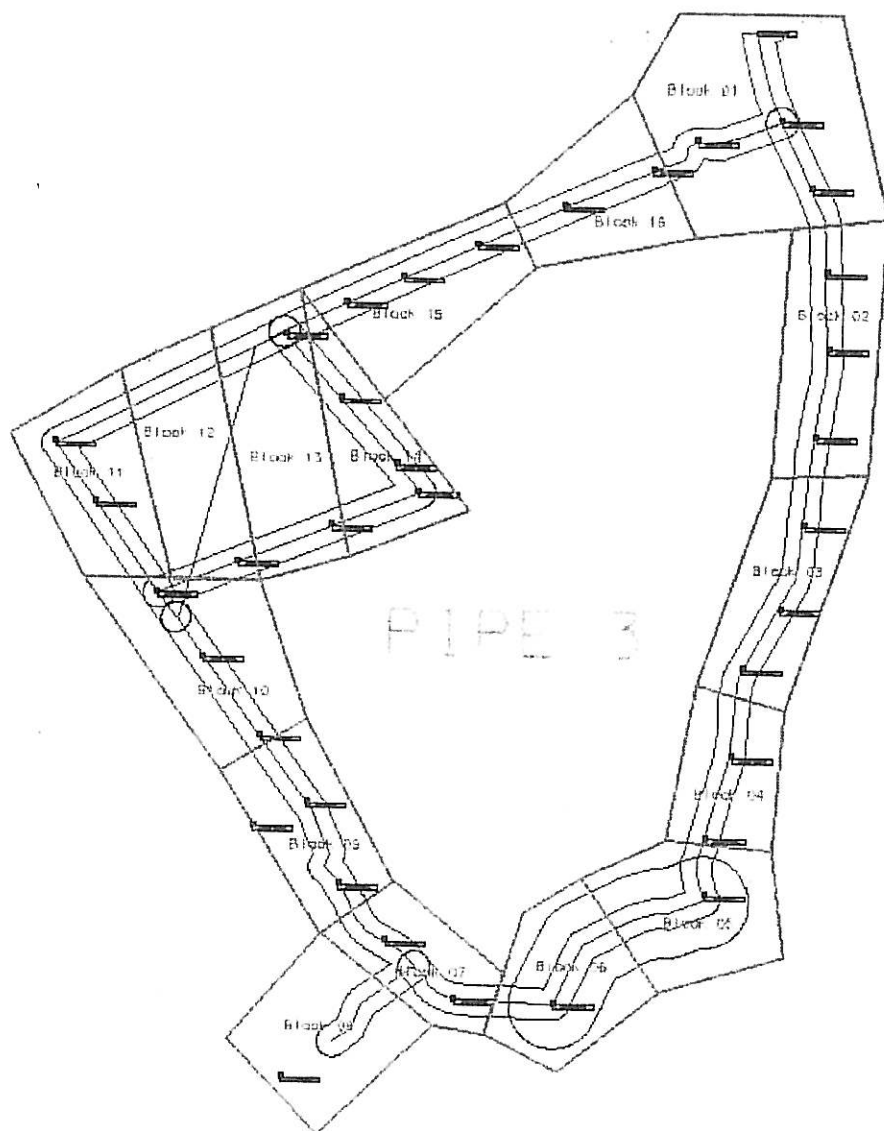


Pipe 1 Point Blocks

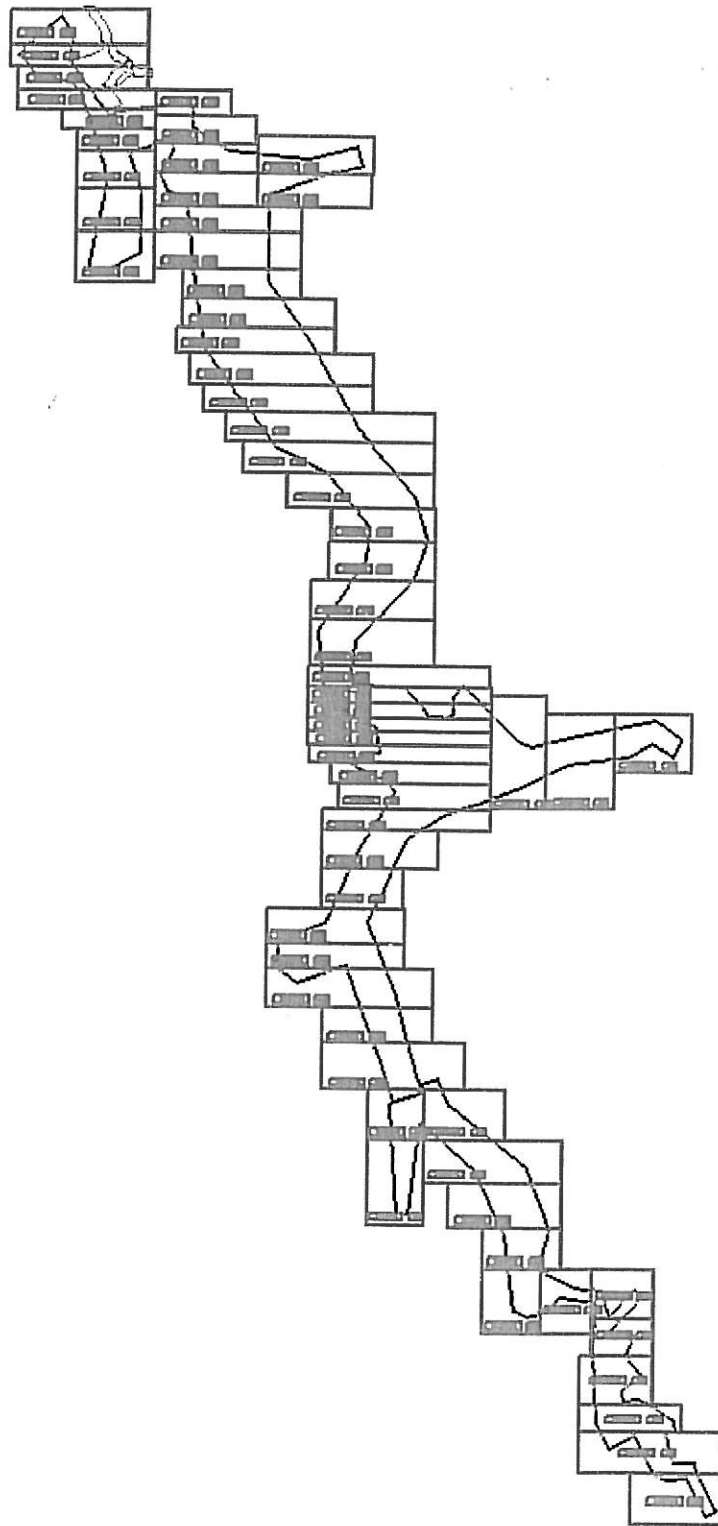
PIPE 2



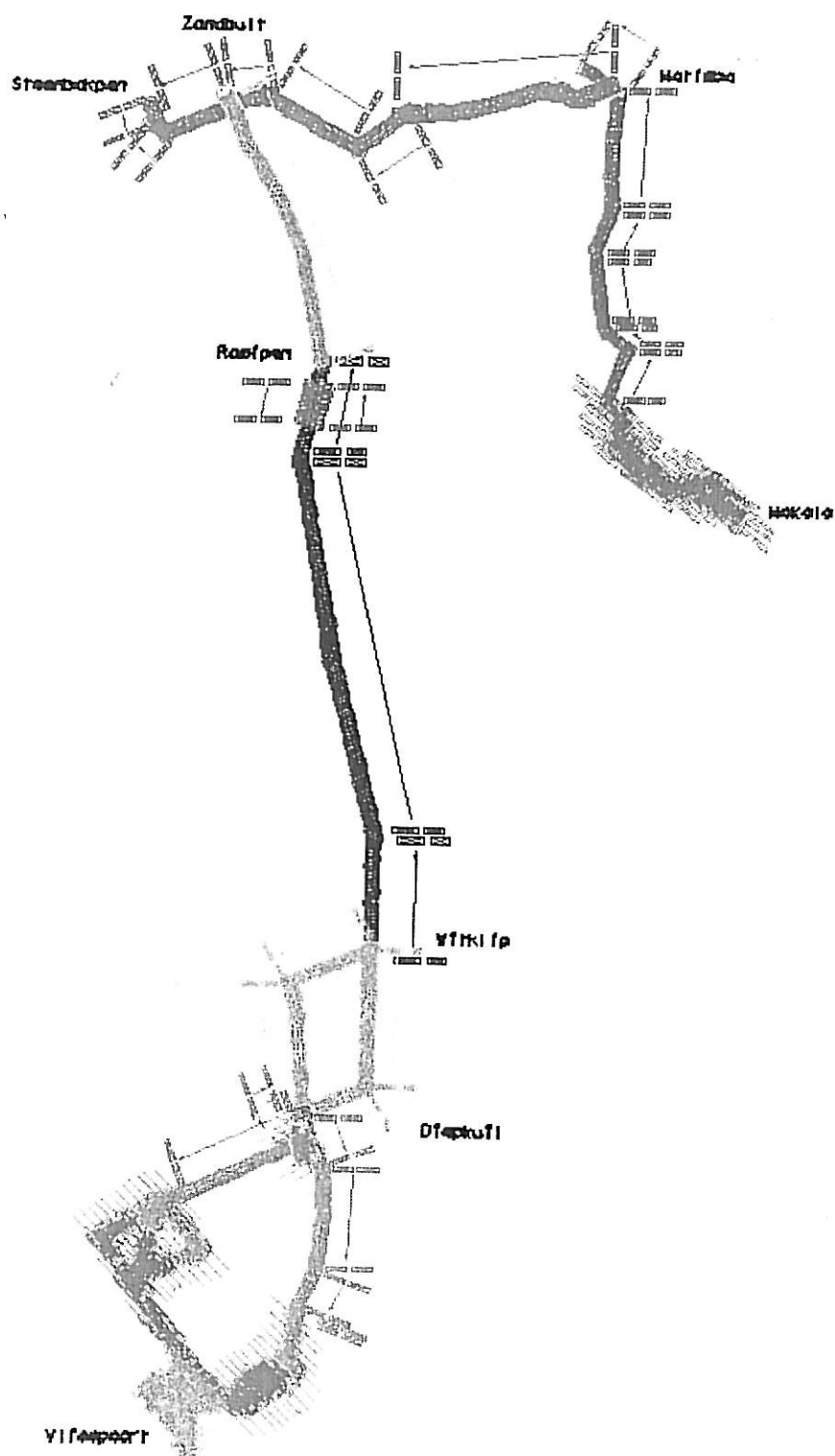
Pipe 2 Point Blocks



Pipe 3 Point Blocks

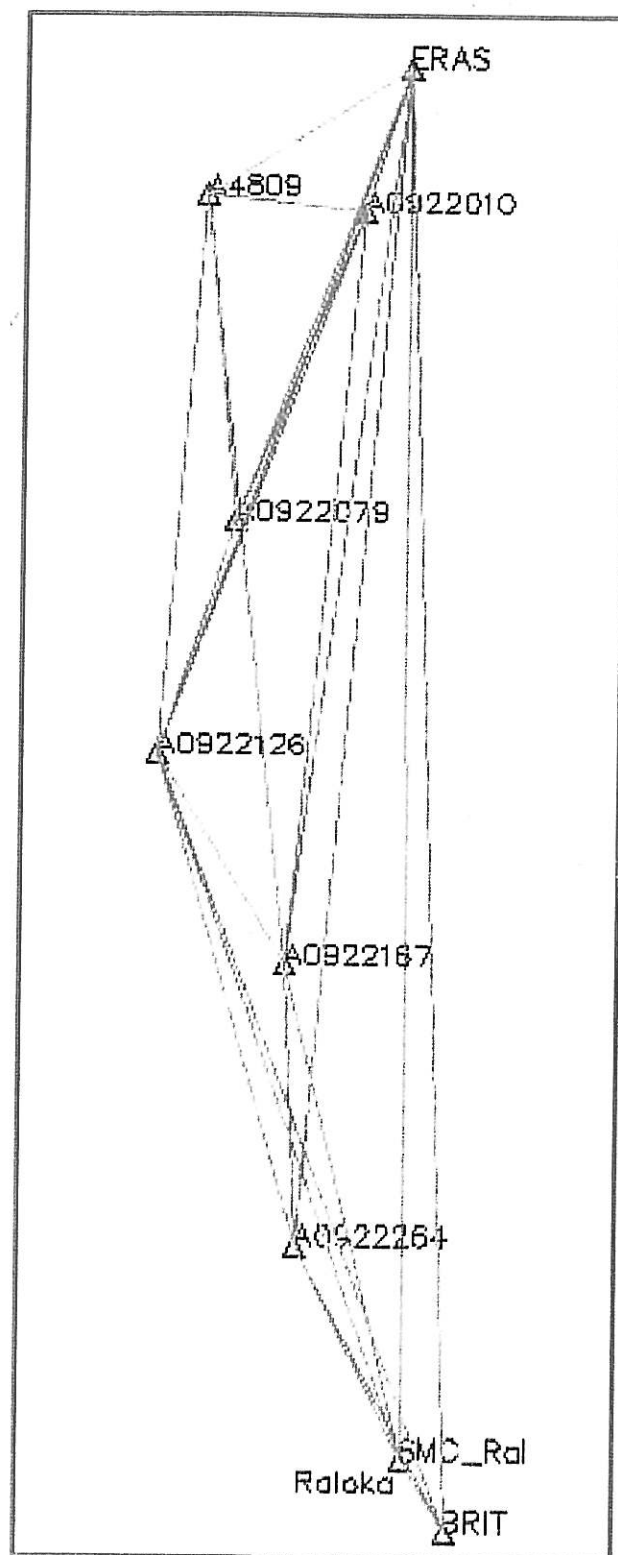


River Area Point Blocks



Stereo images index

Annexure A: GPS network for base station positions.



```

*****
* NETWORK - WEIGHTED GPS NETWORK ADJUSTMENT *
* *
* (c) Copyright NovAtel Inc., (2007) *
* *
* Version: 7.80.2315 *
* *
* FILE: Mokolo_Crocodile_Water_Augmentation_Project
*****

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DATE(m/d/y): Thur. 7/30/09 TIME: 5:33:18

DATUM: 'WGS84'
 SCALE_FACTOR: 478.9880
 CONFIDENCE LEVEL: 80.00 % (Scale factor is 1.7943)

INPUT CONTROL/CHECK POINTS

STA_ID	TYPE	-- LATITUDE --	-- LONGITUDE --	ELLHGT -	HZ-SD	V-SD
A4809	GCP-3D	-23 51 27.79913	27 24 00.65649	994.253	0.00500	0.00500 Fixed Point
Hartebeesthoek 94 ITRF200						
BRIT	CHK-3D	-25 38 08.72300	27 46 35.79070	1166.787		
ERAS	CHK-3D	-23 41 12.01105	27 41 45.91622	868.547		

INPUT VECTORS

SESSION NAME	VECTOR(m)	----- Covariance (m) [unscaled] -----
	DX/DY/DZ	standard deviations in brackets
SMCA0922010 to SMCA0922079 (1)	-7897.2924	2.9823e-007 (0.0005)
	-25000.0412	1.5657e-007 1.4420e-007 (0.0004)
	-41674.6732	-1.0877e-007 -5.9659e-008 1.2347e-007 (0.0004)
SMCA0922010 to SMCA0922126 (1)	-15476.9201	5.8387e-007 (0.0008)
	-41656.0693	2.9890e-007 2.7308e-007 (0.0005)
	-73303.8761	-2.0622e-007 -1.1206e-007 2.4107e-007 (0.0005)
SMCA0922010 to SMCA0922126 (2)	-15476.9732	7.3785e-007 (0.0009)
	-41656.1096	3.6419e-007 3.3333e-007 (0.0006)
	-73303.8867	-2.6631e-007 -1.5119e-007 3.0649e-007 (0.0006)
SMCA0922010 to SMCA0922167 (1)	-35955.1852	2.0545e-006 (0.0014)
	-30646.2270	7.6899e-007 7.2681e-007 (0.0009)
	-101577.6244	-8.1888e-007 -3.3506e-007 8.0213e-007 (0.0009)
SMCA0922010 to ERAS (1)	4471.5517	3.8313e-007 (0.0006)
	9764.8698	1.9510e-007 1.9596e-007 (0.0004)
	19536.9145	-1.3991e-007 -7.9673e-008 1.7217e-007 (0.0004)
SMCA0922079 to SMCA0922126 (1)	-7579.6337	1.7391e-007 (0.0004)
	-16656.0352	8.4914e-008 7.5755e-008 (0.0003)
	-31629.1965	-5.4546e-008 -2.3496e-008 5.9830e-008 (0.0002)
SMCA0922079 to ERAS (1)	12368.8513	4.2335e-007 (0.0007)
	34764.9176	2.0722e-007 1.8400e-007 (0.0004)
	61211.5854	-1.3074e-007 -5.6914e-008 1.4187e-007 (0.0004)
SMCA0922126 to SMCA0922167 (1)	-20478.2420	2.7453e-007 (0.0005)
	11009.8451	1.3261e-007 1.2309e-007 (0.0004)
	-28273.7695	-9.9697e-008 -5.1527e-008 1.1841e-007 (0.0003)

SMCA0922126 to SMCA0922167 (2) -20478.2415 6.1954e-007 (0.0008)
 11009.8558 2.4963e-007 1.6939e-007 (0.0004)
 -28273.7954 -2.1334e-007 -1.2726e-007 2.3038e-007 (0.0005)

SMCA0922126 to SMCA0922167 (3) -20478.2341 1.0399e-007 (0.0003)
 11009.8504 4.9650e-008 4.4190e-008 (0.0002)
 -28273.7803 -3.4481e-008 -1.8522e-008 3.7325e-008 (0.0002)

SMCA0922126 to SMCA0922264 (1) -37065.6155 8.0059e-007 (0.0009)
 4898.2640 4.0136e-007 4.2035e-007 (0.0006)
 -65859.5920 -3.1688e-007 -8.8437e-008 4.0767e-007 (0.0006)

SMCA0922126 to SMCA0922264 (2) -37065.6203 3.4265e-007 (0.0006)
 4898.2867 1.5809e-007 1.3690e-007 (0.0004)
 -65859.5682 -1.1260e-007 -5.5330e-008 1.2165e-007 (0.0003)

SMCA0922126 to SMCA0922264 (3) -37065.6252 1.4323e-006 (0.0012)
 4898.2904 7.4898e-007 9.6717e-007 (0.0010)
 -65859.5814 -5.8232e-007 -2.3380e-008 8.8218e-007 (0.0009)

SMCA0922126 to BRIT (1) -63346.5143 2.4865e-005 (0.0050)
 16831.6771 1.1068e-005 8.4191e-006 (0.0029)
 -103510.1082 -6.0136e-006 -3.8624e-006 5.6483e-006 (0.0024)

SMCA0922126 to ERAS (1) 19948.4800 7.0113e-007 (0.0008)
 51420.9527 3.2621e-007 2.9223e-007 (0.0005)
 92840.7826 -2.3542e-007 -1.0456e-007 2.3346e-007 (0.0005)

SMCA0922126 to ERAS (2) 19948.5440 3.9957e-007 (0.0006)
 51420.9872 2.1091e-007 2.0610e-007 (0.0005)
 92840.7713 -1.4680e-007 -9.3034e-008 1.6655e-007 (0.0004)

SMCA0922126 to Raloka (2) -56376.4955 4.0823e-006 (0.0020)
 12955.7013 1.9288e-006 1.8909e-006 (0.0014)
 -94244.7392 -1.4069e-006 -5.7739e-007 1.7404e-006 (0.0013)

SMCA0922167 to SMCA0922264 (2) -16587.3756 1.2865e-007 (0.0004)
 -6111.5911 6.1804e-008 5.9283e-008 (0.0002)
 -37585.7966 -3.9675e-008 -1.7627e-008 4.7017e-008 (0.0002)

SMCA0922167 to SMCA0922264 (3) -16587.3702 1.2887e-006 (0.0011)
 -6111.5825 7.3788e-007 8.2964e-007 (0.0009)
 -37585.8057 -3.9356e-007 -1.0952e-007 5.5672e-007 (0.0007)

SMCA0922167 to ERAS (1) 40426.7915 4.6992e-006 (0.0022)
 40411.1592 1.9094e-006 1.3018e-006 (0.0011)
 121114.5254 -1.6587e-006 -9.8527e-007 1.7657e-006 (0.0013)

SMCA0922264 to BRIT (1) -26280.9133 9.8899e-007 (0.0010)
 11933.3863 4.0659e-007 2.7418e-007 (0.0005)
 -37650.5575 -3.5380e-007 -2.0977e-007 3.6720e-007 (0.0006)

SMCA0922264 to Raloka (1) -19310.8268 3.6111e-007 (0.0006)
 8057.4333 1.8545e-007 1.7208e-007 (0.0004)
 -28385.1642 -1.1950e-007 -4.6191e-008 1.2095e-007 (0.0003)

SMCA0922264 to Raloka (2) -19310.8118 1.5818e-006 (0.0013)
 8057.4266 4.1273e-007 5.5684e-007 (0.0007)
 -28385.1462 -5.3883e-007 7.8774e-008 6.3611e-007 (0.0008)

A4809 to SMCA0922010 (1) -11753.1533 1.2512e-007 (0.0004)
 20460.1826 6.4667e-008 5.8861e-008 (0.0002)
 -2146.2092 -4.2249e-008 -2.1902e-008 4.6869e-008 (0.0002)

A4809 to SMCA0922010 (2) -11753.1569 1.2582e-007 (0.0004)
 20460.1835 5.8386e-008 5.0491e-008 (0.0002)
 -2146.2077 -4.1196e-008 -2.4410e-008 4.6454e-008 (0.0002)

A4809 to SMCA0922079 (1) -19650.4507 1.2540e-006 (0.0011)

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-4539.8616 6.1545e-007 5.4703e-007 (0.0007)
-43820.8793 -3.9178e-007 -1.7376e-007 4.2439e-007 (0.0007)

A4809 to SMCA0922126 (1) -27230.0711 6.6787e-007 (0.0008)
-21195.8719 2.7809e-007 2.2451e-007 (0.0005)
-75450.0773 -1.9210e-007 -9.9935e-008 2.4661e-007 (0.0005)

A4809 to SMCA0922126 (2) -27230.0865 5.1101e-007 (0.0007)
-21195.8987 2.4189e-007 2.0895e-007 (0.0005)
-75450.0764 -1.6083e-007 -6.8322e-008 1.6154e-007 (0.0004)

A4809 to ERAS (1) -7281.6137 3.5738e-006 (0.0019)
30225.0534 1.6518e-006 1.2349e-006 (0.0011)
17390.7042 -1.2436e-006 -6.7788e-007 9.8305e-007 (0.0010)

BRIT to Raloka (1) 6970.0767 9.3241e-008 (0.0003)
-3875.9610 4.4779e-008 4.0143e-008 (0.0002)
9265.3885 -3.1678e-008 -1.7107e-008 3.5065e-008 (0.0002)

BRIT to Raloka (2) 6970.0582 6.1662e-008 (0.0002)
-3875.9696 3.0387e-008 2.7301e-008 (0.0002)
9265.4003 -1.9787e-008 -8.6202e-009 2.1960e-008 (0.0001)

BRIT to SMC_Ral (1) 7049.0099 6.4184e-008 (0.0003)
-3906.8320 3.1863e-008 2.9050e-008 (0.0002)
9374.8181 -2.1202e-008 -9.4293e-009 2.4206e-008 (0.0002)

ERAS to SMCA0922264 (1) -57014.1518 1.9130e-006 (0.0014)
-46522.6977 8.8912e-007 7.5581e-007 (0.0009)
-158700.3430 -6.3361e-007 -3.1707e-007 6.1936e-007 (0.0008)

ERAS to BRIT (1) -83295.0960 9.4045e-006 (0.0031)
-34589.3150 2.5305e-006 2.2962e-006 (0.0015)
-196350.8823 -3.1856e-006 -2.1065e-006 3.5710e-006 (0.0019)

Raloka to SMC_Ral (1) 78.9527 3.0256e-008 (0.0002)
-30.8619 1.5015e-008 1.3687e-008 (0.0001)
109.4175 -9.9712e-009 -4.4271e-009 1.1368e-008 (0.0001)

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*****
OUTPUT VECTOR RESIDUALS (East, North, Height - Local Level)
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SESSION NAME	-- RE -- (m)	-- RN -- (m)	-- RH -- (m)	- PPM -	DIST - (km)	STD - (m)
SMCA0922010 to SMCA0922079 (1)	0.0004	-0.0026	-0.0044	0.105	49.2	0.0165
SMCA0922010 to SMCA0922126 (1)	-0.0028	-0.0036	-0.0240	0.285	85.7	0.0229
SMCA0922010 to SMCA0922126 (2)	0.0084	0.0331	0.0316	0.543	85.7	0.0257
SMCA0922010 to SMCA0922167 (1)	-0.0056	-0.0200	0.0130	0.219	112.0	0.0414
SMCA0922010 to ERAS (1)	0.0037	0.0028	0.0213	0.977	22.3	0.0190
SMCA0922079 to SMCA0922126 (1)	0.0003	-0.0033	-0.0091	0.264	36.5	0.0122
SMCA0922079 to ERAS (1)	0.0008	0.0037	0.0162	0.232	71.5	0.0189
SMCA0922126 to SMCA0922167 (1)	0.0054	-0.0060	0.0084	0.319	36.6	0.0157
SMCA0922126 to SMCA0922167 (2)	-0.0038	0.0153	-0.0073	0.474	36.6	0.0221
SMCA0922126 to SMCA0922167 (3)	0.0044	-0.0002	-0.0047	0.175	36.6	0.0094
SMCA0922126 to SMCA0922264 (1)	0.0072	0.0158	-0.0077	0.251	75.7	0.0279
SMCA0922126 to SMCA0922264 (2)	-0.0151	-0.0084	-0.0033	0.233	75.7	0.0170
SMCA0922126 to SMCA0922264 (3)	-0.0207	0.0047	-0.0065	0.293	75.7	0.0396
SMCA0922126 to BRIT (1)	-0.0101	-0.0249	-0.0005	0.219	122.5	0.1366
SMCA0922126 to ERAS (1)	-0.0017	0.0082	0.0296	0.285	108.0	0.0242
SMCA0922126 to ERAS (2)	-0.0028	-0.0112	-0.0414	0.398	108.0	0.0192
SMCA0922126 to Raloka (2)	-0.0231	0.0191	0.0273	0.367	110.6	0.0608
SMCA0922167 to SMCA0922264 (2)	0.0097	0.0010	0.0007	0.235	41.5	0.0106
SMCA0922167 to SMCA0922264 (3)	0.0046	0.0056	-0.0111	0.319	41.5	0.0358
SMCA0922167 to ERAS (1)	-0.0207	0.0035	-0.0677	0.529	133.9	0.0610
SMCA0922264 to BRIT (1)	-0.0003	0.0075	0.0125	0.308	47.4	0.0279
SMCA0922264 to Raloka (1)	-0.0021	-0.0006	-0.0132	0.380	35.3	0.0177
SMCA0922264 to Raloka (2)	0.0108	-0.0212	-0.0147	0.792	35.3	0.0365
A4809 to SMCA0922010 (1)	0.0021	0.0018	0.0015	0.134	23.7	0.0105

A4809 to SMCA0922010 (2)	-0.0003	0.0016	0.0046	0.207	23.7	0.0103
A4809 to SMCA0922079 (1)	0.0029	-0.0012	0.0036	0.099	48.2	0.0326
A4809 to SMCA0922126 (1)	-0.0128	-0.0126	-0.0273	0.394	83.0	0.0234
A4809 to SMCA0922126 (2)	0.0039	-0.0028	-0.0032	0.069	83.0	0.0205
A4809 to ERAS (1)	-0.0006	0.0098	0.0317	0.932	35.6	0.0527
BRIT to Raloka (1)	0.0007	0.0015	-0.0166	1.363	12.2	0.0090
BRIT to Raloka (2)	-0.0003	-0.0003	0.0069	0.565	12.2	0.0073
BRIT to SMC_Ral (1)	-0.0002	-0.0001	0.0055	0.442	12.4	0.0075
ERAS to SMCA0922264 (1)	-0.0091	0.0011	0.0252	0.153	174.9	0.0397
ERAS to BRIT (1)	-0.0207	0.0041	0.0717	0.346	216.1	0.0855
Raloka to SMC_Ral (1)	0.0001	0.0000	-0.0026	18.591	0.1	0.0051
RMS	0.0091	0.0109	0.0235			

\$ - This session is flagged as a 3-sigma outlier

CHECK POINT RESIDUALS (East, North, Height - Local Level)

STA. NAME	-- RE -- (m)	-- RN -- (m)	-- RH -- (m)
BRIT	-0.0627	0.1072	0.1842
ERAS	-0.0913	0.0323	0.1246
RMS	0.0783	0.0792	0.1573

CONTROL POINT RESIDUALS (ADJUSTMENT MADE)

STA. NAME	-- RE -- (m)	-- RN -- (m)	-- RH -- (m)
A4809	0.0000	-0.0000	0.0000
RMS	0.0000	0.0000	0.0000

OUTPUT STATION COORDINATES (LAT/LONG/HT)

STA_ID	-- LATITUDE --	-- LONGITUDE --	-- ELLHGT --
SMCA0922010	-23 52 44.35419	27 37 53.79575	974.5723
SMCA0922079	-24 17 26.95091	27 26 58.37767	1035.6875
SMCA0922126	-24 36 16.19383	27 20 17.21282	1023.0848
SMCA0922167	-24 53 08.81524	27 31 40.62734	958.0331
SMCA0922264	-25 15 36.46704	27 33 00.90507	1004.3882
A4809	-23 51 27.79913	27 24 00.65649	994.2534
BRIT	-25 38 08.71952	27 46 35.78845	1166.9712
ERAS	-23 41 12.01000	27 41 45.91300	868.6716
Raloka	-25 32 35.96193	27 42 36.63697	1101.4290
SMC_Ral	-25 32 31.97612	27 42 34.34362	1104.3655

OUTPUT VARIANCE/COVARIANCE

STA_ID	SE/SN/SUP	CX matrix (m) ² (80.00 %) (not scaled by confidence level) (m) (ECEF, XYZ cartesian)		
SMCA0922010	0.0096	5.0234e-005		
	0.0100	1.2282e-005	3.5829e-005	
	0.0140	-8.4387e-006	-4.6114e-006	3.4338e-005
SMCA0922079	0.0107	9.3100e-005		
	0.0116	3.3446e-005	5.4806e-005	
	0.0197	-2.2547e-005	-1.1158e-005	4.9934e-005
SMCA0922126	0.0103	7.7490e-005		

	0.0110	2.4816e-005	4.6741e-005
	0.0177	-1.7350e-005	-8.6655e-006 4.4128e-005
SMCA0922167	0.0108	9.9695e-005	
	0.0117	3.4875e-005	5.5439e-005
	0.0204	-2.5148e-005	-1.2777e-005 5.2582e-005
SMCA0922264	0.0113	1.1679e-004	
	0.0124	4.3356e-005	6.3892e-005
	0.0222	-3.0798e-005	-1.4846e-005 5.9273e-005
A4809	0.0090	2.5000e-005	
	0.0090	-1.0070e-020	2.5000e-005
	0.0090	-3.4315e-020	-6.1503e-021 2.5000e-005
BRIT	0.0130	2.1208e-004	
	0.0148	8.4370e-005	9.6971e-005
	0.0301	-6.3929e-005	-2.9791e-005 9.2229e-005
ERAS	0.0110	1.0418e-004	
	0.0119	3.8326e-005	5.9575e-005
	0.0210	-2.7034e-005	-1.4260e-005 5.4594e-005
Raloka	0.0129	2.0593e-004	
	0.0147	8.1997e-005	9.5735e-005
	0.0296	-6.1517e-005	-2.8027e-005 8.9885e-005
SMC_Ral	0.0131	2.1504e-004	
	0.0149	8.6325e-005	9.9406e-005
	0.0303	-6.4642e-005	-2.9613e-005 9.3347e-005

 VARIANCE FACTOR = 1.0000

Note: Values < 1.0 indicate statistics are pessimistic, while
 values > 1.0 indicate optimistic statistics. Entering this
 value as the network adjustment scale factor will bring
 variance factor to one.

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ANNEXURE B: FINAL CO-ORDINATE LIST OF ALL POINTS.

MOKOLO / CROCODILE WATER AUGMENTATION PROJECT
Control Points

(System: hartebeesthoek94, Lo.27)

Pt. ID.	Y	X	Z (Ortho)	Description
60DW1	-52450.489	2773080.026	944.328	16mm iron peg in conc
60DW2	-52560.068	2773157.300	944.269	25mm iron peg in conc
A09220001	-72039.778	2651737.579	1003.604	12mm iron peg in conc
A09220002	-70338.512	2651186.722	1096.064	12mm iron peg in conc
A09220003	-68989.929	2651887.880	1098.414	12mm iron peg in conc
A09220004	-67230.195	2651047.655	1038.818	12mm iron peg in conc
A09220005	-66436.122	2650686.661	1016.997	12mm iron peg in conc
A09220006	-65026.456	2649243.000	1001.296	12mm iron peg in conc
A09220007	-64155.370	2647781.965	976.786	12mm iron peg in conc
A09220008	-64211.688	2645849.045	967.904	12mm iron peg in conc
A09220009	-63620.294	2643851.374	1003.783	12mm iron peg in conc
A09220010	-64328.282	2642029.142	957.158	12mm iron peg in conc
A09220011	-64606.372	2640945.897	968.729	12mm iron peg in conc
A09220012	-63122.468	2639757.116	1008.996	12mm iron peg in conc
A09220013	-62601.563	2637779.461	910.740	12mm iron peg in conc
A09220014	-62374.416	2635954.430	906.343	12mm iron peg in conc
A09220015	-62131.505	2634091.546	943.789	12mm iron peg in conc
A09220016	-62487.754	2632497.701	927.354	12mm iron peg in conc
A09220017	-63189.783	2630731.217	898.577	12mm iron peg in conc
A09220018	-63327.988	2628805.124	913.434	12mm iron peg in conc
A09220019	-63255.668	2626883.356	887.016	12mm iron peg in conc
A09220020	-63332.484	2624847.306	861.276	12mm iron peg in conc
A09220021	-63546.668	2622860.110	872.630	12mm iron peg in conc
A0922021A	-63769.804	2621517.603	865.146	12mm iron peg in conc
A09220022	-62966.635	2620844.960	864.977	12mm iron peg in conc
A09220023	-60877.350	2619141.994	875.342	12mm iron peg in conc
A09220024	-61170.232	2621666.523	875.969	12mm iron peg in conc
A09220025	-59479.308	2622286.402	889.419	12mm iron peg in conc
A09220026	-59799.512	2622336.251	887.641	12mm iron peg in conc
A09220027	-58128.258	2623305.318	895.405	12mm iron peg in conc
A09220028	-56251.799	2623879.609	909.265	12mm iron peg in conc
A09220029	-55419.397	2624214.233	913.205	12mm iron peg in conc
A0922029A	-55581.893	2622940.448	906.241	12mm iron peg in conc
A09220030	-53580.967	2623070.634	914.671	12mm iron peg in conc
A09220031	-51610.738	2623074.563	918.432	12mm iron peg in conc
A09220032	-49624.366	2623273.293	915.329	12mm iron peg in conc
A0922032A	-47624.476	2623445.477	922.277	12mm iron peg in conc
A09220033	-46221.091	2624234.158	933.131	12mm iron peg in conc
A09220034	-45356.507	2624880.543	944.340	12mm iron peg in conc
A09220035	-43799.417	2625944.270	950.044	12mm iron peg in conc
A09220036	-42234.543	2625178.602	935.148	12mm iron peg in conc
A09220037	-40789.064	2624394.670	930.505	12mm iron peg in conc
A09220038	-38816.543	2623283.139	927.978	12mm iron peg in conc
A09220039	-36830.085	2622164.025	915.735	12mm iron peg in conc

A09220040	-34930.600	2622484.181	912.601	12mm	iron	peg	in	conc
A09220041	-33255.071	2623359.288	917.270	12mm	iron	peg	in	conc
A09220042	-31513.643	2624078.802	919.454	12mm	iron	peg	in	conc
A09220043	-29705.399	2624826.500	924.548	12mm	iron	peg	in	conc
A09220044	-27240.655	2622573.069	910.866	12mm	iron	peg	in	conc
A09220045	-28306.080	2624462.010	923.215	12mm	iron	peg	in	conc
A09220046	-34035.618	2622632.522	915.436	12mm	iron	peg	in	conc
A09220047	-34721.966	2624432.945	923.238	12mm	iron	peg	in	conc
A09220048	-35484.800	2626066.424	931.243	12mm	iron	peg	in	conc
A09220049	-36367.300	2627503.814	940.038	12mm	iron	peg	in	conc
A09220050	-37296.600	2629016.144	945.954	12mm	iron	peg	in	conc
A09220051	-38100.836	2630526.670	957.290	12mm	iron	peg	in	conc
A09220052	-38850.791	2632244.384	970.761	12mm	iron	peg	in	conc
A09220053	-39619.511	2634027.523	975.175	12mm	iron	peg	in	conc
A09220054	-39865.046	2635889.735	978.101	12mm	iron	peg	in	conc
A09220056	-41376.086	2642613.232	1007.223	12mm	iron	peg	in	conc
A09220057	-41143.582	2643611.552	1016.164	12mm	iron	peg	in	conc
A09220058	-40696.876	2645598.953	1018.830	12mm	iron	peg	in	conc
A09220059	-40260.747	2647525.829	1012.774	12mm	iron	peg	in	conc
A09220060	-39840.527	2649408.140	993.778	12mm	iron	peg	in	conc
A09220061	-40083.019	2651345.223	987.849	12mm	iron	peg	in	conc
A09220062	-40413.038	2653279.106	980.843	12mm	iron	peg	in	conc
A09220063	-40753.721	2655246.361	963.695	12mm	iron	peg	in	conc
A09220064	-41079.776	2657136.394	939.138	12mm	iron	peg	in	conc
A09220065	-41407.659	2659084.863	949.501	12mm	iron	peg	in	conc
A09220066	-41741.660	2661060.358	949.020	12mm	iron	peg	in	conc
A09220067	-42090.153	2663045.922	941.995	12mm	iron	peg	in	conc
A09220068	-42423.538	2664995.636	922.587	12mm	iron	peg	in	conc
A09220069	-42896.105	2666938.495	954.543	12mm	iron	peg	in	conc
A09220070	-43388.166	2668884.884	953.314	12mm	iron	peg	in	conc
A09220071	-43912.648	2670919.483	950.238	12mm	iron	peg	in	conc
A09220072	-44414.378	2672865.317	969.684	12mm	iron	peg	in	conc
A09220073	-44924.858	2674843.419	977.371	12mm	iron	peg	in	conc
A09220074	-45424.247	2676777.731	980.868	12mm	iron	peg	in	conc
A09220075	-45701.712	2678737.364	988.202	12mm	iron	peg	in	conc
A09220076	-45689.394	2680742.265	993.310	12mm	iron	peg	in	conc
A09220077	-45672.879	2682660.636	1002.331	12mm	iron	peg	in	conc
A09220078	-45653.064	2684672.881	1012.347	12mm	iron	peg	in	conc
A0922078A	-45634.524	2686699.964	1020.007	12mm	iron	peg	in	conc
A09220079	-45639.377	2687573.623	1017.526	12mm	iron	peg	in	conc
A09220080	-45606.226	2689648.766	1012.530	12mm	iron	peg	in	conc
A09220081	-45587.501	2691670.933	1020.250	12mm	iron	peg	in	conc
A09220082	-45566.713	2693673.937	1034.620	12mm	iron	peg	in	conc
A09220083	-45548.960	2695629.482	1038.580	12mm	iron	peg	in	conc
A09220084	-45532.287	2697763.687	1040.060	12mm	iron	peg	in	conc
A09220085	-44308.035	2698751.636	1051.790	12mm	iron	peg	in	conc
A09220086	-42378.166	2699633.610	1076.440	12mm	iron	peg	in	conc
A09220088	-40654.126	2700407.550	1075.970	12mm	iron	peg	in	conc
A09220089	-41266.495	2702420.232	1100.503	12mm	iron	peg	in	conc
A09220090	-39395.870	2702898.007	1118.065	12mm	iron	peg	in	conc

A09220091	-38407.277	2703541.585	1085.615	12mm	iron	peg	in	conc
A09220092	-36423.735	2704384.662	1052.662	12mm	iron	peg	in	conc
A09220093	-34503.158	2705275.135	1023.392	12mm	iron	peg	in	conc
A09220094	-32846.645	2706032.699	1003.389	12mm	iron	peg	in	conc
A09220095	-31573.816	2706615.006	989.164	12mm	iron	peg	in	conc
A09220096	-30234.960	2707329.199	976.795	12mm	iron	peg	in	conc
A09220097	-31483.432	2708763.584	987.490	12mm	iron	peg	in	conc
A09220099	-25073.577	2709812.394	937.232	12mm	iron	peg	in	conc
A09220100	-26006.708	2711162.069	932.867	12mm	iron	peg	in	conc
A09220101	-27427.448	2713169.529	939.335	12mm	iron	peg	in	conc
A09220102	-28471.850	2714615.660	942.651	12mm	iron	peg	in	conc
A09220103	-29777.234	2716399.931	951.191	12mm	iron	peg	in	conc
A09220104	-30853.938	2717896.259	956.898	12mm	iron	peg	in	conc
A09220105	-29645.158	2718437.672	941.196	12mm	iron	peg	in	conc
A09220106	-27771.194	2718843.427	913.907	12mm	iron	peg	in	conc
A09220107	-25975.184	2719365.481	899.713	12mm	iron	peg	in	conc
A09220108	-23773.759	2720322.489	904.130	12mm	iron	peg	in	conc
A09220109	-25526.116	2720949.637	897.385	12mm	iron	peg	in	conc
A09220110	-26897.473	2722208.900	900.483	12mm	iron	peg	in	conc
A09220111	-28677.574	2722889.345	907.738	12mm	iron	peg	in	conc
A09220112	-30363.657	2724101.522	903.506	12mm	iron	peg	in	conc
A09220113	-31596.452	2725329.118	907.809	12mm	iron	peg	in	conc
A09220114	-31706.643	2726881.096	941.673	12mm	iron	peg	in	conc
A09220115	-31702.392	2728821.028	911.482	12mm	iron	peg	in	conc
A09220116	-32408.318	2730544.157	912.882	12mm	iron	peg	in	conc
A09220117	-32768.666	2731162.899	910.657	12mm	iron	peg	in	conc
A09220118	-33700.544	2730777.579	921.477	12mm	iron	peg	in	conc
A09220119	-35026.472	2730439.200	935.197	12mm	iron	peg	in	conc
A09220120	-37248.632	2729808.882	916.190	12mm	iron	peg	in	conc
A09220121	-38431.175	2728165.774	908.845	12mm	iron	peg	in	conc
A09220122	-38077.672	2726051.101	911.164	12mm	iron	peg	in	conc
A09220123	-39463.337	2724432.201	932.261	12mm	iron	peg	in	conc
A09220126	-34241.284	2722286.566	1003.809	12mm	iron	peg	in	conc
A09220127	-32658.295	2721001.488	977.245	12mm	iron	peg	in	conc
A09220128	-31603.716	2719732.969	956.183	12mm	iron	peg	in	conc
A09220129	-32930.718	2732865.306	911.998	12mm	iron	peg	in	conc
A09220130	-33024.542	2735035.468	914.256	12mm	iron	peg	in	conc
A09220131	-33041.080	2736688.400	926.974	12mm	iron	peg	in	conc
A09220141	-43825.677	2737133.476	917.684	12mm	iron	peg	in	conc
A09220142	-44229.595	2735173.535	913.514	12mm	iron	peg	in	conc
A09220143	-44355.941	2733247.960	913.691	12mm	iron	peg	in	conc
A09220144	-44419.725	2731267.895	914.501	12mm	iron	peg	in	conc
A09220145	-44497.733	2729254.410	925.014	12mm	iron	peg	in	conc
A09220146	-42169.261	2729013.002	922.250	12mm	iron	peg	in	conc
A09220147	-40195.456	2728327.246	911.915	12mm	iron	peg	in	conc
A09220148	-45696.924	2729134.875	925.423	12mm	iron	peg	in	conc
A09220149	-47163.536	2730080.799	916.588	12mm	iron	peg	in	conc
A09220150	-47522.133	2731321.335	920.257	12mm	iron	peg	in	conc
A09220157	-43396.964	2739031.186	920.021	12mm	iron	peg	in	conc
A09220158	-40453.834	2698162.424	1079.530	12mm	iron	peg	in	conc

A09220159	-40271.015	2696112.114	1072.408	12mm iron peg in conc
A09220160	-40087.415	2694051.866	1062.009	12mm iron peg in conc
A09220161	-39833.998	2692155.490	1050.182	12mm iron peg in conc
A09220162	-39289.044	2690175.781	1035.183	12mm iron peg in conc
A09220163	-40653.097	2689621.690	1037.321	12mm iron peg in conc
A09220164	-42304.389	2688947.886	1042.660	12mm iron peg in conc
A09220165	-44242.166	2688157.415	1023.348	12mm iron peg in conc
A09220172	-32758.081	2710233.025	1003.201	12mm iron peg in conc
A09220173	-33263.011	2710838.991	1015.233	12mm iron peg in conc
A09220174	-31312.612	2711618.293	982.768	12mm iron peg in conc
A09220175	-29219.381	2712453.068	955.989	12mm iron peg in conc
A09220176	-36467.809	2722355.764	994.663	12mm iron peg in conc
A09220180	-39836.482	2719876.374	994.240	12mm iron peg in conc
A09220181	-39841.281	2718582.023	1022.825	12mm iron peg in conc
A09220182	-40414.860	2716743.624	1067.687	12mm iron peg in conc
A09220183	-40618.308	2714753.548	1132.038	12mm iron peg in conc
A09220184	-41426.514	2713379.888	1081.163	12mm iron peg in conc
A09220185	-41946.888	2711494.768	1070.499	12mm iron peg in conc
A09220186	-42154.969	2709499.021	1067.665	12mm iron peg in conc
A09220187	-42407.385	2707514.289	1085.034	12mm iron peg in conc
A09220188	-42338.014	2705814.645	1100.012	12mm iron peg in conc
A09220189	-41986.233	2703922.063	1097.215	12mm iron peg in conc
A09220212	-57245.915	2778158.195	948.092	12mm iron peg in conc
BOS1	-53026.167	2775948.443	955.010	12mm iron peg in conc
BOS2	-53516.586	2776244.282	953.754	12mm iron peg in conc
BOS3	-54016.910	2776385.725	947.947	12mm iron peg in conc
DJ2	-64062.416	2666301.398	1071.655	Iron standard
MKDW2	-73283.434	2653074.815	877.403	Iron standard
SMCA084101	-36423.362	2636050.390	983.889	20mm iron peg in conc
SMCA084803	-28151.854	2622787.661	914.097	12mm iron peg in conc
SMCA084804	-35400.869	2620448.030	907.860	12mm iron peg in conc
SMCA084805	-43068.830	2622964.189	929.605	12mm iron peg in conc
SMCA084806	-50757.343	2623175.646	914.387	12mm iron peg in conc
SMCA084809	-40764.132	2639587.920	977.281	12mm iron peg in conc
SMCA092001	-73217.005	2653177.620	877.220	12mm iron peg in conc
TR34	-39608.087	2690642.063	1069.0	Trig beacon
TR38	-67340.871	2622755.252	876.1	Trig beacon
TR42	-59879.762	2662100.323	1258.6	Trig beacon
TR75	-82195.626	2838622.205	1137.7	Trig beacon
TR82	-74424.903	2834876.805	1204.0	Trig beacon
TR94	-48799.552	2746560.119	944.1	Trig beacon
TR118	-33291.336	2735417.534	942.5	Trig beacon
TR122	-39466.966	2703045.126	1172.5	Trig beacon
TR310	-60397.512	2785350.260	1031.3	Trig beacon
TR347	-81763.555	2787039.463	1063.4	Trig beacon
ERAS	-70999.718	2620758.698	851.07	Trignet Base Station
SMCA0922010	-64328.267	2642029.140	957.158	12mm iron peg in conc
SMCA0922079	-45639.375	2687573.593	1017.526	12mm iron peg in conc
SMCA0922126	-34241.288	2722286.528	1003.809	12mm iron peg in conc
SMCA0922167	-53346.462	2753505.439	937.115	12mm iron peg in conc

SMCA0922264	-55430.951	2794983.581	981.807	12mm iron peg in conc
A4809	-40764.132	2639587.920	977.281	12mm iron peg in conc
Raloka	-71375.098	2826432.550	1077.777	Unmarked.

The orthometric heights highlighted in red in the above list have been adjusted to the custom geoidal model based on the leveled heights.

ANNEXURE C: REALM SURVEY SUITE

REALM (Results of Airborne Laser Mapping) is a modular, tab-based survey software suite for processing raw data derived from Optech's ALTM (Airborne Laser Terrain Mapper).

REALM software enables the user to download, convert, and manipulate airborne laser data. The processed data files can then be brought into an "off-the-shelf" visualization software package such as TerraModel or TerraScan to output graphic representations of the ALTM's 3D point data.

In general, the REALM Survey Suite software produces three-dimensional (3D) point data acquired by an Airborne Laser Terrain Mapper (ALTM). This data is processed from various inputs including: laser ranges, intensity values, scan angles, Differential Global Positioning System (DGPS) data, Inertial Navigation System (INS) data and system calibration data.

Integrated classification and output algorithms allow for the structured output of the 3D point data into various types, such as ground or vegetation only, time sequential, flightline, patches (input for DEM generation), buildings (3D city modeling), power lines, etc.

REALM's graphical user interface presents a well organized tool box (e.g., Geodetic Tools, GPS Positioning Tools, INS Tools, ALS Tools) in a modular, tab-oriented structure.

A common front-end user interface connects the various tools with each other to ensure an optimally controlled process flow.

ANNEXURE D: TERRASCAN

TerraScan is a dedicated software solution for processing laser scanning points. It can easily handle millions of points as all routines are tweaked for optimum performance.

Its versatile tools prove useful whether you are surveying transmission lines, flood plains, proposed highways, stock piles, forest areas or for city models.

The application reads points from XYZ text files or binary files. It lets you:

- view the points three dimensionally
- define your own point classes such as ground, vegetation, buildings or wires
- classify the points
- classify points using automatic routines
- classify 3D objects such as towers interactively
- delete unnecessary or erroneous points in a fenced area
- remove unnecessary points by thinning
- digitize features by snapping onto laser points
- detect powerline wires or building roofs
- export elevation color raster images
- project points into profiles
- output classified points into text files

TerraScan is fully integrated with MicroStation. This CAD environment provides a huge number of useful tools and capabilities in the areas of view manipulation, visualization, vector placement, labeling and plotting.

ANNEXURE E: TERRAPHOTO

TerraPhoto produces orthorectified images from airborne images. It is specifically written for handling images taken during a laser scanning mission and uses the laser data for an accurate ground model. The complete orthorectification process can be performed without having any known points at the site.

TerraPhoto's approach to orthorectification is simpler and more accurate than in most competing packages.

The rectification routine has the following advantages:

- Single pass which directly creates a mosaic of orthorectified rasters.
- Triangulated laser surface model accurately follows all terrain features. The system computes an elevation value for each pixel in the ortho image.
- Automatic smoothing of color transitions between images.

TerraPhoto also serves as an application for displaying raster images in the background of MicroStation views. The supported file formats include ECW, GeoTIFF, TIFF, BMP, CIT, COT, RLE, PIC, PCX, GIF, JPG and PNG raster files.

TerraPhoto is fully integrated with MicroStation. This CAD environment provides a huge number of useful tools and capabilities in the areas of view manipulation, visualization, vector placement, labeling and plotting.

ANNEXURE F: XForm

XForm is a multipurpose co-ordinate transformation package designed for the African environment. It is capable of carrying out a variety of transformations and the user can choose from any combination of the following for both source (input) and target (output) systems:

Datums: WGS84
 Cape (old South African) - valid for Botswana, Lesotho and Zimbabwe
 Schwarzek (Namibia)
 Tete (Mozambique)
 Camacupa (Angola)
 Arc 1960 (for Tanzania)
 Dabola (Guinea)
 Adindan (as used in Mali)
 Adindan (Mean, as used in Ethiopia/ Sudan)
 European 1950 (for Western Europe)
 North American 1927 (conterminous USA)
 South American 1969 (mean solution)
 Provisional South American 1956 (Northern & Southern Chile)

Coordinate Systems: Geographical (latitude, longitude, height)
 Gauss Conform (Lo) (y, x, height)
 Namibian (modified Gauss Conform)
 UTM (E, N, height)
 Cartesian (X, Y, Z)

Height Systems: Ellipsoidal
 Orthometric