



INNOVA
Drilling & Intervention

Survey QAQC, SCC & MSA Quick Start Guide

Rev 1.3

Contents

1.0 - Introduction	4
2.0 - QAQC Module	5
2.1 - Required Inputs.....	5
2.2 - RAW survey QC Limits.....	6
2.3 - QAQC calculation and Outputs	7
2.3.1 – Calculation Setup	7
2.3.2 - Outputs	7
3.0 – Short Collar Correction Module	8
3.1 - Magnetic Calculator	8
3.2 - SCC Limitations	10
3.3 - Running SCC	11
4.0 – Multi-Station Analysis (MSA) Module	12
4.1– MSA Setup.....	12
4.2 - Running MSA.....	13
5.0 - QAQC, SCC & MSA Reports & Outputs	14
5.1 – QAQC & SCC Report	14
5.2 – MSA Report	15
5.3 – MSA Charts & Data Tables	16
5.3.1 – LSQ Data Table	16
5.3.2 – Azimuth Comparison Chart	17
5.3.3 – HL Comparison Chart	17
5.3.4 – Dip Comparison Chart	18
5.3.5 -BH BV Scatter Plot.....	18
5.3.6 – LQS Chart.....	19
5.3.7 - TF vs Azimuth Correction Plot.....	19
5.3.8 - Delta Azi Plot.....	20
5.3.9 - Delta Dip Plot	20
5.3.10 - Delta HL Plot	21
5.3.11 - Corrected vs Uncorrected Surveys – Plan View Plot.....	21
5.3.12 - Corrected vs Uncorrected Surveys – Section View Plot.....	22
5.3.13 - GT Plot.....	22
5.3.14 - Show Labels on Scatter	22
5.3.15 - Report Options.....	22

1.0 - Introduction

The following document is a guide to Innova's QAQC, Short Collar Correction (SCC) and Multi Station Analysis modules within Innova Engineering.

The purpose of this document is to guide a new user through the layout, setup, calculation and outputs for these modules.

2.0 - QAQC Module

This module takes raw data from the MWD accelerometer (GX, GY & GZ) and magnetometer (HX, HY & HZ) and checks the generated outputs against the local geomagnetic data to ensure that the survey falls within accepted tolerances.

2.1 - Required Inputs

In order to run the QAQC check, the following inputs are required.

- **RAW Survey Data section of the Surveys tab**

- **Latitude:** Required to calculate the SCC Delta Azi in the Magnetic Spacing Calculator
- **HL Ref** – Reference magnetic field
- **Dip Ref** – Reference magnetic dip angle
- **TAC** – Total Applied Correction - Automatically calculated based on North Reference selected
- **Grid convergence** – Angle between True North & Grid North from True North
- **Declination** – Magnetic declination - Angle between True North & Magnetic North from True North
- **North reference** – The north reference the surveys are referenced to. Either True or Grid.
- This data is generally obtained from the well planning department who generate the data using programs like IGRF, BGGM & HDGM.

Latitude	HL Ref (μT)	Dip	TAC	Grid Conv	Dec	North Ref
0.00	0.00	0.00	0.00	0.00	0.00	Grid ▼

- **Magnetic Units** associated with HX, HY & HZ.

- Geolink / Tensor (mv), SSP / SUCOP (uT), nT, nT no XY inversion, EVO / Applied Physics or Vertex

Magnetics	>	✓	Geolink / Tensor (mv)
Accelerometers	>		SSP / SUCOP (uT)
Jet Size	>		nT
Set API Units			nT no XY inversion
Set SI Units			EVO / Applied Physics
Set Canadian Units			Vertex

- **Accelerometer Units:** Associated with GX, GY & GZ.

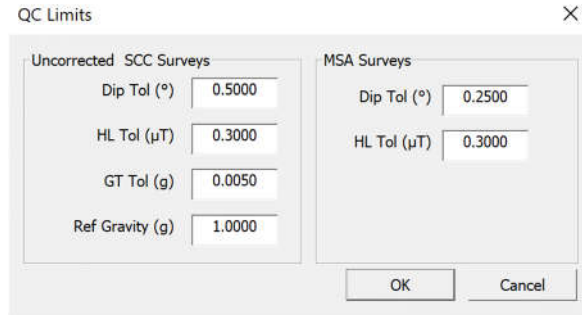
- G or mG. The option to Invert Z Axis can be checked or unchecked irrespective of the accelerometer unit choice

Accelerometers	>	✓	G
Jet Size	>		mG
Set API Units			Invert Z Axis

- Raw data from the MWD tool (GX, GY, GZ, HX, HY & HZ) + Measured Depth

2.2 - RAW survey QC Limits

It is important that the correct QC limits are set. These values are the $\pm$ limits used to compare the measured values against the calculated values. If these limits are not accurate it is possible that surveys may pass, which should not pass and conversely surveys may fail, when they should pass.

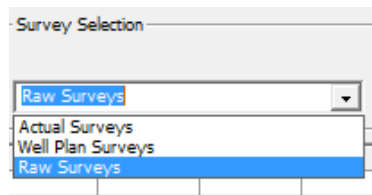


The QC Limits dialog box is divided into two main sections: 'Uncorrected SCC Surveys' and 'MSA Surveys'. Each section contains four input fields for different tolerance types. The 'Uncorrected SCC Surveys' section has fields for Dip Tol (°) set to 0.5000, HL Tol (μT) set to 0.3000, GT Tol (g) set to 0.0050, and Ref Gravity (g) set to 1.0000. The 'MSA Surveys' section has fields for Dip Tol (°) set to 0.2500 and HL Tol (μT) set to 0.3000. At the bottom right of the dialog are 'OK' and 'Cancel' buttons.

Survey Type	Dip Tol (°)	HL Tol (μT)	GT Tol (g)	Ref Gravity (g)
Uncorrected SCC Surveys	0.5000	0.3000	0.0050	1.0000
MSA Surveys	0.2500	0.3000		

The QC default limits set in Engineer are industry standard. It is however possible to change these if required. You can do this as follows:

- In the **Surveys** tab, select **Raw Surveys** from the **Survey Selection** drop down.



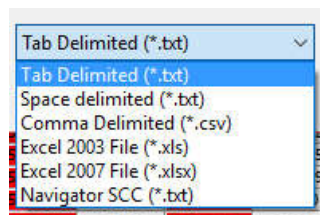
The Survey Selection dropdown menu is open, showing four options: 'Raw Surveys' (highlighted in blue), 'Actual Surveys', 'Well Plan Surveys', and 'Raw Surveys' (listed again at the bottom). The dropdown is part of a larger window titled 'Survey Selection'.

- Select **Options** from the top toolbar and then **Raw Survey QC Limits**.
- Note, that you can only access these values when you have **Raw Surveys** selected.
- Individual limits can now be changed as required.
- Note, that any changes made to these limits will only be valid for each specific project. When creating a new project, limits will be the default values until changed.

2.3 - QAQC calculation and Outputs

2.3.1 – Calculation Setup

- Ensure that the correct units have been selected, fill in the RAW Surveys Tab data (HL, Dip etc) and ensure that you have the correct RAW survey QC limits assigned.
- Ensure that you have the correct survey calculation method selected: **Options - Survey Calculation Method**. The default is **Minimum Curvature** and is very unlikely to be anything other than this.
- Select **Raw surveys** from the survey selection drop down menu.
- You can now enter your raw MWD data on a survey by survey basis, or if you are retrospectively checking an existing survey you can add the whole thing in one go
 - You can copy and paste the data, or
 - Go to **File - Import Survey** - you can then select the file you want to import
 - Note that in the drop down file type menu, there is an option that says Navigator SCC .txt. This should be used when importing Navigator export files (Navigator export files also contain the Geomag data; therefore, once imported ensure the Geomag data that has been pulled in is correct)



2.3.2 - Outputs

The generated HL, GT and Dip values are compared to the reference data in the RAW surveys Tab and any of the generated values out with the selected QC limits will be highlighted in **RED**. For a survey station to pass the QAQC procedure, they must fall within the QC limits and therefore not be highlighted.

Any surveys which have been highlighted should be rejected and retaken, **unless** it is possible to use the Short Collar Correction (SCC) algorithm to correct them to within the accepted limits.

Drilling, Well Geometry and Fluids Surveys Engineering Parameters Drilling Data Cementing																						
Vertical Section			Survey Selection			Raw Survey Data							Survey Corrections									
Azi Origin NS Origin EW						HL Ref		Dip	TAC	Grid Conv	Declination	North Ref	Offset (m) Inc Start Inc Stop Inc Step DLS Inc TF BHA Analysis Calc									
0.000 0.000 0.000						49.9822		59.505	6.430	-0.08000	6.350	Grid	19 0.0 0.0 0.0 0.0 0.0 0.0 Single									
Raw Surveys																						
	MD (m)	GX	GY	GZ	HX	HY	HZ	Inc	Azi	Inc SAG	Azi SCC	HL SCC	Dip SCC	HL	GT	Dip	Rot	Delta Inc	Delta Azi	TVD (m)	NS	
1	616.00	0.0025	0.0115	1.0000	-0.1937	-0.1710	0.4449	0.67	223.43		223.40	50.0204	59.4321	51.4339	1.0001	60.3519	-40.7386	0.0272	615.88	-8.		
2	645.00	-0.0080	-0.0145	1.0000	0.2285	0.1216	0.4431	0.95	220.44		220.41	49.9433	59.5783	51.3774	1.0001	60.4795	-27.1071	0.0344	644.88	-8.		
3	673.00	0.0160	-0.0045	1.0000	-0.1421	0.2157	0.4435	0.95	228.45		228.40	49.9448	59.5756	51.3314	1.0001	60.4595	57.7198	0.0462	672.87	-9.		
4	701.80	0.0045	0.0030	1.0000	-0.1179	0.2241	0.4468	0.31	282.91		282.89	49.9744	59.5199	51.3555	1.0000	60.4200	62.7922	0.0171	701.67	-9.		
5	730.40	-0.0085	0.0030	1.0000	-0.1732	-0.1827	0.4482	0.52	301.29		301.26	49.9684	59.5318	51.4119	1.0000	60.4619	-45.6978	0.0286	730.27	-9.		
6	759.60	0.0130	-0.0075	1.0000	0.0952	-0.2281	0.4508	0.86	42.87		42.90	49.9203	59.6290	51.4138	1.0001	60.5728	66.4174	-0.0330	759.47	-8.		
7	787.40	0.0435	0.0130	0.9990	0.2212	-0.0839	0.4563	2.60	41.01		41.11	49.9289	59.6182	51.3972	1.0000	60.4809	17.9161	-0.0961	787.26	-8.		

The values in the SCC column's will be generated regardless of whether a survey passes QAQC or not, and should therefore be disregarded, unless of course you are using the correction.

3.0 – Short Collar Correction Module

Short Collar Correction (SCC) corrects for magnetic interference in the Z axis. It should be noted that for the short collar correction algorithm to work correctly the Z axis must be aligned with the hole direction i.e. the Z axis points along hole. If this is not the case the short collar correction algorithm will not work. All major MWD companies with the exception of Schlumberger have the Z axis aligned with the along hole direction.

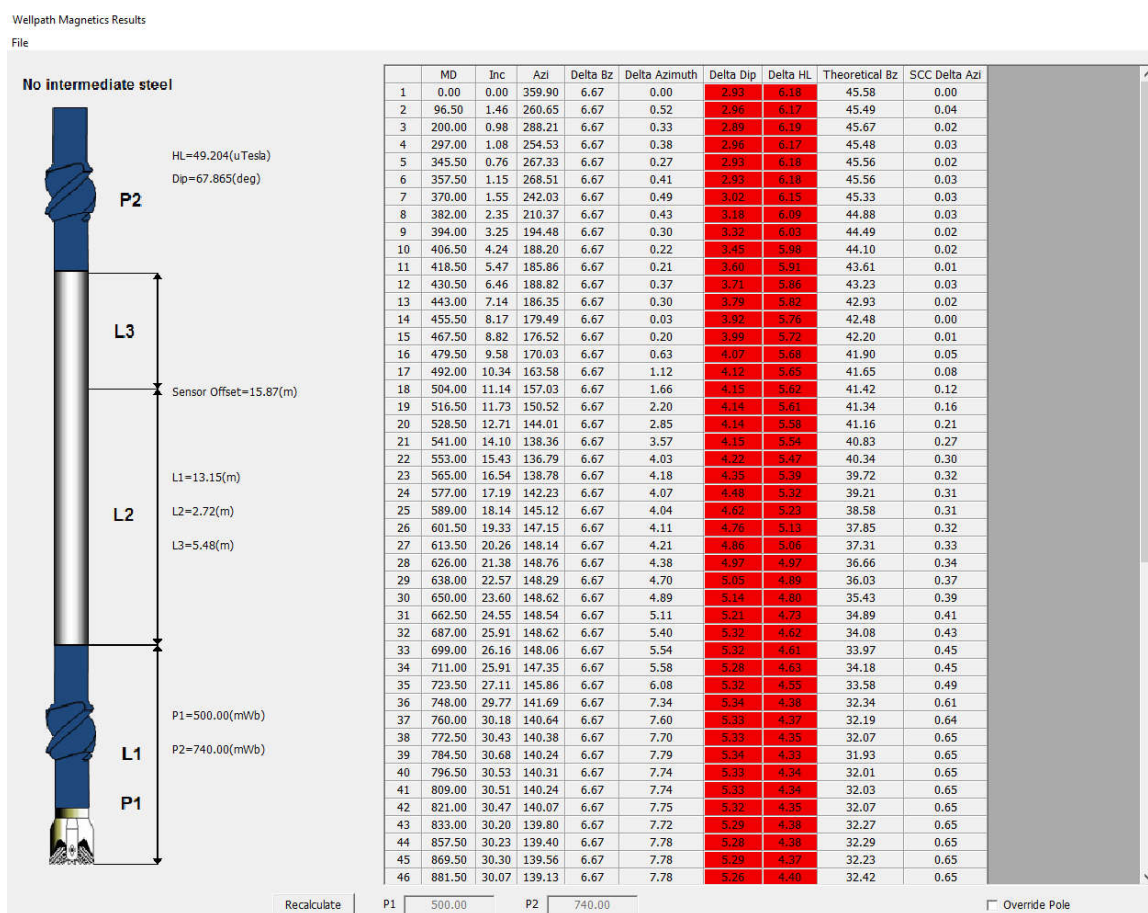
3.1 - Magnetic Calculator

Firstly, you need to ensure that the following data has been added to Engineering.

- Proposed BHA with the relevant components marked as non-magnetic
- Well Plan, in the Surveys Tab under Well Plan Surveys
- **Raw Survey Data** section and **Sensor offset** in the *Survey Corrections* section

You can now calculate the well path magnetics: **Calculate - Wellpath Magnetic Interference or** 

A window will now appear with the results and will look like the screen shot below.



Results

- **Azimuth:** The azimuth displayed is referenced to **Magnetic North** and will therefore look different when compared to the azimuth that was entered in the plan (which could be referenced to Grid or True North). The correction applied to the input azimuth is automatic and is based on the Geomagnetic data that you have entered in the Raw Survey Data Section.
- **Delta Bz:** The expected error between the **Theoretical Bz** and the Measured Bz (from MWD) for raw, uncorrected surveys.
- **Delta Azimuth:** The expected error in the raw uncorrected azimuth reading, <0.5 degrees is considered acceptable
- **Delta Dip:** The expected error between the calculated dip (from the geo-mag data) and the actual measured value (from MWD). This will be highlighted in red if the value is greater than the tolerance entered in the QC Limits dialog.
- **Delta HL:** The expected error between the calculated magnetic field strength (from the geo-mag data) and the actual measured value (from MWD). This will be highlighted in red if the value is greater than the tolerance entered in the QC Limits dialog.
- **Theoretical Bz:** The theoretical magnetic field strength expected in the Z axis with no interference.
- **SCC Delta Azi:** The expected error in the SCC corrected azimuth, <0.5 degrees is considered acceptable. This is affected by the Latitude entered in the Raw Survey Data section.

The **P1** and **P2** pole strength values are automatically selected based on the component type and size above and below the non mag components in the string. These can be overridden by the user if necessary, by checking the **override pole** box at the bottom right of the dialog and alternative values can then be entered by the user. Once entered, the user must select **recalculate**.

The whole output can be saved to pdf by selecting **File – Export to PDF**.

The data table can be exported to Excel by selecting **File - Export**.

These results can be used to make an informed decision as to whether there is a requirement to run the SCC algorithm, add additional non-mag or do nothing. Company policy will dictate what error values are considered acceptable.

3.2 - SCC Limitations

When it is deemed necessary to run SCC, careful consideration should be given to the planned well path, as there are defined limitations to the SCC which must be adhered to. Failure to follow these guidelines could result in surveys passing correction which should not. The SCC limits are listed in the table below.

Inclination Range (Deg)	Azimuth Range (Deg)	Limitations
0-60	0-360	No Limitations
60-90	0-60, 120-240, 300-360	No Limitations
60-90	60-70, 110-120, 240-250, 290-300	See Note (1)
60-90	70-110, 250-290	See Note (2)

- **Note 1** – If **possible, SCC should NOT be used** and the BHA should be correctly spaced with non-magnetic tubulars as required.
- **Note 2** – **SCC must NOT be used if the well path is known to be within these parameters.** Again, the BHA should be correctly spaced with non-magnetic tubulars as required.
- If the above parameters are encountered, then the SCC algorithm will not function correctly and erratic corrected data will be seen. It is therefore necessary to discuss beforehand with the Directional Driller/Company Representative as to an agreeable plan of action if the above criteria are expected to be encountered during the drilling that particular borehole.

If the planned wellbore falls out with the above limitations, SCC should NOT be used, and you should ensure that the BHA has the correct non-mag spacing.

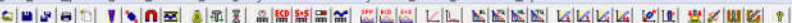
3.3 - Running SCC

When running the SCC, raw survey data is added in the same way as you do for the QAQC.

As with the QAQC, any numbers which are out of spec are highlighted red and should not be used. However, there are 3 columns (Azi SCC, HL SCC & Dip SCC) which contain corrected values, and as long as all 3 of these columns are not red, the **Azi SCC** value can be used instead of the calculated azimuth.

INNOVA Engineering

FileUnitsOptionsToolsCalculatePlotsSurvey Correction ResultsHydraulics ResultsIAD ResultsHelp



Project Name Description

Drifting Well Geometry SURVEY9 Engineering Parameters Drilling Data

Vertical Section

Azi

Origin NS

Origin EW

0.00

0.00

0.00

Survey Selection

Raw Surveys

Raw Survey Data

HL Ref

Dip Ref

TAC

Grid Convergence

Declination

North Ref

49.1727

67.77

0.140

0.45

0.59

296

Survey Corrections

Offset (ft)

Inc Start

Inc Stop

Inc Step

DLS

Inc

SAG Calc Type

0.00

0.00

0.00

0.00

0.0

0.0

Band

	MD (ft)	GX	GY	GZ	HX	HY	HZ	Inc	Azi	Inc SAG	Azi SCC	HL SCC	Dip SCC	HL	GT	Dip	Rot	Delta Inc	Delta Azi	TYD (ft)	NS (ft)
1	78.50	-0.0200	0.0100	1.0000	-0.0700	-0.1700	0.5000	1.28	269.44		269.13	49.0709	68.0621	68.1278	1.0002	68.1884	-64.1349	0.3131			
2	163.50	-0.0200	-0.0000	1.0000	-0.0000	-0.1800	0.4900	1.15	273.25		273.04	48.9566	68.0018	68.2015	1.0002	68.1768	-96.0843	0.2247		84.99	0.96
3	274.00	0.0200	0.0100	1.0000	-0.0700	0.1700	0.4900	1.28	277.71		277.47	49.1269	67.9017	68.1314	1.0002	68.1884	71.0059	0.2362		195.47	1.11
4	371.50	0.0000	-0.0100	1.0000	0.1800	0.0400	0.4800	0.57	259.11		259.00	49.0731	68.0541	68.1346	1.0000	68.0000	-11.0343	0.1122		292.96	1.21
5	383.50	-0.0000	-0.0100	1.0000	0.1800	0.0400	0.4900	0.57	259.11		259.00	49.0731	68.0541	68.1346	1.0000	68.0000	-11.0343	0.1122		304.96	1.31
6	395.50	-0.0100	-0.0100	1.0000	0.1900	0.0400	0.4900	0.81	214.41		214.32	49.2817	67.4715	68.0977	1.0001	68.1000	-10.7375	0.0942		316.96	1.36
7	407.50	-0.0300	-0.0000	1.0000	0.2000	-0.0300	0.4800	1.72	189.33		189.28	49.2846	67.4783	68.2063	1.0004	68.0000	9.1814	0.0490		328.96	0.81
8	420.00	-0.0400	-0.0200	1.0000	0.1900	0.0700	0.4800	2.56	187.24		187.18	49.0244	68.1480	68.2061	1.0010	68.0000	-19.4760	0.0612		341.45	0.4
9	432.00	-0.0600	-0.0100	1.0000	0.2100	0.0200	0.4800	3.48	184.82		184.76	49.0710	68.0174	68.4309	1.0018	68.0000	-9.4623	0.0614		353.43	-0.2
10	444.00	-0.0300	0.0500	1.0000	0.1200	-0.1800	0.4700	3.84	171.79		171.87	49.1531	67.7213	68.1797	1.0022	68.0000	63.4349	-0.0804		365.41	-0.9
11	456.50	-0.0700	0.0500	1.0000	0.1900	-0.1100	0.4700	4.92	173.42		173.52	48.9646	68.2492	68.1874	1.0037	68.0000	35.5377	-0.0976		377.77	-1.9
12	469.00	-0.0900	-0.0300	1.0000	0.2100	0.1000	0.4700	5.42	171.41		171.56	49.3963	67.2774	68.1404	1.0045	68.0000	-18.4349	-0.1511		390.32	-3.0
13	481.00	0.0500	-0.1100	0.9900	-0.1200	0.2100	0.4600	6.96	173.19		173.33	49.2850	67.5368	68.0911	0.9973	68.0000	65.5560	-0.1374		402.25	-4.3
14	493.00	-0.0900	-0.1200	0.9200	0.1200	0.2100	0.4600	9.26	169.70		170.09	49.4432	68.2152	68.1711	0.9901	71.4208	-53.1301	-0.3937		414.13	-6.0
15	505.00	-0.1300	-0.0900	0.9900	0.1800	0.1700	0.4500	9.07	167.81		168.13	49.4432	68.4036	68.1615	1.0025	70.1079	-34.6952	-0.3164		426.47	-7.9
16	529.50	-0.1900	-0.0000	0.9300	0.2600	0.0600	0.4400	11.55	160.34		160.96	48.5843	68.1087	68.1457	0.9988	68.0000	-0.0000	-0.6225		450.08	-12.1
17	541.50	-0.0900	-0.2000	0.9800	0.0500	0.2800	0.4400	12.61	158.32		159.13	48.3810	67.2607	68.2927	1.0042	68.1316	-65.7723	-0.8134		461.82	-14.1
18	554.50	0.2300	0.0200	0.9700	-0.2700	-0.0900	0.4300	13.39	158.81		159.51	49.2955	67.5649	68.1653	0.9971	68.1109	-4.9697	-0.7034		474.49	-17.2
19	566.50	-0.2200	0.1000	0.9700	0.2800	-0.0500	0.4300	13.99	156.86		157.74	49.0865	67.9125	68.2158	0.9996	68.0070	24.4440	-0.8848		486.15	-19.5
20	578.50	-0.2200	0.1400	0.9700	0.2800	-0.1000	0.4300	15.05	158.74		159.77	49.3808	67.4434	68.2781	1.0044	69.7669	32.4712	-1.0277		497.77	-22.1
21	591.00	-0.2500	0.1300	0.9600	0.2900	-0.0700	0.4200	16.36	155.95		157.09	48.9862	68.0565	68.1519	1.0005	70.1499	27.4744	-1.1352		509.80	-25.4
22	603.00	-0.2700	0.0900	0.9600	0.3000	-0.0200	0.4200	16.51	154.70		155.90	49.1008	67.8798	68.1687	1.0013	69.9979	18.4349	-1.2044		521.31	-28.1
23	615.00	-0.3000	0.0500	0.9500	0.3100	0.0200	0.4100	17.85	153.45		154.64	49.2177	67.7039	68.1793	0.9980	69.6361	11.3099	-1.1925		533.77	-32.2
24	627.50	-0.2600	0.1900	0.9500	0.3000	-0.1100	0.4100	18.73	151.16		152.65	48.3542	67.2979	68.1808	1.0031	68.5011	36.1582	-1.4886		544.64	-35.1
25	639.50	-0.3100	0.1500	0.9400	0.3200	-0.0600	0.4000	20.12	151.67		153.15	49.3128	67.5782	68.1572	1.0011	69.6841	25.8210	-1.4771		556.99	-39.1
26	652.00	-0.1900	0.3000	0.9400	0.2500	-0.2200	0.4000	20.70	149.47		151.17	49.6395	67.1290	68.2048	1.0048	69.3819	57.6526	-1.6983		567.68	-43.1
27	664.00	-0.0900	0.3600	0.9300	0.1700	-0.2900	0.3900	21.75	148.76		150.33	49.4701	67.3796	68.1699	1.0013	69.3422	75.9638	-1.5702		578.87	-46.1

Insert Before

Insert After

Delete

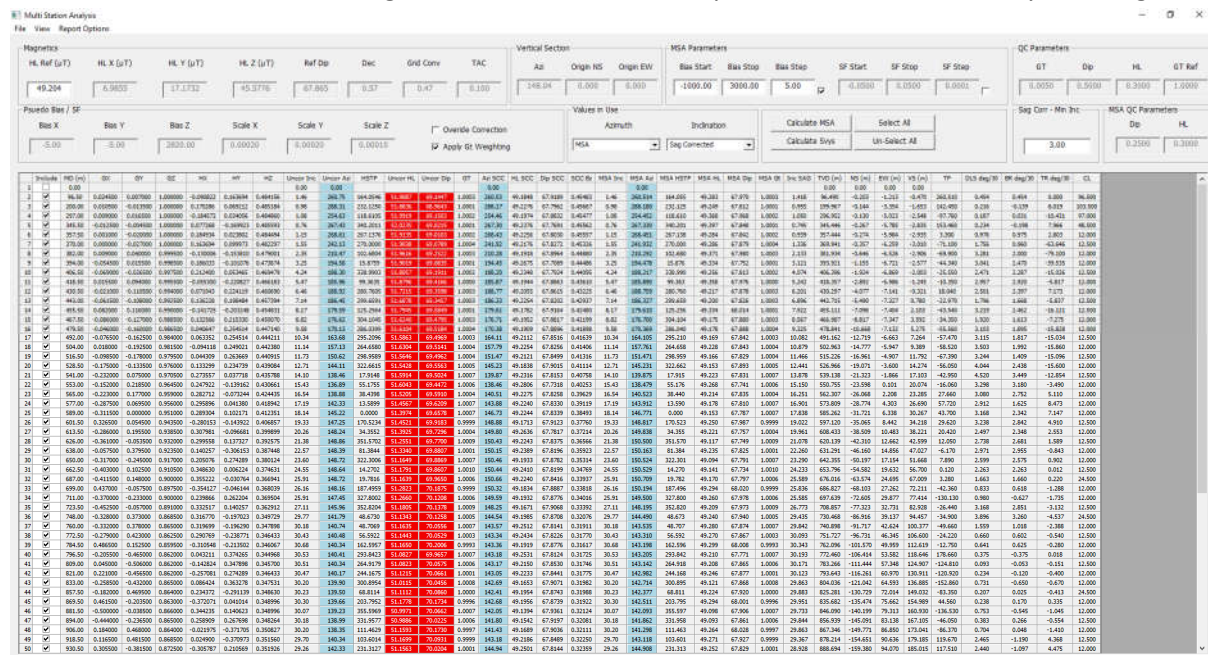
If even one of these 3 cells are **red**, the corrected azimuth should not be used, and the survey should be retaken.

4.0 – Multi-Station Analysis (MSA) Module

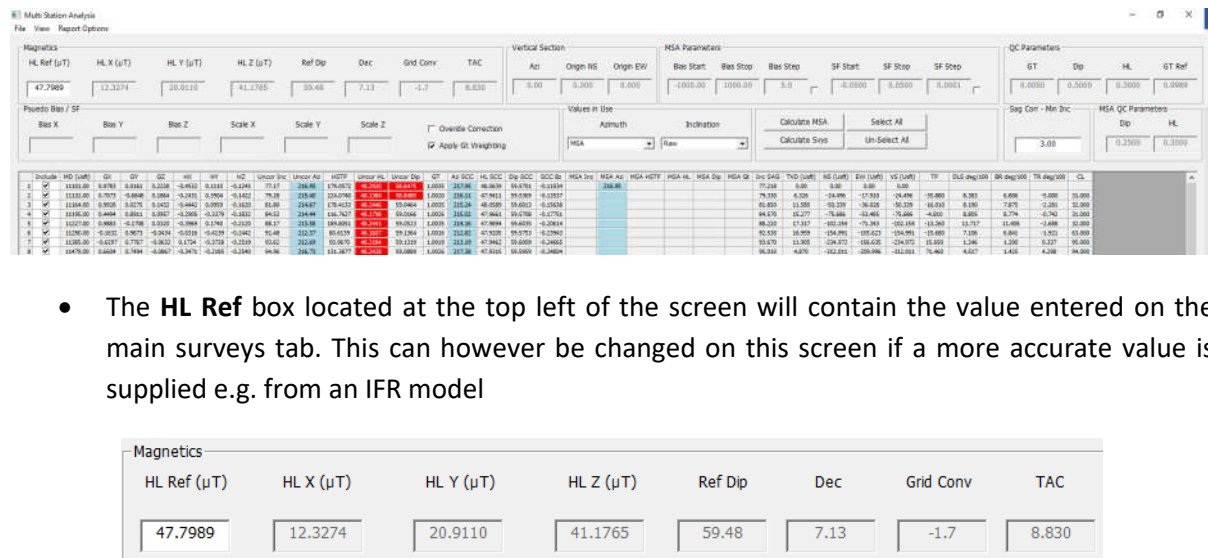
Multi Station Analysis is a technique which can be used to calculate Magnetometer biases in the X, Y & Z axis. This is achieved by examining the measured and theoretical values at each sensor over multiple stations to find correlations which minimise the errors. These corrections are then applied to all the raw values to produce corrected surveys.

4.1– MSA Setup

This section will assume that the user has input all data required to run SCC, as these steps must be complete before MSA can be calculated. In the Surveys tab on the main screen, select the MSA radio button located at the bottom right of the screen, this will open the Multi Station Analysis dialog.



- All the RAW surveys populated on the main screen can be found here – Note that these inputs are NOT editable on this page.



- The **HL Ref** box located at the top left of the screen will contain the value entered on the main surveys tab. This can however be changed on this screen if a more accurate value is supplied e.g. from an IFR model

- **MSA Parameters:** The user can select the required Bias and SF start, stop and Step values. If the LSQ fit does not show a good curve with a minimum found these values can be adjusted to extend the range of the calculation. Changing the step size can speed up / slow down the calculation but a smaller step size can increase the accuracy.

MSA Parameters

Bias Start	Bias Stop	Bias Step	SF Start	SF Stop	SF Step
-1000.0	1000.0	5.00	-0.0500	0.0500	0.0001

- **Values in Use:** The user can choose which values to use for the calculation:
 - **Bz:** Choose between SCC or raw. This determines which Bz value is used in the MSA calculation. If there is a large amount of interference in the Z axis, select the SCC option as the Z axis interference from the drill string must be removed before the MSA calculation can be run. If, however the BHA is correctly spaced or the assembly is run in the SCC no-go zones, then the raw value should be used.
 - **Azimuth:** This selection determines which azimuth is used in the survey calculation and only affects TVD, NS, EW, DLS etc
 - **Inclination:** This selection determines which inclination is used in the survey calculation and only affects TVD, NS, EW, DLS etc

Values in Use

Bz	Azimuth	Inclination
Raw	MSA	Raw

- **Apply Gt Weighting:** Surveys at a higher inclination are given more weighting in the calculation than surveys at lower inclinations. This is because they have more of an effect on azimuth. Ticking this box defines if the weighting is applied.
- **Override Correction:** When this box is ticked the user can manually edit the Bias X, Y, Z and Scale X, Y, Z values.

4.2 - Running MSA

To run the MSA calculation, select the **"Calculate MSA"** radio button. The MSA columns will populate with the relevant corrected values. As with the SCC results, anything out of spec will be highlighted in red.

Calculate MSA Select All Un-Select All

Mag Params		H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L				H/L			
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5.2 – MSA Report

The MSA reports are accessed directly from the MSA window and are NOT available from the Print Reports section. Once MSA has been calculated the user can select **File – Print Report**.

Multi Station Analysis

File	View
Print Report	
Export	
Exit	

This generates a PDF report which includes the MSA results, Magnetics, Pseudo Bias & SF values and a listing of the corrected surveys. Note that any stations which were deselected will not appear in this listing.

MSA Survey Report

Project Details		MSA Results	
Project: SDC MSA Test Description: Data Set 1		Bias Start: -1000.00 Bias Stop: 1000.00 Bias Step: 5.0 SF Start: -0.0500 SF Stop: 0.0500 SF Step: 0.0001 Apply Weighting: YES	
Magnetics		Pseudo Bias & SF	
B Total: 46.3114uT X Field: 13.4430uT Y Field: 21.0202uT Z Field: 39.0151uT Dip: 57.4deg Dec: 4.18deg Convergence: 0.35deg TAC: 3.830Deg North Ref: Grid		Bias X: 25.00 Bias Y: -10.00 Bias Z: -40.00 Scale X: -0.01660 Scale Y: -0.01670 Scale Z: -0.00230	

Survey Report												
MD (ft)	Uncor Inc	MSA Azi	TVD (ft)	NS (ft)	EW (ft)	VS (ft)	TF	DLS deg/100	BR deg/100	TR deg/100	CL	
12127.01	91.71	316.078	0.00	0.00	0.00	0.00	0	-	-	-	-	
12211.00	93.69	316.475	-3.956	60.628	-57.985	60.628	11	2.404	2.357	0.473	83.990	
12305.00	94.46	317.441	-10.636	129.152	-121.980	129.152	51	1.312	0.819	1.028	94.000	
12399.00	93.69	316.667	-17.316	197.785	-185.860	197.785	-135	1.160	-0.819	-0.823	94.000	
12468.30	93.52	316.711	-21.674	248.111	-233.303	248.111	166	0.253	-0.245	0.064	69.300	
12494.00	93.62	317.028	-23.274	266.830	-250.839	266.830	72	1.291	0.389	1.234	25.700	
12588.00	93.38	315.169	-29.013	334.431	-315.896	334.431	-97	1.990	-0.255	-1.978	94.000	
12678.80	92.55	317.758	-33.710	400.161	-378.351	400.161	108	2.991	-0.914	2.851	90.800	
12679.31	92.55	318.377	-33.733	400.540	-378.691	400.540	90	121.252	0.000	121.373	0.510	
12679.83	92.51	317.731	-33.756	400.926	-379.038	400.926	-94	124.348	-7.692	-124.231	0.520	

The user can also export the main MSA data table, as displayed on the main MSA interface. This can be exported as a .txt or Excel file. To export this data, select **File – Export**.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	
1	Include	MD (ft)	DX	DY	DZ	HX	HY	HZ	Uncor Inc	Uncor Azi	Rel	Uncor Inc	Uncor Azi	Uncor Dip	GT	Adj SCL	HL SCL	Dip SCL	SCL B	MSA Inc	MSA Azi	MSA Rel	MSA HL	MSA Dip	MSA Cl	Inc SAG	TVD (ft)	NS (ft)	EW (ft)	VS (ft)	TF	DLS deg/100	BR deg/100	TR deg/100	CL
1	1	12127	0.10547	0.99668	-0.0299	22350.65	66602.29	17255.3	91.71	318.84	-83.959	46.2644	55.8348	1.003	316.35	45.713	56.967	0.1569	91.708	316.078	90.041	46.471	57.127	1.003											
2	1	12211	-0.4049	0.91406	-0.0645	688.94	43487.55	16067.5	93.69	319.35	66.1092	46.366	55.8408	1.002	316.72	45.826	57.088	0.1444	93.689	316.475	66.109	46.348	57.24	1.002	-3.956	60.628	-57.985	60.628	11.32	2.404	2.357	0.473	84		
3	1	12305	0.95566	0.29062	-0.0779	43553.17	5589.29	15815.7	94.46	320.24	-16.915	46.4852	55.9813	1.003	315.47	45.973	57.18	0.1425	93.384	315.169	216.501	46.669	57.271	1.003	-10.636	129.152	-121.98	129.152	51.34	1.312	0.819	1.028	94		
4	1	12399	-0.8707	-0.4893	-0.0845	-42455.6	3558.82	15921	93.69	319.24	-29.352	46.398	56.0796	1.001	316.89	45.935	57.158	0.1452	93.692	316.667	230.688	46.688	57.276	1.001	-17.316	197.785	-185.86	197.785	134.9	1.16	-0.819	-0.823	94		
5	1	12468.3	-0.1143	-0.9998	-0.0615	-22220	-37010.2	16090.4	93.52	319.35	-83.441	46.2148	55.9216	1.002	317.03	45.734	57.024	0.1465	93.519	316.711	276.559	46.447	57.129	1.002	-21.674	248.111	-233.303	248.111	166.52	0.253	-0.245	0.064	69.3		
6	1	12494	0.20273	-0.9797	-0.0633	-9702.45	42196.7	16035.5	93.62	319.51	78.3086	46.1718	55.9695	1.002	317.35	45.72	57.016	0.1469	93.619	317.028	258.309	46.425	57.115	1.002	-23.274	266.83	-250.839	266.83	72.45	1.291	0.389	1.234	25.7		
7	1	12588	-0.80449	-0.3953	-0.0492	20707.26	38493.4	15852.4	93.38	318.1	36.5009	46.4954	55.9813	1.003	315.47	45.973	57.18	0.1425	93.384	315.169	216.501	46.669	57.271	1.003	-29.013	334.431	-315.896	334.431	-97.31	1.99	-0.255	-1.978	94		
8	1	12678.8	-0.385	0.17227	-0.0445	-35543.6	24339.28	16845.7	92.55	319.96	9.9007	46.255	56.1554	1.001	318.07	45.884	57.071	0.1465	92.55	317.758	9.901	46.559	57.218	1.001	-33.71	400.161	-378.351	400.161	108.73	2.991	-0.914	2.851	90.8		
9	1	12679.31	-0.0832	0.99785	-0.0445	14362.55	40438.84	16901	92.55	320.42	85.2337	46.1436	56.1306	1.002	318.64	45.741	57.004	0.1583	92.546	318.377	85.234	46.441	57.173	1.002	-33.733	400.54	-378.691	400.54	89.99	121.252	0	121.373	0.51		
10	1	12679.83	0.58008	-0.8162	-0.044	7999.54	-42054.8	16937.3	92.51	320.06	54.5986	46.0377	55.9255	1.002	318.06	45.589	56.896	0.1568	92.513	317.731	234.599	46.273	57.008	1.002	-33.756	400.926	-379.038	400.926	-94.33	124.348	-7.692	-124.231	0.52		
11	1	12680	-0.40487	0.32495	-0.0422	42886.24	-4202.27	17070	92.41	319.98	-19.05	46.3495	55.9727	1.002	317.68	45.839	57.071	0.1561	92.412	317.409	160.99	46.513	57.205	1.003	-33.849	402.527	-380.501	402.527	-107.3	15.525	-4.608	-14.899	2.17		
12	1	12776	0.68789	0.72832	-0.0299	39819.18	15994.26	17642.2	91.71	320.12	-46.635	46.3965	55.9152	1.002	317.71	45.84	57.058	0.1612	91.708	317.44	333.365	46.517	57.214	1.002	-37.228	471.702	-444.056	471.702	177.47	0.745	-0.745	0.033	94		
13	1	12870	-0.9193	-0.3943	-0.0229	-43005.3	1286.32	17605.6	91.31	319.39	-23.216	46.4873	56.141	1.001	317.18	45.985	57.158	0.1623	-37.228	471.702	-444.056	471.702	177.47	0.745	-0.745	0.033	94								
14	1	12965	-0.5982	-0.8039	-0.0106	37484.6	-12082.1	18049.6	90.6	319.41	-53.345	46.1971	55.9948	1.002	317.36	45.714	56.936	0.1678	90.603	316.994	306.655	46.417	57.064	1.002	-38.89	558.014	-478.065	558.014	-90.52	45.269	-0.747	45.27	95		
15	1	13008	-0.9891	0.1541	-0.0229	-35914.4	22695.92	18804.9	91.31	323.2	8.8557	46.4605	56.0518	1.001	320.17	45.99	57.115	0.1745	-38.89	558.014	-478.065	558.014	-90.52	45.269	-0.747	45.27	95								
16	1	13153	-0.1512	0.99141	-0.034	10004.58	40704.34	19235.2	91.94	325.86	81.3303	46.1186	55.6099	1.003	323.8	45.528	56.828	0.1777	91.941	323.523	81.33	46.208	57.026	1.003	-41.879	646.688	-507.28	646.688	-88.51	38.886	0.663	38.897	95		
17	1	13247	-0.1061	0.99609	-0.034	11062.01	40571.59	19844.1	91.94	327.97	83.9228	46.4996	55.8402	1.002	325.99	45.89	57.094	0.1837	91.943	325.718	83.923	46.569	57.306	1.002	-44.861	723.281	-561.671	723.281	89.96	2.334	0	2.335	94		
18	1	13340	0.98079	-0.1954	-0.0246	5519.12	-23857.8	20072.9	91.41	327.21	11.195	46.507	55.7246	1.003	325.04	45.844	57.051	0.1848	91.408	324.72	131.12	46.491	57.219	1.003	-47.58	799.632	-614.699	799.632	-118	1.215	-0.57	-1.073	93		
19	0	13434	0.14355	0.99258	-0.0147	20409.71	36994.66	20814.5	90.84	328.71	-81.771	46.3964	55.718	1.003	326.76	45.793	56.97	0.1934	-47.58	799.632	-614.699	799.632	-118	1.215	-0.57	-1.073	93								
20	1	13529	-0.8379	-0.5484	-0.0205	-41581.6	7525.63	19162	91.17	324.28	-33.207	46.3988	56.1016	1.002	322.48	45.904	57.093	0.1793	91.173	322.121	326.793	46.603	57.256	1.002	-49.31	887.847	-644.968	887.847	-89.17	39.868	0.947	39.873	95		
21	1	13623	0.67969	-0.7365	-0.0357	14596.02	39761.4	18951.4	92.04	325.22	47.2979	46.4022	55.8889	1.003	323.17	45.837	57.059	0.1752	92.042	322.831	227.298	46.505	57.208	1.003	-51.943	962.367	-702.199	962.367	39.2	1.194	0.925	0.755	94		
22	1	13717	0.9457	0.33971	-0.0902	42776.98	2719.12	17788.7	93.38	324.24	-19.167	46.4074	55.8248	1.003	322.01	45.844	57.084	0.1626	93.381	321.742	160.833	46.512	57.238	1.003	-56.367	1056.64	-759.613	1056.64	-99.04	1.806	1.426	-1.159	94		
23	1	13812	0.79805	-0.6047	-0.0486	20972.76	-37202.5	17770.4	92.78	322.99	37.1516	46.2565	55.8388	1.002	320.84	45.723	56.996	0.1634	92.781	320.518	217.152	46.399	57.122	1.002	-61.491	1110.5	-819.164	1110.5	-116.1	1.433	-0.632	-1.288	95		
24	0	13905	0.18833	0.98379	-0.0504	23481.35	33815.43	18310.6	92.88	324.85	-79.275	46.5768	55.9457	1.003	322.68	46.006	57.191	0.1681	-61.491	1110.5	-819.164	1110.5	-116.1	1.433	-0.632	-1.288	95								
25	1	14000	-0.97951	-0.2074	-0.041	-41691.5	8175.66	18338	92.35	323.96	-11.961	46.1742	55.8786	1.002	321.93	45.744	56.998	0.1696	92.347	321.595	348.039	46.454	57.165	1.002	-65.995	1198.44	-849.8	1198.44	-89.85	40.386	-0.558	-40.426	95		

5.3 – MSA Charts & Data Tables

In addition to the reports, the View menu contains QA/QC and other tools to evaluate the data.

View	Report Options
	LSQ Data
	Azimuth Comparison
	HL Comparison
	Dip Comparison
	BH BV Scatter Plot
	LSQ Chart
	TF v Azi Correction Plot
	Delta Azi Plot
	Delta Dip Plot
	Delta HL Plot
	Plan View Plot
	Section View Plot
	GT Plot
	Show Labels On Scatter

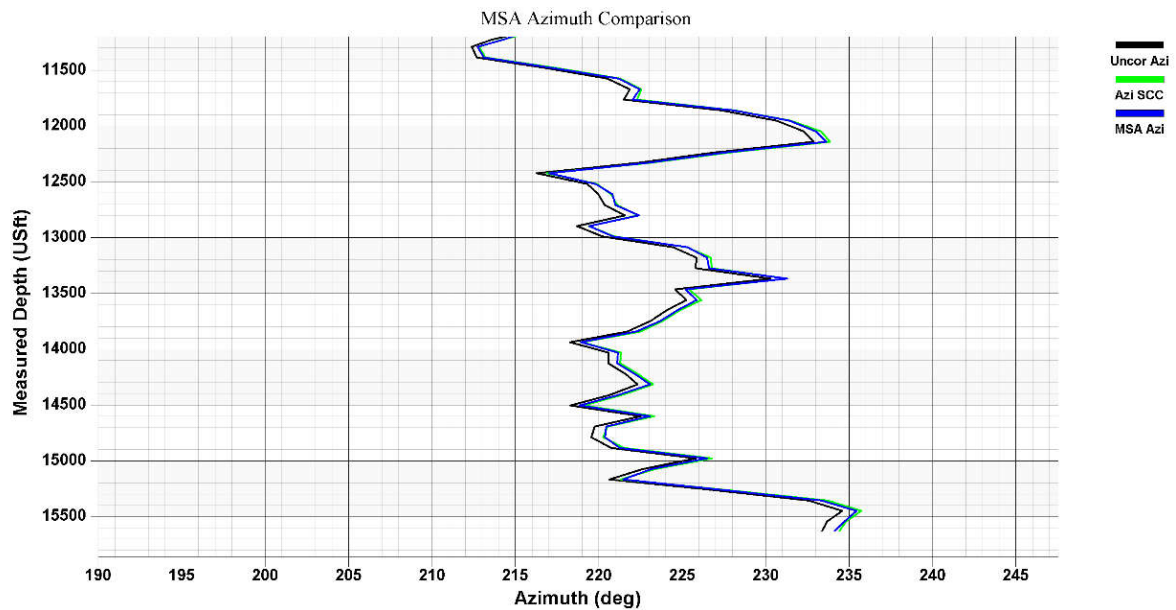
5.3.1 – LSQ Data Table

The LSQ Data table shows the data from the least squares fit

BIAS	SCALE FACTOR	LSQ BX	LSQ BY	LSQ BZ	LSQ SX	LSQ SY	LSQ SZ
-1000.00000000	-0.05000000	8333.01861016	8337.77291780	8361.55665852	13240.29384019	11292.49964860	8482.41294497
-995.00000000	-0.04990000	8292.05906991	8296.81628695	8320.55268158	13214.37416300	11270.63103195	8465.37029470
-990.00000000	-0.04980000	8251.10002393	8255.86017896	8279.54875732	13188.45451728	11248.76243845	8448.32766420
-985.00000000	-0.04970000	8210.14147963	8214.90460165	8238.54488652	13162.53490323	11226.89386822	8431.28505361
-980.00000000	-0.04960000	8169.18344455	8173.94956299	8197.54106999	13136.61532103	11205.02532140	8414.24246303
-975.00000000	-0.04950000	8128.22592639	8132.99507112	8156.53730854	13110.69577087	11183.15679813	8397.19989259
-970.00000000	-0.04940000	8087.26893300	8092.04113436	8115.53360301	13084.77625294	11161.28829856	8380.15734241
-965.00000000	-0.04930000	8046.31247240	8051.08776116	8074.52995425	13058.85676743	11139.41982281	8363.11481262
-960.00000000	-0.04920000	8005.35655275	8010.13496017	8033.52636313	13032.93731453	11117.55137103	8346.07230335
-955.00000000	-0.04910000	7964.40118242	7969.18274021	7992.52283053	13007.01789444	11095.68294336	8329.02981471
-950.00000000	-0.04900000	7923.44636991	7928.23111029	7951.51935737	12981.09850736	11073.81453995	8311.98734684
-945.00000000	-0.04890000	7882.49212392	7887.28007960	7910.51594457	12955.17915348	11051.94616093	8294.94489985
-940.00000000	-0.04880000	7841.53845333	7846.32965751	7869.51259306	12929.25983301	11030.07780645	8277.90247390
-935.00000000	-0.04870000	7800.58536720	7805.37985362	7828.50930382	12903.34054614	11008.20947667	8260.86006909
-930.00000000	-0.04860000	7759.63287478	7764.43067769	7787.50607783	12877.42129308	10986.34117172	8243.81768556
-925.00000000	-0.04850000	7718.68098553	7723.48213972	7746.50291609	12851.50207404	10964.47289175	8226.77532346
-920.00000000	-0.04840000	7677.72970909	7682.53424991	7705.49981962	12825.58288921	10942.60463692	8209.73298290
-915.00000000	-0.04830000	7636.77905533	7641.58701868	7664.49678948	12799.66373881	10920.73640738	8192.69066402
-910.00000000	-0.04820000	7595.82903431	7600.64045667	7623.49382673	12773.74462304	10898.86820327	8175.64836696
-905.00000000	-0.04810000	7554.87965632	7559.69457476	7582.49093247	12747.82554213	10877.00002476	8158.60609186
-900.00000000	-0.04800000	7513.93093188	7518.74938405	7541.48810782	12721.90649627	10855.13187199	8141.56383885
-895.00000000	-0.04790000	7472.98287173	7477.80489591	7500.48535391	12695.98748569	10833.26374512	8124.52160807
-890.00000000	-0.04780000	7432.03548686	7436.86112193	7459.48267191	12670.06851060	10811.39564431	8107.47939967

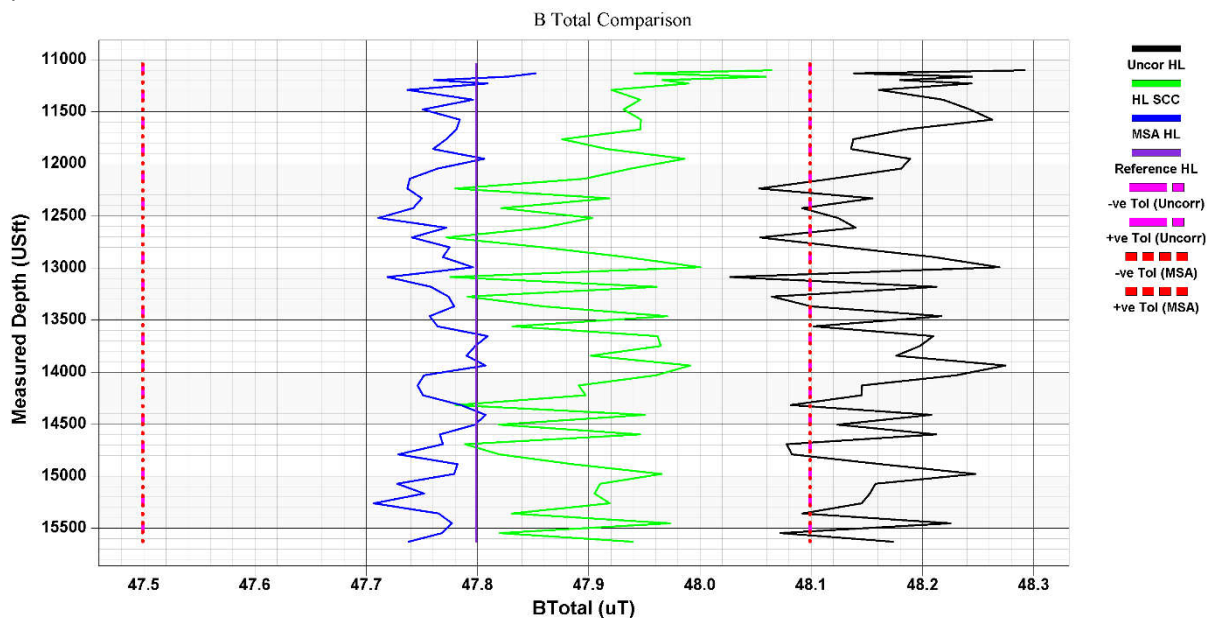
5.3.2 – Azimuth Comparison Chart

The Azimuth Comparison chart, provides the user with a visual representation of the Uncorrected azimuth against the SCC corrected azimuth and the MSA azimuth.



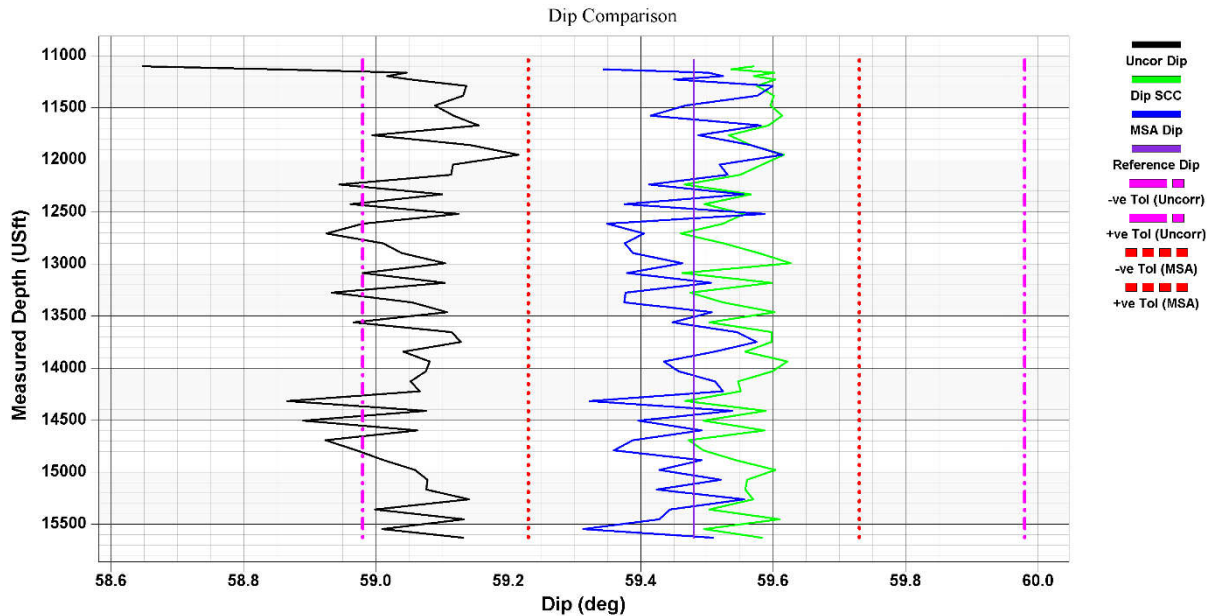
5.3.3 – HL Comparison Chart

The HL comparison chart gives the user a visual representation of the reference HL against the measured (uncorrected) HL and the SCC & MSA corrected HL values. The chart also includes the tolerance lines which make it very easy to quickly identify any points which are out with the QC parameters



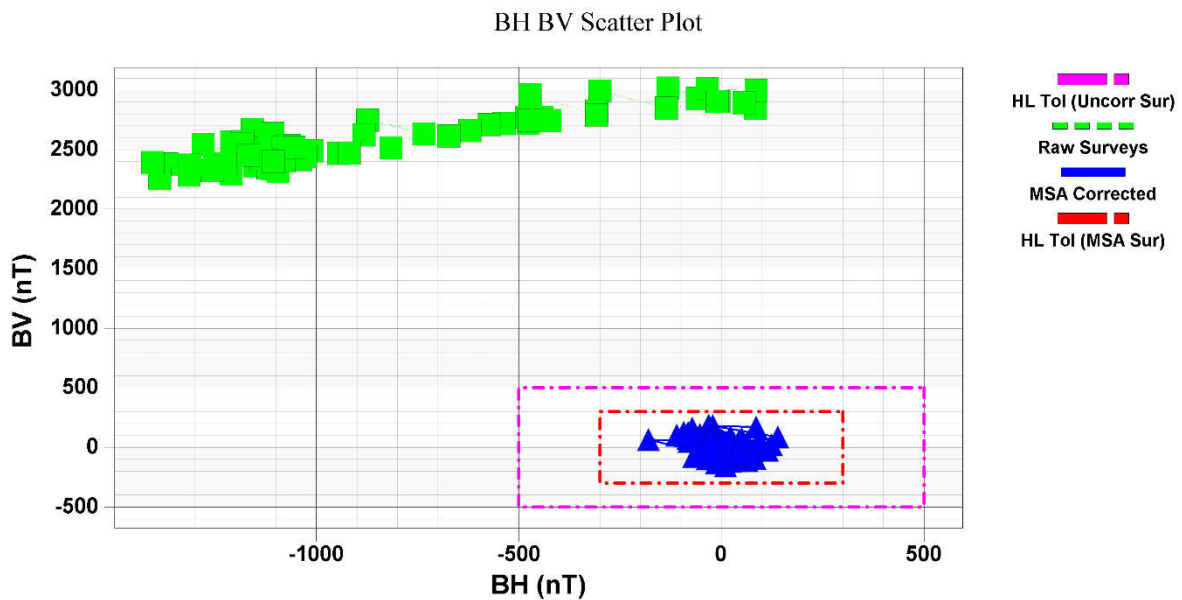
5.3.4 – Dip Comparison Chart

The Dip comparison chart gives the user a visual representation of the reference Dip against the measured (uncorrected) Dip and the SCC & MSA corrected Dip values. The chart also includes the tolerance lines which make it very easy to quickly identify any points which are out with the QC parameters



5.3.5 -BH BV Scatter Plot

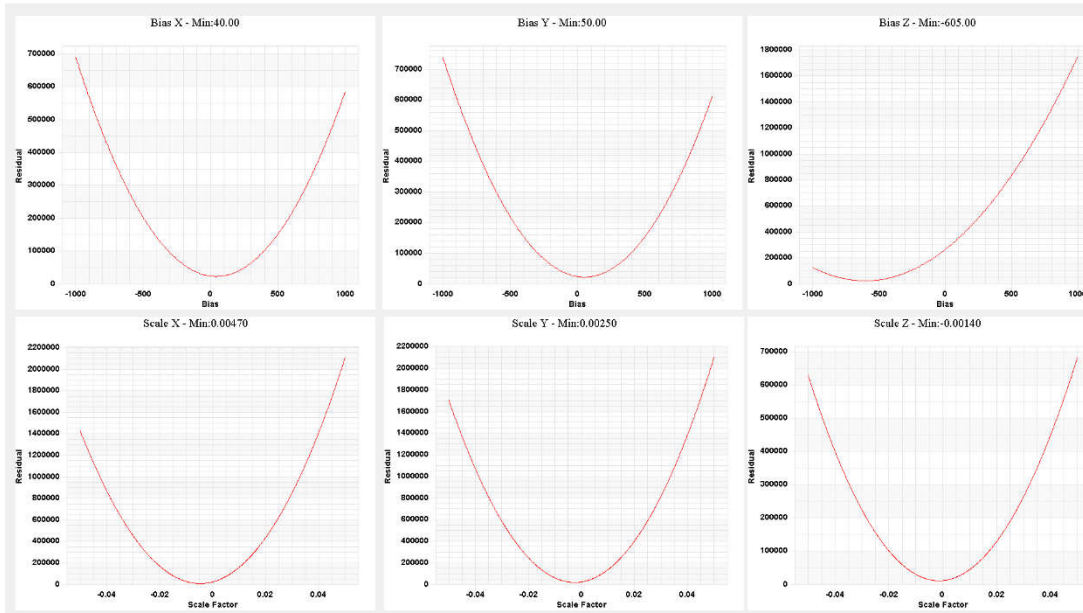
The BH BV Scatter Plot shows the horizontal and vertical components of the sensor readings plotted against the QC values. Ideally, they should all reside within the limits



5.3.6 - LQS Chart

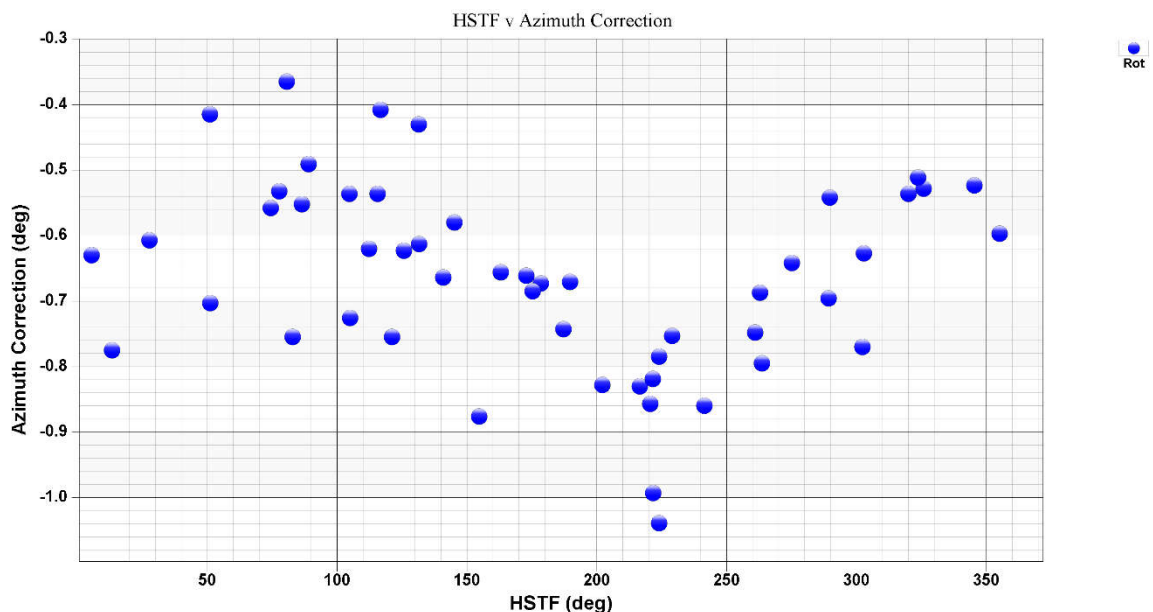
The LQS Chart shows the least squares fit. If a V shape curve is seen the minimum has been found and the calculation is a success. If any one of the charts does not show a “*minimum found*” the calculation must be re-run.

LSQ View



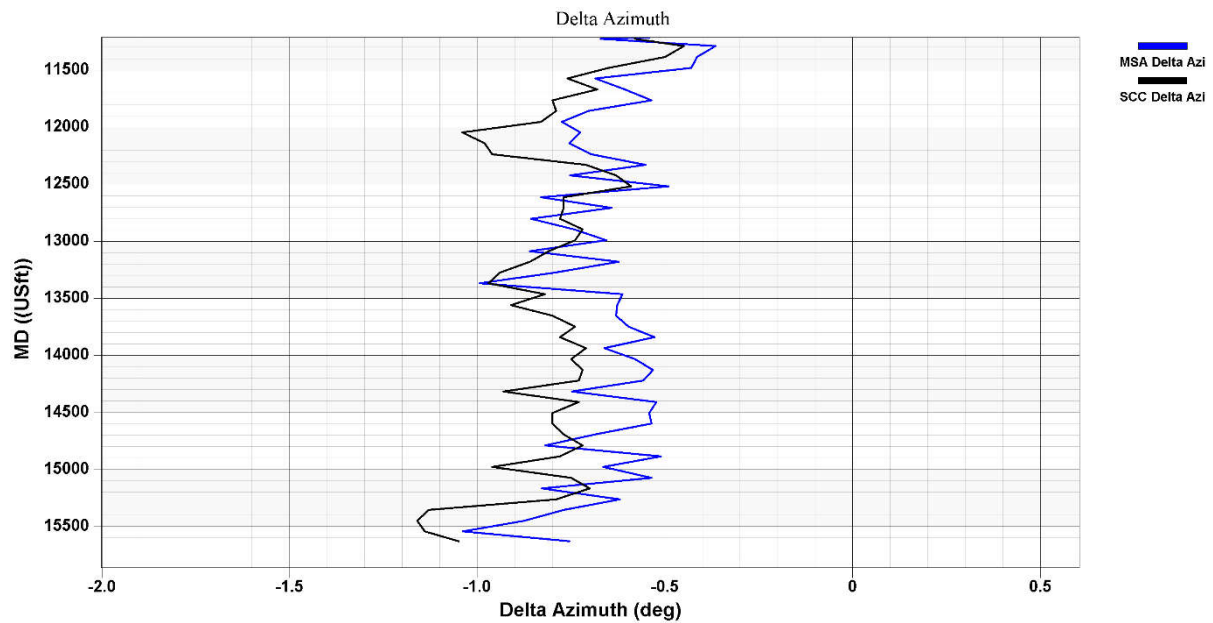
5.3.7 - TF vs Azimuth Correction Plot

This Chart plots the difference in the RAW and MSA corrected azimuths against the HSTF recorded when the survey was taken. This chart gives a good visual representation of the number of surveys taken in each quadrant. For best results, an even spread is ideal, but it is **essential** that there are at least some survey points in each quadrant.



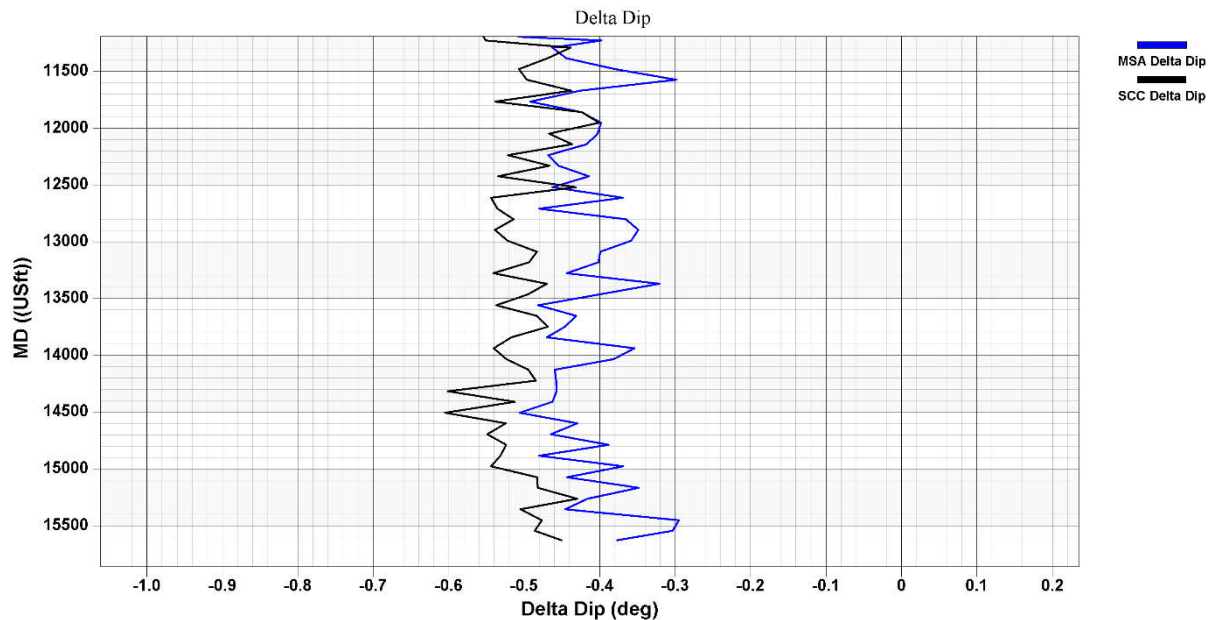
5.3.8 - Delta Azi Plot

The Delta Azi Plot shows the difference in azimuth between the MSA and RAW azimuth and the SCC and RAW azimuth.



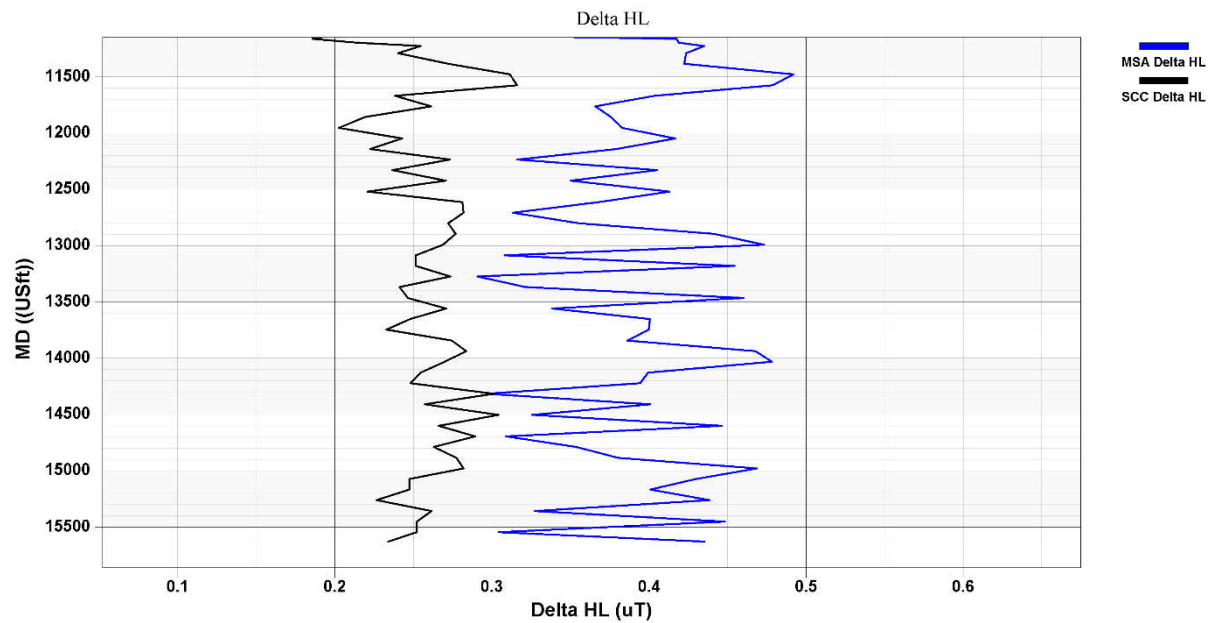
5.3.9 - Delta Dip Plot

The Delta Dip Plot shows the difference in the dip between the MSA and RAW dip and the SCC and RAW dip.



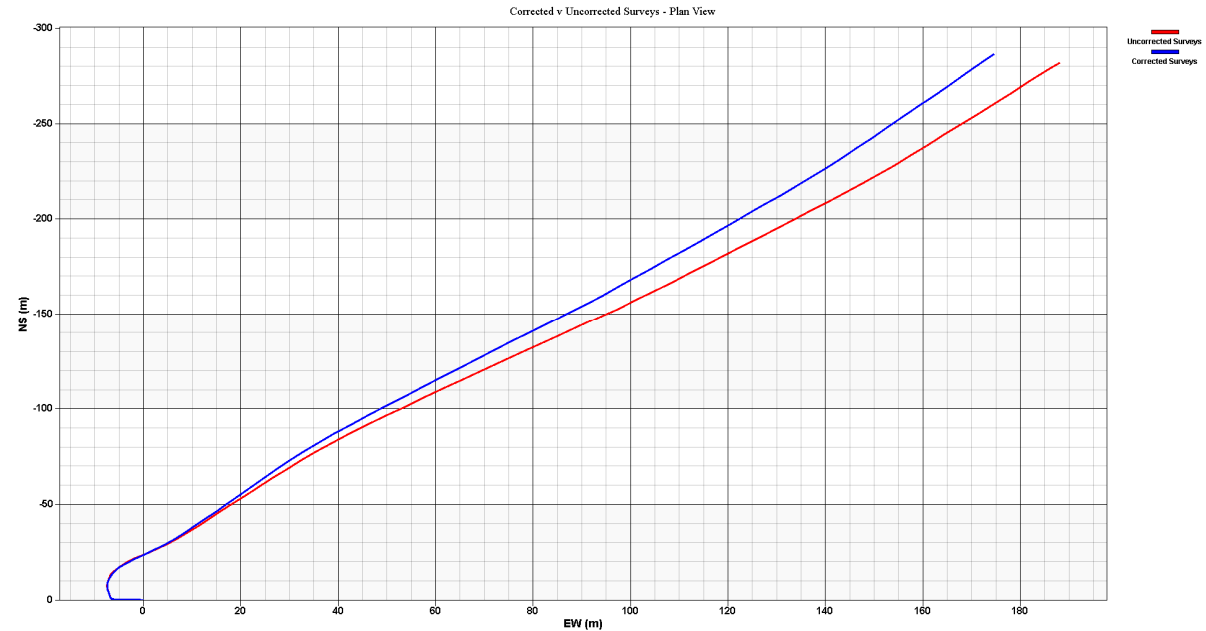
5.3.10 - Delta HL Plot

The Delta HL Plot shows the difference in the HL between the MSA and RAW dip and the SCC and RAW dip.



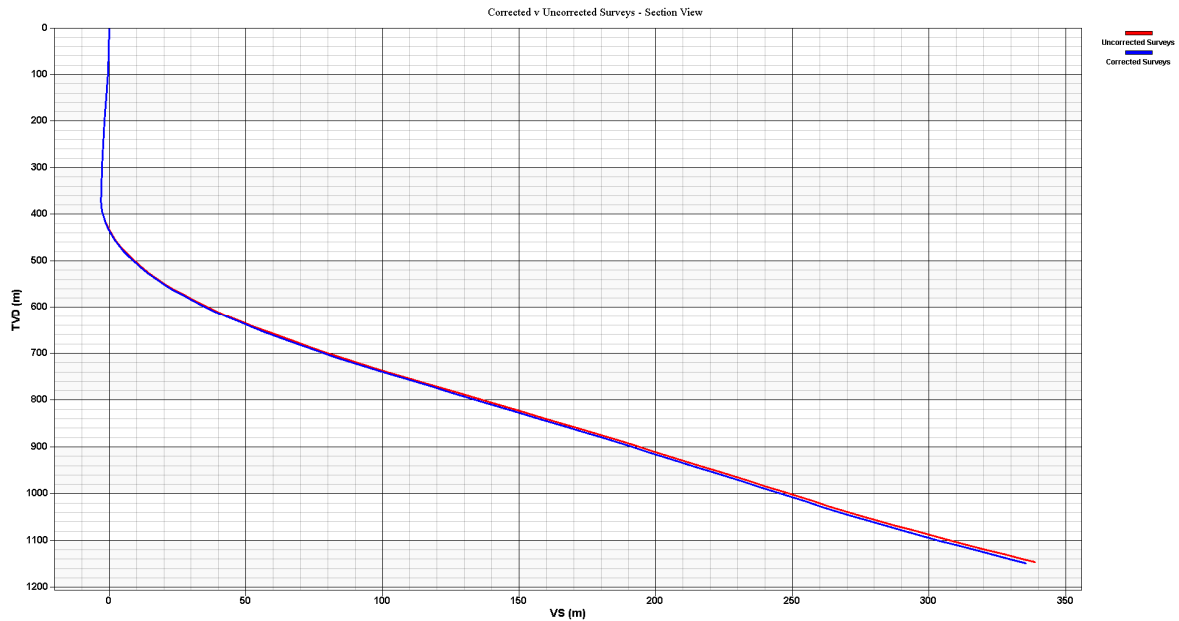
5.3.11 - Corrected vs Uncorrected Surveys - Plan View Plot

This plot shows the difference between the corrected and uncorrected surveys in the plan view.



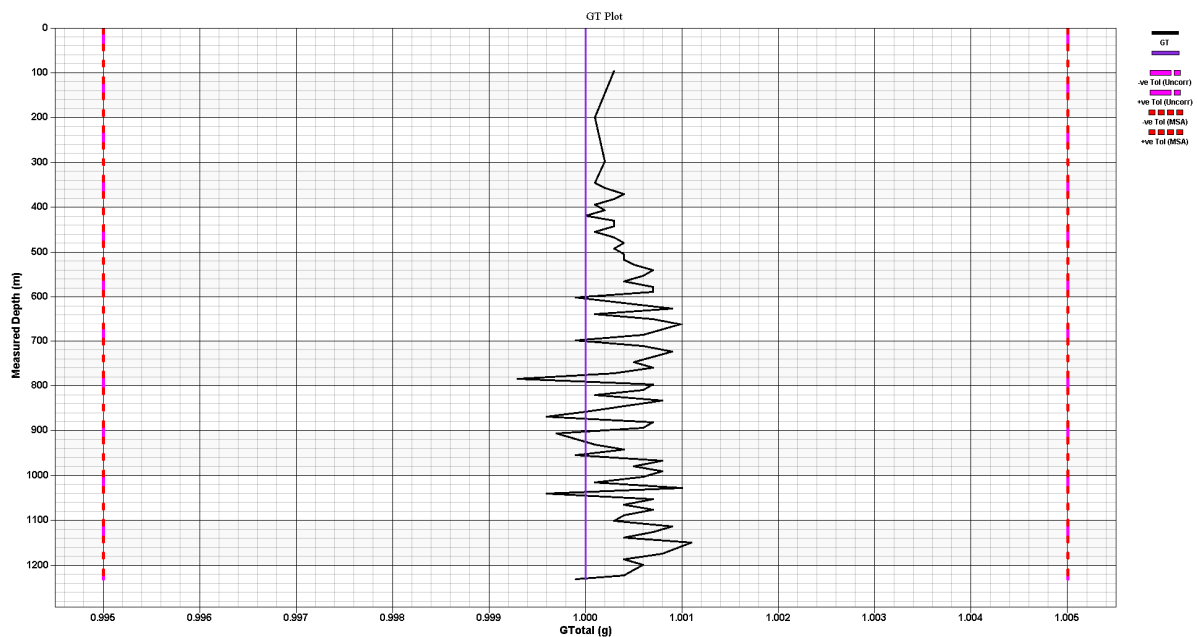
5.3.12 - Corrected vs Uncorrected Surveys – Section View Plot

This plot shows the difference between the corrected and uncorrected surveys in the section view.



5.3.13 - GT Plot

The GT Plot shows the measured GT values against the value entered in the magnetics section.



5.3.14 - Show Labels on Scatter

Selecting this option, displays labels on the BH BV Scatter plot.

5.3.15 - Report Options

Allows the user to select which plots to include in the reports.