

SKELLIG MICHAEL MONITORING SURVEY REPORT

September 2020



The Discovery
Programme

Centre for Archaeology
and Innovation Ireland

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1. Project Background

In September 2015 a series of precise observations were measured at three locations around the Monastery on Skellig Michael, see Figure 1. At these locations marine bronze bolts were fixed into both the bedrock and the built fabric of the structure, providing a local control network and monitoring points respectively. The precise locations of these points are available in the report appendices. These survey points were re-observed in September 2016, September 2017, and September 2018, with the 3D positions and deviations published in the 2016, 2017 & 2018 reports. Due to adverse weather conditions no survey work took place in September 2019, although an interim set was taken at Area 2 in May 2019 due to ongoing concerns over stability in that area.

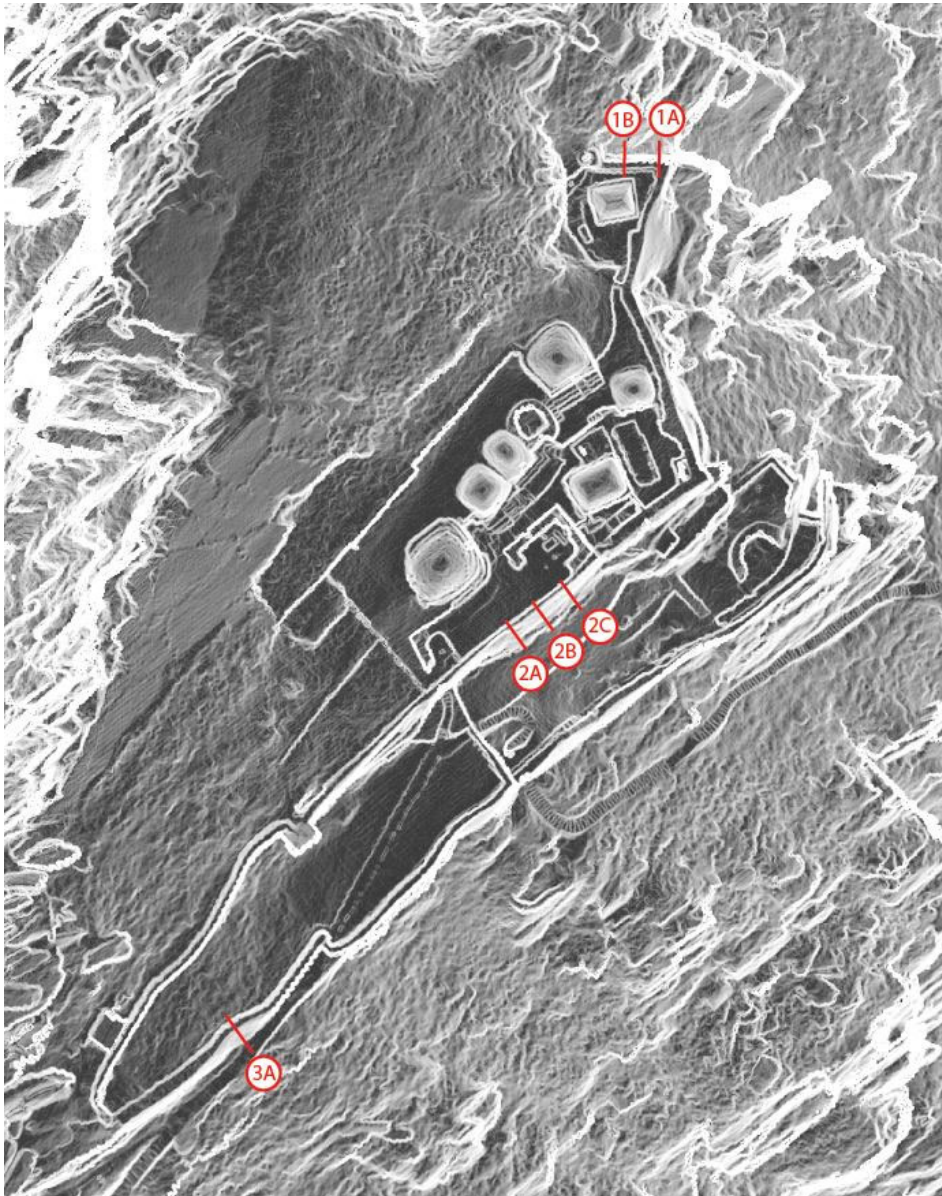


Figure 1 - Initial location of the monitoring project

In July 2017 after an extensive reconnaissance of the South Peak, a further four locations were added to the monitoring network. These locations are named and numbered based on the position of the instrument when taking observations, see Figure 2. In total there are now 7 areas being monitored since 2017, measuring the precise positions of 99 brass survey markers. As with Areas 1 - 3 no survey was possible in September 2019.

The monitoring surveys are undertaken by the Discovery Programme on behalf of the OPW. The report presents the results of the latest survey, September 2020, and gives some basic analysis of the results and the significance of vector change over the duration of the project.

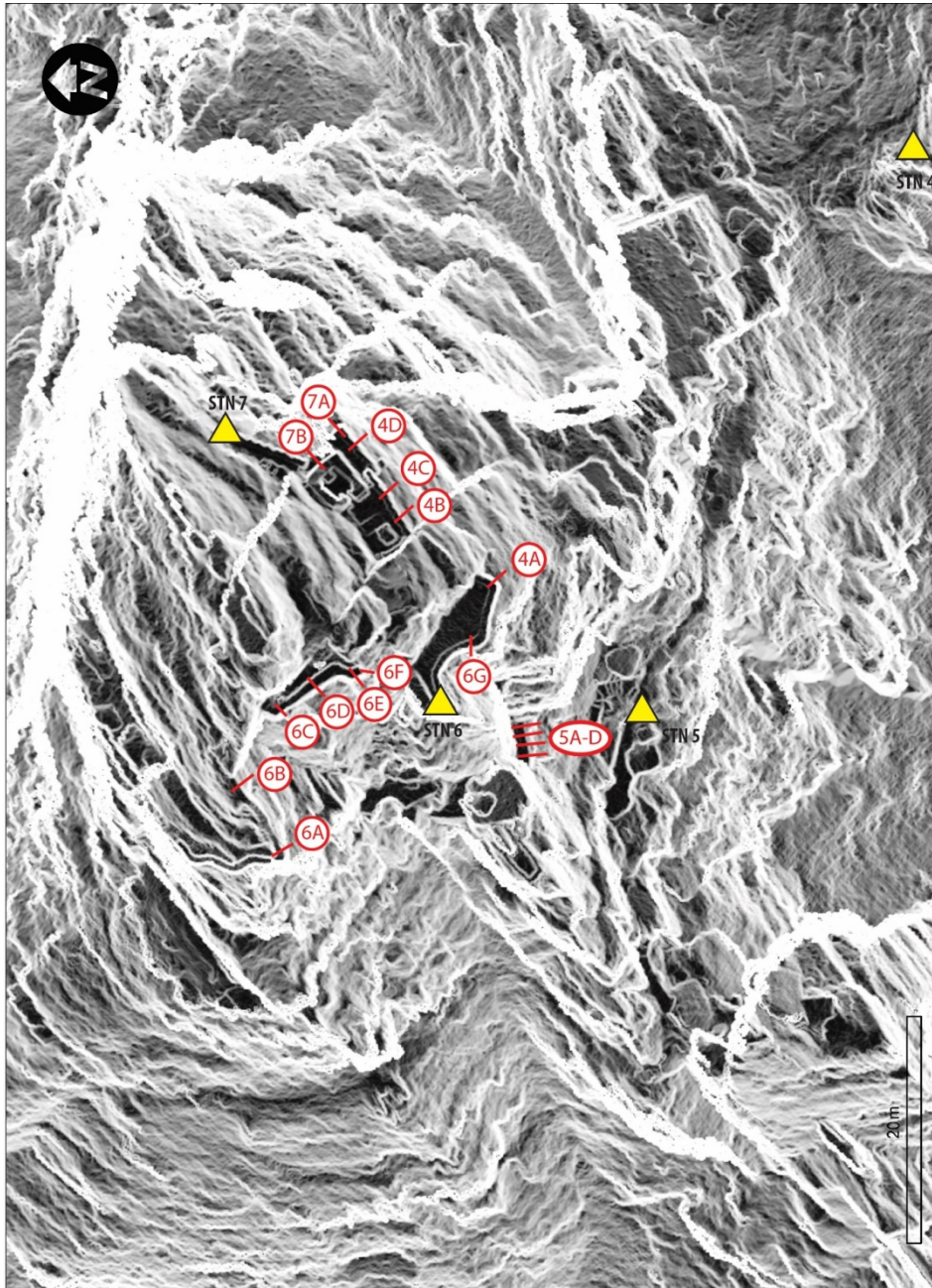


Figure 2 – 2017 monitoring network

2. Equipment & Observations 2020

The observations took place in the week 7th to 11th September 2020. The instrument used was a Trimble VX total station, Figure 3, operated in standard DR (reflectorless mode) which has a manufacturer defined accuracy (RSME) of 2mm + 2ppm, set to average 5 readings per observation. The full specification of the instrument is available online:-

http://trl.trimble.com/docushare/dsweb/Get/Document-348124/022543-261G_TrimbleVX_DS_0613_LR.pdf



Figure 3– VX Total Station

This was the same instrument as used for the observations since 2015 and was re-calibrated by the manufacturer during the week before the survey.



Figure 4 - Calibration Certificate

Two sets of observations, from independent resections were taken at each of the seven locations. Areas 1 - 3 were initially observed in poor weather (mist and wind) on 7th and 8th September, but re-observed in dry calmer conditions on the 10th. Areas 4 - 7 were observed on 9th September with clear, calm conditions.

For each set of readings an average value is taken to establish a final set of coordinates for each monitoring survey marker.

The following sections present the September 2020 list of coordinates for each area, and the calculated annual and overall vector differences. The overall vector shift is calculated by comparing the original coordinates (2015, 2017 or 2018 depending on when established) with the 2020 values. This is the critical value to consider as it indicates the overall stability, or otherwise of the survey markers.

Also included for each area is a comment on the significance of the survey data, and suggestions of appropriate survey actions.

3. Area 1 - Results

SEPTEMBER 2020 COORDS - AREA 1

POINT	X (m)	Y (m)	Z (m)
1-m-a-1	1495.301	1509.923	95.182
1-m-a-2	1495.348	1509.933	94.596
1-m-a-3	1495.377	1510.051	93.851
1-m-a-4	1495.427	1510.363	92.449
1-m-b-1	1497.838	1509.396	95.347
1-m-b-2	1497.78	1509.3	94.949
1-m-b-3	1497.794	1509.319	94.584
1-m-b-4	1497.884	1509.424	93.864

Figure 5 - Table of Area 1 final coordinates, September 2020

PHASE 1 – MONASTERY - AREA 1 VECTOR SHIFTS

POINT	VECTOR SHIFT (2015 -2016)	VECTOR SHIFT (2016 -2017)	VECTOR SHIFT (2017 – 2018)	VECTOR SHIFT (2018 - 2020) Two years	VECTOR SHIFT (2015 -2020) Five year Cumulative
1-m-a-1	0.001m	0.001m	0.001m	0.001m	0.001m
1-m-a-2	0.001m	0.002m	0.010m	0.009m	0.004m
1-m-a-3	0.001m	0.001m	0.003m	0.005m	0.002m
1-m-a-4	0.001m	0.002m	0.002m	0.004m	0.004m
1-m-b-1	0.000m	0.000m	0.001m	0.003m	0.003m
1-m-b-2	0.000m	0.000m	0.001m	0.004m	0.003m
1-m-b-3	0.004m	0.004m	0.002m	0.004m	0.006m
1-m-b-4	0.001m	0.002m	0.001m	0.003m	0.004m

Figure 6 - Area 1, vector shift calculated annually and the overall cumulative vector calculated from original to latest position. This is not the sum of the annual shifts as movement is not necessarily linear.

COMMENT & ANALYSIS

All readings appear within the accepted tolerances. 1-m-a-2 larger shift has brought it back towards original position, suggesting 2018 reading may have had issues. No particular concerns at this stage, continue monitoring with a repeat survey in September 2021 as planned.

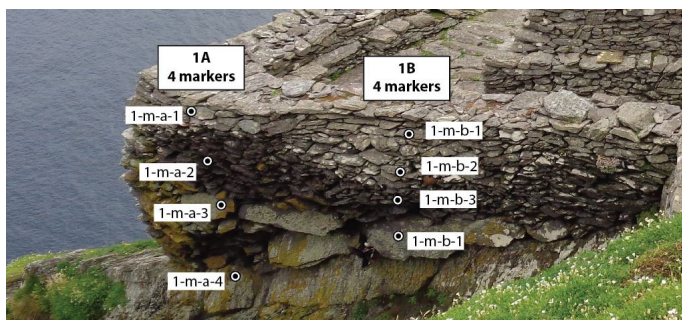


Figure 7 - Survey marker locations, Area 1

4. Area 2 - Results

SEPTEMBER 2020 COORDS - AREA 2

POINT	X (m)	Y (m)	Z (m)
2-m-a-1	2498.726	2508.717	105.207
2-m-a-2	2498.839	2509.525	106.593
2-m-a-3	2498.88	2510.106	108.022
2-m-a-4	2499.013	2510.668	109.522
2-m-b-1	2503.97	2508.912	104.296
2-m-b-2	2504.001	2509.578	105.847
2-m-b-3	2504.08	2510.21	106.996
2-m-b-4	2503.993	2510.613	107.886
2-m-b-5	2503.984	2510.955	109.168
2-m-c-1	2507.656	2509.702	104.018
2-m-c-2	2507.525	2510.142	105.113
2-m-c-3	2507.45	2510.724	106.617
2-m-c-4	2507.38	2510.948	107.657
2-m-c-5	2507.341	2511.127	108.261
2-m-d-1	2496.602	2509.191	105.643
2-m-d-2	2496.529	2509.622	106.553
2-m-d-3	2496.513	2509.841	107.471
2-m-d-4	2496.553	2510.189	108.398
2-m-d-5	2496.508	2510.702	109.209
2-m-d-6	2496.511	2510.756	109.755
2-m-e-1	2498.444	2505.061	102.072
2-m-e-2	2498.397	2505.083	102.597
2-m-e-3	2498.501	2505.14	103.002
2-m-f-1	2504.162	2505.979	101.61
2-m-f-2	2504.162	2505.979	101.61
2-m-f-3	2504.193	2506.027	101.942
2-m-f-4	2504.166	2506.057	102.627
2-m-g-1	2508.155	2507.05	100.874
2-m-g-2	2508.143	2507.129	101.497
2-m-g-3	2508.177	2507.164	101.998
2-m-g-4	2508.201	2507.24	102.464

Figure 8 - Table of Area 2 final coordinates, September 2020

PHASE 1 – MONASTERY - AREA 2 VECTOR SHIFTS

POINT	VECTOR SHIFT Sept 2015 – Sept 2016	VECTOR SHIFT Sept 2016 – Sept 2017	VECTOR SHIFT Sept 2017 – Sept 2018	VECTOR SHIFT (8months) Sept 2018 – May 2019	VECTOR SHIFT (16months) May 2019 - Sept 2020	TOTAL SHIFT (2 years) Sept 2018 – Sept 2020	TOTAL SHIFT (5 years) Sept 2015 – Sept 2020
2-m-a-1	0.006m	0.005m	0.003m	0.003m	0.010m	0.012m	0.030m
2-m-a-2	0.005m	0.004m	0.006m	0.005m	0.010m	0.015m	0.030m
2-m-a-3	0.004m	0.006m	0.007m	0.003m	0.010m	0.013m	0.030m
2-m-a-4	0.006m	0.007m	0.007m	0.003m	0.013m	0.016m	0.035m
2-m-b-1	0.006m	0.006m	0.010m	0.005m	0.015m	0.011m	0.031m
2-m-b-2	0.004m	0.007m	0.004m	0.005m	0.009m	0.014m	0.028m
2-m-b-3	0.004m	0.005m	0.008m	0.003m	0.010m	0.013m	0.029m
2-m-b-4	0.006m	0.005m	0.006m	0.004m	0.008m	0.012m	0.030m
2-m-b-5	0.005m	0.006m	0.005m	0.004m	0.007m	0.013m	0.026m
2-m-c-1	0.002m	0.003m	0.003m	0.001m	0.007m	0.008m	0.014m
2-m-c-2	0.002m	0.003m	0.003m	0.001m	0.006m	0.006m	0.013m
2-m-c-3	0.004m	0.002m	0.004m	0.001m	0.008m	0.009m	0.018m
2-m-c-4	0.003m	0.003m	0.004m	0.001m	0.007m	0.008m	0.018m
2-m-c-5	0.001m	0.004m	0.004m	0.001m	0.008m	0.009m	0.018m
2-m-d-1				0.003m	0.009m	0.012m	na
2-m-d-2				0.002m	0.009m	0.012m	na
2-m-d-3				0.004m	0.009m	0.013m	na
2-m-d-4				0.020m	0.036m*	0.057m*	na
2-m-d-5				0.004m	0.009m	0.013m	na
2-m-d-6				0.003m	0.010m	0.013m	na
2-m-e-1				0.002m	0.004m	0.002m	na
2-m-e-2				0.001m	0.003m	0.002m	na
2-m-e-3				0.002m	0.004m	0.002m	na
2-m-f-1				0.001m	0.004m	0.002m	na
2-m-f-2				0.001m	0.005m	0.004m	na
2-m-f-3				0.001m	0.004m	0.004m	na
2-m-f-4				0.001m	0.005m	0.005m	na
2-m-g-1				0.002m	0.005m	0.005m	na
2-m-g-2				0.002m	0.005m	0.008m	na
2-m-g-3				0.001m	0.003m	0.003m	na
2-m-g-4				0.002m	0.004m	0.004m	na

Figure 9- Area 2, vector shift calculated annually, and the overall cumulative vector calculated from original to latest position. This is not the sum of the annual shifts as movement is not necessarily linear. * Note, survey marker 2-m-d-4 (highlighted in red) appears to be out of alignment with others, and has moved significantly over the past 3 years. This needs confirmation through examination of the stone and survey marker.

COMMENT & ANALYSIS

Lines A,B and C were from original network, measured in 2015.

Lines D, E, F and G were added in 2017 to address concerns over the large vector shifts on the line A and line B markers, observed as 5-10mm annually since monitoring began. By 2018 this was cumulatively 15-20mm over 3 years, with the trend direction forward and down.



Figure 10 -Survey markers in Area 2

The 2020 readings confirm the movement of Lines A and B has continued with potentially a slight acceleration in the rate, giving a cumulative 25-35mm shift over the 5 year period. Line C continues to be more stable than A or B, but has now a cumulative shift of 15mm over 5 years. Line D, with cumulative shifts over 3 years of 10-15mm is showing similar trends to Lines A and B. Point 2-m-d-4 has returned abnormally high shifts in both 2019 and 2020 readings and a visual inspection of the stability of this stone would be useful as the markers above and below are trending normally. The points added to the lower section of wall, Lines E, F and G are generally stable within the tolerance of the survey instrument and methodology, with all but one point within 5mm after three years of observation.

Graphical Illustration

To illustrate the magnitude and characteristics of the movement, the change in position over time has been graphed in 3D for Lines A, B,C & D. These are generated with each survey marker in the Area given the coordinate (0,0,0) as the start position, with the subsequent observations plotted as the (x,y,z) difference. In this way the magnitude and trend of each point can be evaluated.

Observations were taken in September each year except for 2019, when the May 2019 survey was the only one available. This needs to be considered when interpreting the graphs, The 2018-19 period is only 8 months, with the 2019-20 period being 16 months.

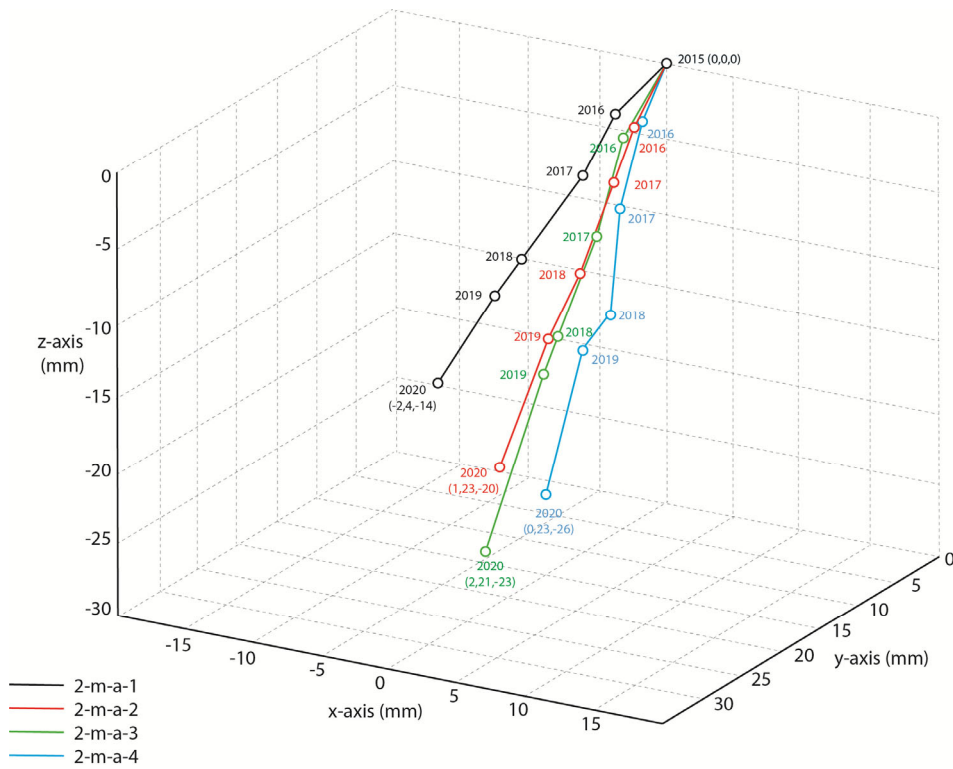


Figure 11 - Area 2, Line A, 3D graph of x,y,z movement over duration of the monitoring survey of each survey marker. *Note, readings from September each year except for 2019 which was observed in May

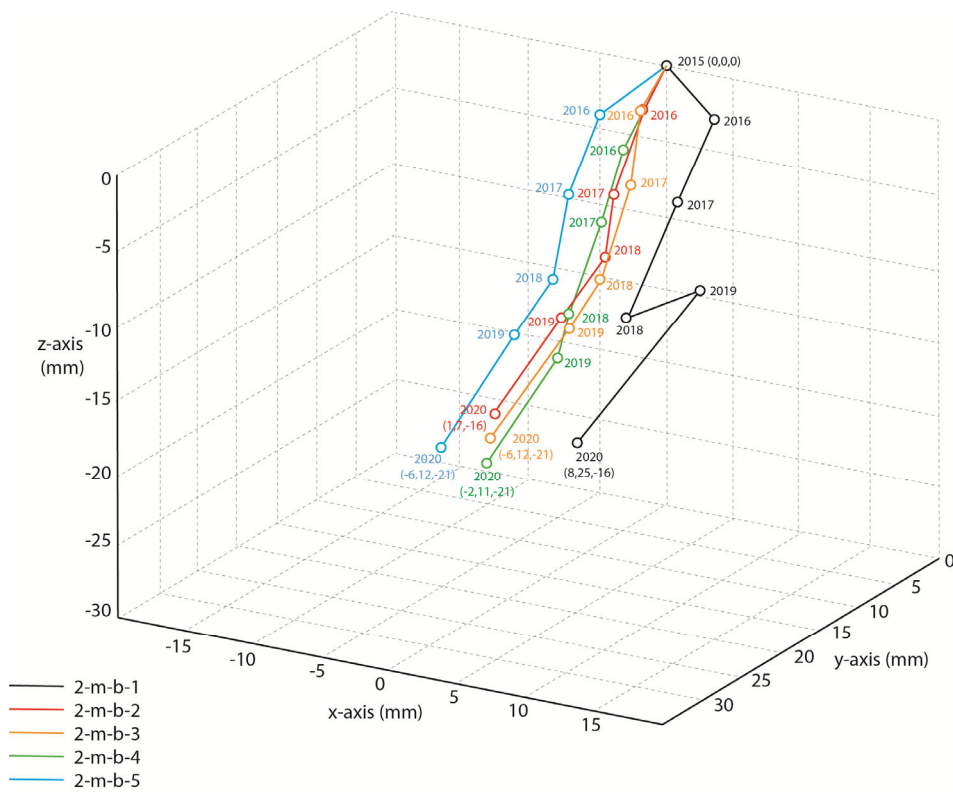


Figure 12 - Area 2, Line B, 3D graph of x,y,z movement over duration of the monitoring survey of each survey marker. *Note, readings from September each year except for 2019 which was observed in May

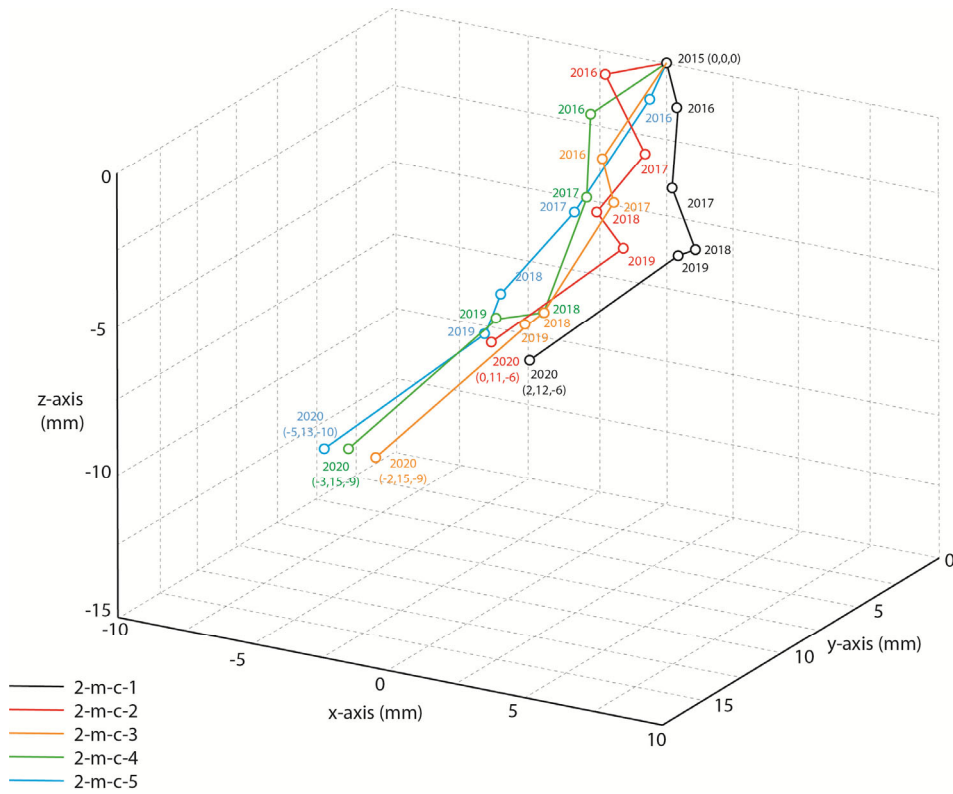


Figure 13 - Area 2, Line C, 3D graph of x,y,z movement over duration of the monitoring survey of each survey marker.
 *Note, readings from September each year except for 2019 which was observed in May

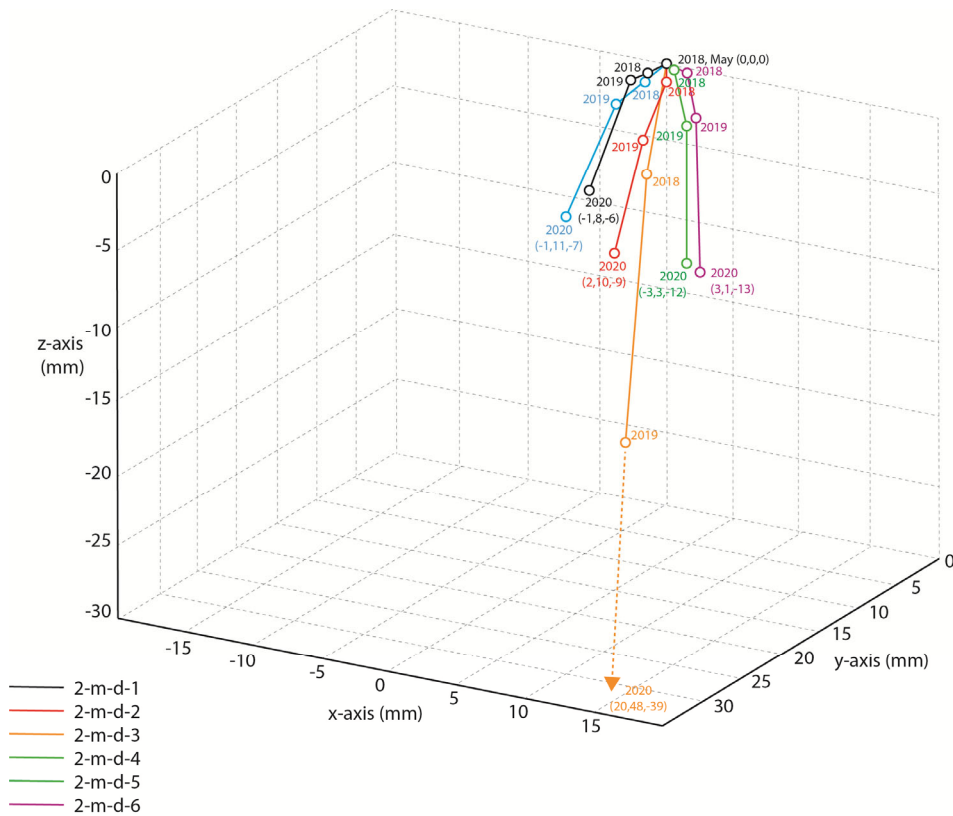


Figure 14- Area 2, Line D, 3D graph of x,y,z movement over duration of the monitoring survey of each survey marker.
 *Note, readings from September each year except for 2019 which was observed in May

Future Strategy

Repeat the annual observation of area " in September 2021, with an additional survey earlier in the year, after the winter if access can be arranged.

Upgrading the monitoring, adding high resolution 3D scanning, based on the existing resection network as a reference framework would be beneficial. It would give a more complete picture of the overall geometry of the wall. Subsequent scans would identify more subtle and localised changes and allow the dynamics of any movement to be observed.

5. Area 3 Results

SEPTEMBER 2020 COORDS - AREA 3

POINT	X (m)	Y (m)	Z (m)
3-m-a-1	3500.040	3502.912	101.412
3-m-a-2	3500.175	3503.338	102.274
3-m-a-3	3500.269	3503.620	102.918
3-m-a-4	3500.366	3504.127	104.025

Figure 15 - Table of Area 3 final coordinates, September 2020

PHASE 1 – MONASTERY - AREA

POINT	VECTOR SHIFT (2015 -2016)	VECTOR SHIFT (2016 -2017)	VECTOR SHIFT (2017 – 2018)	VECTOR SHIFT (2018 - 2020) Two years	VECTOR SHIFT (2015 -2020) Five year Cumulative
3-m-1-1	0.002m	0.001m	0.001m	0.003m	0.003m
3-m-1-2	0.000m	0.001m	0.001m	0.003m	0.002m
3-m-1-3	0.004m	0.000m	0.001m	0.003m	0.004m
3-m-1-4	0.003m	0.001m	0.003m	0.007m	0.006m

Figure 16 - Area 3, annual vector shift, and the overall cumulative vector calculated from original to latest position. This is not the sum of the annual shifts as movement is not necessarily linear.

COMMENT & ANALYSIS

Reading 3-m-1-4 slightly above tolerance, but it is only based on the 2020 observations. Cumulative vector shifts over 5 years are small indicating general stability. Strategy should be to continue monitoring, with observations in September 2021.

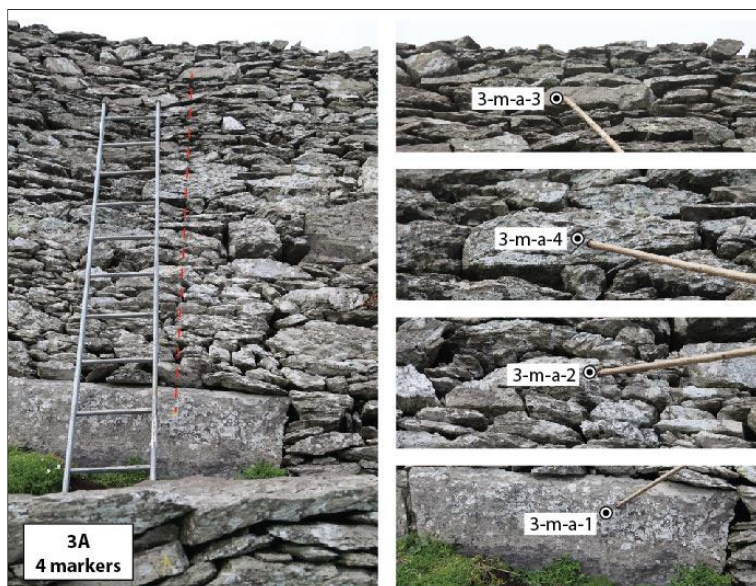


Figure 17- Survey Markers in Area 3

6. Area 4 Results

SEPTEMBER 2020 COORDS - AREA 4

POINT	X (m)	Y (m)	Z (m)
4-m-a-1	4533.275	4546.028	141.034
4-m-a-2	4533.221	4546.123	141.686
4-m-a-3	4533.316	4546.122	142.124
4-m-b-1	4542.375	4539.605	142.302
4-m-b-2	4542.655	4539.752	142.781
4-m-b-3	4542.695	4539.751	143.049
4-m-b-4	4542.724	4539.813	143.395
4-m-c-1	4543.368	4537.929	141.659
4-m-c-2	4544.067	4538.313	142.529
4-m-c-3	4544.080	4538.291	142.947
4-m-c-4	4544.129	4538.271	143.291
4-m-d-1	4546.251	4535.021	140.988
4-m-d-2	4546.318	4535.089	141.540
4-m-d-3	4546.302	4535.174	141.887

Figure 18 - Table of Area 4 final coordinates, September 2020

PHASE 2 – SOUTH PEAK - AREA 4 VECTOR SHIFTS

POINT	VECTOR SHIFT (2017 -2018)	VECTOR SHIFT (2018 - 2020) Two years	VECTOR SHIFT (2017-2020) Three years
4-m-a-1	0.003m	0.003m	0.006m
4-m-a-2	0.002m	0.012m	0.014m
4-m-a-3	0.003m	0.007m	0.009m
4-m-b-1	0.005m	0.048m	0.051m
4-m-b-2	0.004m	0.012m	0.009m
4-m-b-3	0.003m	0.003m	0.003m
4-m-b-4	0.002m	0.002m	0.001m
4-m-c-1	0.002m	0.014m	0.012m
4-m-c-2	0.003m	0.018m	0.017m
4-m-c-3	0.002m	0.005m	0.006m
4-m-c-4	0.003m	0.005m	0.006m
4-m-d-1	0.002m	0.005m	0.006m
4-m-d-2	0.004m	0.006m	0.005m
4-m-d-3	0.002m	0.005m	0.005m

Figure 19 - Area 4, annual vector shift, and the overall cumulative vector calculated from original to latest position. This is not the sum of the annual shifts as movement is not necessarily linear. Readings highlighted in green affected by vegetation growth obscuring the marker. 4-m-b-1, highlighted in red requires visual inspection.

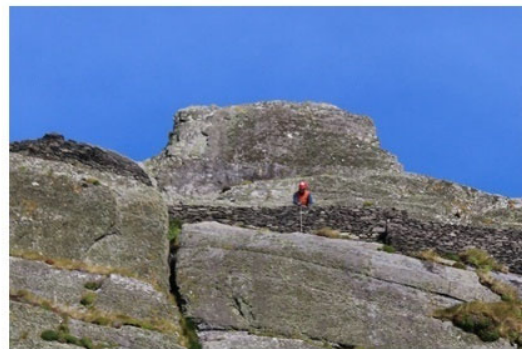
COMMENT & ANALYSIS

These monitoring markers are on the South and South West facing walls of the terraces high on the south peak with observations from a resection position to the South, above Christ's Saddle. As noted in previous report this requires observing over longer distances and at acute angles, the only solution for these difficult locations, but slightly larger values might be expected.

During 2020 observation it was noted that for three points, highlighted in green, vegetation was partially obscuring the markers. Vegetation generally seemed to be more significant on the walls of the South Peak than in previous surveys. With the exception of these points the three year cumulative vector shifts are generally around 5mm indicating the area is largely stable, although the trend needs to be carefully monitored going forward. One point, 4-m-b-1 (highlighted in red) has a significant shift observed, and a visual inspection is required. It is at the interface of the bedrock and stone built feature and may potentially have been disrupted by vegetation.



4-m-a-1, 4-m-a-2, 4-m-a-3, from bottom



4-m-b-1, 4-m-b-2, 4-m-b-3, 4-m-b-4 from bottom



4-m-c-1, 4-m-c-2, 4-m-c-3, 4-m-c-4 from bottom



4-m-d-1, 4-m-d-2, 4-m-d-3, from bottom

Figure 20 - Survey markers in Area 4

7. Area 5 Results

SEPTEMBER 2020 COORDS - AREA 5

POINT	EAST	NORTH	ELEVATION
5-m-a-1	5505.185	5508.874	107.789
5-m-a-2	5505.183	5509.285	108.431
5-m-b-1	5505.628	5507.545	107.116
5-m-b-2	5505.911	5507.824	107.565
5-m-b-3	5505.809	5507.736	107.773
5-m-b-4	5506.072	5507.979	108.355
5-m-c-1	5506.271	5506.680	106.749
5-m-c-2	5506.620	5506.981	107.698
5-m-c-3	5506.748	5507.183	108.326
5-m-d-1	5506.784	5506.021	106.762
5-m-d-2	5506.849	5506.015	107.301
5-m-d-3	5506.957	5506.177	107.821
5-m-d-4	n/a	n/a	n/a

Figure 21 - Table of Area 5 final coordinates, September 2020

PHASE 2 – SOUTH PEAK - AREA 5 VECTOR SHIFTS

POINT	VECTOR SHIFT (2017 -2018)	VECTOR SHIFT (2018 - 2020) Two years	VECTOR SHIFT (2017-2020) Three years
5-m-a-1	0.001m	0.005m	0.004m
5-m-a-2	0.001m	0.003m	0.004m
5-m-b-1	0.001m	0.009m	0.009m
5-m-b-2	0.000m	0.003m	0.003m
5-m-b-3	0.001m	0.005m	0.005m
5-m-b-4	0.008m	0.019m	0.010m
5-m-c-1	0.001m	0.004m	0.003m
5-m-c-2	0.004m	0.006m	0.003m
5-m-c-3	0.007m	0.008m	0.002m
5-m-d-1	0.003m	0.003m	0.005m
5-m-d-2	0.001m	0.003m	0.004m
5-m-d-3	0.001m	0.003m	0.004m
5-m-d-4	0.002m	n/a	n/a

Figure 22 - Area 5, annual vector shift, and the overall cumulative vector calculated from original to latest position. This is not the sum of the annual shifts as movement is not necessarily linear. Readings highlighted in green potentially affected by vegetation growth obscuring the marker.

COMMENT & ANALYSIS

2020 observations, and the low cumulative vector change over 2017-2020 indicate general stability in Area 5. Two points are beyond tolerance. 5-m-b-4 showed movement in 2018, thought to be disturbance as at the top of the wall near the access to the eye-of-the-needle climb. This has continues and a visual inspection would be worthwhile. 5-m-b-1 also needs an inspection, possible vegetation interference could explain this larger shift. No 2020 reading was available for 5-m-d-4.

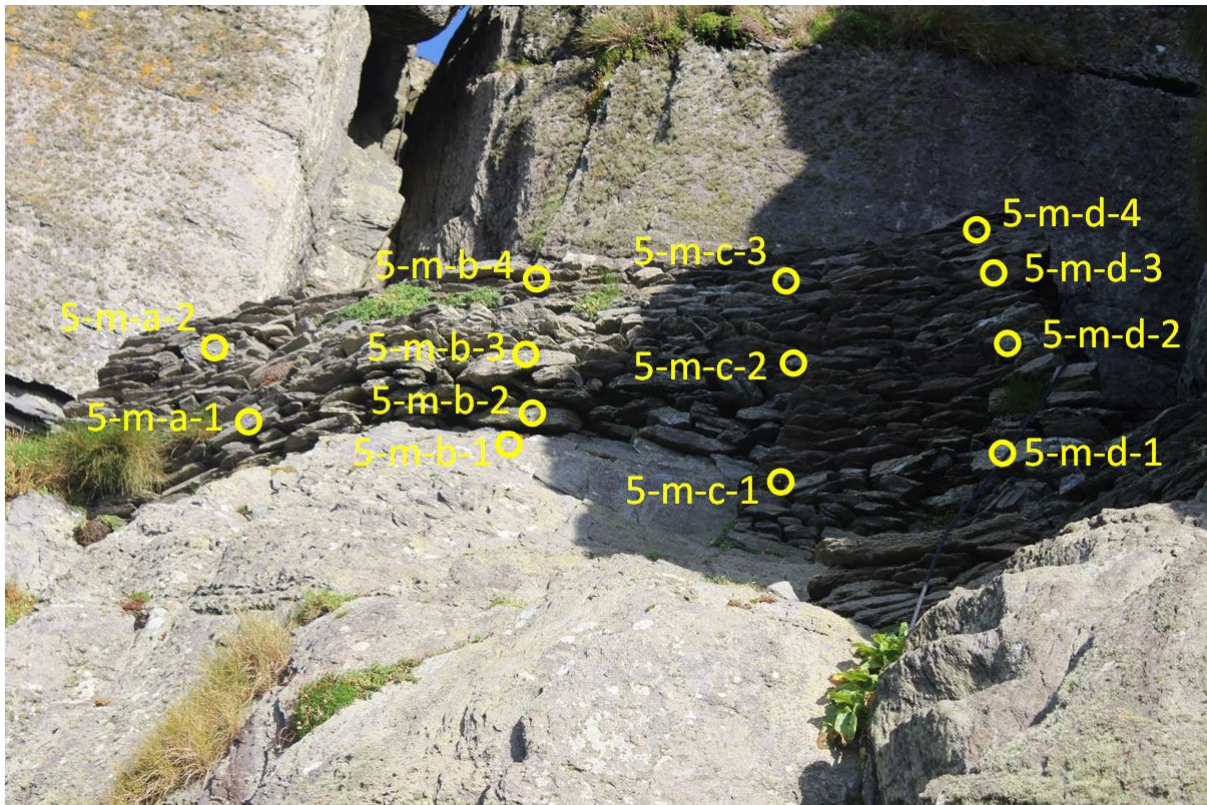


Figure 23 - Survey markers in Area 5

8. Area 6 Results

SEPT 2020 COORDS - AREA 6

POINT	X (m)	Y (m)	Z (m)
6-m-a-1	6499.125	6517.84	101.051
6-m-a-2	6499.181	6517.82	101.505
6-m-a-3	6499.146	6517.837	102.058
6-m-a-4	6499.194	6517.9	102.592
6-m-b-1	6504.432	6516.68	104.413
6-m-b-2	6504.362	6516.8	105.107
6-m-b-3	6504.549	6516.898	105.669
6-m-c-1	6507.318	6509.205	103.88
6-m-c-2	6507.858	6509.873	104.48
6-m-c-3	6507.945	6509.785	104.842
6-m-c-4	6508.001	6509.862	105.245
6-m-d-1	na	na	na
6-m-d-2	6507.353	6506.322	103.875
6-m-d-3	6507.374	6506.287	104.398
6-m-e-1	6505.56	6503.278	103.396
6-m-e-2	6505.66	6503.189	103.831
6-m-e-3	6505.754	6503.146	104.421
6-m-f-1	6504.805	6502.069	102.694
6-m-f-2	6505.439	6502.683	103.488
6-m-f-3	6505.476	6502.578	103.885
6-m-f-4	6505.591	6502.522	104.488
6-m-g-1	6500.626	6494.16	96.959
6-m-g-2	6500.651	6494.065	97.168
6-m-g-3	6500.775	6494.19	97.578

Figure 24 - Table of Area 6 final coordinates, September 2020

PHASE 2 – SOUTH PEAK - AREA 6 VECTOR SHIFTS

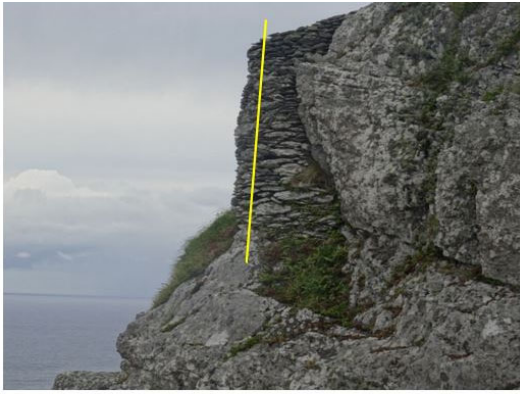
POINT	VECTOR SHIFT (2017 -2018)	VECTOR SHIFT (2018 - 2020) Two years	VECTOR SHIFT (2017 - 2020) Three years
6-m-a-1	0.003m	0.003m	0.003m
6-m-a-2	0.003m	0.004m	0.004m
6-m-a-3	0.001m	0.004m	0.005m
6-m-a-4	0.002m	0.008m	0.008m
6-m-b-1	0.001m	0.004m	0.004m
6-m-b-2	0.001m	0.005m	0.005m
6-m-b-3	0.001m	0.005m	0.005m
6-m-c-1	0.002m	0.013m	0.014m
6-m-c-2	0.001m	0.018m	0.019m
6-m-c-3	0.001m	0.003m	0.003m
6-m-c-4	0.002m	0.003m	0.004m
6-m-d-1	0.001m	na	na
6-m-d-2	0.001m	0.002m	0.002m
6-m-d-3	0.001m	0.003m	0.003m
6-m-e-1	0.001m	0.015m	0.015m
6-m-e-2	0.001m	0.024m	0.024m
6-m-e-3	0.002m	0.004m	0.004m
6-m-f-1	0.002m	0.002m	0.002m
6-m-f-2	0.004m	0.005m	0.005m
6-m-f-3	0.003m	0.002m	0.002m
6-m-f-4	0.005m	0.009m	0.009m
6-m-g-1	0.002m	0.001m	0.001m
6-m-g-2	0.002m	0.001m	0.001m
6-m-g-3	0.004m	0.001m	0.001m

Figure 25 - Area 6, annual vector shift, and the overall cumulative vector calculated from original to latest position. This is not the sum of the annual shifts as movement is not necessarily linear. Readings highlighted in green affected by vegetation growth obscuring the marker.

COMMENT & ANALYSIS

The vector shifts measured at Area 6 over the 2017-2020 three year observation period are generally within tolerance and continue to indicate no significant change. Vegetation growth hampered the observations of a number of points, with grass moving in front of the marker, or obscuring it completely, indicated in green in the table. It may be necessary to check the visibility of the markers in advance of future observations, to avoid compromising the survey.

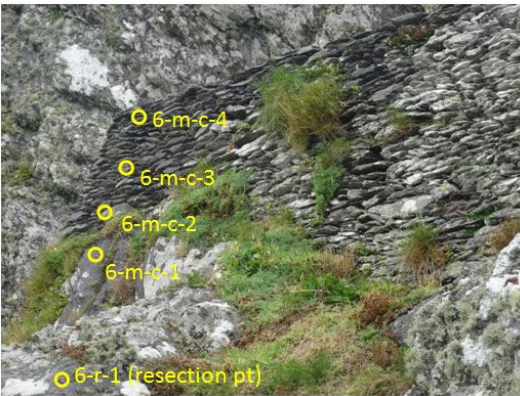
Given the number of markers, and issues with vegetation this area may also benefit from a 3D laser scanning approach going forward.



6-m-a-1, 6-m-a-2, 6-m-a-3, 6-m-a-4 from bottom



6-m-b-1, 6-m-b-2, 6-m-b-3 from bottom



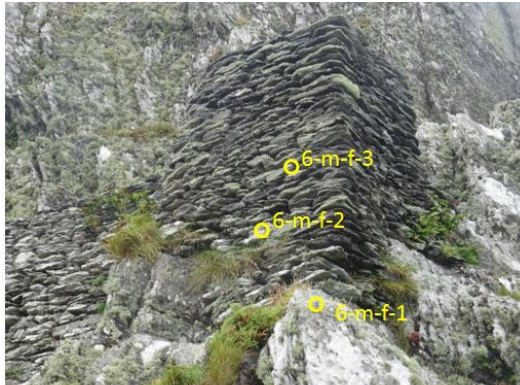
6-m-c-1, 6-m-c-2, 6-m-c-3, 6-m-c-4



6-m-d-1, 6-m-d-2, 6-m-d-3



6-m-e-1, 6-m-e-2, 6-m-e-3



6-m-f-1, 6-m-f-2, 6-m-f-3



6-m-g-1, 6-m-g-2, 6-m-g-3

Figure 26 - Survey markers in Area 6

9. Area 7 results

SEPTEMBER 2020 COORDS - AREA 7

POINT	EAST	NORTH	ELEVATION
7-m-a-1	7507.502	7503.245	96.44
7-m-a-2	7507.475	7503.242	96.662
7-m-a-3	7507.435	7503.213	96.988
7-m-a-4	7507.445	7503.141	97.281
7-m-b-1	7506.813	7500.076	98.284
7-m-b-2	7506.801	7500.051	98.442

Figure 27- Table of Area 7 final coordinates, September 2020

PHASE 2 – SOUTH PEAK - AREA 7 VECTOR SHIFT

POINT	VECTOR SHIFT (2017 -2018)	VECTOR SHIFT (2018-2020) Two years	VECTOR SHIFT	VECTOR SHIFT (2017-2020) Three years
7-m-a-1	0.002m	0.003m		0.005m
7-m-a-2	0.002m	0.002m		0.004m
7-m-a-3	0.002m	0.003m		0.005m
7-m-a-4	0.002m	0.001m		0.003m
7-m-b-1	0.002m	0.001m		0.002m
7-m-b-2	0.004m	0.002m		0.003m

Figure 28 - Area 7, annual vector shift, and the overall cumulative vector calculated from original to latest position. This is not the sum of the annual shifts as movement is not necessarily linear.

COMMENT & ANALYSIS

Area 7 indicates all the markers are within tolerance over the 2017-2020 period. Continue to monitor with repeat survey as scheduled in Sept 2021.



7-m-a-1,7-m-a-2,7-m-a-3,7-m-a-4



7-m-b-1,7-m-b-2

Figure 29 - Survey Markers in Area 7

10. Conclusions

Area 2 still presents the largest vector shifts, and subsequently the greatest concern. (Area 2 is the retaining wall below St Michael's Church). Since 2018 the survey observations have shown a downward and forward vector shift of 5-10mm. The 2020 survey observations continue to measure change at a similar annual rate to previous years, particularly the survey markers in lines A, B and D.

This is potentially a cause for concern, and as in previous years the results should be considered by the OPW engineers alongside other scientific evidence when considering appropriate responses.

The complex nature of the wall, with different phases of construction, repair and re-construction would benefit from more detailed 3D survey in the form of 3D laser scanning. The latest equipment would allow such scans to be registered with our existing control network, and provide a basis for on-going detailed 3D deviation analysis of the entire surface of the wall.

Given the other areas had not been surveyed for two years the readings suggest a high level of stability, with a small number of points presenting residuals worthy of inspection - see individual area chapters for details.

A significant issue worth considering is the growth of vegetation, particularly on the South Peak (Areas 4, 5, 6 & 7). This obscured one of the control points, which needed to be cleared, and potentially disrupted a number of marker points. It may be necessary to check the points before survey in future, with a view to careful removal of any interfering grass, although this would require rope access.

Robert Shaw

The Discovery Programme

September 2020

Appendix I - Resection Networks

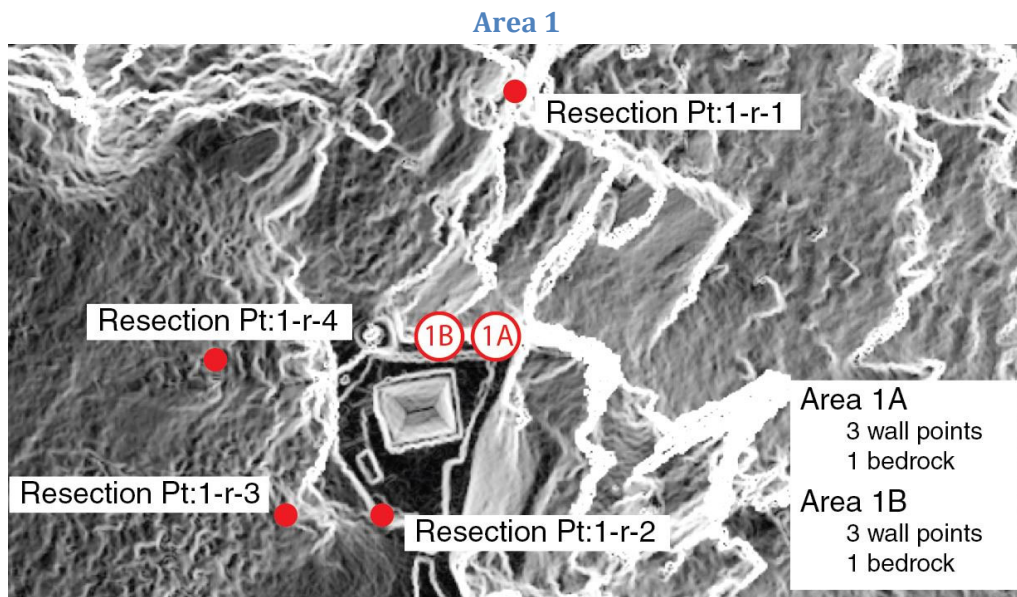


Figure i - Plan locating resection control network for Area 1



1-r-1



1-r-2



1-r-3



1-r-4

Figure i - Photos to identify Areas 1 resection markers

Area 2

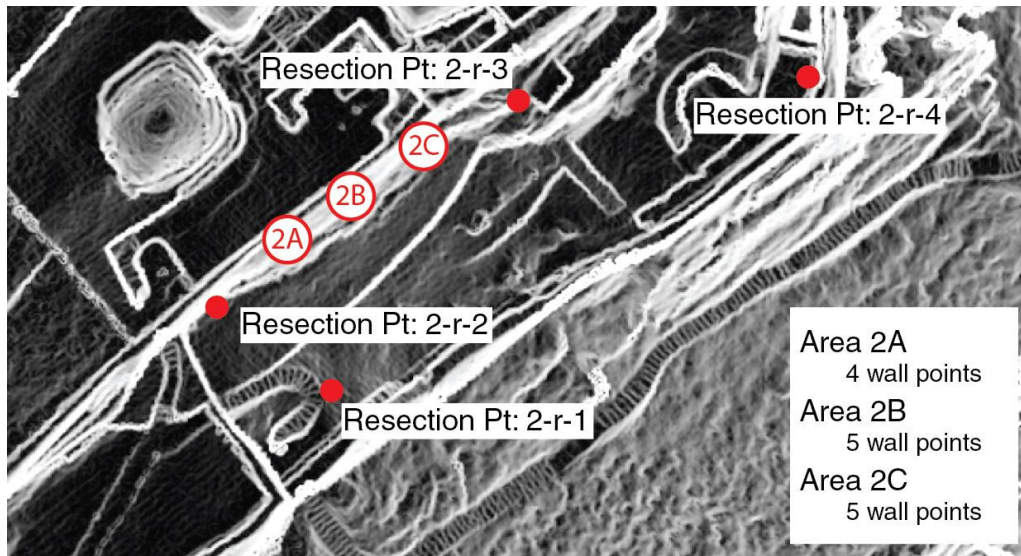


Figure ii - Plan locating resection control network for Area 2



Figure iii - Photos to identify Areas 2 resection markers

Area 3

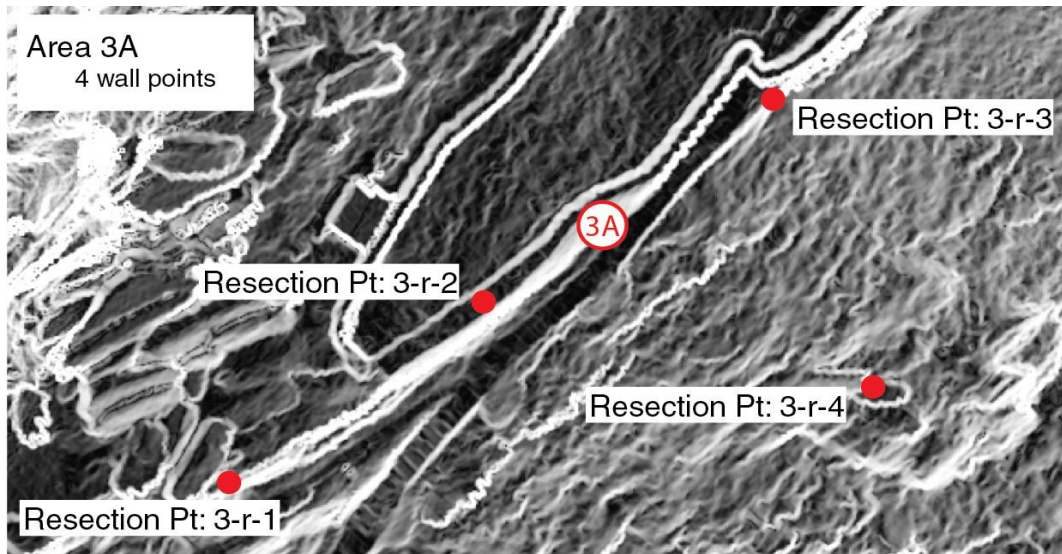


Figure iv - Plan locating resection control network for Area 3



3-r-1



3-r-2



3-r-3



3-r-4

Figure v - Photos to identify Areas 3 resection markers

Area 4

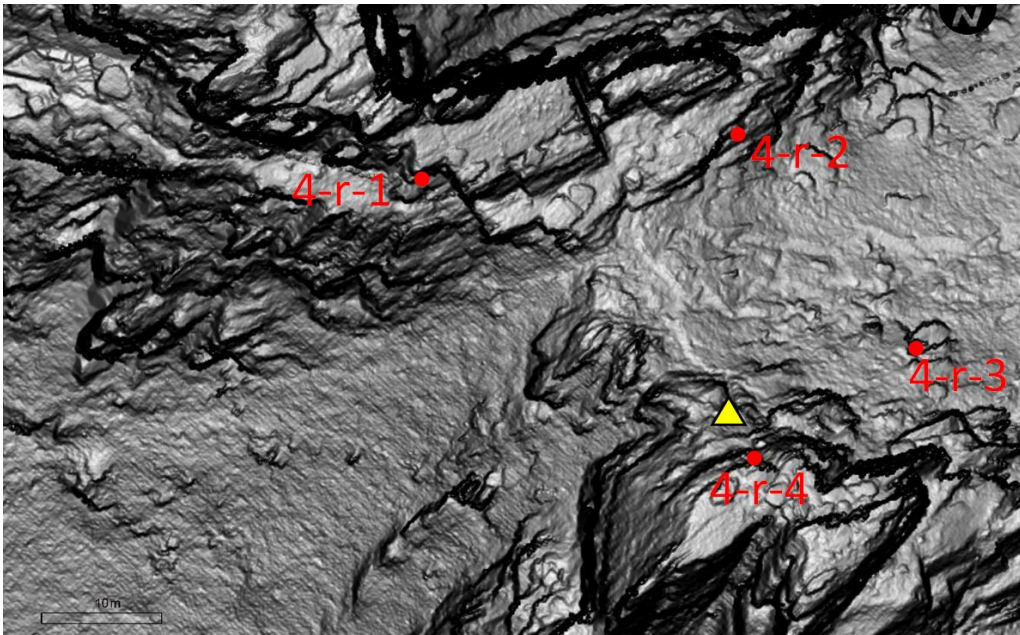


Figure vi - Plan locating resection control network for Area 4



Figure vii Photos to identify Areas 4 resection markers

Area 5

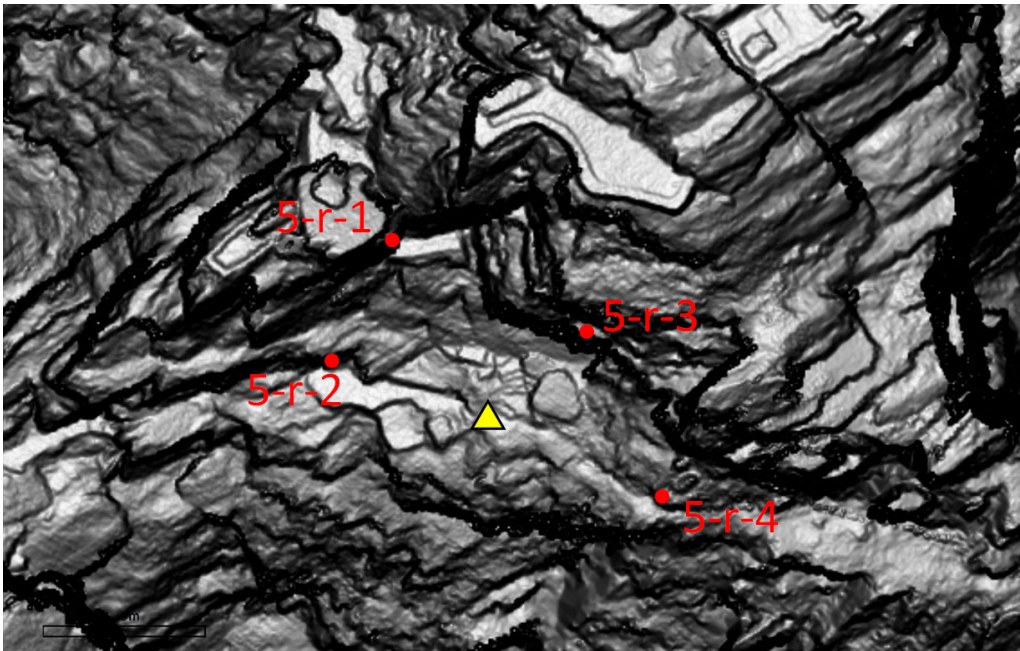


Figure viii - Plan locating resection control network for Area 5



Figure ix - Photos to identify Areas 5 resection markers

Area 6

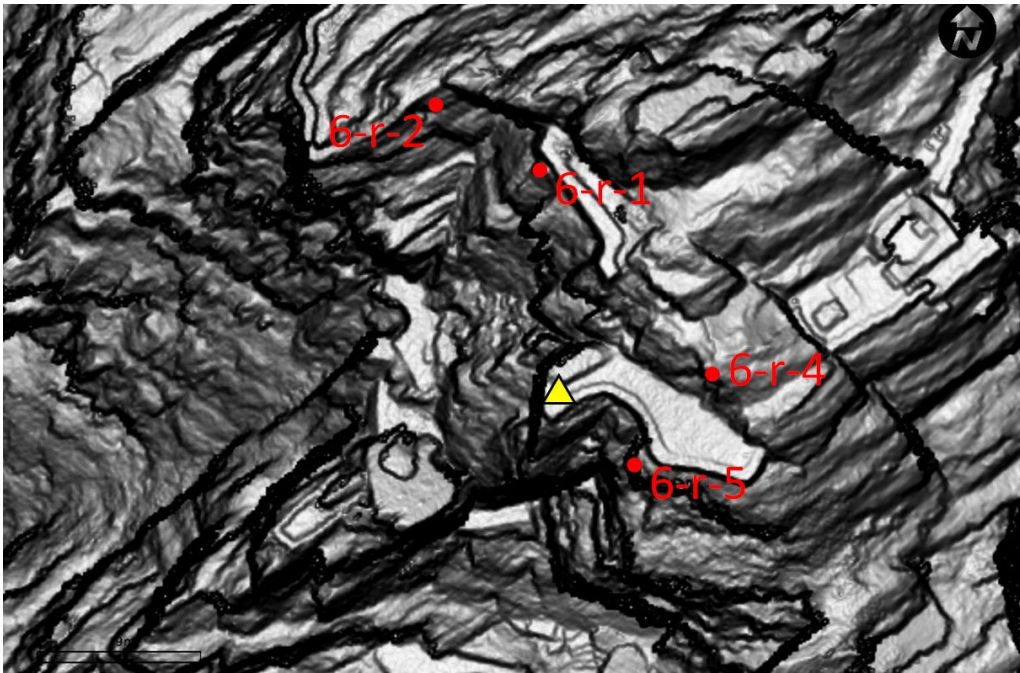


Figure x Plan locating resection control network for Area 6



6-r-2 (approx)



6-r-1 – (see 6-m-c diagram)



6-r-3



6-r-5

Figure xi - Photos to identify Areas 6 resection markers

Area 7

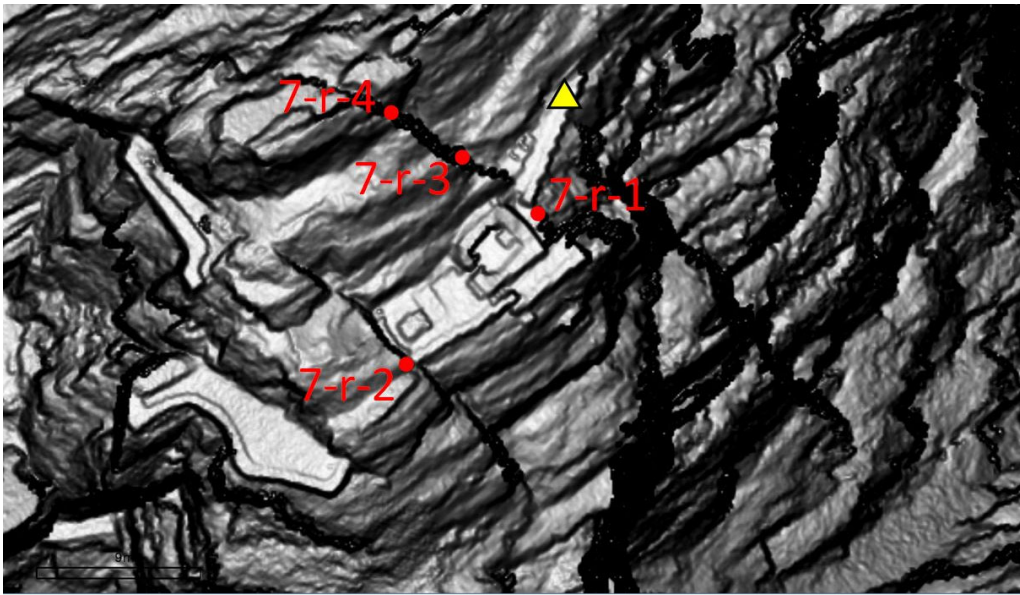


Figure xii - Plan locating resection control network for Area 6



7-r-3 (approx.)



7-r-4



7-r-1



7-r-2

Figure xiii - Photos to identify Areas 7 resection markers

Appendix II - Resection Point Coordinate Lists

Area 1

<u>POINT</u>	<u>X COORD(m)</u>	<u>Y COORD (m)</u>	<u>Z COORD (m)</u>
1-r-1	1493.380	1490.603	101.814
1-r-2	1503.874	1518.655	96.169
1-r-3	1508.541	1517.604	99.624
1-r-4	1511.401	1508.181	105.085

Area 2

<u>POINT</u>	<u>X COORD(m)</u>	<u>Y COORD (m)</u>	<u>Z COORD (m)</u>
2-r-1	2495.86	2500.888	102.184
2-r-2	2494.024	2509.697	106.525
2-r-3	2509.455	2510.428	105.374
2-r-4	2529.449	2501.391	97.352

Area 3

<u>POINT</u>	<u>X COORD(m)</u>	<u>Y COORD (m)</u>	<u>Z COORD (m)</u>
3-r-1	3471.063	3509.188	103.28
3-r-2	3493.696	3503.877	101.411
3-r-3	3516.941	3499.897	98.889
3-r-4	3503.643	3484.744	88.498

Area 4

<u>POINT</u>	<u>X COORD(m)</u>	<u>Y COORD (m)</u>	<u>Z COORD (m)</u>
4-r-1	4515.563	4523.675	103.916
4-r-2	4522.681	4500.303	90.815
4-r-3	4508.317	4487.155	88.061
4-r-4	4496.091	4498.067	102.521

Area 5

<u>POINT</u>	<u>X COORD(m)</u>	<u>Y COORD (m)</u>	<u>Z COORD (m)</u>
5-r-1	5505.584	5509.863	110.1
5-r-2	5492.348	5515.485	98.521
5-r-3	5507.077	5497.315	102.117
5-r-4	5501.321	5490.037	98.23

Area 6

<u>POINT</u>	<u>X COORD(m)</u>	<u>Y COORD (m)</u>	<u>Z COORD (m)</u>
6-r-1	6505.561	6507.147	102.375
6-r-2	6505.737	6515.834	104.464
6-r-4	6505.355	6493.549	99.289
6-r-5	6500.437	6493.73	96.62

Area 7

<u>POINT</u>	<u>X COORD(m)</u>	<u>Y COORD (m)</u>	<u>Z COORD (m)</u>
7-r-1	7506.146	7500.693	97.826
7-r-2	7515.189	7494.625	100.349
7-r-3	7504.306	7497.76	99.985
7-r-4	7503.356	7493.865	104.055

Appendix III - Annual Monitoring Point Coordinate Lists

2015

POINT	X COORD(m)	Y COORD (m)	Z COORD (m)
1-m-a-1	1495.302	1509.924	95.182
1-m-a-2	1495.351	1509.933	94.597
1-m-a-3	1495.377	1510.053	93.85
1-m-a-4	1495.426	1510.366	92.447
1-m-b-1	1497.838	1509.399	95.346
1-m-b-2	1497.78	1509.303	94.948
1-m-b-3	1497.795	1509.325	94.582
1-m-b-4	1497.884	1509.427	93.862
2-m-a-1	2498.728	2508.743	105.221
2-m-a-2	2498.838	2509.548	106.613
2-m-a-3	2498.878	2510.125	108.045
2-m-a-4	2499.013	2510.691	109.548
2-m-b-1	2503.962	2508.937	104.312
2-m-b-2	2503.999	2509.601	105.863
2-m-b-3	2504.08	2510.232	107.014
2-m-b-4	2503.995	2510.634	107.907
2-m-b-5	2503.99	2510.973	109.189
2-m-c-1	2507.654	2509.714	104.024
2-m-c-2	2507.525	2510.153	105.119
2-m-c-3	2507.452	2510.739	106.626
2-m-c-4	2507.383	2510.963	107.666
2-m-c-5	2507.346	2511.14	108.271
3-m-a-1	3500.04	3502.913	101.414
3-m-a-2	3500.175	3503.338	102.276
3-m-a-3	3500.269	3503.617	102.92
3-m-a-4	3500.365	3504.123	104.029

2016

POINT	X COORD(m)	Y COORD (m)	Z COORD (m)
1-m-a-1	1495.302	1509.923	95.182
1-m-a-2	1495.35	1509.933	94.597
1-m-a-3	1495.376	1510.053	93.85
1-m-a-4	1495.426	1510.366	92.446
1-m-b-1	1497.838	1509.399	95.346
1-m-b-2	1497.78	1509.303	94.948
1-m-b-3	1497.795	1509.321	94.584
1-m-b-4	1497.883	1509.427	93.862
2-m-a-1	2498.727	2508.738	105.219
2-m-a-2	2498.838	2509.544	106.61
2-m-a-3	2498.878	2510.122	108.042
2-m-a-4	2499.012	2510.687	109.544
2-m-b-1	2503.967	2508.935	104.31
2-m-b-2	2503.999	2509.598	105.861
2-m-b-3	2504.08	2510.229	107.012
2-m-b-4	2503.995	2510.629	107.903
2-m-b-5	2503.987	2510.97	109.186

2-m-c-1	2507.655	2509.713	104.023
2-m-c-2	2507.524	2510.151	105.119
2-m-c-3	2507.452	2510.735	106.624
2-m-c-4	2507.382	2510.96	107.665
2-m-c-5	2507.346	2511.139	108.27
3-m-a-1	3500.041	3502.914	101.413
3-m-a-2	3500.175	3503.338	102.276
3-m-a-3	3500.269	3503.621	102.921
3-m-a-4	3500.366	3504.126	104.03

2017

POINT	X COORD(m)	Y COORD (m)	Z COORD (m)
1-m-a-1	1495.302	1509.924	95.182
1-m-a-2	1495.351	1509.932	94.598
1-m-a-3	1495.377	1510.054	93.85
1-m-a-4	1495.427	1510.365	92.447
1-m-b-1	1497.838	1509.399	95.346
1-m-b-2	1497.78	1509.303	94.948
1-m-b-3	1497.795	1509.324	94.582
1-m-b-4	1497.885	1509.427	93.862
2-m-a-1	2498.727	2508.734	105.216
2-m-a-2	2498.838	2509.541	106.607
2-m-a-3	2498.878	2510.119	108.037
2-m-a-4	2499.013	2510.682	109.539
2-m-b-1	2503.967	2508.93	104.306
2-m-b-2	2504	2509.593	105.857
2-m-b-3	2504.081	2510.226	107.008
2-m-b-4	2503.995	2510.626	107.899
2-m-b-5	2503.987	2510.966	109.182
2-m-c-1	2507.656	2509.711	104.021
2-m-c-2	2507.526	2510.15	105.117
2-m-c-3	2507.453	2510.734	106.623
2-m-c-4	2507.383	2510.958	107.663
2-m-c-5	2507.345	2511.136	108.267
3-m-a-1	3500.041	3502.914	101.414
3-m-a-2	3500.175	3503.339	102.276
3-m-a-3	3500.269	3503.621	102.921
3-m-a-4	3500.367	3504.127	104.03
4-m-a-1	4533.276	4546.03	141.04
4-m-a-2	4533.228	4546.132	141.694
4-m-a-3	4533.32	4546.128	142.129
4-m-b-1	4542.404	4539.635	142.335
4-m-b-2	4542.659	4539.757	142.788
4-m-b-3	4542.696	4539.753	143.051
4-m-b-4	4542.724	4539.814	143.395
4-m-c-1	4543.359	4537.924	141.652
4-m-c-2	4544.076	4538.323	142.539
4-m-c-3	4544.081	4538.296	142.95
4-m-c-4	4544.129	4538.275	143.294

4-m-d-1	4546.254	4535.025	140.991
4-m-d-2	4546.319	4535.093	141.545
4-m-d-3	4546.305	4535.176	141.891
5-m-a-1	5505.187	5508.877	107.791
5-m-a-2	5505.185	5509.288	108.433
5-m-b-1	5505.632	5507.551	107.121
5-m-b-2	5505.913	5507.826	107.567
5-m-b-3	5505.812	5507.74	107.775
5-m-b-4	5506.077	5507.986	108.361
5-m-c-1	5506.273	5506.682	106.75
5-m-c-2	5506.621	5506.983	107.7
5-m-c-3	5506.747	5507.184	108.325
5-m-d-1	5506.787	5506.025	106.764
5-m-d-2	5506.851	5506.018	107.303
5-m-d-3	5506.959	5506.18	107.823
5-m-d-4	5507.106	5506.39	108.269
6-m-a-1	6499.125	6517.846	101.052
6-m-a-2	6499.181	6517.827	101.507
6-m-a-3	6499.146	6517.842	102.06
6-m-a-4	6499.195	6517.906	102.595
6-m-b-1	6504.433	6516.684	104.414
6-m-b-2	6504.363	6516.803	105.108
6-m-b-3	6504.55	6516.902	105.671
6-m-c-1	6507.326	6509.215	103.885
6-m-c-2	6507.869	6509.885	104.487
6-m-c-3	6507.948	6509.787	104.844
6-m-c-4	6508.002	6509.862	105.247
6-m-d-1	6507.285	6506.218	103.594
6-m-d-2	6507.354	6506.323	103.876
6-m-d-3	6507.375	6506.289	104.399
6-m-e-1	6505.57	6503.284	103.403
6-m-e-2	6505.676	6503.199	103.844
6-m-e-3	6505.755	6503.146	104.423
6-m-f-1	6504.805	6502.07	102.694
6-m-f-2	6505.44	6502.683	103.489
6-m-f-3	6505.475	6502.577	103.885
6-m-f-4	6505.594	6502.523	104.492
6-m-g-1	6500.625	6494.162	96.961
6-m-g-2	6500.65	6494.067	97.169
6-m-g-3	6500.774	6494.192	97.58
7-m-a-1	7507.507	7503.244	96.44
7-m-a-2	7507.479	7503.242	96.661
7-m-a-3	7507.44	7503.212	96.987
7-m-a-4	7507.448	7503.141	97.281
7-m-b-1	7506.815	7500.075	98.283
7-m-b-2	7506.803	7500.05	98.442

2018 May

POINT	X COORD(m)	Y COORD (m)	Z COORD (m)
2-m-a-1	2498.726	2508.729	105.213
2-m-a-2	2498.838	2509.537	106.603
2-m-a-3	2498.878	2510.116	108.033
2-m-a-4	2499.012	2510.68	109.536
2-m-b-1	2503.968	2508.924	104.302
2-m-b-2	2504.001	2509.591	105.854
2-m-b-3	2504.081	2510.222	107.004
2-m-b-4	2503.994	2510.623	107.896
2-m-b-5	2503.987	2510.965	109.179
2-m-c-1	2507.658	2509.709	104.02
2-m-c-2	2507.525	2510.147	105.116
2-m-c-3	2507.452	2510.731	106.621
2-m-c-4	2507.383	2510.956	107.661
2-m-c-5	2507.345	2511.134	108.266
2-m-d-1	2496.603	2509.199	105.649
2-m-d-2	2496.53	2509.633	106.56
2-m-d-3	2496.511	2509.851	107.48
2-m-d-4	2496.533	2510.237	108.437
2-m-d-5	2496.505	2510.705	109.221
2-m-d-6	2496.508	2510.757	109.768
2-m-e-1	2498.442	2505.064	102.071
2-m-e-2	2498.396	2505.086	102.597
2-m-e-3	2498.5	2505.143	103.002
2-m-f-1	2504.122	2505.93	101.108
2-m-f-2	2504.166	2505.983	101.609
2-m-f-3	2504.196	2506.031	101.942
2-m-f-4	2504.169	2506.062	102.627
2-m-g-1	2508.152	2507.049	100.875
2-m-g-2	2508.137	2507.128	101.497
2-m-g-3	2508.179	2507.169	101.998
2-m-g-4	2508.202	2507.244	102.465

2018 July

POINT	X COORD(m)	Y COORD (m)	Z COORD (m)
2-m-a-1	2498.726	2508.729	105.212
2-m-a-2	2498.838	2509.536	106.602
2-m-a-3	2498.879	2510.115	108.032
2-m-a-4	2499.013	2510.679	109.534
2-m-b-1	2503.969	2508.924	104.302
2-m-b-2	2504.001	2509.59	105.854
2-m-b-3	2504.082	2510.221	107.004
2-m-b-4	2503.995	2510.622	107.895
2-m-b-5	2503.988	2510.964	109.178
2-m-c-1	2507.658	2509.708	104.02
2-m-c-2	2507.527	2510.147	105.116
2-m-c-3	2507.453	2510.731	106.621
2-m-c-4	2507.383	2510.955	107.661
2-m-c-5	2507.343	2511.132	108.264

2-m-d-1	2496.602	2509.2	105.649
2-m-d-2	2496.529	2509.633	106.561
2-m-d-3	2496.511	2509.851	107.479
2-m-d-4	2496.534	2510.236	108.436
2-m-d-5	2496.505	2510.706	109.221
2-m-d-6	2496.508	2510.758	109.768
2-m-e-1	2498.442	2505.064	102.071
2-m-e-2	2498.396	2505.086	102.597
2-m-e-3	2498.5	2505.143	103.002
2-m-f-1	2504.123	2505.93	101.108
2-m-f-2	2504.165	2505.983	101.609
2-m-f-3	2504.195	2506.029	101.942
2-m-f-4	2504.17	2506.062	102.627
2-m-g-1	2508.152	2507.051	100.875
2-m-g-2	2508.136	2507.126	101.497
2-m-g-3	2508.178	2507.168	101.998
2-m-g-4	2508.201	2507.243	102.464

2018 September

POINT	X COORD(m)	Y COORD (m)	Z COORD (m)
1-m-a-1	1495.301	1509.924	95.181
1-m-a-2	1495.345	1509.938	94.592
1-m-a-3	1495.375	1510.055	93.848
1-m-a-4	1495.426	1510.366	92.446
1-m-b-1	1497.838	1509.399	95.345
1-m-b-2	1497.78	1509.302	94.948
1-m-b-3	1497.794	1509.322	94.582
1-m-b-4	1497.884	1509.427	93.861
2-m-a-1	2498.726	2508.728	105.212
2-m-a-2	2498.838	2509.537	106.602
2-m-a-3	2498.879	2510.116	108.031
2-m-a-4	2499.012	2510.679	109.533
2-m-b-1	2503.968	2508.922	104.301
2-m-b-2	2504.001	2509.59	05.854
2-m-b-3	2504.081	2510.22	107.003
2-m-b-4	2503.995	2510.622	107.894
2-m-b-5	2503.987	2510.964	109.177
2-m-c-1	2507.658	2509.709	104.02
2-m-c-2	2507.526	2510.147	105.116
2-m-c-3	2507.452	2510.731	106.62
2-m-c-4	2507.383	2510.955	107.66
2-m-c-5	2507.344	2511.133	108.265
2-m-d-1	2496.602	2509.201	105.649
2-m-d-2	2496.529	2509.632	106.559
2-m-d-3	2496.511	2509.851	107.479
2-m-d-4	2496.535	2510.231	108.432
2-m-d-5	2496.505	2510.706	109.221
2-m-d-6	2496.508	2510.759	109.767

2-m-e-1	2498.443	2505.063	102.071
2-m-e-2	2498.396	2505.085	102.597
2-m-e-3	2498.5	2505.142	103.001
2-m-f-1	2504.122	2505.93	101.108
2-m-f-2	2504.164	2505.983	101.609
2-m-f-3	2504.195	2506.03	101.941
2-m-f-4	2504.169	2506.061	102.627
2-m-g-1	2508.151	2507.052	100.875
2-m-g-2	2508.135	2507.127	101.497
2-m-g-3	2508.176	2507.167	101.998
2-m-g-4	2508.199	2507.242	102.464
3-m-a-1	3500.04	3502.914	101.414
3-m-a-2	3500.174	3503.34	102.276
3-m-a-3	3500.269	3503.622	102.921
3-m-a-4	3500.367	3504.13	104.031
4-m-a-1	4533.276	4546.029	141.037
4-m-a-2	4533.227	4546.131	141.692
4-m-a-3	4533.32	4546.127	142.126
4-m-b-1	4542.401	4539.633	142.331
4-m-b-2	4542.661	4539.76	142.787
4-m-b-3	4542.698	4539.752	143.049
4-m-b-4	4542.726	4539.814	143.394
4-m-c-1	4543.358	4537.923	141.651
4-m-c-2	4544.079	4538.323	142.539
4-m-c-3	4544.082	4538.295	142.949
4-m-c-4	4544.132	4538.274	143.293
4-m-d-1	4546.255	4535.024	140.989
4-m-d-2	4546.322	4535.092	141.543
4-m-d-3	4546.306	4535.175	141.889
5-m-a-1	5505.187	5508.878	107.792
5-m-a-2	5505.185	5509.287	108.433
5-m-b-1	5505.633	5507.551	107.12
5-m-b-2	5505.913	5507.826	107.567
5-m-b-3	5505.812	5507.739	107.775
5-m-b-4	5506.081	5507.991	108.366
5-m-c-1	5506.274	5506.683	106.75
5-m-c-2	5506.624	5506.985	107.701
5-m-c-3	5506.751	5507.187	108.33
5-m-d-1	5506.789	5506.025	106.766
5-m-d-2	5506.851	5506.017	107.302
5-m-d-3	5506.959	5506.179	107.823
5-m-d-4	5507.108	5506.391	108.269
6-m-a-1	6499.125	6517.843	101.052
6-m-a-2	6499.181	6517.824	101.506
6-m-a-3	6499.146	6517.842	102.059
6-m-a-4	6499.196	6517.907	102.596
6-m-b-1	6504.432	6516.684	104.415
6-m-b-2	6504.363	6516.804	105.109
6-m-b-3	6504.55	6516.902	105.672

6-m-c-1	6507.325	6509.214	103.886
6-m-c-2	6507.87	6509.885	104.487
6-m-c-3	6507.947	6509.786	104.844
6-m-c-4	6508.003	6509.864	105.248
6-m-d-1	6507.285	6506.219	103.593
6-m-d-2	6507.353	6506.323	103.877
6-m-d-3	6507.376	6506.289	104.399
6-m-e-1	6505.571	6503.285	103.403
6-m-e-2	6505.677	6503.2	103.844
6-m-e-3	6505.757	6503.146	104.423
6-m-f-1	6504.807	6502.07	102.694
6-m-f-2	6505.443	6502.685	103.491
6-m-f-3	6505.478	6502.578	103.886
6-m-f-4	6505.598	6502.524	104.494
6-m-g-1	6500.626	6494.16	96.96
6-m-g-2	6500.651	6494.065	97.168
6-m-g-3	6500.775	6494.189	97.578
7-m-a-1	7507.505	7503.245	96.44
7-m-a-2	7507.477	7503.242	96.661
7-m-a-3	7507.438	7503.212	96.988
7-m-a-4	7507.446	7503.141	97.281
7-m-b-1	7506.813	7500.075	98.284
7-m-b-2	7506.799	7500.05	98.443

2019 May

POINT	X COORD(m)	Y COORD (m)	Z COORD (m)
2-m-a-1	2498.725	2508.726	105.21
2-m-a-2	2498.838	2509.533	106.599
2-m-a-3	2498.878	2510.114	108.029
2-m-a-4	2499.012	2510.677	109.531
2-m-b-1	2503.971	2508.926	104.302
2-m-b-2	2504.001	2509.586	105.851
2-m-b-3	2504.081	2510.218	107.001
2-m-b-4	2503.994	2510.62	107.891
2-m-b-5	2503.986	2510.961	109.174
2-m-c-1	2507.658	2509.708	104.02
2-m-c-2	2507.527	2510.147	105.115
2-m-c-3	2507.452	2510.73	106.62
2-m-c-4	2507.382	2510.954	107.66
2-m-c-5	2507.344	2511.132	108.264
2-m-d-1	2496.601	2509.198	105.648
2-m-d-2	2496.528	2509.63	106.558
2-m-d-3	2496.511	2509.848	107.476
2-m-d-4	2496.542	2510.216	108.42
2-m-d-5	2496.506	2510.706	109.217
2-m-d-6	2496.509	2510.759	109.764

2-m-e-1	2498.442	2505.064	102.072
2-m-e-2	2498.396	2505.086	102.597
2-m-e-3	2498.499	2505.143	103.002
2-m-f-1	2504.123	2505.931	101.108
2-m-f-2	2504.165	2505.983	101.61
2-m-f-3	2504.195	2506.031	101.942
2-m-f-4	2504.169	2506.061	102.628
2-m-g-1	2508.152	2507.053	100.876
2-m-g-2	2508.136	2507.128	101.498
2-m-g-3	2508.177	2507.167	101.999
2-m-g-4	2508.2	2507.243	102.465

2020 September

POINT	X COORD(m)	Y COORD (m)	Z COORD (m)
1-m-a-1	1495.301	1509.923	95.182
1-m-a-2	1495.348	1509.933	94.596
1-m-a-3	1495.377	1510.051	93.851
1-m-a-4	1495.427	1510.363	92.449
1-m-b-1	1497.838	1509.396	95.347
1-m-b-2	1497.78	1509.3	94.949
1-m-b-3	1497.794	1509.319	94.584
1-m-b-4	1497.884	1509.424	93.864
2-m-a-1	2498.726	2508.717	105.207
2-m-a-2	2498.839	2509.525	106.593
2-m-a-3	2498.88	2510.106	108.022
2-m-a-4	2499.013	2510.668	109.522
2-m-b-1	2503.97	2508.912	104.296
2-m-b-2	2504.001	2509.578	105.847
2-m-b-3	2504.08	2510.21	106.996
2-m-b-4	2503.993	2510.613	107.886
2-m-b-5	2503.984	2510.955	109.168
2-m-c-1	2507.656	2509.702	104.018
2-m-c-2	2507.525	2510.142	105.113
2-m-c-3	2507.45	2510.724	106.617
2-m-c-4	2507.38	2510.948	107.657
2-m-c-5	2507.341	2511.127	108.261
2-m-d-1	2496.602	2509.191	105.643
2-m-d-2	2496.529	2509.622	106.553
2-m-d-3	2496.513	2509.841	107.471
2-m-d-4	2496.553	2510.189	108.398
2-m-d-5	2496.508	2510.702	109.209
2-m-d-6	2496.511	2510.756	109.755
2-m-e-1	2498.444	2505.061	102.072
2-m-e-2	2498.397	2505.083	102.597
2-m-e-3	2498.501	2505.14	103.002
2-m-f-1	2504.121	2505.928	101.109
2-m-f-2	2504.162	2505.979	101.61
2-m-f-3	2504.193	2506.027	101.942
2-m-f-4	2504.166	2506.057	102.627

2-m-g-1	2508.155	2507.05	100.874
2-m-g-2	2508.143	2507.129	101.497
2-m-g-3	2508.177	2507.164	101.998
2-m-g-4	2508.201	2507.24	102.464
3-m-a-1	3500.04	3502.912	101.412
3-m-a-2	3500.175	3503.338	102.274
3-m-a-3	3500.269	3503.62	102.918
3-m-a-4	3500.366	3504.127	104.025
4-m-a-1	4533.275	4546.028	141.034
4-m-a-2	4533.221	4546.123	141.686
4-m-a-3	4533.316	4546.122	142.124
4-m-b-1	4542.375	4539.605	142.302
4-m-b-2	4542.655	4539.752	142.781
4-m-b-3	4542.695	4539.751	143.049
4-m-b-4	4542.724	4539.813	143.395
4-m-c-1	4543.368	4537.929	141.659
4-m-c-2	4544.067	4538.313	142.529
4-m-c-3	4544.08	4538.291	142.947
4-m-c-4	4544.129	4538.271	143.291
4-m-d-1	4546.251	4535.021	140.988
4-m-d-2	4546.318	4535.089	141.54
4-m-d-3	4546.302	4535.174	141.887
5-m-a-1	5505.185	5508.874	107.789
5-m-a-2	5505.183	5509.285	108.431
5-m-b-1	5505.628	5507.545	107.116
5-m-b-2	5505.911	5507.824	107.565
5-m-b-3	5505.809	5507.736	107.773
5-m-b-4	5506.072	5507.979	108.355
5-m-c-1	5506.271	5506.68	106.749
5-m-c-2	5506.62	5506.981	107.698
5-m-c-3	5506.748	5507.183	108.326
5-m-d-1	5506.784	5506.021	106.762
5-m-d-2	5506.849	5506.015	107.301
5-m-d-3	5506.957	5506.177	107.821
5-m-d-4	na	na	na
6-m-a-1	6499.125	6517.84	101.051
6-m-a-2	6499.181	6517.82	101.505
6-m-a-3	6499.146	6517.837	102.058
6-m-a-4	6499.194	6517.9	102.592
6-m-b-1	6504.432	6516.68	104.413
6-m-b-2	6504.362	6516.8	105.107
6-m-b-3	6504.549	6516.898	105.669
6-m-c-1	6507.318	6509.205	103.88
6-m-c-2	6507.858	6509.873	104.48
6-m-c-3	6507.945	6509.785	104.842
6-m-c-4	6508.001	6509.862	105.245
6-m-d-1	na	na	na
6-m-d-2	6507.353	6506.322	103.875
6-m-d-3	6507.374	6506.287	104.398

6-m-e-1	6505.56	6503.278	103.396
6-m-e-2	6505.66	6503.189	103.831
6-m-e-3	6505.754	6503.146	104.421
6-m-f-1	6504.805	6502.069	102.694
6-m-f-2	6505.439	6502.683	103.488
6-m-f-3	6505.476	6502.578	103.885
6-m-f-4	6505.591	6502.522	104.488
6-m-g-1	6500.626	6494.16	96.959
6-m-g-2	6500.651	6494.065	97.168
6-m-g-3	6500.775	6494.19	97.578
7-m-a-1	7507.502	7503.245	96.44
7-m-a-2	7507.475	7503.242	96.662
7-m-a-3	7507.435	7503.213	96.988
7-m-a-4	7507.445	7503.141	97.281
7-m-b-1	7506.813	7500.076	98.284
7-m-b-2	7506.801	7500.051	98.442

Appendix III - Available resources

All the original survey files (trimble .job format) are available on request

The coordinate lists are available as excel spreadsheets or .csv files

All previous reports are available as pdf documents