

PhotoSat Stereo Satellite Surveying Project Report:

Ref. No: 3936
Previous Ref. No: 3848
Client: Metallic Minerals Corp
Project Area: Keno Lightning and Formo, Yukon
Project Datum: NAD83 (CSRS)
Project Projection: UTM zone 8N
Project Elevations: Orthometric HTV2.0 CGVD28

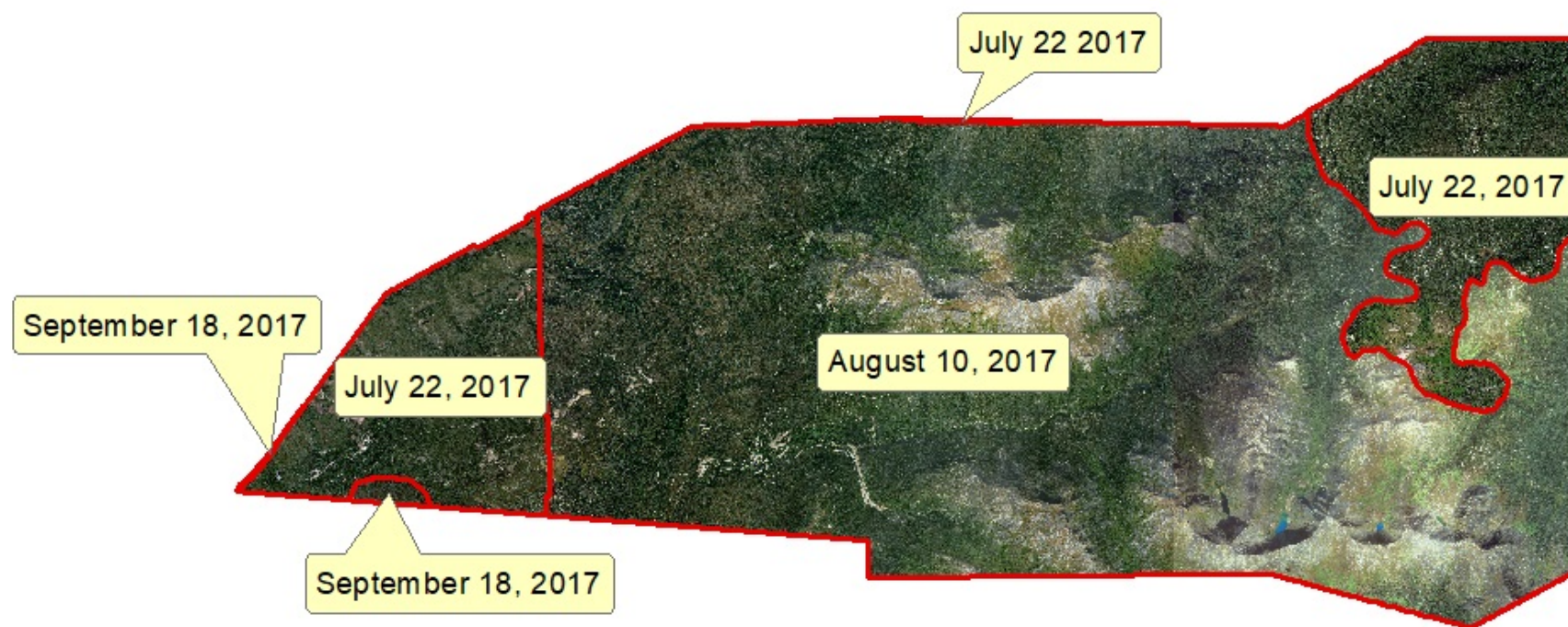


Figure 1: The Worldview-2 and WorldView-3 orthophoto. Photo date: July 22, August 10 and September 18 2017.

PhotoSat Stereo Satellite Surveying Project Report:

Project Overview:

In April 2018, PhotoSat produced satellite surveys of 28 km² and 191 km² for the Formo and Keno Lightning projects in Yukon, Canada. A colour orthophoto was also produced for the surrounding 106 km² for the Formo area and for the 191 km² in the Keno Lightning area. A complete list of all delivered files is in the Appendix.

Processing Overview:

The Keno Lightning and Formo 1 m stereo satellite surveys and 50 cm precision orthophotos were produced from 50 cm pixel resolution WorldView-3 stereo satellite photos. The satellite photos were acquired on July 22, August 10 and September 18 2018 (see Figure 1).

The 1 m satellite survey and 50 cm precision orthophoto were produced using PhotoSat's proprietary Geophysical Satellite Processing system. To our knowledge, the PhotoSat processing system currently produces the highest quality and best accuracy stereo satellite surveys and precision orthophotos in the world. Please refer to the following article for a description of PhotoSat's Geophysical Satellite Processing methods:

www.photosat.ca/pdf/asprs_geophysical_mapping_system_2010.pdf

There are a number of white papers on accuracy studies on PhotoSat satellite surveying at the following url:

www.photosat.ca/surveying/satellite-surveying-accuracy-studies

Accuracy Assessment for this Project:

We expect the relative accuracy of the 1 m satellite survey, over distances of up to 5 km, to be better than 20 cm for level areas of bare ground. Our process has been tested by comparing to tens of thousands of ground control points during accuracy tests. We have also verified this with over 900 client projects. The actual accuracy of each project depends on the angles of the satellite photos and the quality and density of the ground control points.

PhotoSat Stereo Satellite Surveying Project Report:

Areas of the satellite survey that are extremely foreshortened or occluded in the satellite photos due to very steep topography will be interpolated from the surrounding elevation data.

In areas of vegetation with tree canopy openings about every 100 m, the PhotoSat estimates of bare ground elevations beneath the tree canopy are usually accurate to about 10% of the vegetation height. In areas of temperate climate continuous coniferous tree cover, with very few openings to bare ground, the PhotoSat estimates of bare ground elevations are usually accurate to better than 5 m in elevation.

To assess the accuracy of this project we used one client supplied ground control point as a registration point and the remaining points as check points.

Using this methodology the RMS elevation difference between the client supplied ground control and the project satellite survey is 10 cm. The LE90 for the project is 20 cm.

The relative horizontal accuracy of PhotoSat's precision orthophotos is generally better than 50 cm over distances of 10 km.

Please see the detailed discussion of the use of the ground control included in the Ground Reference section. More detailed information about specific control points including photographs of their locations is also included in the Ground Reference section.

Data Delivered:

- 1 m bare earth satellite survey - DXF Point File (Thinned)
- 50 cm WorldView-2/WorldView-3 satellite orthophoto - GeoTIFF format
- 1 m, 5 m, 10 m, and 50 m contours - 3D ArcGIS Shapefile
- 1 m colour elevation image and 1 m direction of slope image - GeoTIFF format
- Project report

PhotoSat Stereo Satellite Surveying Project Report:

- Licence documents

PhotoSat Stereo Satellite Surveying Project Report:



Figure 2: Formo orthophoto mosaic showing the tile index.

PhotoSat Stereo Satellite Surveying Project Report:

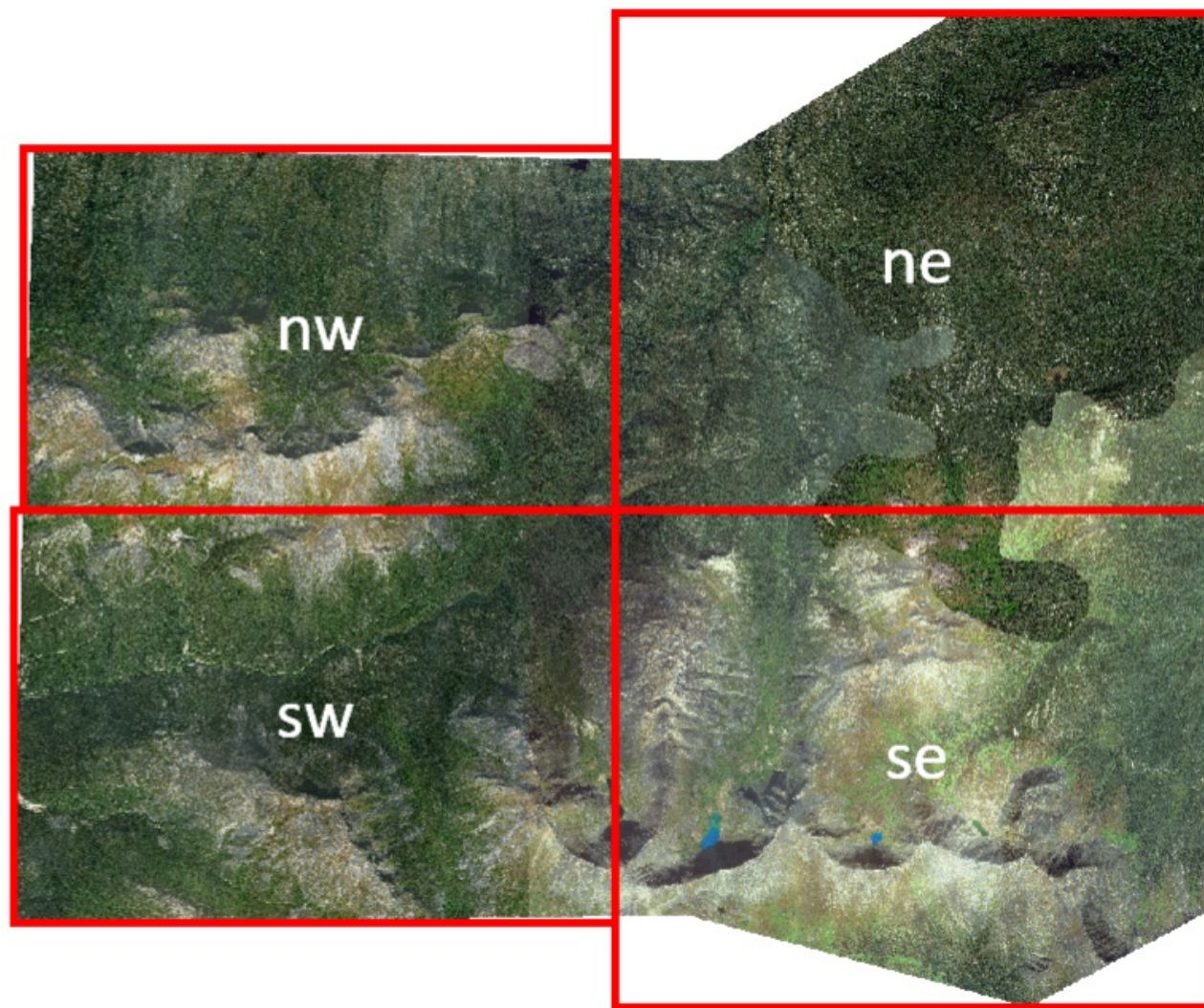


Figure 3: Keno Lightning orthophoto mosaic showing the tile index.

PhotoSat Stereo Satellite Surveying Project Report:

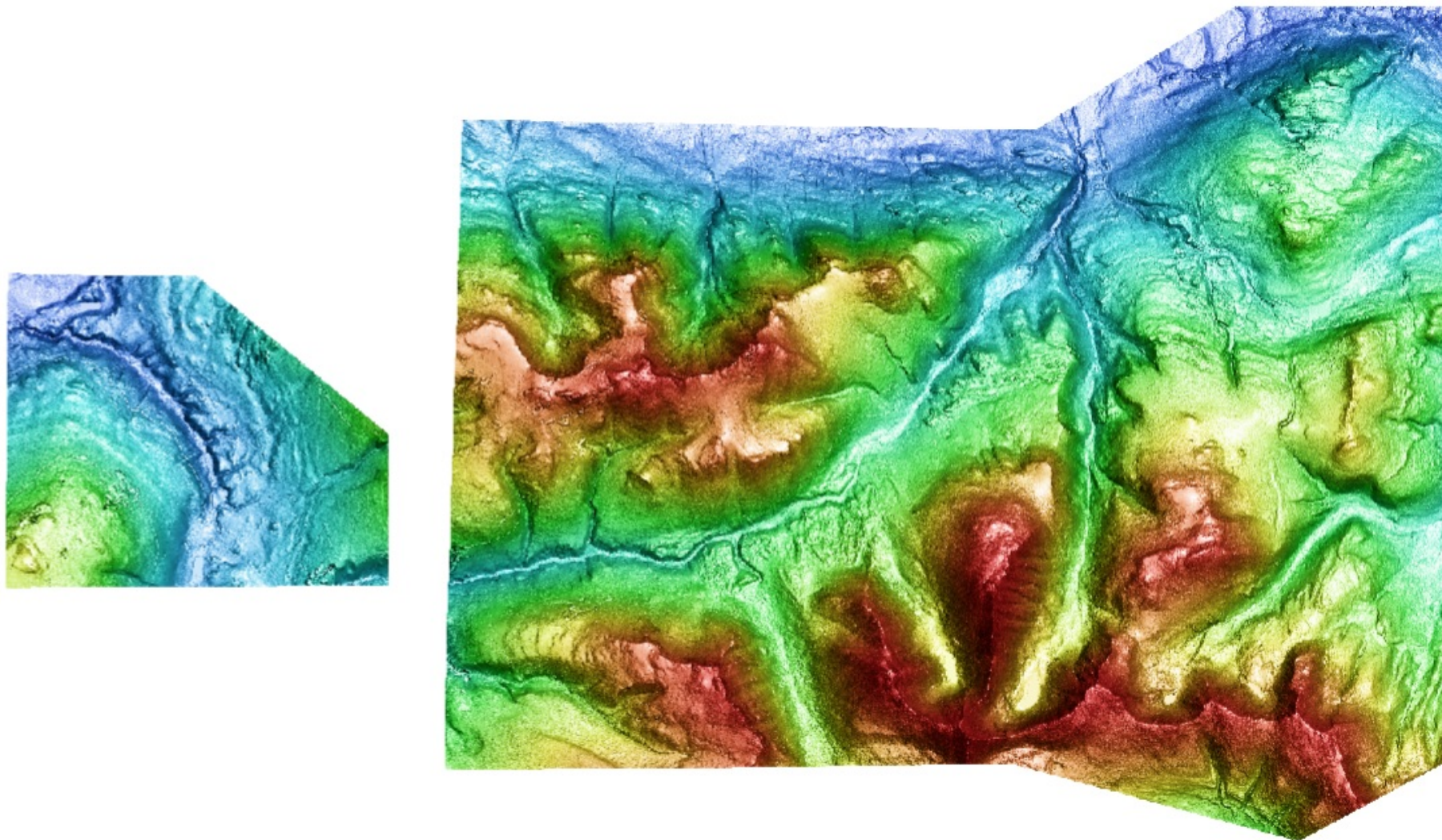


Figure 4: Colour elevation image of the satellite survey. Formo is the west area, Keno Lightning is the east area.

PhotoSat Stereo Satellite Surveying Project Report:

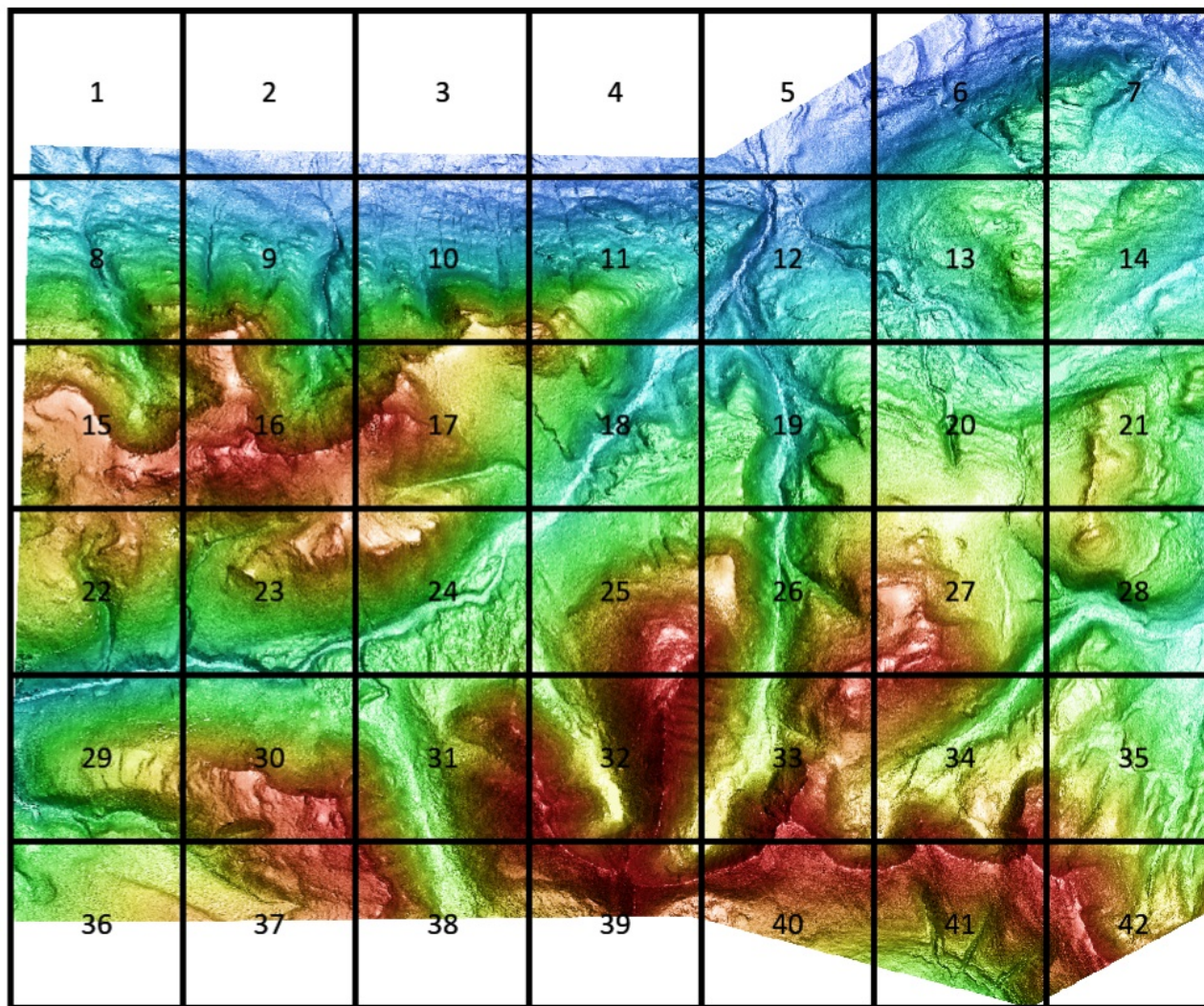


Figure 5: Colour elevation image of the Keno Lightning satellite survey showing the tile index.

PhotoSat Stereo Satellite Surveying Project Report:

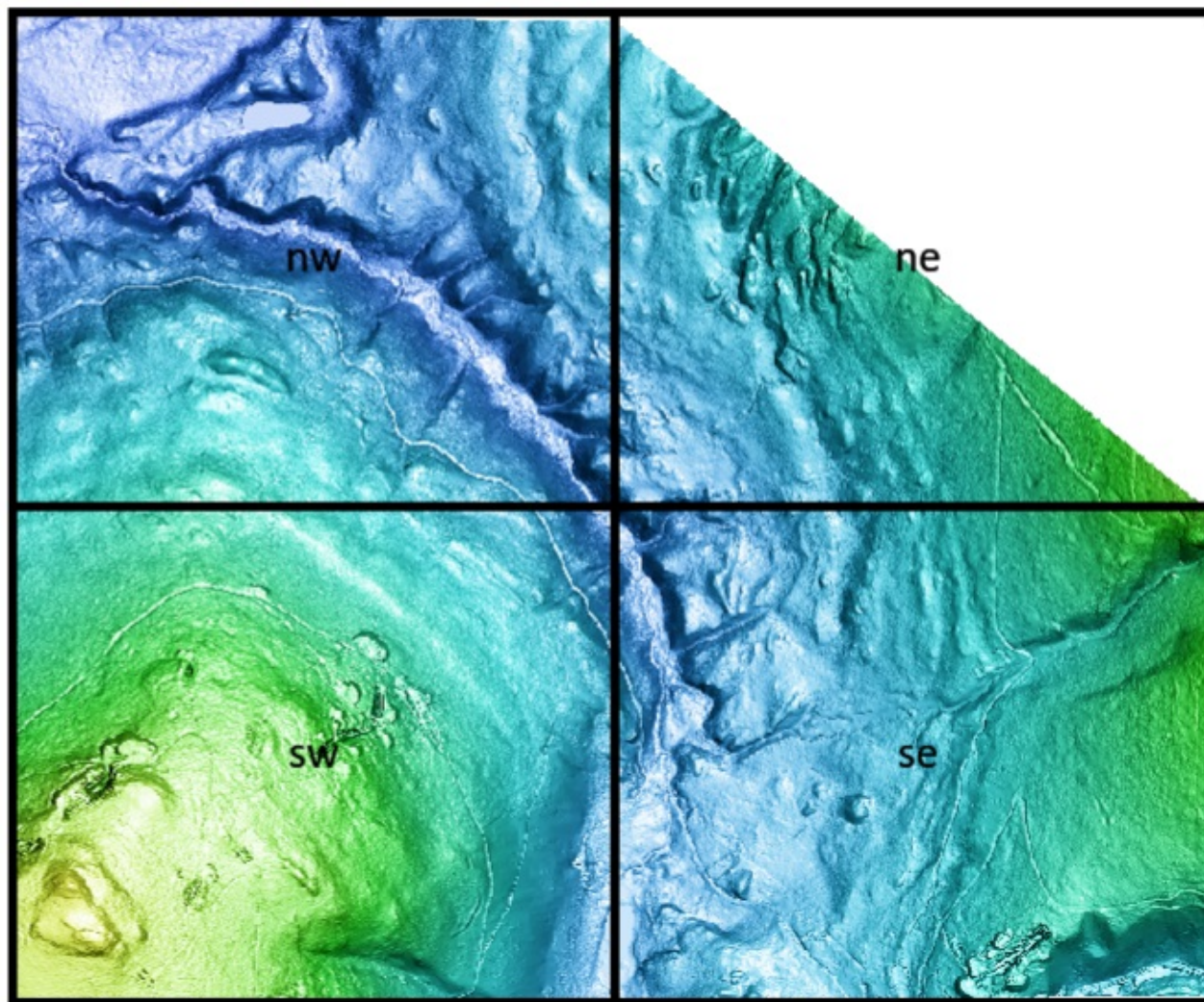


Figure 6: Colour elevation image of the Formo satellite survey showing the tile index.

PhotoSat Stereo Satellite Surveying Project Report:

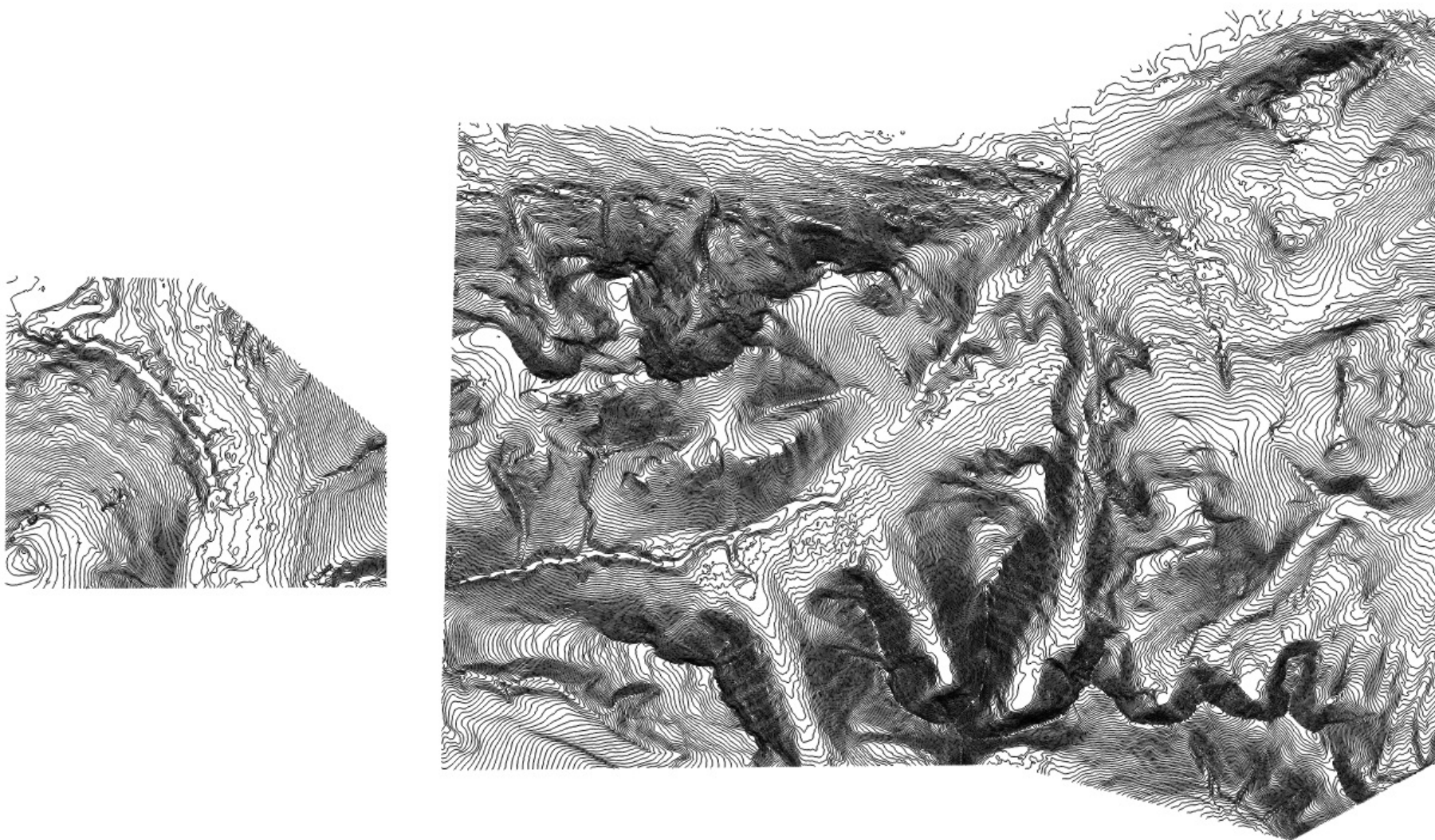


Figure 7: The 10 m contours. Formo is the west area, Keno Lightning is the east area

PhotoSat Stereo Satellite Surveying Project Report:

Ground Reference:

The stereo satellite project was referenced to nine survey points provided by Metallic Minerals. These points were photo identifiable targets that were used as horizontal and vertical control. The table below summarizes the control fit for the project. Additional survey data was provided but it was not in the survey area. One additional control point inside the Formo survey area was provided but the geoid used for the elevations was not known so it could not be used.

Client Control:

File Name	Description	Datum	Projection	Elevations
Targets coordinates.xlsx	Surveyed targets	NAD83 (CSRS)	NUTM08	HTV2.0 CGVD28
Poss Metallic Pts.csv	Surveyed features	NAD83 (CSRS)	NUTM08	unknown

Control Points:

Point Name	Type	East (m)	East Difference (m)	North (m)	North Difference (m)	Elevation (m)	Elevation Difference (m)
1261 KENO 700	Check Point	490070.73	0	7089469.92	0	1459.41	0.01
KL-06	Check Point	489429.16	0	7086500.88	0	1428.50	0.12
KL-07	Check Point	493793.91	0	7085190.70	0	1335.94	-0.08
KL-08A	Check Point	494816.42	-0.2	7087675.02	0.3	1364.70	-0.20
KL-09	Registration Point	501221.30	0	7085789.97	0	1520.69	0.00
KL-10	Check Point	501861.78	-0.15	7092939.46	0	1319.47	-0.16
KL-11A	Check Point	494735.90	0.15	7090310.86	0	1234.95	0.02
KL-12A	Check Point	493267.65	N/A	7091873.95	N/A	1561.75	-0.08
KL-13A	Check Point	490708.05	0.3	7091726.78	0	1636.45	0.10

PhotoSat Stereo Satellite Surveying Project Report:

Point Name	Type	East (m)	East Difference (m)	North (m)	North Difference (m)	Elevation (m)	Elevation Difference (m)
MK-1	Check Point	479247.26	N/A	7136716.08	N/A	1550.10	N/A
MK-2	Check Point	484280.16	N/A	7136244.68	N/A	1471.03	N/A
MK-4	Check Point	486396.72	N/A	7140046.52	N/A	860.92	N/A
MK-5	Check Point	485375.14	N/A	7134774.37	N/A	825.84	N/A
MK-6	Check Point	478576.03	N/A	7139161.54	N/A	1374.07	N/A
KL-01A	Check Point	477311.52	N/A	7079406.83	N/A	794.75	N/A
KL-04A	Check Point	484687.68	N/A	7084091.50	N/A	1022.85	N/A
UKHM 1253	Check Point	472013.07	N/A	7085355.24	N/A	800.59	N/A
Engineering Office	Check Point	475996.55	N/A	7087390.26	N/A	819.08	N/A
Husky S-W	Check Point	474061.56	N/A	7086616.87	N/A	751.81	N/A
yes tag 012954 GalKeno 300	Check Point	482629.14	N/A	7088707.37	N/A	1126.53	N/A
Mia BM Dump	Check Point	478838.37	N/A	7086966.74	N/A	1312.90	N/A

Comments:

- KL-12A: the entire 'X' was not clearly visible and may have been damaged by the time the satellite photo was captured, so the horizontal accuracy could not be measured at this point
- The remaining points with differences of N/A in the table above were outside of the survey area.
- The last four points in the list were not used as they were either not in the survey area or were not visible in the satellite photos. The geoid that the elevations referenced was unknown, therefore these points could not be used as vertical control.

PhotoSat Stereo Satellite Surveying Project Report:

Overview

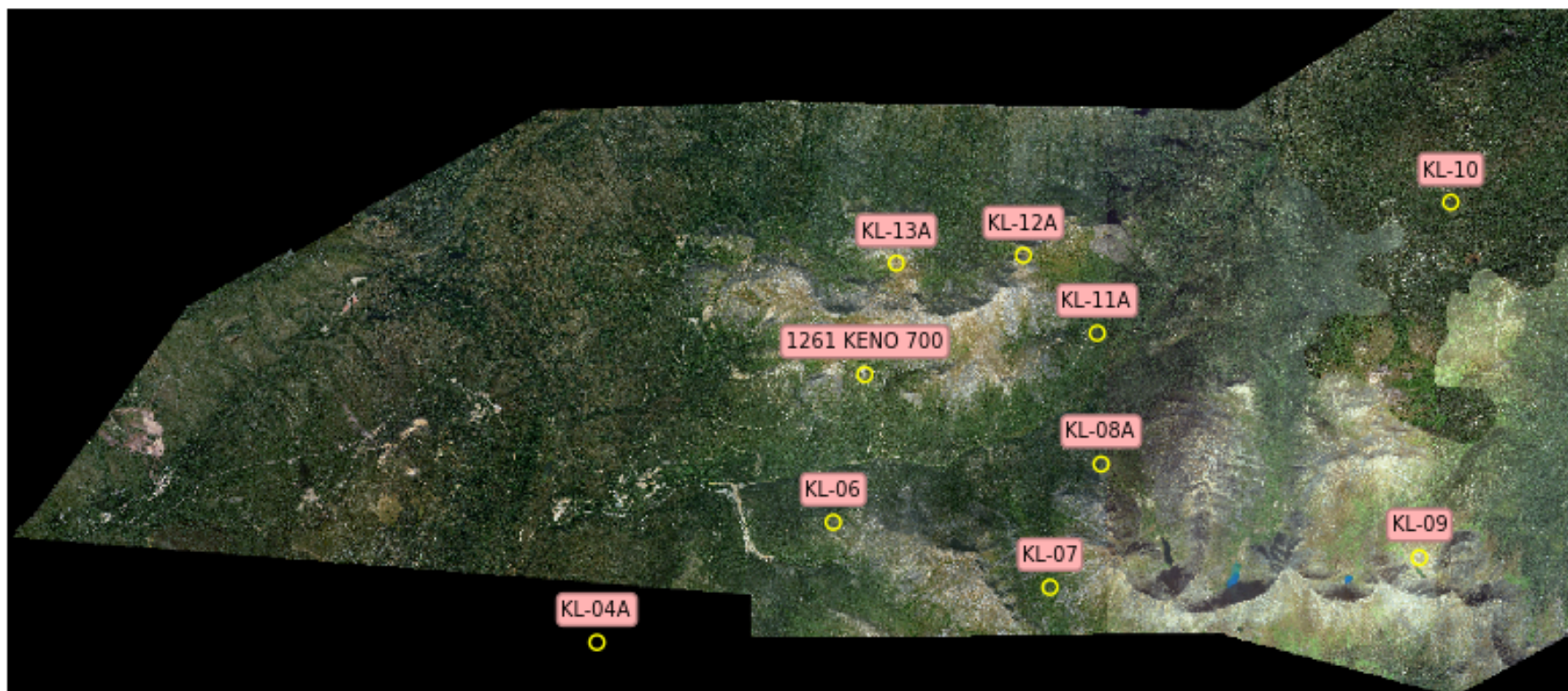
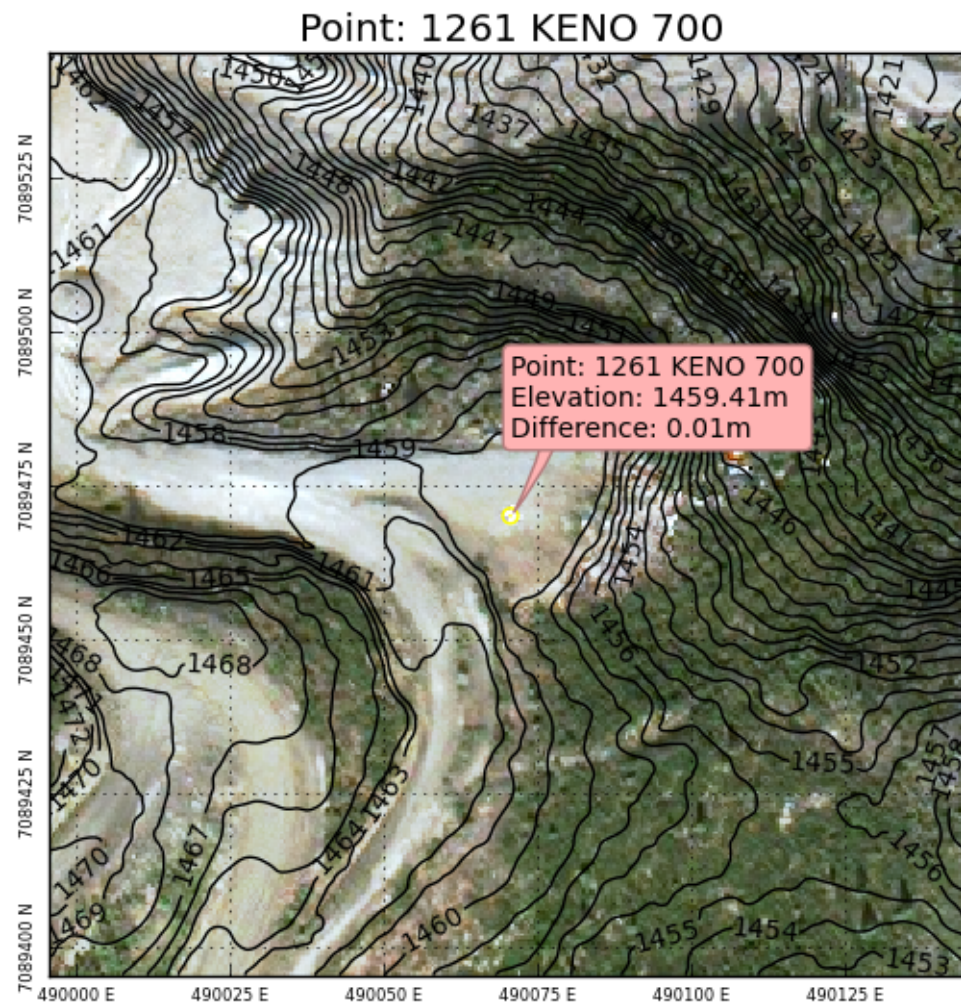
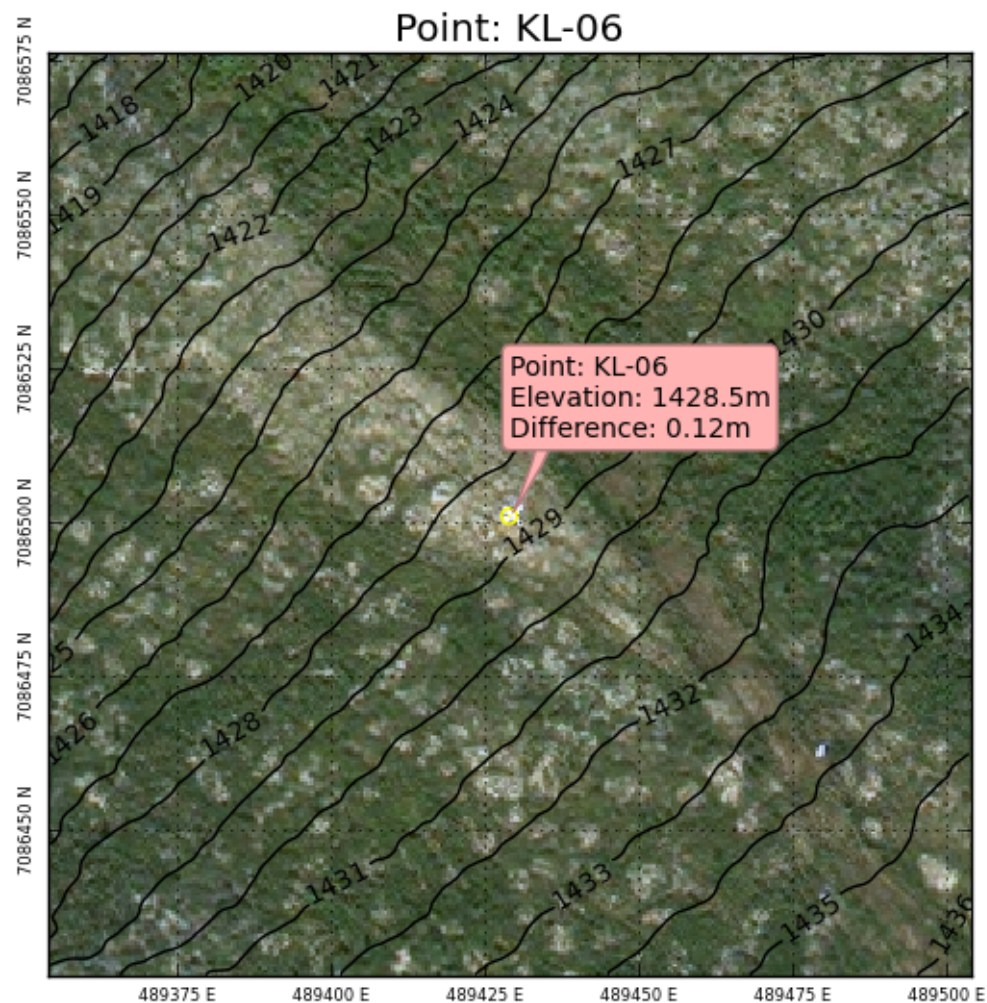


Figure 8: Distribution of Survey ground points.

PhotoSat Stereo Satellite Surveying Project Report:

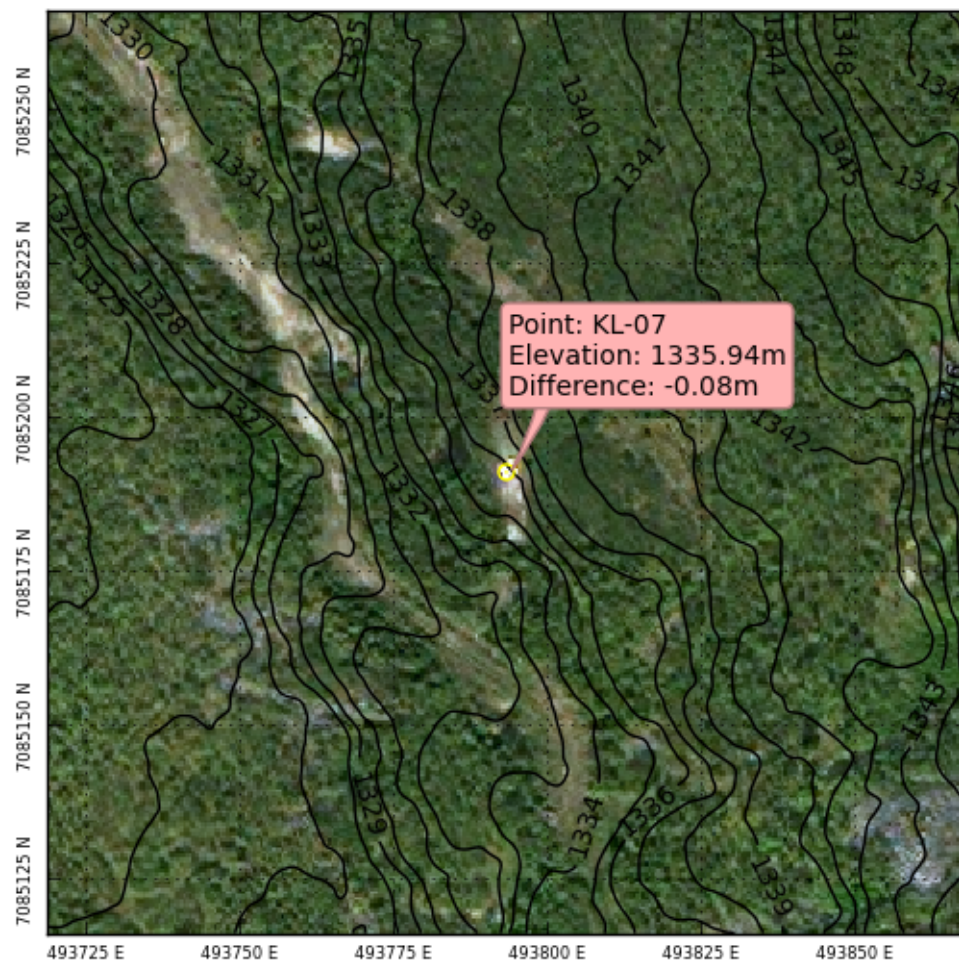


PhotoSat Stereo Satellite Surveying Project Report:

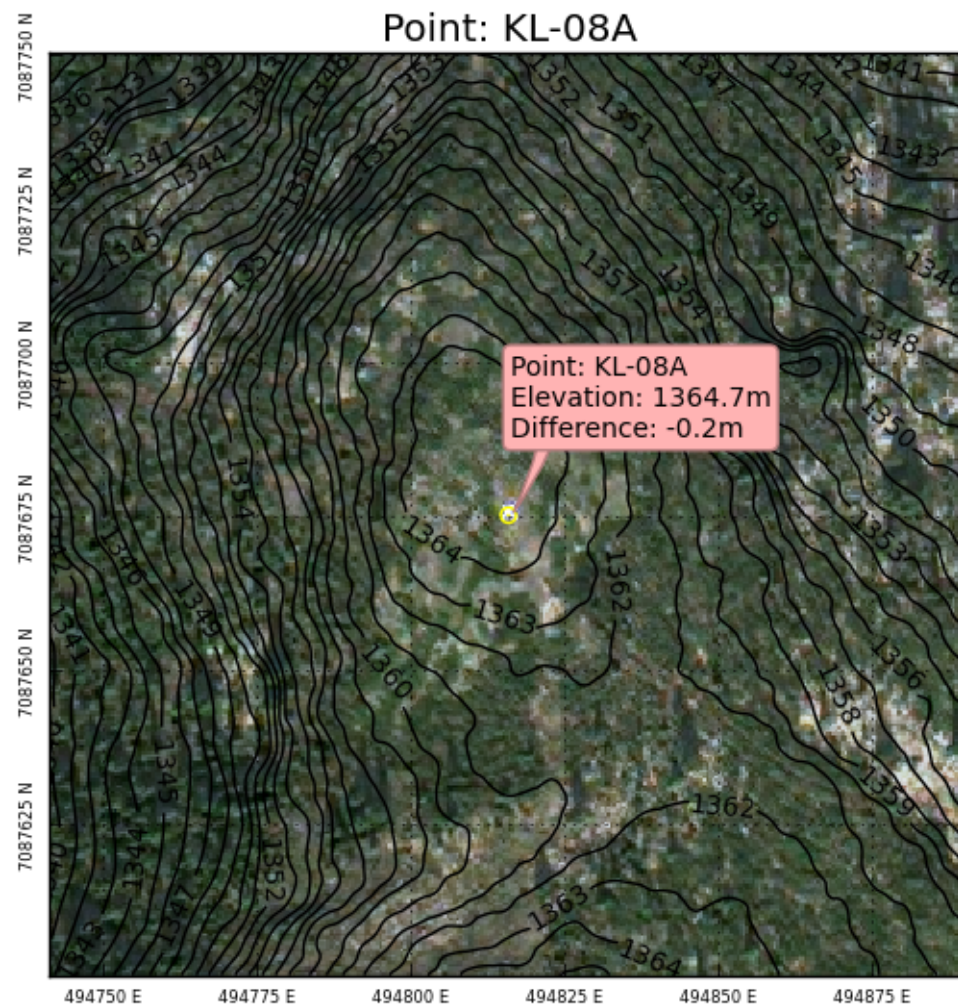


PhotoSat Stereo Satellite Surveying Project Report:

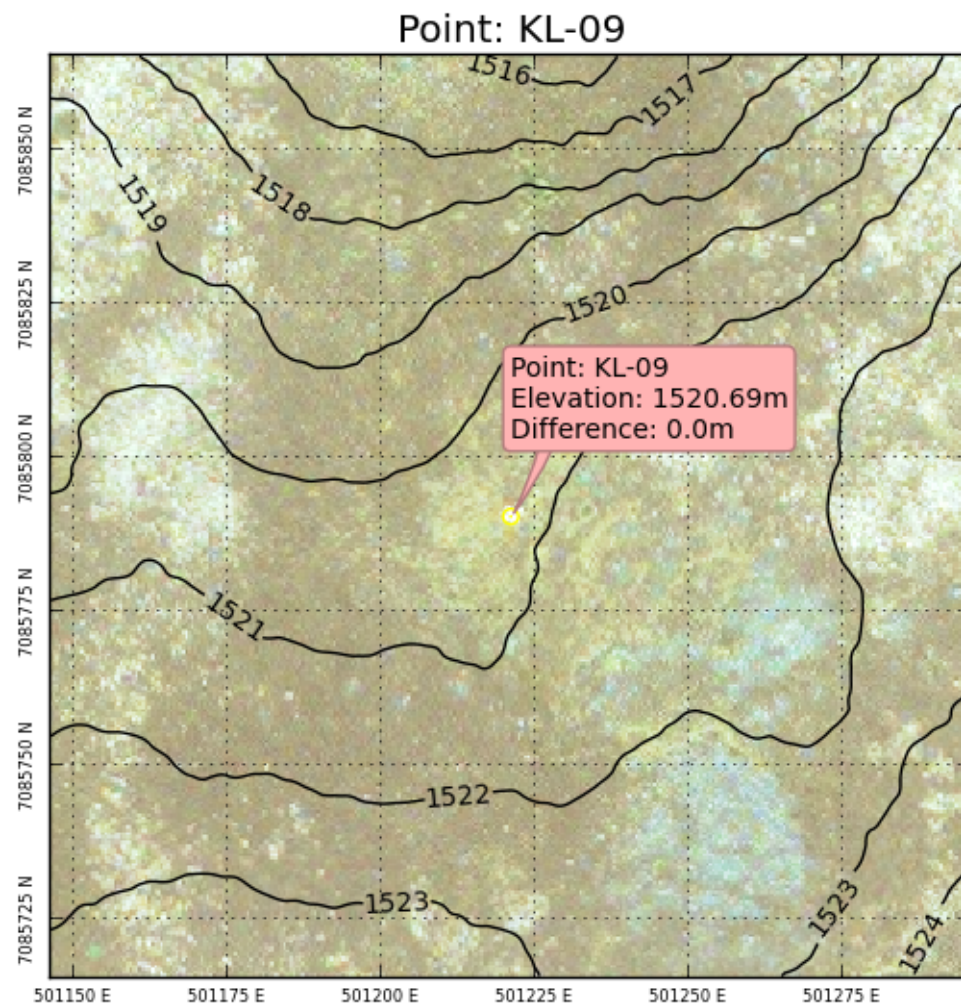
Point: KL-07



PhotoSat Stereo Satellite Surveying Project Report:

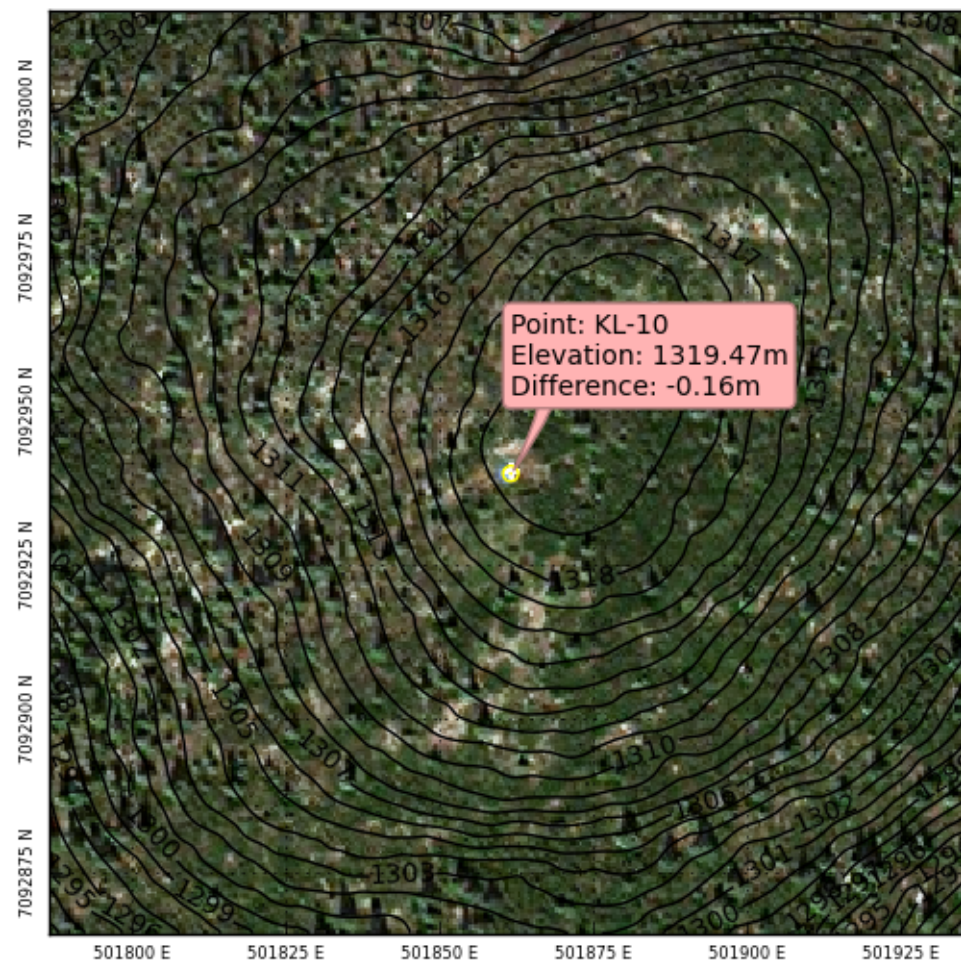


PhotoSat Stereo Satellite Surveying Project Report:



PhotoSat Stereo Satellite Surveying Project Report:

Point: KL-10

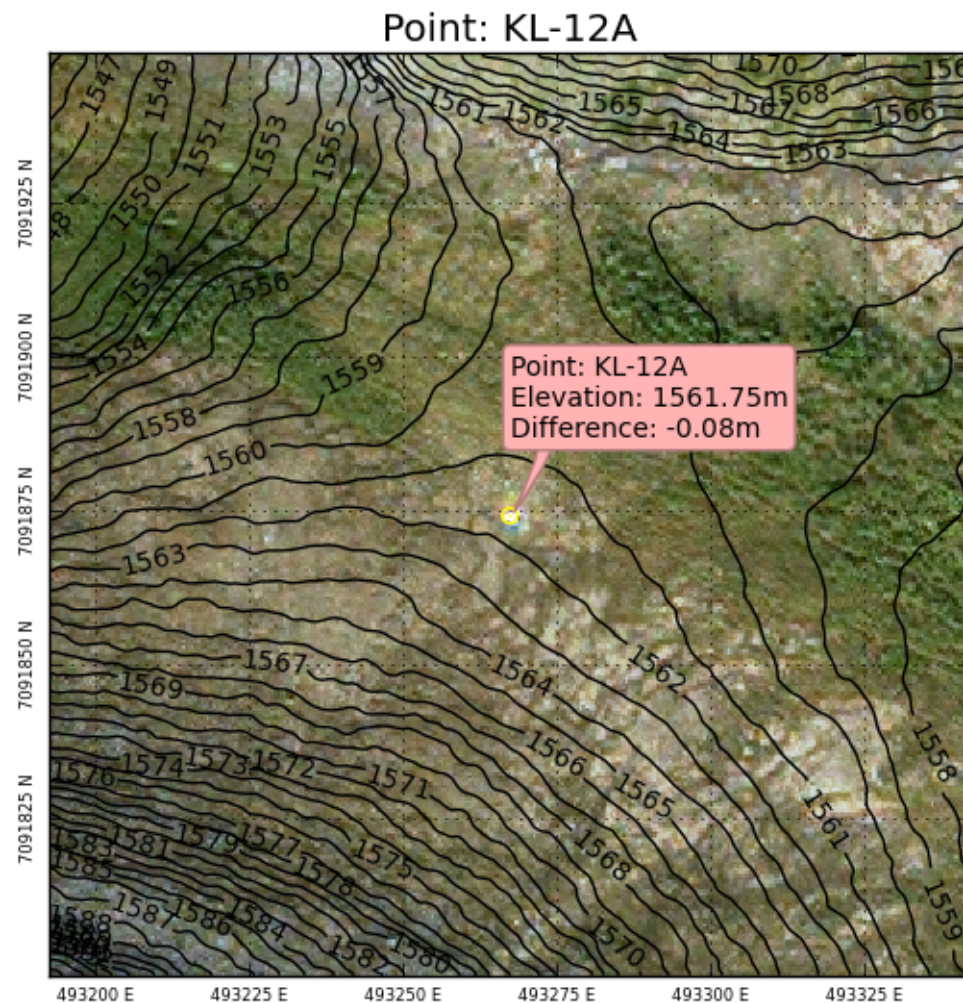


PhotoSat Stereo Satellite Surveying Project Report:

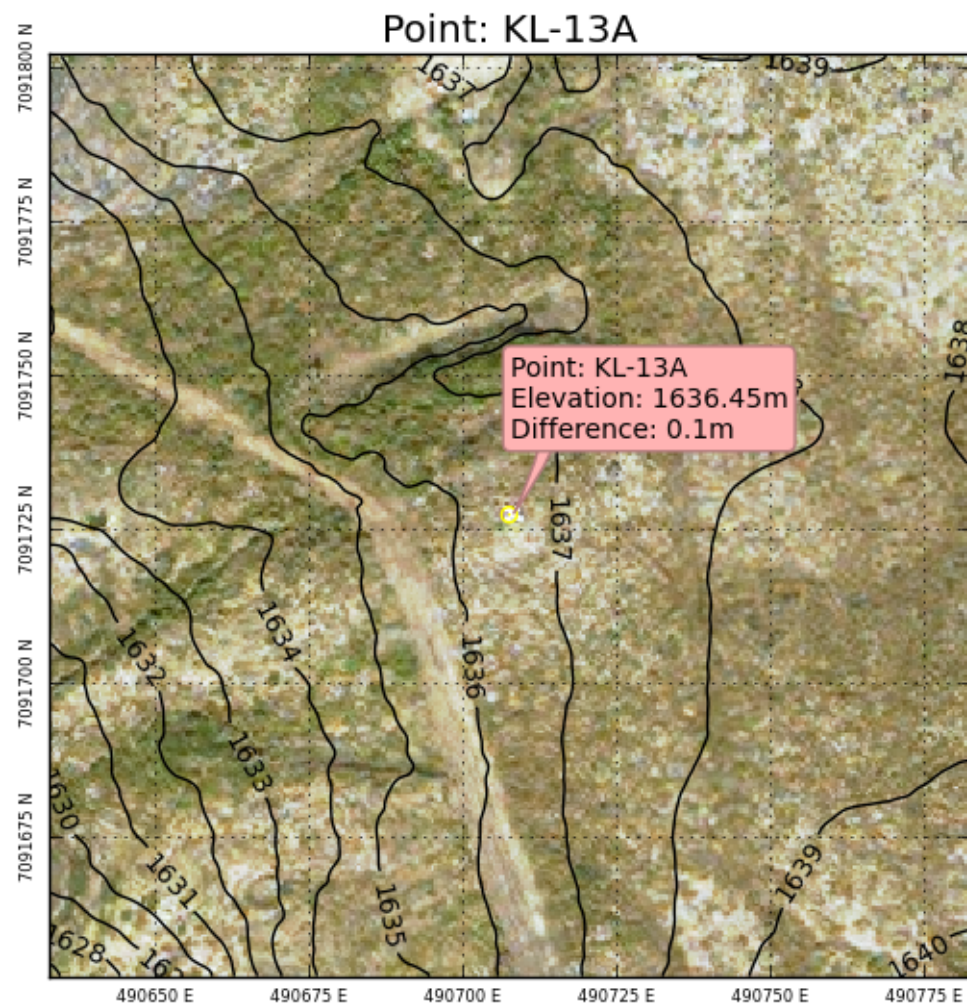
Point: KL-11A



PhotoSat Stereo Satellite Surveying Project Report:



PhotoSat Stereo Satellite Surveying Project Report:



PhotoSat Stereo Satellite Surveying Project Report:

Appendix: Listing of delivered files

- 50cm_wv2_wv3/
 - formo_wv2_wv3_[east/west] (.tif, .tfw, .txt)
 - keno_lighting_wv3_[ne/nw/se/sw] (.tif, .tfw, .txt)
 - keno_lighting_and_formo_wv2_wv3_dates (.shp, .shx, .dbf, .prj)
- 1m_survey/
 - formo_1m_survey_[ne/nw/se/sw]_thinned.dxf
 - formo_1m_survey_tile_index.jpg
 - keno_lightning_1m_survey_tile[01-42]_thinned.dxf
 - keno_lightning_1m_survey_tile_index.jpg
- 1m_survey_images/
 - formo_1m_colour_elevation (.tif, .tfw, .txt)
 - keno_lightning_1m_colour_elevation (.tif, .tfw, .txt)
 - keno_lightning_and_formo_1m_colour_elevation_scalebar.jpg
 - formo_1m_slope_direction (.tif, .tfw, .txt)
 - keno_lightning_1m_slope_direction (.tif, .tfw, .txt)
 - keno_lightning_and_formo_1m_slope_direction_readme.txt
- contours/
 - formo_1m_contours (.shp, .shx, .dbf, .prj)
 - formo_5m_contours (.shp, .shx, .dbf, .prj)
 - formo_10m_contours (.shp, .shx, .dbf, .prj)

PhotoSat Stereo Satellite Surveying Project Report:

formo_50m_contours (.shp, .shx, .dbf, .prj)
keno_lightning_1m_contours_[east/west] (.shp, .shx, .dbf, .prj)
keno_lightning_5m_contours (.shp, .shx, .dbf, .prj)
keno_lightning_10m_contours (.shp, .shx, .dbf, .prj)
keno_lightning_50m_contours (.shp, .shx, .dbf, .prj)

- Licence files
- Project report