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Assessment Report on a  
Stereo Satellite Surveying Project  
for the Jackfish Property

Syine Township  
Thunder Bay Mining Division  
District of Thunder Bay, Ontario

NTS 42D15

NAD83 Zone 16 UTM

504,107 mE 5,409,480 mN

Latitude 48° 50' 17.8"N Longitude 86° 56' 38.5"W

July 26 – September 1, 2017

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Cl. #409847

July 24, 2019



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Appendix 1: Jackfish Property Cell Mining Claims

Appendix 2: Stereo Satellite Surveying Project Report

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## Summary

The Jackfish property is located within the Syine Township, on the north shore of Lake Superior in northwestern Ontario, approximately 250 km east of Thunder Bay (Figure 1). In total, the Jackfish property comprises 281 combined single and boundary cell mining claims covering an area of 3,769 hectares, held under option by Sanatana Resources Inc. from three separate parties. The property is accessed by bush trails off of the Trans-Canada Highway 17. All co-ordinates quoted in text or appearing on maps are either latitude and longitude or Universal Transverse Mercator (UTM) metres easting and northing using the North American Datum 83 (NAD83) Zone 16.

The property is located in the Wawa terrane of the Superior Province of the Canadian Shield, specifically the Schreiber-Hemlo greenstone belt. The greenstone belt in the region consists of metavolcanic and metasedimentary rocks into which the Terrace Bay pluton was emplaced. The property encompasses the eastern half of the Terrace Bay pluton as well as the contact metamorphic zone and part of the the Schreiber-Hemlo greenstone belt supracrustal sequence of folded and foliated metavolcanic basalts and felsic flows and tuffs intercalated with metasedimentary rocks in the northern and eastern parts of the property. The Terrace Bay Pluton is host to numerous small historic gold and base metal occurrences and there is potential to find others, perhaps of economic significance in current times.

Historic mining and exploration on the property dates back to the late 19th century. Since then various companies explored in the area completing surveys, including geophysical surveys, mapping, trenching, sampling and drilling and discovered several mineral occurrences.

A stereo satellite surveying project was undertaken over the Jackfish property near Terrace Bay, Ontario for Sanatana Resources Inc. ("Sanatana") between the dates of July 26 and September 1, 2017. The purpose of the work was to provide a high resolution topographic base onto which field exploration data could be displayed and analyzed in three dimensional ("3D") space to better understand the nature of gold and base metal mineralization within the Jackfish property.

This report presents the stereo satellite surveying project report, adds some additional information about the property mining claims and provides some qualitative interpretations that will help to guide future exploration work on the Jackfish property.

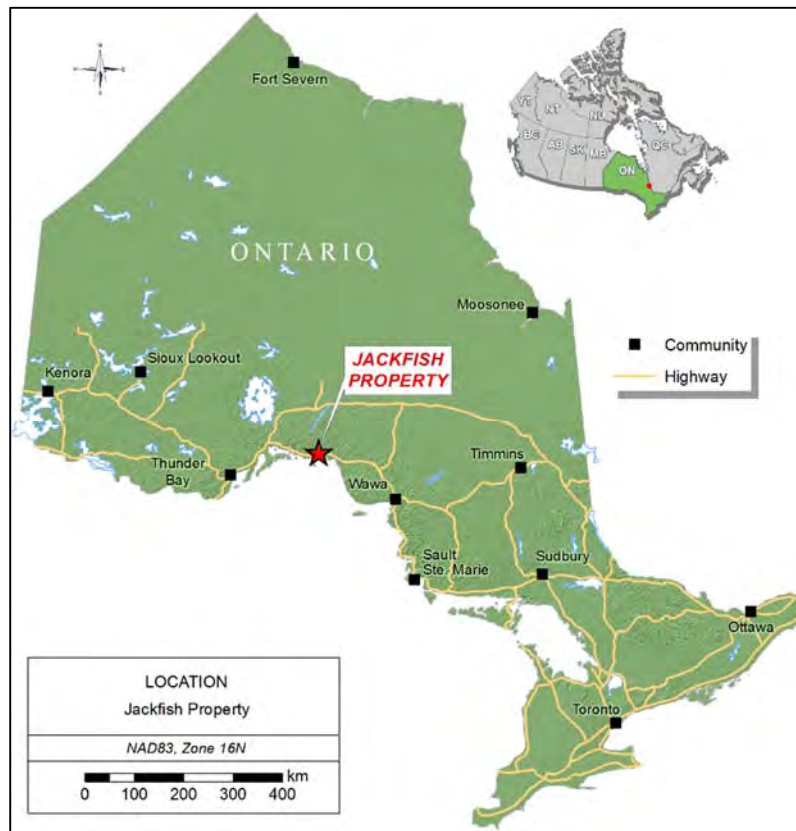
## Introduction

A stereo satellite surveying project was undertaken over the Jackfish property near Terrace Bay, Ontario for Sanatana Resources Inc. ("Sanatana") between the dates of July 26 and September 1, 2017. The purpose of the work was to provide a high resolution topographic base onto which field exploration data could be displayed and analyzed in three dimensional ("3D") space to better understand the nature of gold and base metal mineralization within the Jackfish property.

This report presents the stereo satellite surveying project report, adds some additional information about the property mining claims and provides some qualitative interpretations that will help to guide future exploration work on the Jackfish property.

## Property Location, Description and Access

The Jackfish property is located within the Syine Township, on the north shore of Lake Superior in northwestern Ontario, approximately 250 km east of Thunder Bay (Figure 1). The property is centered on 504,107 mE 5,409,480 mN (NAD 83 Zone 16) or at Latitude 48° 50' 17.8"N Longitude 86° 56' 38.5"W.



**Figure 1: Property Location Map.**

In total, the Jackfish property comprises 281 combined single and boundary cell mining claims (Appendix 1) covering an area of 3,769 hectares, held under option by Sanatana with three optionor groups; Alto Ventures Ltd., Rudy Wahl and Richards *et al* (including Wayne Richards, Francine Richards and James Hamel) (Figure 2). The stereo satellite surveying project covered all the cell mining claims of the Jackfish property as listed in Appendix 1.

The property is accessed by travelling 20 km east of Terrace Bay or 63 km west from Marathon via Trans-Canada Highway 17. The mining claims are readily accessible off the Highway 17 by all-terrain vehicle (ATV) along bush trails (Figure 2).

The terrain around the property is quite rugged and vegetation cover is moderately thick. There is a sparse to moderate amount of bedrock outcrop on the property, mostly along cliffs and at highway road cuttings, but exposure in the forest is commonly masked by moss cover.

All co-ordinates quoted in text or appearing on maps are either latitude and longitude or Universal Transverse Mercator (UTM) metres easting and northing using the North American Datum 83 (NAD83) Zone 16.

## Property History

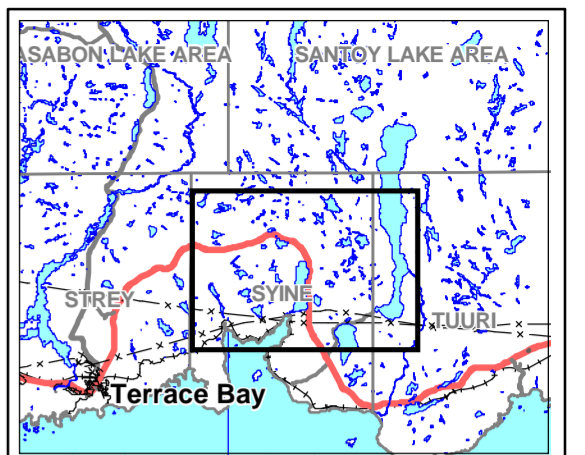
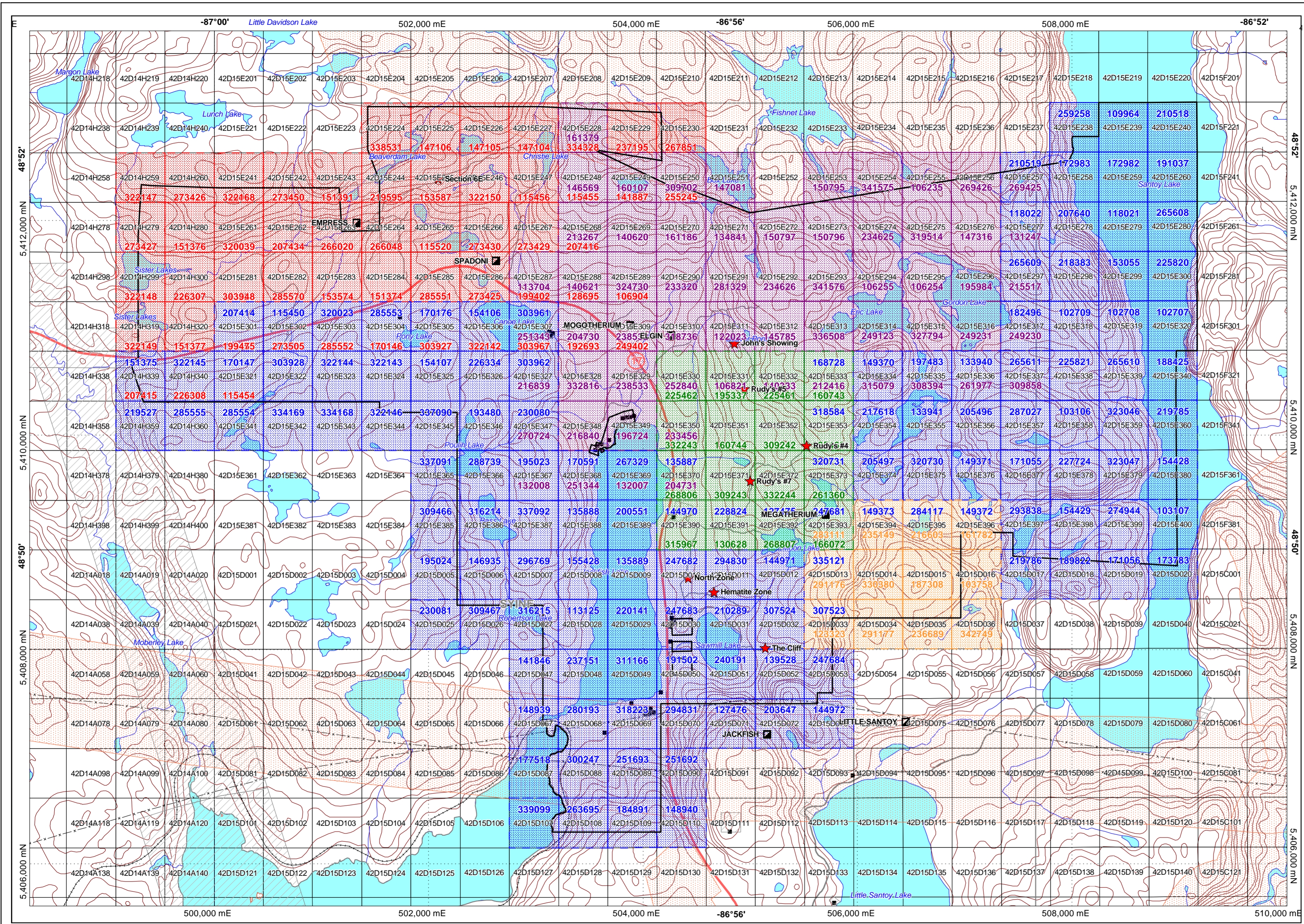
The exploration activity in the area of the Jackfish property started at the end of the 19th century sparked by the discovery of the Empress Mine in 1895 (Walker, 1967) in metavolcanic rocks of the Schreiber-Hemlo Greenstone Belt just north of the Terrace Bay Pluton. Relevant historical mining and exploration work conducted on the property, mostly sourced from assessment reports filed with the Ministry of Energy, Northern Development and Mines, is summarized in Table 1.

***Table 1: Historical exploration work in the property area.***

Year	Company	Type of Work	Results	Assessment Report #
1882	Elgin Silver	Underground mining from 2 adits	No production data	42D15SW8353
1932	Siville-Ferrier Syndicate	Stripping, sampling	Up to 10.29 g/t Au over 0.91 m	42D15SW8353
1982	Micham Explorations Inc.	Magnetic and electromagnetic (VLF) surveys	No magnetic anomalies; several weak to moderate conductors	42D14SE1074
1983	Rose Resource Corp.	Magnetic and electromagnetic (VLF) surveys	10 EM conductors and no significant magnetic anomalies	42D15SE0128
1983	Wasabi Resources	Airborne magnetic and EM (VLF) survey	Identified 6 EM conductors	42D15SW0088
1983	Wasabi Resources	Ground proofing of airborne EM conductors	All 6 conductors sulfide iron formation with no Au values	42D15SW0066
1984	John Ferguson	Magnetic and electromagnetic surveys	No significant mag; 2 weak VLF anomalies	42D15SW0121
1984	Goldhurst Resources	Magnetic and electromagnetic surveys	No significant mag; 11 very weak EM conductors	42D15SW0116
1984	Goldhurst Resources	Drilling, 4 drill holes; total 305.1m (1001 feet)	Drill hole 84-04: 2.87 g/t Au over 2.44 m including 6.07g/t Au over 0.91m and 0.96g/t Au over 1.22m	42D15SW0118
1985	Micham Explorations Inc.	Mapping, trenching, sampling (58 rock samples)	Highest assay 13.54 g/t Au in quartz vein at N Siville showing outside of Jackfish claims	42D15SW0114
1985	Micham Explorations Inc.	Soil sampling (1521 samples)	Two anomalous areas: Empress structure W Siville showing; Mocan valley structure	42D15SW0115
1985	Micham Explorations Inc.	Diamond drilling 4 drill holes 482.9m (1584.2 ft)	Highest assays 1166 ppb Au over 1.52m; 1588 ppb Au over 1.83m, 44.23 g/t Au over 0.61 m	42D15SW0117
1986	John Ferguson	Stripping, de-watering, trenching; sampling	Highest assay 13.03 g/t Au; 4,075 g/t Ag	42D15SW0504
1986	John Ferguson	Magnetic and electromagnetic surveys	No significant results	42D15SW0111
1987	John Ferguson	Soil sampling	No significant results	42D15SW0106
1987	Forerunner Resources	Mapping, stripping, trenching, sampling	Highest assay 93.24 g/t Au; 109.03 g/t Ag; 1.2% Cu; 7.85% Pb	42D15SW0505
1987	Micham Explorations Inc.	Diamond drilling 10 drill holes 1674m	No assays recorded	42D15SW0109

Year	Company	Type of Work	Results	Assessment Report #
1988	Beardmore Resources	Trenching, soil sampling, bedrock sampling	Highest assays: 21.05 g/t Au plus 13.3 g/t Ag and 11.45 g/t Au plus 0.2 g/t Ag	42D15SW8353
1989	J.R. Hamel	Sampling	Highest assay 93.26 g/t Au, 82.79 g/t Ag	42D15SW0110
1991	J.R. Hamel	Stripping and sampling	Highest assay 21.05 g/t Au and 26.06g/t Ag	42D15SW0102
1992	Beavercreek Exploration (J.R. Hamel)	Drilling 2 drill holes 28.04 m (92 ft)	Highest assay 12.21 g/t Au over 1.52 m	42D15SW0002
1994	Beavercreek Exploration (J.R. Hamel)	Drilling 5 drill holes 45.1 m (148 ft)	Best result: 0.51 g/t Au over 3.05 m	42D15SW0001
1995	George Daniels et al.	Stripping, trenching, sampling, line cutting, VLF survey	16.39 g/t Au on claim #1207882 Santoy Lake; 15.77 g/t Au Syine Twp. Historic claim #1224852	42D15NW0009
1996	Big Lake Geological Consulting on behalf of J. Ferguson	Mapping, sampling	Highest assays from trench 14.3 g/t Au and 16.39 g/t Au	42D15NW0038
1996	George Daniels	Prospecting, stripping, trenching	Highest assays from trench 21.94 g/t Au	42D15NW0028
1996	Rudolph Wahl et al.,	Rock sampling (100 samples); soil sampling	No significant results	42D15SW0008
1997	Landis Mining Corp.	Evaluation of previous exploration activity in the area	20 lb composite grab sample: 22.97 g/t Au over 3.05 m from Empress structure	42D15SW2002
1998	George Daniels	Sampling	Highest assays from Jon's showing 1.45 g/t Au	42D15SW2003
1999	Cameco Gold Inc.	Line cutting; mag., IP; trenching; re-logging & re-sampling	DDH 441087-9: 8.07 g/t Au; 93.8 g/t Ag over 0.52 m; DDH 44184-7: 7.09 g/t Au; 19.8 g/t Ag over 1.4 m	42D15SW2010
2000	George Daniels	Trench cleaning, minor blasting	No results	42D15SW2013
2004	Brian Fowler	Line cutting; mag; prospecting, sampling (21)	Highest assay 324 ppb Au	42D15SW2024
2005	Phoenix Matachewan Mines	Prospecting sampling (19 rock samples)	Highest assay 262 ppb Au	20000001155
2007	Wayne Richards	Prospecting, mapping, stripping, sampling (4 samples)	No Au assays; two samples >100 g/t Ag	20000003831
2007	Alto Ventures Ltd.	Mapping, prospecting and sampling (47 rock samples)	Highest assay 2,278 ppb Au	20000002005
2008	Alto Ventures Ltd.	Drilling 2 drill holes 332 m on Empress structure	0.66 g/t Au over 2.3 m	20000003772
2009	Rudolph Wahl	Prospecting, mapping, sampling (22 samples)	No significant results	120000004525
2010	Galahad Metals	Soil sampling (619 samples), mapping trenching, sampling (89 samples)	26.8 g/t Au and 119 g/t Ag; 24.7 g/t Au and 40.4 g/t Ag at creek showing	20000005783
2010	Bond et al.	Prospecting, mapping, rock samples (63 samples) and lake sediment samples (7 samples)	309 and 459 ppb Au	20000006073
2010	Bond et al.	Drilling 2 holes 240 m	No significant results	20000006073
2012	Rudolph Wahl	Prospecting, mapping, sampling (30 samples)	1.9 g/t Au sample # 997103	20000007183
2012	Hamel et al.	Prospecting, mapping, sampling (11 samples), diamond drilling	No significant results	20000007081, 2.53866
2014	Alto Ventures Ltd.	Bedrock sampling (21 samples)	No significant results	20000008044





- Building
- ▣ Historical Workings
- ★ Mineralized Showings
- Hydro Line
- Railway
- Trails
- Roads
- Highway 17
- Watercourse
- Contour
- Jackfish Property
- ▨ Alto Ventures Ltd Cell Mining Claims
- ▨ Francine Richards Cell Mining Claims
- ▨ Kellyn Property Cell Mining Claims
- ▨ Rudy Wahl Cell Mining Claims
- ▨ Wayne Richards Cell Mining Claims
- ▨ Land Withdrawals
- ▨ Land Disposition
- Provincial Grid
- Waterbody

%

500 0 500 1000

Metres

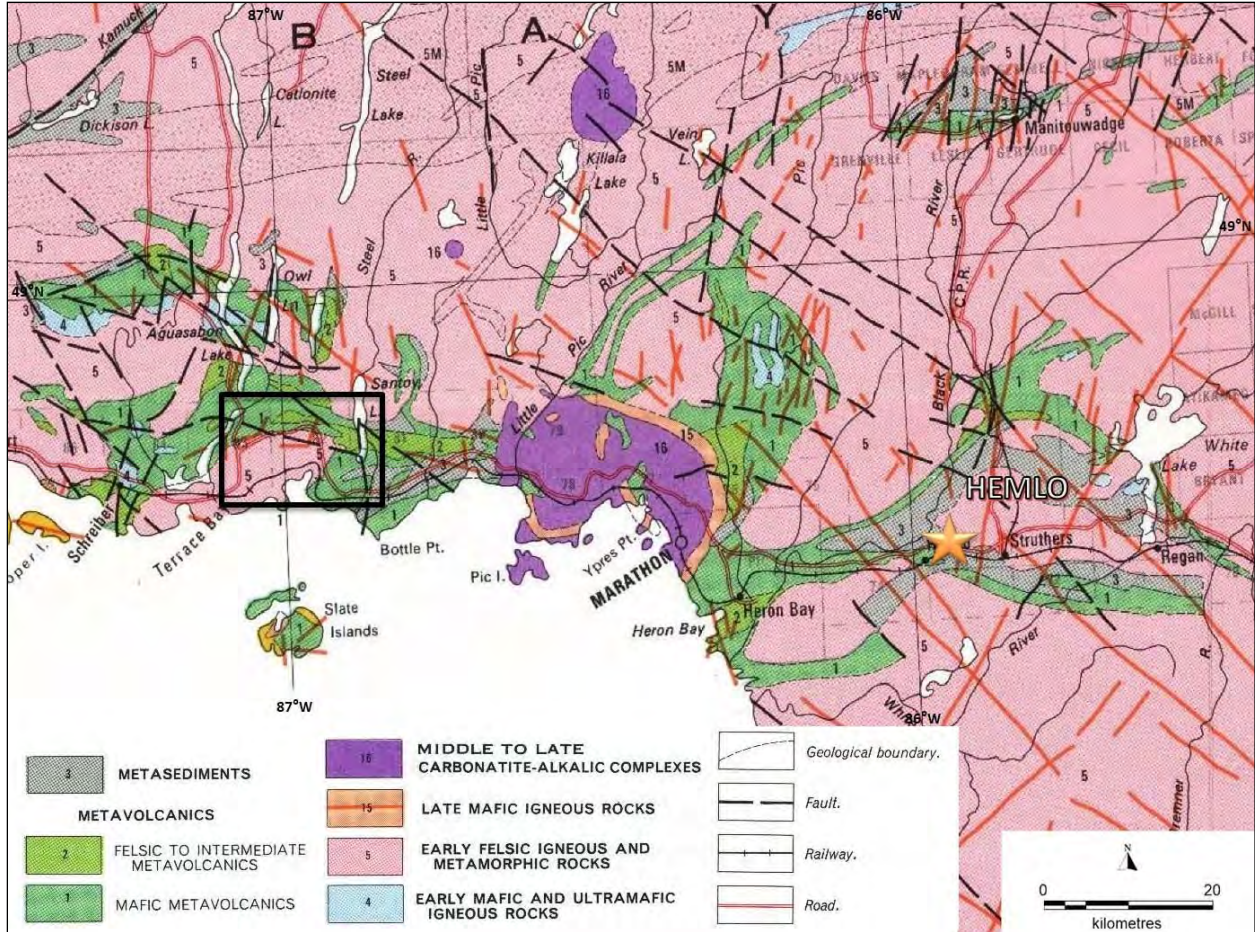
**Jackfish Property  
Report Figure 2**

**2017 Stereo Satellite Surveying  
Project Area, Mining Claims  
Ownership and Key Locations Map**

Author: T. Gill	Date: July 2019
Projection: UTM NAD83 Zone 16	Scale: 1 : 25 000
Mapsheet: NTS 042D15	District: Thunder Bay

## Regional Geological Setting

The property is located in the Wawa terrane of the Superior Province of the Canadian Shield, specifically the Schreiber-Hemlo greenstone belt (Figure 3). The greenstone belt in the region consists of metavolcanic and metasedimentary rocks into which the Terrace Bay pluton was emplaced.

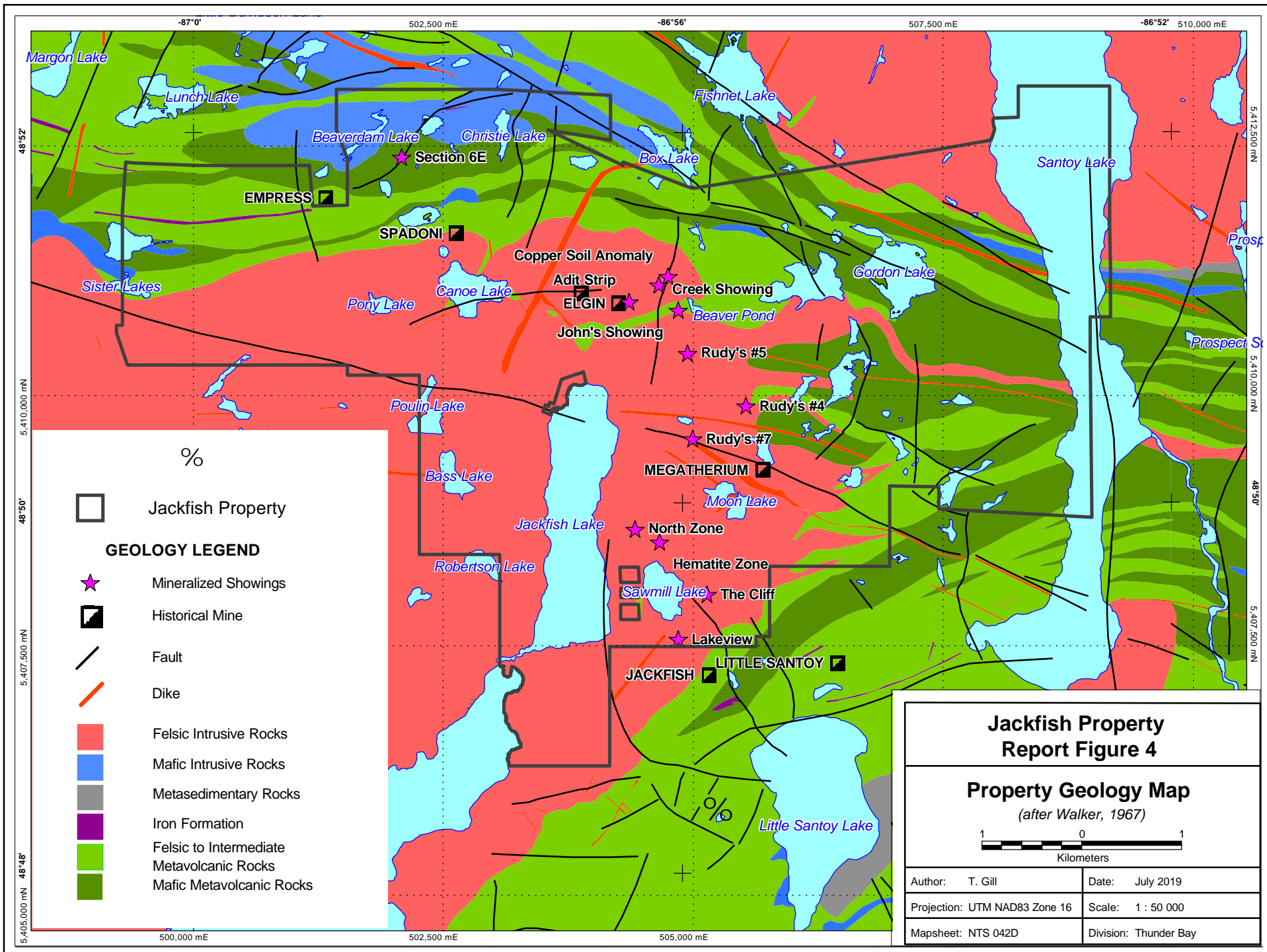


**Figure 3:** Regional Geological Setting Map (after Ayres et al, 1970).

## Property Geology and Mineralization

The Jackfish property straddles the eastern margin of the Terrace Bay Pluton where the granodiorite rocks of the intrusive come into contact with the folded and foliated supracrustal sequence of the Schreiber-Hemlo greenstone belt in a combination of an intrusive and structural setting. The various rock types that have been observed or interpreted to underlie the area are depicted on the property geology map in Figure 4.

Gold, silver and base metal mineralization is known to occur and has been mined historically from quartz-carbonate veins in three different settings across the region; as lenses or stringers within shear zones of the greenstone belt, as networks parallel to the contact between the pluton and supracrustal rocks and as fracture fill within the pluton. These styles of orogenic gold deposits are the key targets of focus for exploration activities on the Jackfish property. The more prominent historical workings and currently active mineralized showings are shown on Figure 4.



## **Exploration Work**

The field work component in preparation for the stereo satellite surveying project commenced on July 26, 2017 with the locating of four appropriately positioned roadside geodetic stations that would provide good ground reference for both location and elevation across the property area. Materials were purchased for the construction of large white crosses measuring at least three metres along both axes and placed over the geodetic station so that they would be recognizable in the satellite image (Figure 5). This work took four days to build the crosses and put them securely in place as well as accurately measure the distance above the geodetic station survey disc in order to account for this in the elevation calculation of the stereo satellite surveying project. The crosses were checked daily to ensure they were still in place and level until the day that the SPOT satellite photo was taken. After that a further two days was spent recovering the crosses and restoring the geodetic station sites and disposing of materials appropriately.

The data acquisition occurred on August 18, 2017. A description of the data processing methods and the production of deliverable products including the SPOT colour orthophoto, contour lines at 2m, 5m, 10m and 20m, a digital surface model(DSM) and a slope direction image is all provided in the Photosat Stereo Satellite Surveying Project Report (Appendix 2).

The data and report were received on September 1, 2017. Images of the data overlaid with key features of the Jackfish property are provided in Figures 5 - 7.

## **Interpretations**

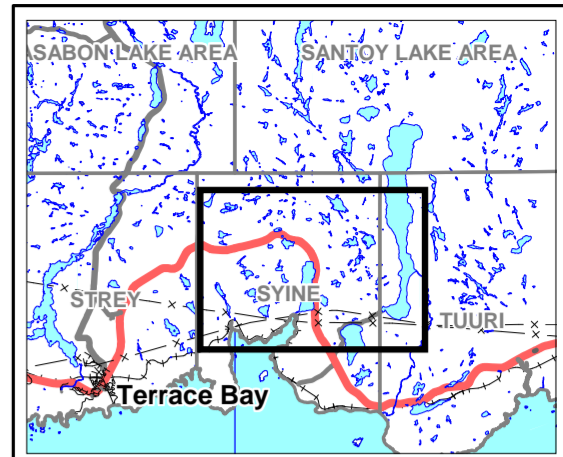
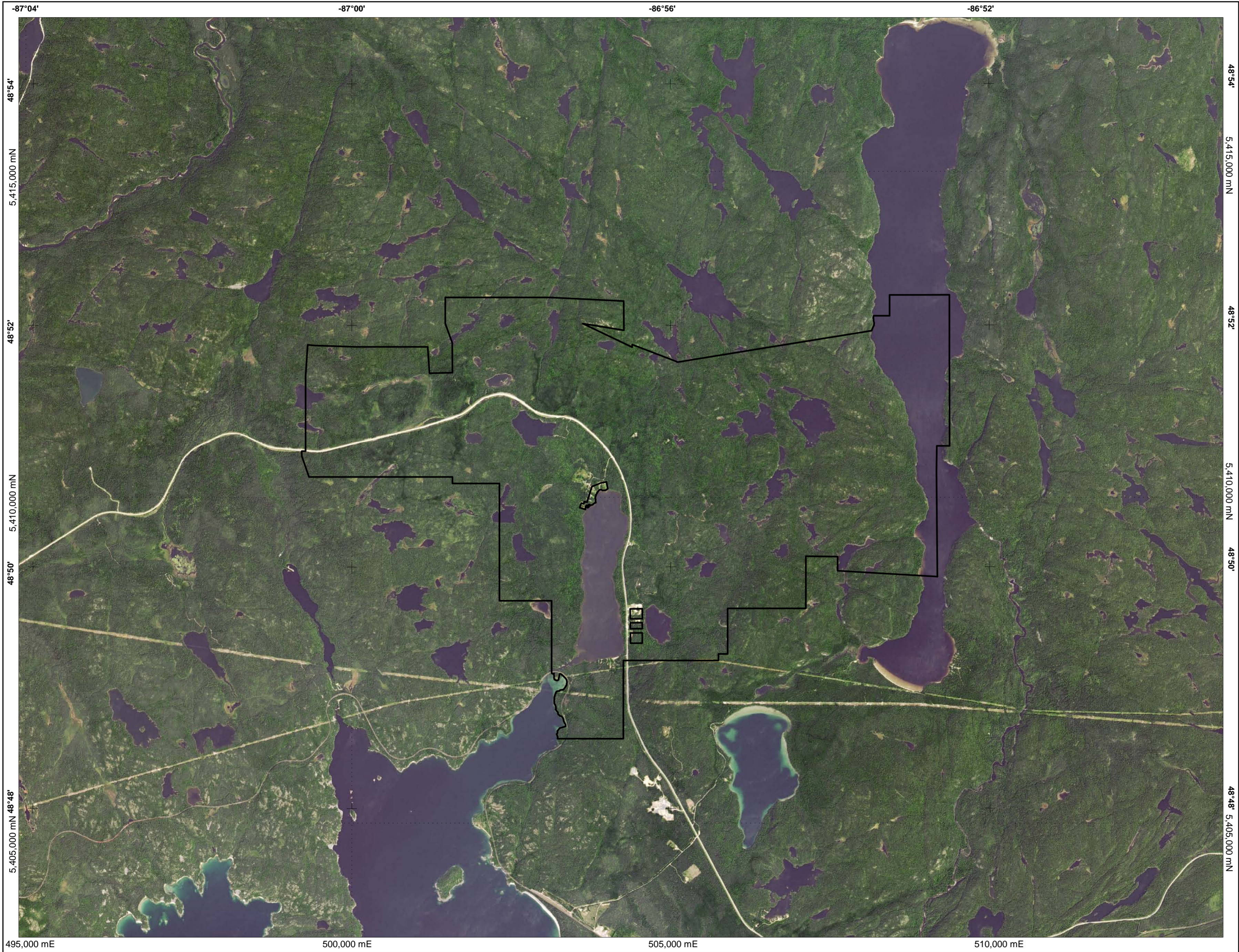
The purpose of the work was to provide a high resolution topographic base onto which field exploration data could be displayed and analyzed in three dimensional (“3D”) space to better understand the nature of gold and base metal mineralization within the Jackfish property, and the products delivered by the stereo satellite surveying project certainly fulfilled the purpose.

The orthophoto provided visual evidence on the ground of where mapped and interpreted structures cut through the stratigraphy. The DSM provided another dataset that could be interpreted for structure especially of features that weren’t highlighted in other datasets like magnetics for example. In another case, the DSM showed that the east-west oriented remnantly magnetized Keewenawen related dykes interpreted from airborne magnetics do not present a significant surficial footprint and are therefore either not significantly wide dykes or are “blind” and do not outcrop at surface.

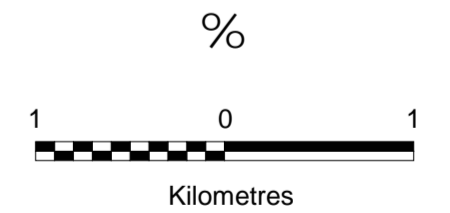
The slope direction image provides a graphical indication of the spatial distribution of dominant structural orientations in certain parts of the property and how the various directions interact. This was very useful when combined with other geological compilation studies that indicated gold mineralization occurs mostly at or near the intersection of northeast and northwest or more east-west lineaments.



**Figure 5: White crosses marking the four geodetic stations clockwise from the top left corner - 0011993U226, 0011993U367, 0011993U366 and 0011993U368.**



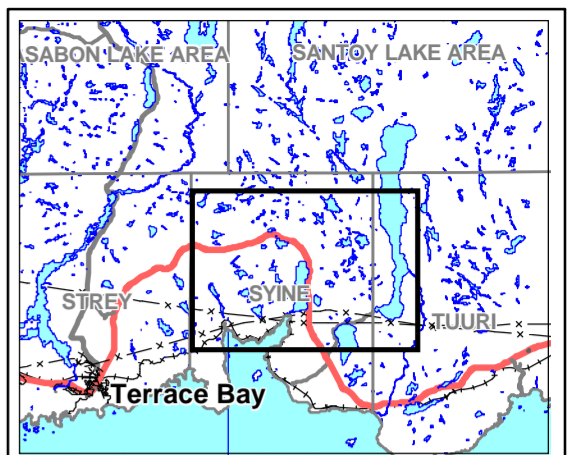
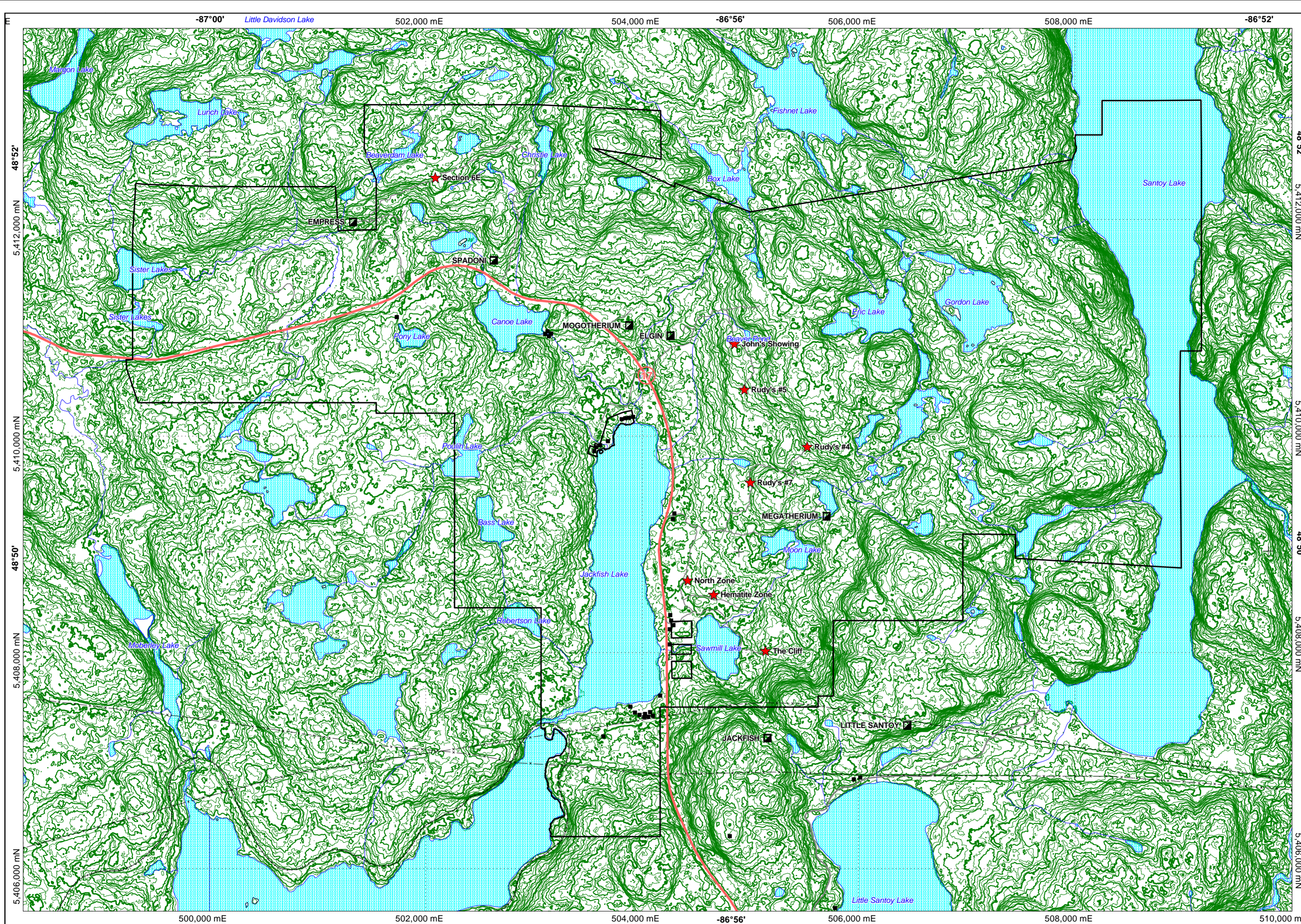
□ Jackfish Property



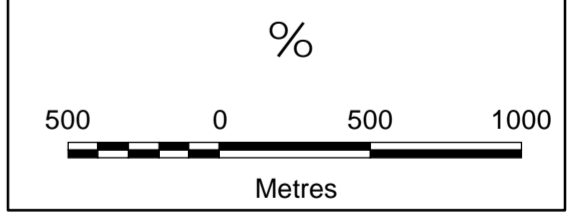
**Jackfish Property  
Report Figure 6**

**2017 Stereo Satellite Surveying  
SPOT 1.5m Orthophoto**

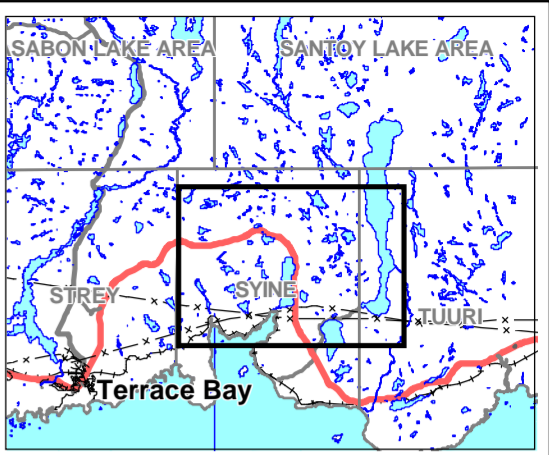
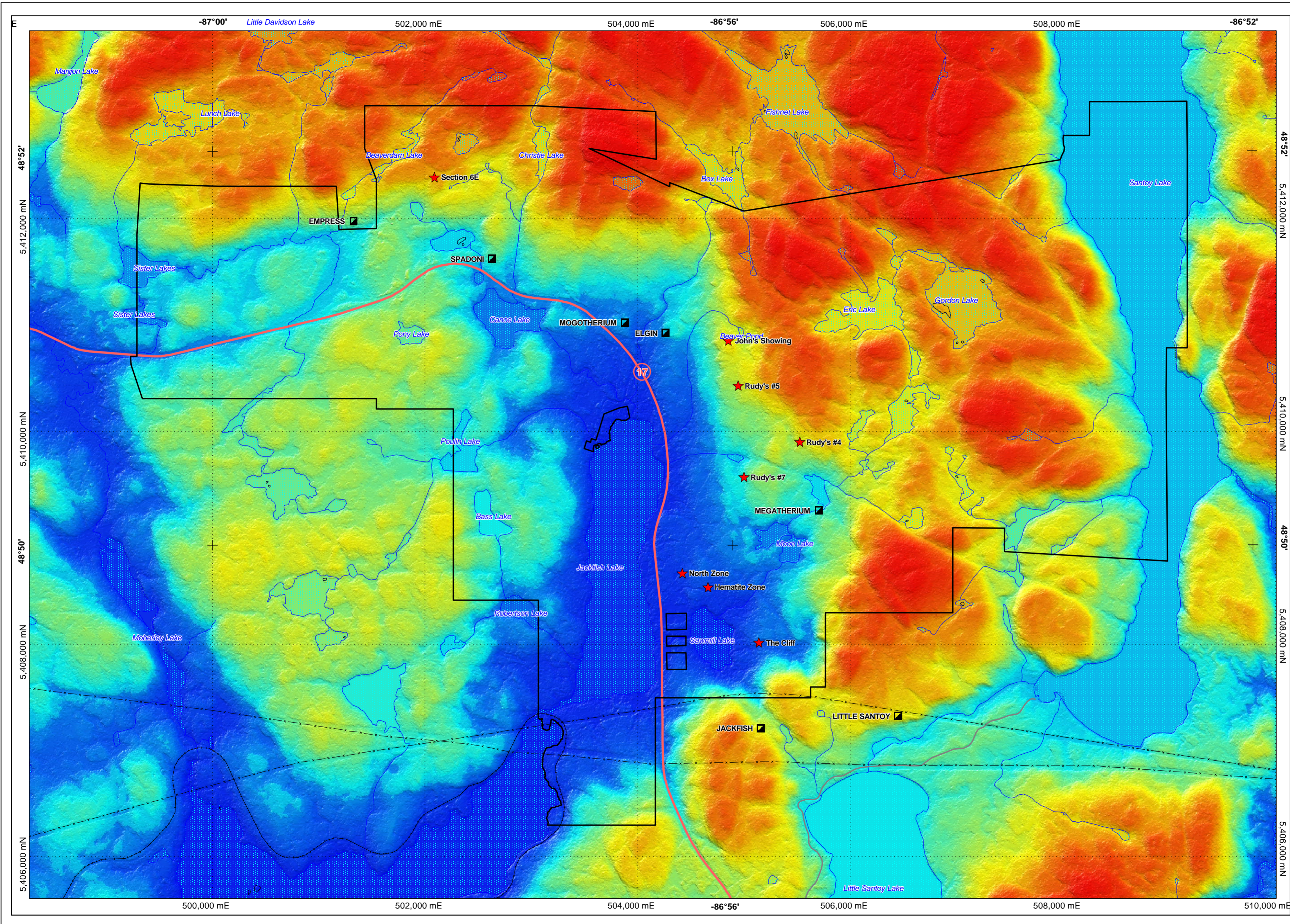
Author: T. Gill	Date: July 2019
Projection: UTM NAD83 Zone 16	Scale: 1 : 40 000
Mapsheet: NTS 042D15	District: Thunder Bay



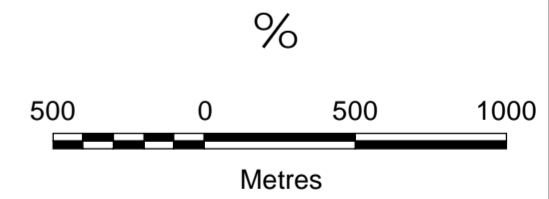
- Building
- ▣ Historical Workings
- ★ Mineralized Showings
- Hydro Line
- Railway
- Trails
- Roads
- Highway 17
- Watercourse
- 20m Contour
- 10m Contour
- 5m Contour
- Jackfish Property
- Waterbody



<b>Jackfish Property Report Figure 7</b>	
<b>2017 Stereo Satellite Surveying 5m, 10m and 20m Contours with Key Locations Map</b>	
Author: T. Gill	Date: July 2019
Projection: UTM NAD83 Zone 16	Scale: 1 : 25 000
Mapsheet: NTS 042D15	District: Thunder Bay



- Historical Workings
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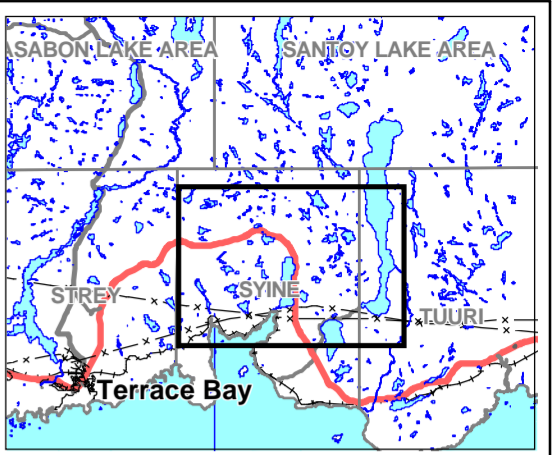
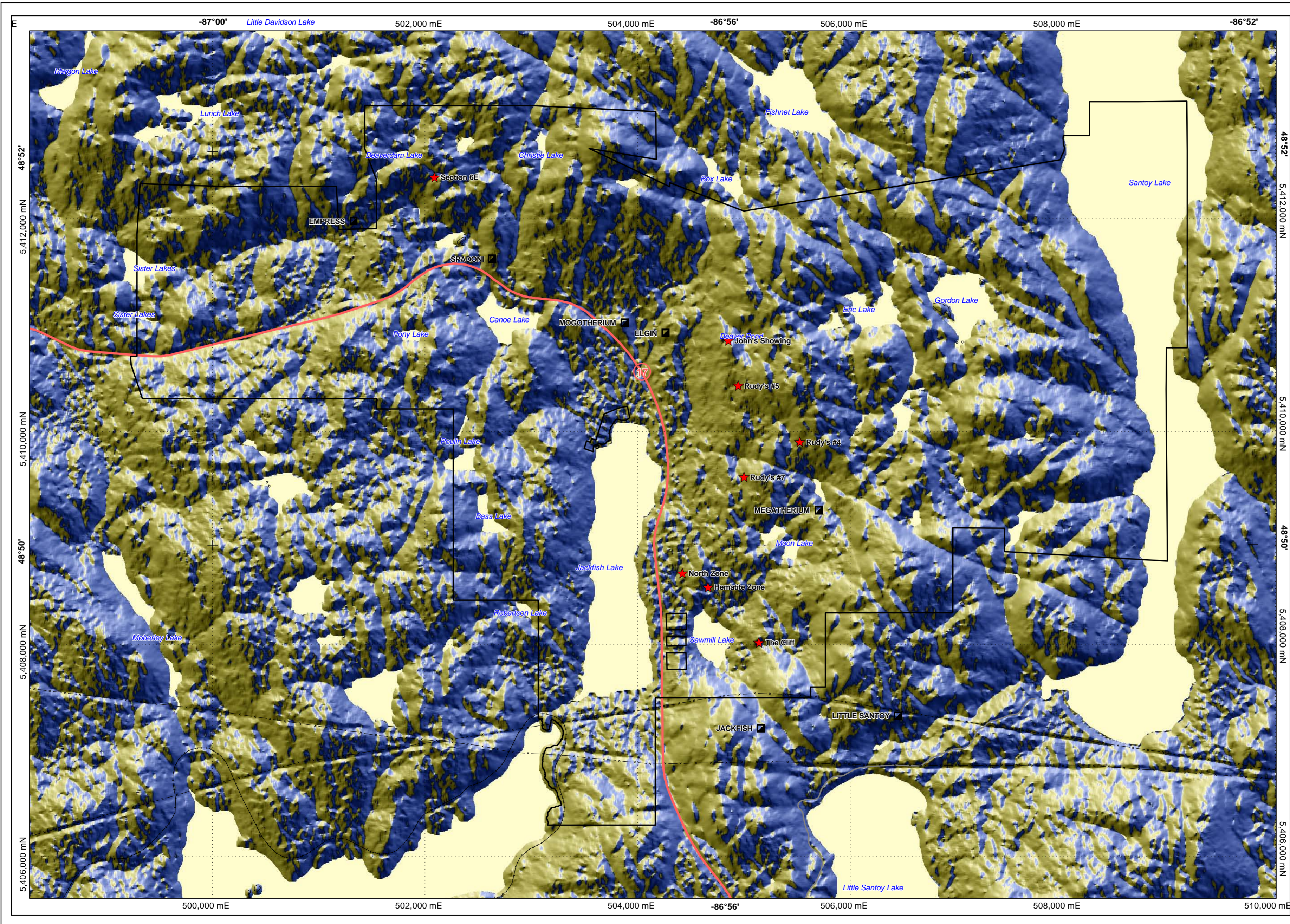


**Jackfish Property  
Report Figure 8**

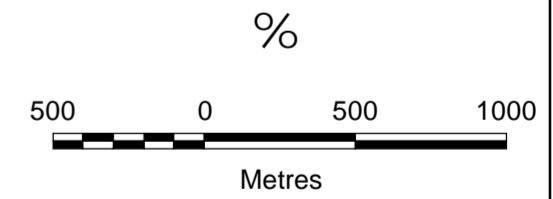
**2017 Stereo Satellite Surveying  
Colour Digital Surface Model  
with Key Locations Map**

Author: T. Gill	Date: July 2019
Projection: UTM NAD83 Zone 16	Scale: 1 : 25 000
Mapsheet: NTS 042D15	District: Thunder Bay





- Historical Workings
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<b>Jackfish Property Report Figure 9</b>	
<b>2017 Stereo Satellite Surveying Image of Slope Direction with Key Locations Map</b>	
Author: T. Gill	Date: July 2019
Projection: UTM NAD83 Zone 16	Scale: 1 : 25 000
Mapsheet: NTS 042D15	District: Thunder Bay

## **Conclusions and Recommendations**

The stereo satellite surveying project has provided a high resolution topographic base for planning, displaying and analyzing field exploration data on the Jackfish property. One thing that must be taken into account when using the DSM to plan drilling of subsurface targets with accuracy is that the DSM has calculated elevations for whatever was at surface. Therefore, in places where there is open ground, like lakes and fresh forestry cuts, the elevation is at the true ground level, however where there is thick forest the elevation is actually calculated at the tops of trees. This is why cultural features like Highway 17 and the hydro line right of ways stand out so much on the maps. It is recommended that an average height of trees in the target area be used to offset the elevation to accurately place drill collars.

Any new interpretations from the DSM and the slope direction image should be incorporated into the geological compilation model to see if any new ideas arise about the nature of gold and base metal mineralization around the Jackfish property. The SPOT orthophoto can be very simply used to identify current areas of bedrock exposure in the forest that can be prospected in the field at a future date.

## Cost Statement and Expenditure Distribution

The main cost involved for acquiring the DSM and other products was the stereo satellite surveying project by Photosat Information Ltd. This was paid on invoice (Appendix 2) as a total charge for performing the work. Support of the data acquisition was provided by Sanatana and involved the construction, monitoring and removal of the ground reference sites as described in this report, including travel, accommodation and meals for two personnel as per receipts (Appendix 2). All the costs are summarized in Table 2.

***Table 2: Stereo Satellite Surveying Project Summary Costs.***

<b>Item</b>	<b>Description</b>	<b>Cost</b>
Photosat Information Ltd.	All-inclusive price for Stereo Satellite Surveying Project	\$ 10,215
Troy Gill	Company fieldwork and supervision of the project 6 days @ \$500 per day.	\$ 3,000
Angus Gill	Field assistance to dismantle geodetic station markers 2 days @ \$100 per day.	\$ 200
Home Hardware, Terrace Bay	Materials for ground reference site cross construction, as receipted.	\$ 210
Cebrario's Hardware, Schreiber	Materials for ground reference site cross construction, as receipted.	\$ 36
Norwood Motel	9 nights room and board accommodation for Troy Gill @ \$75 per night.	\$ 675
Westjet Airlines	Air travel to and from the property for Troy Gill	\$ 1,382
Transport to and from Site	Truck from Thunder Bay to Terrace Bay return and daily to and from the field for a total 560km at \$0.45 per km.	\$ 252
Fuel		\$ 131
<b>Total</b>		<b>\$ 16,101</b>

Since the stereo satellite surveying project was conducted over all the cell mining claims of the Jackfish property equally, the expenditure has been distributed across all 223 cells of the Provincial Grid as a unit price of 1/223 of the total cost where:

- A single cell mining claim (122 total) receives one whole unit,
- A boundary cell mining claim around the perimeter of the property (48 total) receives one whole unit,
- A grid cell internal to the property containing two boundary cell mining claim (96 total) receives one half of a unit,
- A grid cell internal to the property shared by three boundary cell mining claims (15 total) receives one third of a unit,

approximately to the nearest whole dollar.

The distribution of expenditure across the cell mining claims by ownership is shown in Table 3.

**Table 3.1: Distribution of Expenditures across Alto Ventures Ltd. Cell Mining Claims.**

Tenure #	Grid Cell	Township	Title Type	Client ID	Holder	Survey	Labour	Materials	Transport & Accommodation	Total Expenditure
106904	42D15E289	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$23	\$8	\$1	\$6	\$37
115452	42D15E261	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$23	\$8	\$1	\$6	\$37
115453	42D15E301	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$12	\$5	\$0	\$5	\$22
115454	42D15E321	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$23	\$8	\$1	\$6	\$37
115455	42D15E248	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$23	\$8	\$1	\$6	\$37
128695	42D15E288	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$23	\$8	\$1	\$6	\$37
141887	42D15E249	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$23	\$8	\$1	\$6	\$37
151391	42D15E243	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
170146	42D15E304	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$23	\$8	\$1	\$6	\$37
192693	42D15E308	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$23	\$8	\$1	\$6	\$37
199402	42D15E287	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$23	\$8	\$1	\$6	\$37
199475	42D15E301	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$12	\$5	\$0	\$5	\$22
207415	42D14H339	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$23	\$8	\$1	\$6	\$37
207416	42D15E268	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$23	\$8	\$1	\$6	\$37
219595	42D15E244	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
226308	42D14H340	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$23	\$8	\$1	\$6	\$37
249402	42D15E309	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$23	\$8	\$1	\$6	\$37
255245	42D15E250	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$23	\$8	\$1	\$6	\$37
273426	42D14H260	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
273427	42D14H279	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
273428	42D15E281	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$23	\$8	\$1	\$6	\$37
273450	42D15E242	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
273505	42D15E302	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$23	\$8	\$1	\$6	\$37
285552	42D15E303	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$23	\$8	\$1	\$6	\$37
303927	42D15E305	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$23	\$8	\$1	\$6	\$37
303948	42D15E281	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$23	\$8	\$1	\$6	\$37
303967	42D15E307	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$12	\$5	\$1	\$5	\$22
320025	42D15E241	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$23	\$8	\$1	\$6	\$37
320039	42D15E261	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$23	\$8	\$1	\$6	\$37
322142	42D15E306	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$23	\$8	\$1	\$6	\$37
322147	42D14H259	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
322148	42D14H299	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
322149	42D14H319	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
322168	42D15E241	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$23	\$8	\$1	\$6	\$37
334328	42D15E228	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$23	\$8	\$1	\$6	\$37
338531	42D15E224	SYINE	BCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
115456	42D15E247	SYINE	SCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
115520	42D15E265	SYINE	SCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
147104	42D15E227	SYINE	SCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
147105	42D15E226	SYINE	SCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
147106	42D15E225	SYINE	SCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72

Tenure #	Grid Cell	Township	Title Type	Client ID	Holder	Survey	Labour	Materials	Transport & Accommodation	Total Expenditure
151374	42D15E284	SYINE	SCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
151376	42D14H280	SYINE	SCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
151377	42D14H320	SYINE	SCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
153574	42D15E283	SYINE	SCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
153587	42D15E245	SYINE	SCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
207434	42D15E262	SYINE	SCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
226307	42D14H300	SYINE	SCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
237195	42D15E229	SYINE	SCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
266020	42D15E263	SYINE	SCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
266048	42D15E264	SYINE	SCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
267851	42D15E230	SYINE	SCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
273425	42D15E286	SYINE	SCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
273429	42D15E267	SYINE	SCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
273430	42D15E266	SYINE	SCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
285551	42D15E285	SYINE	SCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
285570	42D15E282	SYINE	SCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
322150	42D15E246	SYINE	SCMC	302737	100% Alto Ventures Ltd.	\$46	\$14	\$1	\$11	\$72
			<b>Total</b>	<b>302737</b>	<b>100% Alto Ventures Ltd.</b>	<b>\$2,014</b>	<b>\$641</b>	<b>\$44</b>	<b>\$487</b>	<b>\$3,186</b>

**Table 3.2: Distribution of Expenditures across Francine Richards Cell Mining Claims.**

Tenure #	Grid Cell	Township	Title Type	Client ID	Holder	Survey	Labour	Materials	Transport & Accommodation	Total Expenditure
103758	42D15D016	SYINE	BCMC	412540	50% Francine Richards, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
123323	42D15D033	SYINE	BCMC	412540	50% Francine Richards, 50% Wayne Richards	\$23	\$8	\$2	\$6	\$38
161782	42D15E396	SYINE	BCMC	412540	50% Francine Richards, 50% Wayne Richards	\$23	\$8	\$2	\$6	\$38
216603	42D15E395	SYINE	BCMC	412540	50% Francine Richards, 50% Wayne Richards	\$23	\$8	\$2	\$6	\$38
235149	42D15E394	SYINE	BCMC	412540	50% Francine Richards, 50% Wayne Richards	\$23	\$8	\$2	\$6	\$38
236689	42D15D035	SYINE	BCMC	412540	50% Francine Richards, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
283111	42D15E393	SYINE	BCMC	412540	50% Francine Richards, 50% Wayne Richards	\$13	\$5	\$1	\$4	\$23
291176	42D15D013	SYINE	BCMC	412540	50% Francine Richards, 50% Wayne Richards	\$23	\$8	\$2	\$5	\$38
291177	42D15D034	SYINE	BCMC	412540	50% Francine Richards, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
342749	42D15D036	SYINE	BCMC	412540	50% Francine Richards, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
187308	42D15D015	SYINE	SCMC	412540	50% Francine Richards, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
330380	42D15D014	SYINE	SCMC	412540	50% Francine Richards, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
			<b>Total</b>	<b>412540</b>	<b>50% Francine Richards, 50% Wayne Richards</b>	<b>\$404</b>	<b>\$129</b>	<b>\$15</b>	<b>\$97</b>	<b>\$645</b>

**Table 3.3: Distribution of Expenditures across Kellyn Property Cell Mining Claims.**

Tenure #	Grid Cell	Township	Title Type	Client ID	Holder	Survey	Labour	Materials	Transport & Accommodation	Total Expenditure
106821	42D15E331	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
113704	42D15E287	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
131247	42D15E277	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
132007	42D15E369	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
132008	42D15E367	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
140333	42D15E332	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
140621	42D15E288	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
146569	42D15E248	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
160107	42D15E249	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
161379	42D15E228	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
204730	42D15E308	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
204731	42D15E370	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$13	\$5	\$0	\$4	\$22
212416	42D15E333	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$13	\$5	\$0	\$4	\$22
213267	42D15E268	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
215517	42D15E297	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
216839	42D15E327	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
233456	42D15E350	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
238532	42D15E309	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
249230	42D15E317	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
251343	42D15E307	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$13	\$5	\$1	\$4	\$22
251344	42D15E368	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
252840	42D15E330	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
261977	42D15E336	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
269425	42D15E257	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
270724	42D15E347	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
308394	42D15E335	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
309702	42D15E250	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
309858	42D15E337	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
315079	42D15E334	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$6	\$36
324730	42D15E289	SYINE	BCMC	141000	50% James Hamel, 50% Wayne Richards	\$23	\$7	\$1	\$5	\$36
106235	42D15E255	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
106254	42D15E295	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
106255	42D15E294	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
122023	42D15E311	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
134841	42D15E271	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
140620	42D15E269	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
145785	42D15E312	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
147081	42D15E251	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
147316	42D15E276	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
150795	42D15E253	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
150796	42D15E273	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72

Tenure #	Grid Cell	Township	Title Type	Client ID	Holder	Survey	Labour	Materials	Transport & Accommodation	Total Expenditure
150797	42D15E272	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
161186	42D15E270	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
195984	42D15E296	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
196724	42D15E349	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
216840	42D15E348	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
233320	42D15E290	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
234625	42D15E274	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
234626	42D15E292	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
238533	42D15E329	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
249123	42D15E314	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
249231	42D15E316	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
269426	42D15E256	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
281329	42D15E291	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
318736	42D15E310	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
319514	42D15E275	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
327794	42D15E315	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
332816	42D15E328	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
336508	42D15E313	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
341575	42D15E254	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
341576	42D15E293	SYINE	SCMC	141000	50% James Hamel, 50% Wayne Richards	\$46	\$14	\$1	\$11	\$72
			<b>Total</b>	<b>141000</b>	<b>50% James Hamel, 50% Wayne Richards</b>	<b>\$2,086</b>	<b>\$638</b>	<b>\$46</b>	<b>\$500</b>	<b>\$3,270</b>



**Table 3.4: Distribution of Expenditures across Rudy Wahl Cell Mining Claims.**

Tenure #	Grid Cell	Township	Title Type	Client ID	Holder	Survey	Labour	Materials	Transport & Accommodation	Total Expenditure
130628	42D15E391	SYINE	BCMC	206079	100% Rudolf Wahl	\$23	\$8	\$1	\$6	\$37
160743	42D15E333	SYINE	BCMC	206079	100% Rudolf Wahl	\$13	\$5	\$0	\$4	\$22
166072	42D15E393	SYINE	BCMC	206079	100% Rudolf Wahl	\$13	\$5	\$0	\$4	\$22
195337	42D15E331	SYINE	BCMC	206079	100% Rudolf Wahl	\$23	\$8	\$1	\$6	\$37
225461	42D15E332	SYINE	BCMC	206079	100% Rudolf Wahl	\$23	\$8	\$1	\$6	\$37
225462	42D15E330	SYINE	BCMC	206079	100% Rudolf Wahl	\$23	\$8	\$1	\$6	\$37
225463	42D15E353	SYINE	BCMC	206079	100% Rudolf Wahl	\$23	\$8	\$1	\$6	\$37
261360	42D15E373	SYINE	BCMC	206079	100% Rudolf Wahl	\$23	\$8	\$1	\$6	\$37
268806	42D15E370	SYINE	BCMC	206079	100% Rudolf Wahl	\$13	\$5	\$1	\$5	\$23
268807	42D15E392	SYINE	BCMC	206079	100% Rudolf Wahl	\$23	\$8	\$1	\$6	\$37
315967	42D15E390	SYINE	BCMC	206079	100% Rudolf Wahl	\$23	\$8	\$1	\$6	\$37
332243	42D15E350	SYINE	BCMC	206079	100% Rudolf Wahl	\$23	\$8	\$1	\$5	\$37
160744	42D15E351	SYINE	SCMC	206079	100% Rudolf Wahl	\$46	\$15	\$1	\$11	\$73
309242	42D15E352	SYINE	SCMC	206079	100% Rudolf Wahl	\$46	\$15	\$1	\$11	\$73
309243	42D15E371	SYINE	SCMC	206079	100% Rudolf Wahl	\$46	\$15	\$1	\$11	\$73
332244	42D15E372	SYINE	SCMC	206079	100% Rudolf Wahl	\$46	\$15	\$1	\$11	\$73
			<b>Total</b>	<b>206079</b>	<b>100% Rudolf Wahl</b>	<b>\$430</b>	<b>\$147</b>	<b>\$10</b>	<b>\$105</b>	<b>\$692</b>

**Table 3.5: Distribution of Expenditures across Wayne Richards Cell Mining Claims.**

Tenure #	Grid Cell	Township	Title Type	Client ID	Holder	Survey	Labour	Materials	Transport & Accommodation	Total Expenditure
115450	42D15E302	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
118022	42D15E277	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
127475	42D15E392	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
127476	42D15D071	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
133940	42D15E336	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
135887	42D15E370	SYINE	BCMC	303657	100% Wayne Richards	\$12	\$5	\$0	\$4	\$21
141846	42D15D047	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
144970	42D15E390	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
144972	42D15D073	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
148939	42D15D067	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
148940	42D15D110	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
149370	42D15E334	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
149372	42D15E396	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
149373	42D15E394	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
151375	42D14H339	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
154106	42D15E306	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
168728	42D15E333	SYINE	BCMC	303657	100% Wayne Richards	\$12	\$5	\$0	\$4	\$21
170147	42D15E321	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
170176	42D15E305	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
170591	42D15E368	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
177518	42D15D087	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
182496	42D15E317	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
184891	42D15D109	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
195023	42D15E367	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
195024	42D15D005	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
197483	42D15E335	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
203647	42D15D072	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
207414	42D15E301	SYINE	BCMC	303657	100% Wayne Richards	\$12	\$5	\$0	\$4	\$21
210519	42D15E257	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
219527	42D14H359	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
219786	42D15D017	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
228824	42D15E391	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
230080	42D15E347	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
230081	42D15D025	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
247681	42D15E393	SYINE	BCMC	303657	100% Wayne Richards	\$12	\$5	\$0	\$4	\$21
247684	42D15D053	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
251692	42D15D090	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
263695	42D15D108	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
265609	42D15E297	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
265611	42D15E337	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
267329	42D15E369	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37

Tenure #	Grid Cell	Township	Title Type	Client ID	Holder	Survey	Labour	Materials	Transport & Accommodation	Total Expenditure
284117	42D15E395	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
285553	42D15E304	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
285554	42D15E341	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
285555	42D14H360	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
293838	42D15E397	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
294831	42D15D070	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
303961	42D15E307	SYINE	BCMC	303657	100% Wayne Richards	\$12	\$5	\$1	\$3	\$21
303962	42D15E327	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
307523	42D15D033	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
309466	42D15E385	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
309467	42D15D026	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
316215	42D15D027	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
318584	42D15E353	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
320023	42D15E303	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
320731	42D15E373	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
322145	42D14H340	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
322146	42D15E344	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
334168	42D15E343	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
334169	42D15E342	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
335121	42D15D013	SYINE	BCMC	303657	100% Wayne Richards	\$23	\$8	\$1	\$5	\$37
337090	42D15E345	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
337091	42D15E365	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
339099	42D15D107	SYINE	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
113125	42D15D028	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
133941	42D15E355	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
135888	42D15E388	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
135889	42D15D009	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
139528	42D15D052	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
144971	42D15D012	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
146935	42D15D006	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
149371	42D15E376	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
154107	42D15E325	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
155428	42D15D008	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
171055	42D15E377	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
191502	42D15D050	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
193480	42D15E346	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
200551	42D15E389	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
205496	42D15E356	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
205497	42D15E374	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
210289	42D15D031	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
217618	42D15E354	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
220141	42D15D029	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
226334	42D15E326	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
237151	42D15D048	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
240191	42D15D051	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72

Tenure #	Grid Cell	Township	Title Type	Client ID	Holder	Survey	Labour	Materials	Transport & Accommodation	Total Expenditure
247682	42D15D010	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
247683	42D15D030	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
251693	42D15D089	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
280193	42D15D068	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
287027	42D15E357	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
288739	42D15E366	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
294830	42D15D011	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
296769	42D15D007	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
300247	42D15D088	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
303928	42D15E322	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
307524	42D15D032	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
311166	42D15D049	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
316214	42D15E386	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
318223	42D15D069	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
320730	42D15E375	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
322143	42D15E324	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
322144	42D15E323	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
337092	42D15E387	SYINE	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
103107	42D15E400	TUURI	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
154428	42D15E380	TUURI	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
171056	42D15D019	TUURI	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
173783	42D15D020	TUURI	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
188425	42D15E340	TUURI	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
189822	42D15D018	TUURI	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
219785	42D15E360	TUURI	BCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
102707	42D15E320	TUURI	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
102708	42D15E319	TUURI	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
102709	42D15E318	TUURI	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
103106	42D15E358	TUURI	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
109964	42D15E239	TUURI	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
118021	42D15E279	TUURI	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
153055	42D15E299	TUURI	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
154429	42D15E398	TUURI	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
172982	42D15E259	TUURI	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
172983	42D15E258	TUURI	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
191037	42D15E260	TUURI	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
207640	42D15E278	TUURI	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
210518	42D15E240	TUURI	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
218383	42D15E298	TUURI	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
225820	42D15E300	TUURI	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
225821	42D15E338	TUURI	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
227724	42D15E378	TUURI	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
259258	42D15E238	TUURI	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
265608	42D15E280	TUURI	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
265610	42D15E339	TUURI	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72

Tenure #	Grid Cell	Township	Title Type	Client ID	Holder	Survey	Labour	Materials	Transport & Accommodation	Total Expenditure
274944	42D15E399	TUURI	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
323046	42D15E359	TUURI	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
323047	42D15E379	TUURI	SCMC	303657	100% Wayne Richards	\$46	\$14	\$1	\$11	\$72
			<b>Total</b>	<b>303657</b>	<b>100% Wayne Richards</b>	<b>\$5,281</b>	<b>\$1,645</b>	<b>\$131</b>	<b>\$1,251</b>	<b>\$8,308</b>

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## Statement of Qualifications

### Troy Gill

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Telephone: 604-762-0380

Email: troy@sanatanaresources.com

I, Troy Gill, do hereby certify that:

1. I am employed as Exploration Manager for Sanatana Resources Inc.
2. I am responsible for the Report titled "Assessment Report on a Stereo Satellite Surveying Project on the Jackfish Property, Syine Township, Thunder Bay Mining Division, District of Thunder Bay, Ontario, NTS 42D15" dated July 24, 2019, and prepared for Sanatana Resources Inc.
3. I hold the following academic qualifications: B.Sc. Geology (1993), University of Wollongong, NSW, Australia.
4. I am a member in good standing of the Australian Institute of Geoscientists (MAIG).
5. I have worked on a range of commodities including Au, Cu, Ni, diamonds, coal and iron ore in various geological settings in Australia and Canada since 1993.
6. This Report is compiled from data collected by or on behalf of Sanatana Resources Inc. in 2017. I conducted fieldwork, supervised the data acquisition and provided the data interpretation associated with this report.

Dated this 24th Day of July, 2019.



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Troy Gill, B.Sc., MAIG.

Exploration Manager, Sanatana Resources Inc.

**Appendix 1:** Jackfish Property Cell Mining Claims

Tenure #	Township	Grid Cell	Type	Client ID	Holder
106904	Syine	42D15E289	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
115452	Syine	42D15E261	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
115453	Syine	42D15E301	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
115454	Syine	42D15E321	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
115455	Syine	42D15E248	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
115456	Syine	42D15E247	Single Cell Mining Claim	302737	100% Alto Ventures Ltd.
115520	Syine	42D15E265	Single Cell Mining Claim	302737	100% Alto Ventures Ltd.
128695	Syine	42D15E288	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
141887	Syine	42D15E249	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
147104	Syine	42D15E227	Single Cell Mining Claim	302737	100% Alto Ventures Ltd.
147105	Syine	42D15E226	Single Cell Mining Claim	302737	100% Alto Ventures Ltd.
147106	Syine	42D15E225	Single Cell Mining Claim	302737	100% Alto Ventures Ltd.
151374	Syine	42D15E284	Single Cell Mining Claim	302737	100% Alto Ventures Ltd.
151376	Syine	42D14H280	Single Cell Mining Claim	302737	100% Alto Ventures Ltd.
151377	Syine	42D14H320	Single Cell Mining Claim	302737	100% Alto Ventures Ltd.
151391	Syine	42D15E243	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
153574	Syine	42D15E283	Single Cell Mining Claim	302737	100% Alto Ventures Ltd.
153587	Syine	42D15E245	Single Cell Mining Claim	302737	100% Alto Ventures Ltd.
170146	Syine	42D15E304	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
192693	Syine	42D15E308	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
199402	Syine	42D15E287	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
199475	Syine	42D15E301	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
207415	Syine	42D14H339	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
207416	Syine	42D15E268	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
207434	Syine	42D15E262	Single Cell Mining Claim	302737	100% Alto Ventures Ltd.
219595	Syine	42D15E244	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
226307	Syine	42D14H300	Single Cell Mining Claim	302737	100% Alto Ventures Ltd.
226308	Syine	42D14H340	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
237195	Syine	42D15E229	Single Cell Mining Claim	302737	100% Alto Ventures Ltd.
249402	Syine	42D15E309	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
255245	Syine	42D15E250	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
266020	Syine	42D15E263	Single Cell Mining Claim	302737	100% Alto Ventures Ltd.
266048	Syine	42D15E264	Single Cell Mining Claim	302737	100% Alto Ventures Ltd.
267851	Syine	42D15E230	Single Cell Mining Claim	302737	100% Alto Ventures Ltd.
273425	Syine	42D15E286	Single Cell Mining Claim	302737	100% Alto Ventures Ltd.
273426	Syine	42D14H260	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
273427	Syine	42D14H279	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
273428	Syine	42D15E281	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
273429	Syine	42D15E267	Single Cell Mining Claim	302737	100% Alto Ventures Ltd.
273430	Syine	42D15E266	Single Cell Mining Claim	302737	100% Alto Ventures Ltd.
273450	Syine	42D15E242	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
273505	Syine	42D15E302	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
285551	Syine	42D15E285	Single Cell Mining Claim	302737	100% Alto Ventures Ltd.
285552	Syine	42D15E303	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
285570	Syine	42D15E282	Single Cell Mining Claim	302737	100% Alto Ventures Ltd.
303927	Syine	42D15E305	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
303948	Syine	42D15E281	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
303967	Syine	42D15E307	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
320025	Syine	42D15E241	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
320039	Syine	42D15E261	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
322142	Syine	42D15E306	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
322147	Syine	42D14H259	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
322148	Syine	42D14H299	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
322149	Syine	42D14H319	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
322150	Syine	42D15E246	Single Cell Mining Claim	302737	100% Alto Ventures Ltd.
322168	Syine	42D15E241	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
334328	Syine	42D15E228	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
338531	Syine	42D15E224	Boundary Cell Mining Claim	302737	100% Alto Ventures Ltd.
103758	Syine	42D15D016	Boundary Cell Mining Claim	412540, 303657	50% Francine Richards, 50% Wayne Richards
123323	Syine	42D15D033	Boundary Cell Mining Claim	412540, 303657	50% Francine Richards, 50% Wayne Richards
161782	Syine	42D15E396	Boundary Cell Mining Claim	412540, 303657	50% Francine Richards, 50% Wayne Richards
187308	Syine	42D15D015	Single Cell Mining Claim	412540, 303657	50% Francine Richards, 50% Wayne Richards
216603	Syine	42D15E395	Boundary Cell Mining Claim	412540, 303657	50% Francine Richards, 50% Wayne Richards
235149	Syine	42D15E394	Boundary Cell Mining Claim	412540, 303657	50% Francine Richards, 50% Wayne Richards
236689	Syine	42D15D035	Boundary Cell Mining Claim	412540, 303657	50% Francine Richards, 50% Wayne Richards

Tenure #	Township	Grid Cell	Type	Client ID	Holder
283111	Syine	42D15E393	Boundary Cell Mining Claim	412540, 303657	50% Francine Richards, 50% Wayne Richards
291176	Syine	42D15D013	Boundary Cell Mining Claim	412540, 303657	50% Francine Richards, 50% Wayne Richards
291177	Syine	42D15D034	Boundary Cell Mining Claim	412540, 303657	50% Francine Richards, 50% Wayne Richards
330380	Syine	42D15D014	Single Cell Mining Claim	412540, 303657	50% Francine Richards, 50% Wayne Richards
342749	Syine	42D15D036	Boundary Cell Mining Claim	412540, 303657	50% Francine Richards, 50% Wayne Richards
130628	Syine	42D15E391	Boundary Cell Mining Claim	206079	100% Rudolf Wahl
160743	Syine	42D15E333	Boundary Cell Mining Claim	206079	100% Rudolf Wahl
160744	Syine	42D15E351	Single Cell Mining Claim	206079	100% Rudolf Wahl
166072	Syine	42D15E393	Boundary Cell Mining Claim	206079	100% Rudolf Wahl
195337	Syine	42D15E331	Boundary Cell Mining Claim	206079	100% Rudolf Wahl
225461	Syine	42D15E332	Boundary Cell Mining Claim	206079	100% Rudolf Wahl
225462	Syine	42D15E330	Boundary Cell Mining Claim	206079	100% Rudolf Wahl
225463	Syine	42D15E353	Boundary Cell Mining Claim	206079	100% Rudolf Wahl
261360	Syine	42D15E373	Boundary Cell Mining Claim	206079	100% Rudolf Wahl
268806	Syine	42D15E370	Boundary Cell Mining Claim	206079	100% Rudolf Wahl
268807	Syine	42D15E392	Boundary Cell Mining Claim	206079	100% Rudolf Wahl
309242	Syine	42D15E352	Single Cell Mining Claim	206079	100% Rudolf Wahl
309243	Syine	42D15E371	Single Cell Mining Claim	206079	100% Rudolf Wahl
315967	Syine	42D15E390	Boundary Cell Mining Claim	206079	100% Rudolf Wahl
332243	Syine	42D15E350	Boundary Cell Mining Claim	206079	100% Rudolf Wahl
332244	Syine	42D15E372	Single Cell Mining Claim	206079	100% Rudolf Wahl
102707	Tuuri	42D15E320	Single Cell Mining Claim	303657	100% Wayne Richards
102708	Tuuri	42D15E319	Single Cell Mining Claim	303657	100% Wayne Richards
102709	Tuuri	42D15E318	Single Cell Mining Claim	303657	100% Wayne Richards
103106	Tuuri	42D15E358	Single Cell Mining Claim	303657	100% Wayne Richards
103107	Tuuri	42D15E400	Boundary Cell Mining Claim	303657	100% Wayne Richards
109964	Tuuri	42D15E239	Single Cell Mining Claim	303657	100% Wayne Richards
113125	Syine	42D15D028	Single Cell Mining Claim	303657	100% Wayne Richards
115450	Syine	42D15E302	Boundary Cell Mining Claim	303657	100% Wayne Richards
118021	Tuuri	42D15E279	Single Cell Mining Claim	303657	100% Wayne Richards
118022	Syine	42D15E277	Boundary Cell Mining Claim	303657	100% Wayne Richards
127475	Syine	42D15E392	Boundary Cell Mining Claim	303657	100% Wayne Richards
127476	Syine	42D15D071	Boundary Cell Mining Claim	303657	100% Wayne Richards
133940	Syine	42D15E336	Boundary Cell Mining Claim	303657	100% Wayne Richards
133941	Syine	42D15E355	Single Cell Mining Claim	303657	100% Wayne Richards
135887	Syine	42D15E370	Boundary Cell Mining Claim	303657	100% Wayne Richards
135888	Syine	42D15E388	Single Cell Mining Claim	303657	100% Wayne Richards
135889	Syine	42D15D009	Single Cell Mining Claim	303657	100% Wayne Richards
139528	Syine	42D15D052	Single Cell Mining Claim	303657	100% Wayne Richards
141846	Syine	42D15D047	Boundary Cell Mining Claim	303657	100% Wayne Richards
144970	Syine	42D15E390	Boundary Cell Mining Claim	303657	100% Wayne Richards
144971	Syine	42D15D012	Single Cell Mining Claim	303657	100% Wayne Richards
144972	Syine	42D15D073	Boundary Cell Mining Claim	303657	100% Wayne Richards
146935	Syine	42D15D006	Single Cell Mining Claim	303657	100% Wayne Richards
148939	Syine	42D15D067	Boundary Cell Mining Claim	303657	100% Wayne Richards
148940	Syine	42D15D110	Boundary Cell Mining Claim	303657	100% Wayne Richards
149370	Syine	42D15E334	Boundary Cell Mining Claim	303657	100% Wayne Richards
149371	Syine	42D15E376	Single Cell Mining Claim	303657	100% Wayne Richards
149372	Syine	42D15E396	Boundary Cell Mining Claim	303657	100% Wayne Richards
149373	Syine	42D15E394	Boundary Cell Mining Claim	303657	100% Wayne Richards
151375	Syine	42D14H339	Boundary Cell Mining Claim	303657	100% Wayne Richards
153055	Tuuri	42D15E299	Single Cell Mining Claim	303657	100% Wayne Richards
154106	Syine	42D15E306	Boundary Cell Mining Claim	303657	100% Wayne Richards
154107	Syine	42D15E325	Single Cell Mining Claim	303657	100% Wayne Richards
154428	Tuuri	42D15E380	Boundary Cell Mining Claim	303657	100% Wayne Richards
154429	Tuuri	42D15E398	Single Cell Mining Claim	303657	100% Wayne Richards
155428	Syine	42D15D008	Single Cell Mining Claim	303657	100% Wayne Richards
168728	Syine	42D15E333	Boundary Cell Mining Claim	303657	100% Wayne Richards
170147	Syine	42D15E321	Boundary Cell Mining Claim	303657	100% Wayne Richards
170176	Syine	42D15E305	Boundary Cell Mining Claim	303657	100% Wayne Richards
170591	Syine	42D15E368	Boundary Cell Mining Claim	303657	100% Wayne Richards
171055	Syine	42D15E377	Single Cell Mining Claim	303657	100% Wayne Richards
171056	Tuuri	42D15D019	Boundary Cell Mining Claim	303657	100% Wayne Richards
172982	Tuuri	42D15E259	Single Cell Mining Claim	303657	100% Wayne Richards
172983	Tuuri	42D15E258	Single Cell Mining Claim	303657	100% Wayne Richards

Tenure #	Township	Grid Cell	Type	Client ID	Holder
173783	Tuuri	42D15D020	Boundary Cell Mining Claim	303657	100% Wayne Richards
177518	Syine	42D15D087	Boundary Cell Mining Claim	303657	100% Wayne Richards
182496	Syine	42D15E317	Boundary Cell Mining Claim	303657	100% Wayne Richards
184891	Syine	42D15D109	Boundary Cell Mining Claim	303657	100% Wayne Richards
188425	Tuuri	42D15E340	Boundary Cell Mining Claim	303657	100% Wayne Richards
189822	Tuuri	42D15D018	Boundary Cell Mining Claim	303657	100% Wayne Richards
191037	Tuuri	42D15E260	Single Cell Mining Claim	303657	100% Wayne Richards
191502	Syine	42D15D050	Single Cell Mining Claim	303657	100% Wayne Richards
193480	Syine	42D15E346	Single Cell Mining Claim	303657	100% Wayne Richards
195023	Syine	42D15E367	Boundary Cell Mining Claim	303657	100% Wayne Richards
195024	Syine	42D15D005	Boundary Cell Mining Claim	303657	100% Wayne Richards
197483	Syine	42D15E335	Boundary Cell Mining Claim	303657	100% Wayne Richards
200551	Syine	42D15E389	Single Cell Mining Claim	303657	100% Wayne Richards
203647	Syine	42D15D072	Boundary Cell Mining Claim	303657	100% Wayne Richards
205496	Syine	42D15E356	Single Cell Mining Claim	303657	100% Wayne Richards
205497	Syine	42D15E374	Single Cell Mining Claim	303657	100% Wayne Richards
207414	Syine	42D15E301	Boundary Cell Mining Claim	303657	100% Wayne Richards
207640	Tuuri	42D15E278	Single Cell Mining Claim	303657	100% Wayne Richards
210289	Syine	42D15D031	Single Cell Mining Claim	303657	100% Wayne Richards
210518	Tuuri	42D15E240	Single Cell Mining Claim	303657	100% Wayne Richards
210519	Syine	42D15E257	Boundary Cell Mining Claim	303657	100% Wayne Richards
217618	Syine	42D15E354	Single Cell Mining Claim	303657	100% Wayne Richards
218383	Tuuri	42D15E298	Single Cell Mining Claim	303657	100% Wayne Richards
219527	Syine	42D14H359	Boundary Cell Mining Claim	303657	100% Wayne Richards
219785	Tuuri	42D15E360	Boundary Cell Mining Claim	303657	100% Wayne Richards
219786	Syine	42D15D017	Boundary Cell Mining Claim	303657	100% Wayne Richards
220141	Syine	42D15D029	Single Cell Mining Claim	303657	100% Wayne Richards
225820	Tuuri	42D15E300	Single Cell Mining Claim	303657	100% Wayne Richards
225821	Tuuri	42D15E338	Single Cell Mining Claim	303657	100% Wayne Richards
226334	Syine	42D15E326	Single Cell Mining Claim	303657	100% Wayne Richards
227724	Tuuri	42D15E378	Single Cell Mining Claim	303657	100% Wayne Richards
228824	Syine	42D15E391	Boundary Cell Mining Claim	303657	100% Wayne Richards
230080	Syine	42D15E347	Boundary Cell Mining Claim	303657	100% Wayne Richards
230081	Syine	42D15D025	Boundary Cell Mining Claim	303657	100% Wayne Richards
237151	Syine	42D15D048	Single Cell Mining Claim	303657	100% Wayne Richards
240191	Syine	42D15D051	Single Cell Mining Claim	303657	100% Wayne Richards
247681	Syine	42D15E393	Boundary Cell Mining Claim	303657	100% Wayne Richards
247682	Syine	42D15D010	Single Cell Mining Claim	303657	100% Wayne Richards
247683	Syine	42D15D030	Single Cell Mining Claim	303657	100% Wayne Richards
247684	Syine	42D15D053	Boundary Cell Mining Claim	303657	100% Wayne Richards
251692	Syine	42D15D090	Boundary Cell Mining Claim	303657	100% Wayne Richards
251693	Syine	42D15D089	Single Cell Mining Claim	303657	100% Wayne Richards
259258	Tuuri	42D15E238	Single Cell Mining Claim	303657	100% Wayne Richards
263695	Syine	42D15D108	Boundary Cell Mining Claim	303657	100% Wayne Richards
265608	Tuuri	42D15E280	Single Cell Mining Claim	303657	100% Wayne Richards
265609	Syine	42D15E297	Boundary Cell Mining Claim	303657	100% Wayne Richards
265610	Tuuri	42D15E339	Single Cell Mining Claim	303657	100% Wayne Richards
265611	Syine	42D15E337	Boundary Cell Mining Claim	303657	100% Wayne Richards
267329	Syine	42D15E369	Boundary Cell Mining Claim	303657	100% Wayne Richards
274944	Tuuri	42D15E399	Single Cell Mining Claim	303657	100% Wayne Richards
280193	Syine	42D15D068	Single Cell Mining Claim	303657	100% Wayne Richards
284117	Syine	42D15E395	Boundary Cell Mining Claim	303657	100% Wayne Richards
285553	Syine	42D15E304	Boundary Cell Mining Claim	303657	100% Wayne Richards
285554	Syine	42D15E341	Boundary Cell Mining Claim	303657	100% Wayne Richards
285555	Syine	42D14H360	Boundary Cell Mining Claim	303657	100% Wayne Richards
287027	Syine	42D15E357	Single Cell Mining Claim	303657	100% Wayne Richards
288739	Syine	42D15E366	Single Cell Mining Claim	303657	100% Wayne Richards
293838	Syine	42D15E397	Boundary Cell Mining Claim	303657	100% Wayne Richards
294830	Syine	42D15D011	Single Cell Mining Claim	303657	100% Wayne Richards
294831	Syine	42D15D070	Boundary Cell Mining Claim	303657	100% Wayne Richards
296769	Syine	42D15D007	Single Cell Mining Claim	303657	100% Wayne Richards
300247	Syine	42D15D088	Single Cell Mining Claim	303657	100% Wayne Richards
303928	Syine	42D15E322	Single Cell Mining Claim	303657	100% Wayne Richards
303961	Syine	42D15E307	Boundary Cell Mining Claim	303657	100% Wayne Richards
303962	Syine	42D15E327	Boundary Cell Mining Claim	303657	100% Wayne Richards

Tenure #	Township	Grid Cell	Type	Client ID	Holder
307523	Syine	42D15D033	Boundary Cell Mining Claim	303657	100% Wayne Richards
307524	Syine	42D15D032	Single Cell Mining Claim	303657	100% Wayne Richards
309466	Syine	42D15E385	Boundary Cell Mining Claim	303657	100% Wayne Richards
309467	Syine	42D15D026	Boundary Cell Mining Claim	303657	100% Wayne Richards
311166	Syine	42D15D049	Single Cell Mining Claim	303657	100% Wayne Richards
316214	Syine	42D15E386	Single Cell Mining Claim	303657	100% Wayne Richards
316215	Syine	42D15D027	Boundary Cell Mining Claim	303657	100% Wayne Richards
318223	Syine	42D15D069	Single Cell Mining Claim	303657	100% Wayne Richards
318584	Syine	42D15E353	Boundary Cell Mining Claim	303657	100% Wayne Richards
320023	Syine	42D15E303	Boundary Cell Mining Claim	303657	100% Wayne Richards
320730	Syine	42D15E375	Single Cell Mining Claim	303657	100% Wayne Richards
320731	Syine	42D15E373	Boundary Cell Mining Claim	303657	100% Wayne Richards
322143	Syine	42D15E324	Single Cell Mining Claim	303657	100% Wayne Richards
322144	Syine	42D15E323	Single Cell Mining Claim	303657	100% Wayne Richards
322145	Syine	42D14H340	Boundary Cell Mining Claim	303657	100% Wayne Richards
322146	Syine	42D15E344	Boundary Cell Mining Claim	303657	100% Wayne Richards
323046	Tuuri	42D15E359	Single Cell Mining Claim	303657	100% Wayne Richards
323047	Tuuri	42D15E379	Single Cell Mining Claim	303657	100% Wayne Richards
334168	Syine	42D15E343	Boundary Cell Mining Claim	303657	100% Wayne Richards
334169	Syine	42D15E342	Boundary Cell Mining Claim	303657	100% Wayne Richards
335121	Syine	42D15D013	Boundary Cell Mining Claim	303657	100% Wayne Richards
337090	Syine	42D15E345	Boundary Cell Mining Claim	303657	100% Wayne Richards
337091	Syine	42D15E365	Boundary Cell Mining Claim	303657	100% Wayne Richards
337092	Syine	42D15E387	Single Cell Mining Claim	303657	100% Wayne Richards
339099	Syine	42D15D107	Boundary Cell Mining Claim	303657	100% Wayne Richards
106235	Syine	42D15E255	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
106254	Syine	42D15E295	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
106255	Syine	42D15E294	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
106821	Syine	42D15E331	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
113704	Syine	42D15E287	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
122023	Syine	42D15E311	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
131247	Syine	42D15E277	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
132007	Syine	42D15E369	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
132008	Syine	42D15E367	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
134841	Syine	42D15E271	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
140333	Syine	42D15E332	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
140620	Syine	42D15E269	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
140621	Syine	42D15E288	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
145785	Syine	42D15E312	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
146569	Syine	42D15E248	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
147081	Syine	42D15E251	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
147316	Syine	42D15E276	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
150795	Syine	42D15E253	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
150796	Syine	42D15E273	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
150797	Syine	42D15E272	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
160107	Syine	42D15E249	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
161186	Syine	42D15E270	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
161379	Syine	42D15E228	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
195984	Syine	42D15E296	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
196724	Syine	42D15E349	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
204730	Syine	42D15E308	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
204731	Syine	42D15E370	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
212416	Syine	42D15E333	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
213267	Syine	42D15E268	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
215517	Syine	42D15E297	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
216839	Syine	42D15E327	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
216840	Syine	42D15E348	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
233320	Syine	42D15E290	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
233456	Syine	42D15E350	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
234625	Syine	42D15E274	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
234626	Syine	42D15E292	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
238532	Syine	42D15E309	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
238533	Syine	42D15E329	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
249123	Syine	42D15E314	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
249230	Syine	42D15E317	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards

<b>Tenure #</b>	<b>Township</b>	<b>Grid Cell</b>	<b>Type</b>	<b>Client ID</b>	<b>Holder</b>
249231	Syine	42D15E316	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
251343	Syine	42D15E307	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
251344	Syine	42D15E368	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
252840	Syine	42D15E330	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
261977	Syine	42D15E336	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
269425	Syine	42D15E257	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
269426	Syine	42D15E256	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
270724	Syine	42D15E347	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
281329	Syine	42D15E291	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
308394	Syine	42D15E335	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
309702	Syine	42D15E250	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
309858	Syine	42D15E337	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
315079	Syine	42D15E334	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
318736	Syine	42D15E310	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
319514	Syine	42D15E275	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
324730	Syine	42D15E289	Boundary Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
327794	Syine	42D15E315	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
332816	Syine	42D15E328	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
336508	Syine	42D15E313	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
341575	Syine	42D15E254	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards
341576	Syine	42D15E293	Single Cell Mining Claim	141000, 303657	50% James Hamel, 50% Wayne Richards

## **Appendix 2: Stereo Satellite Surveying Project Report**



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## PhotoSat Stereo Satellite Surveying Project Report:

**Ref. No:** 3867  
**Previous Ref. No:**  
**Client:** Sanatana Resources Inc  
**Project Area:** Jackfish, Ontario  
**Project Datum:** NAD83  
**Project Projection:** UTM zone 16N  
**Project Elevations:** Orthometric EGM2008



Figure 1: SPOT orthophoto mosaic. Photo date: August 15, 2017.

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## **PhotoSat Stereo Satellite Surveying Project Report:**

### **Project Overview:**

In August 2017, PhotoSat produced a satellite survey for a 102 km<sup>2</sup> area in Jackfish, Ontario. A colour orthophoto for the surrounding 250 km<sup>2</sup> was also produced. A complete list of all delivered files is in the Appendix.

### **Processing Overview:**

The Jackfish 3 m stereo satellite survey and 1.5 m orthophoto were produced from 1.5 m pixel resolution SPOT stereo satellite orthophotos. The satellite orthophotos were acquired on August 15, 2017 (see Figure 1).

The 3 m satellite survey and 1.5 m orthophoto were produced using PhotoSat's proprietary Geophysical Satellite Processing system. To our knowledge, the PhotoSat processing system currently produces the highest quality stereo satellite surveys and corresponding 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](http://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](http://www.photosat.ca/surveying/satellite-surveying-accuracy-studies)

### **Accuracy Assessment for this Project:**

We expect the accuracy of the satellite survey to be better than 2 m. Our process has been tested by comparing to tens of thousands of ground control points during accuracy tests.

The actual accuracy of each project depends on the angles of the satellite photos and the quality and the density of the ground control points. Areas of the satellite survey that are extremely foreshortened or occluded on the satellite photos due to very steep topography will be interpolated from the surrounding elevation data.

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## PhotoSat Stereo Satellite Surveying Project Report:

To assess the accuracy of this project, we matched to four ground control points supplied by Sanatana Resources.

Using this methodology the RMS elevation difference between the client supplied ground control and the project satellite survey is 0.49 m.

The relative horizontal accuracy of PhotoSat's SPOT ortho photos is generally better than 1.5 m 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 is also included in the Ground Reference section.

### Data Delivered:

- 3 m satellite survey (digital surface model) - ERS, GeoSoft Grid, and MapINFO grid formats
- 1.5 m SPOT satellite imagery - GeoTIFF format with MapINFO tab file
- 2 m, 5 m, 10 m, and 50 m contours - 2D MapINFO format
- 3 m color elevation image - GeoTIFF format with MapINFO tab file
- 3 m slope direction image - GeoTIFF format with MapINFO tab file
- Project report
- Licence documents

## PhotoSat Stereo Satellite Surveying Project Report:

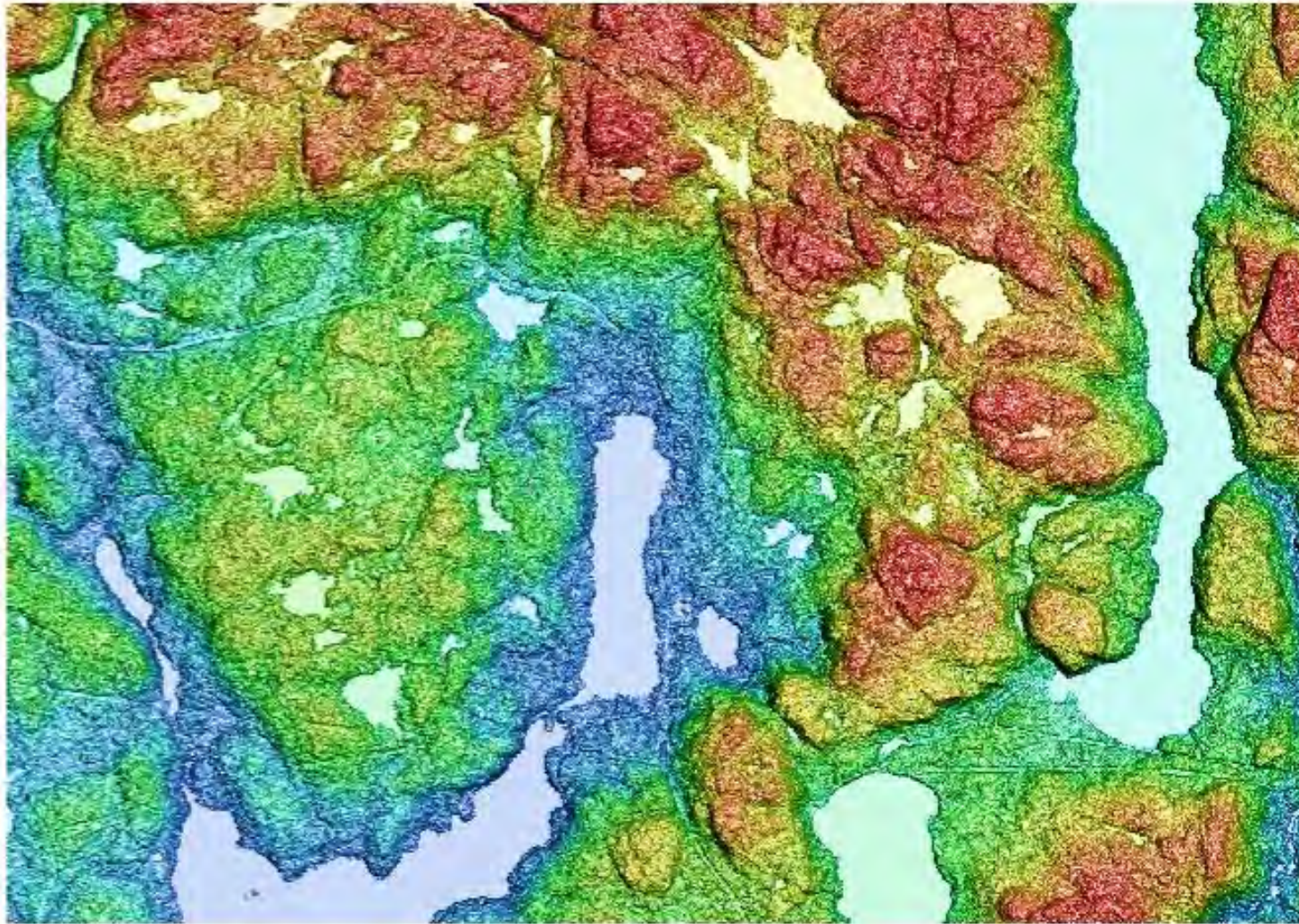


Figure 2: Colour elevation image of the satellite survey.

## PhotoSat Stereo Satellite Surveying Project Report:

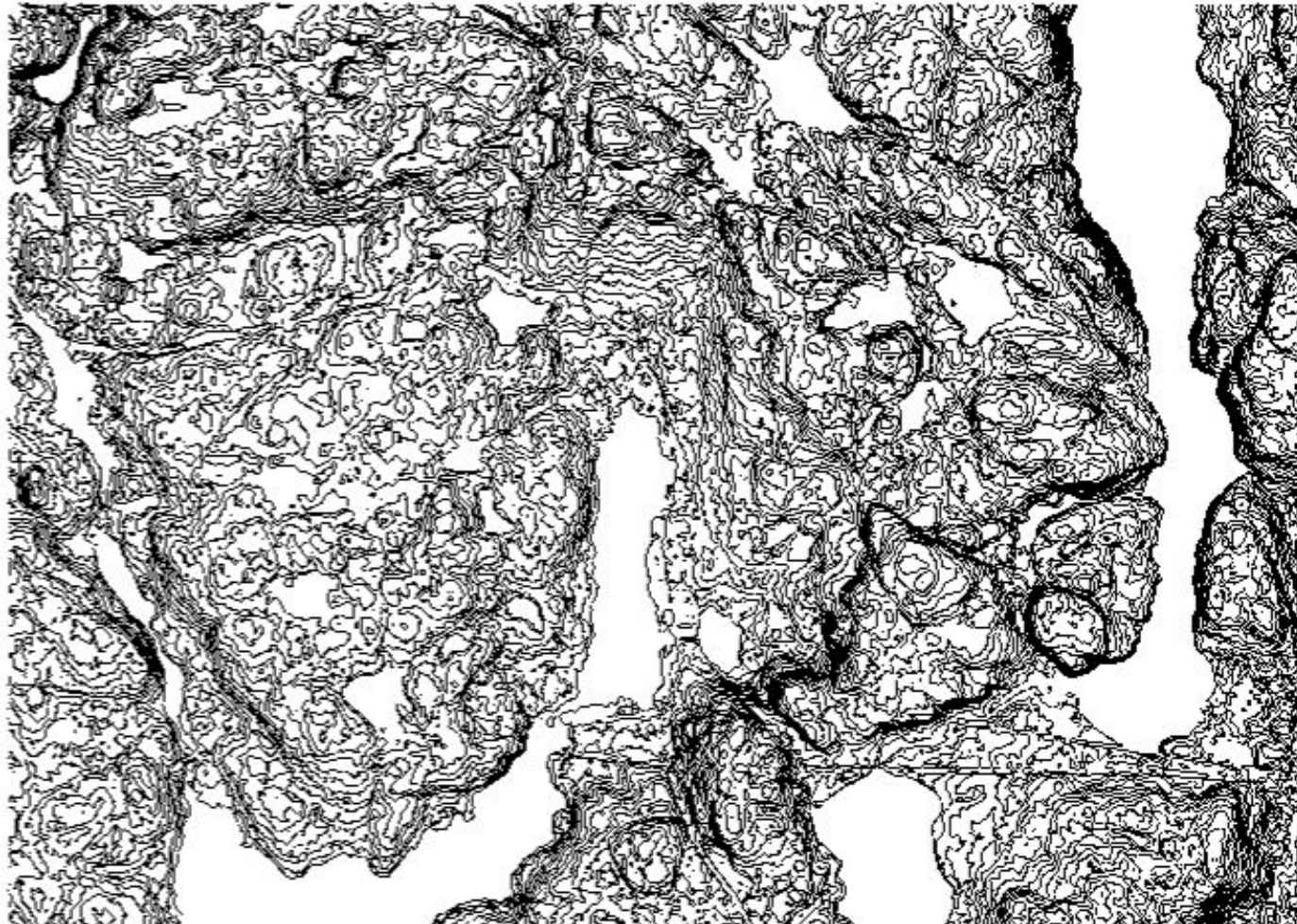


Figure 3: The 10 m contours.

## PhotoSat Stereo Satellite Surveying Project Report:

### Ground Reference:

The stereo satellite orthophotos and satellite survey were referenced to four ground control points provided by Sanatana Resources. These points were photo-identifiable points on the ground and were used for both the horizontal and vertical match. The elevation values of the control points were orthometric CGVD28 but the client requested this project be delivered in orthometric EGM2008. PhotoSat converted the elevation values from CGVD28 to EGM2008 and then matched the satellite survey to the EGM2008 values. The coordinates of the points and the difference between PhotoSat's satellite survey and the point elevations is included in the table below.

### Client Control:

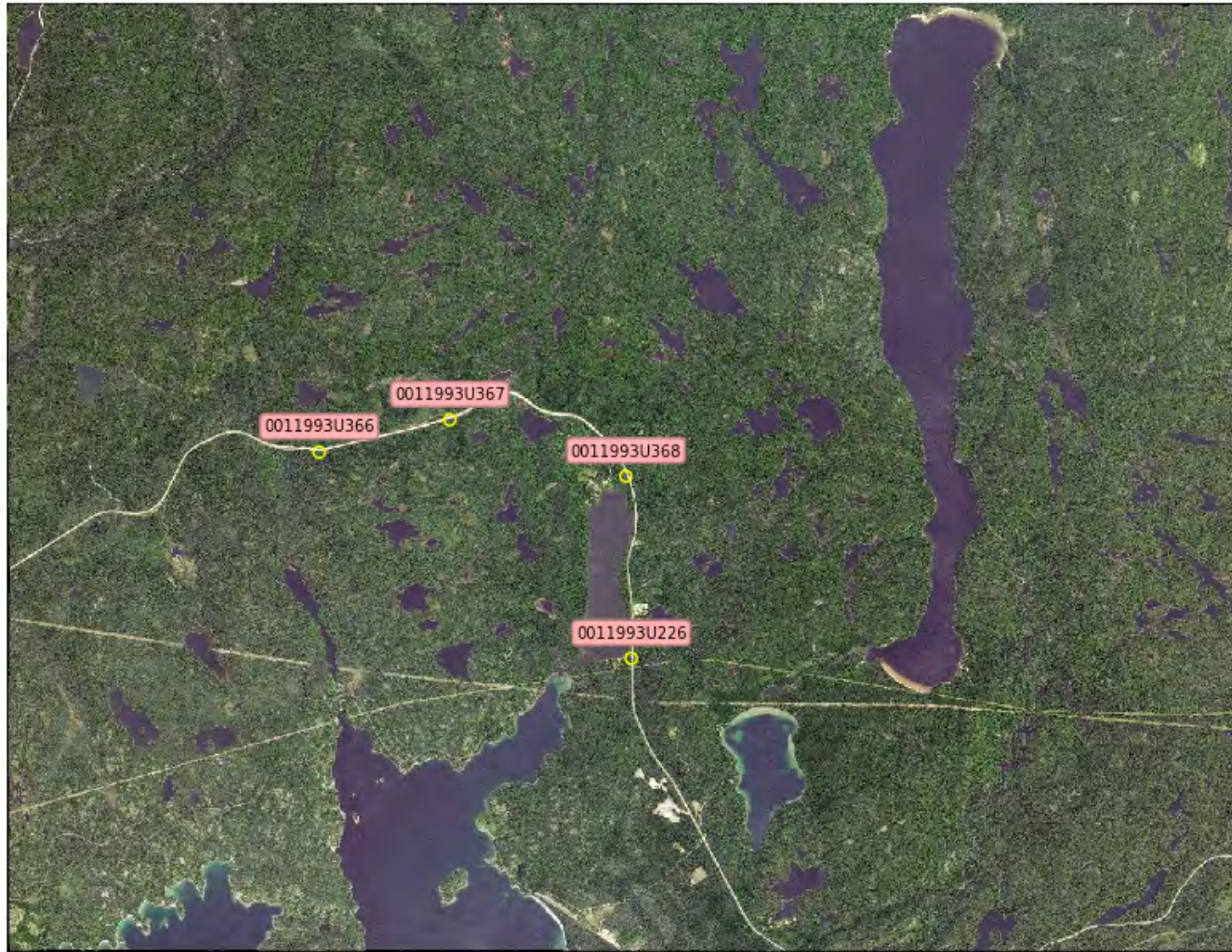
File Name	Description	Datum	Projection
Geodetic Station Data.xlsx	Surveyed Targets	NAD83	NUTM16

### Control Points:

Point Name	Type	East (m)	East Difference (m)	North (m)	North Difference (m)	Elevation (m)	Elevation Difference (m)
0011993U366	Check Points	499474.45	-0.5	5410688.61	0.5	235.28	-0.17
0011993U367	Check Point	501460.47	-1.0	5411178.72	0	287.24	-0.51
0011993U368	Check Point	504134.7	0	5410326.33	-0.5	198.01	0.81
0011993U226	Check Point	504216.24	-0.5	5407551.42	0.5	197.53	-0.12

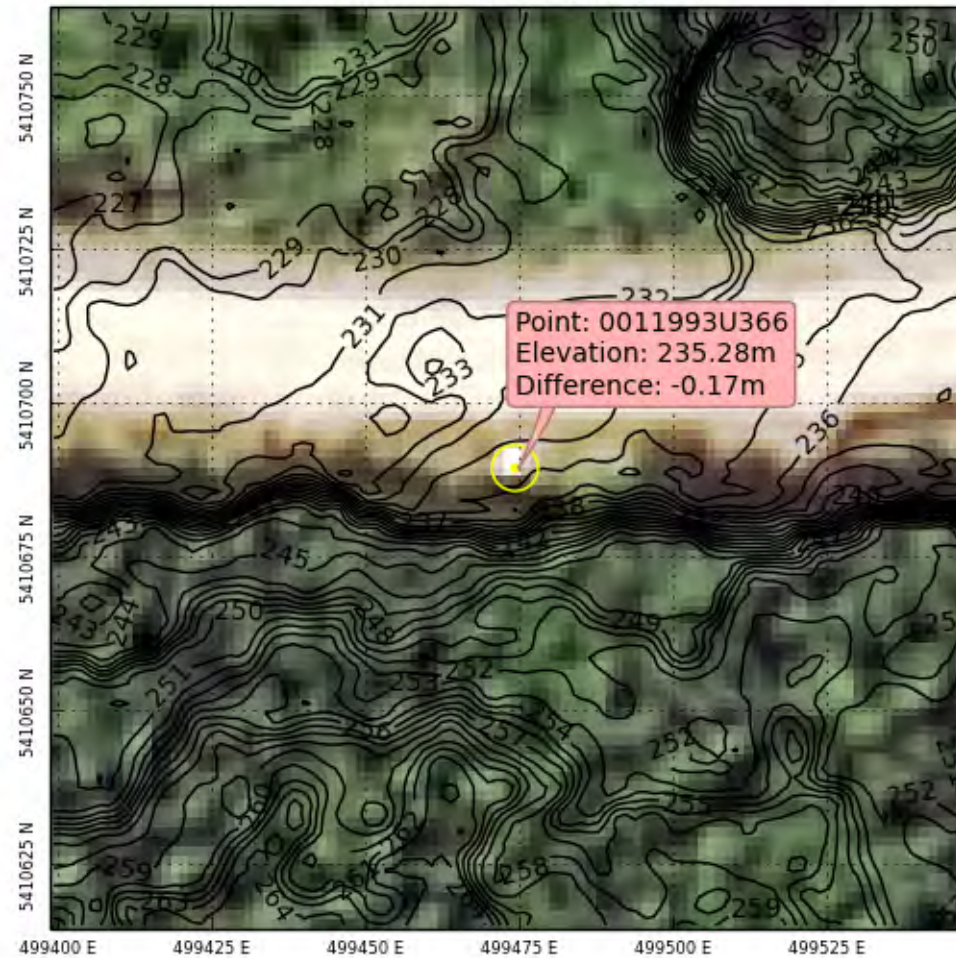
## PhotoSat Stereo Satellite Surveying Project Report:

### Overview



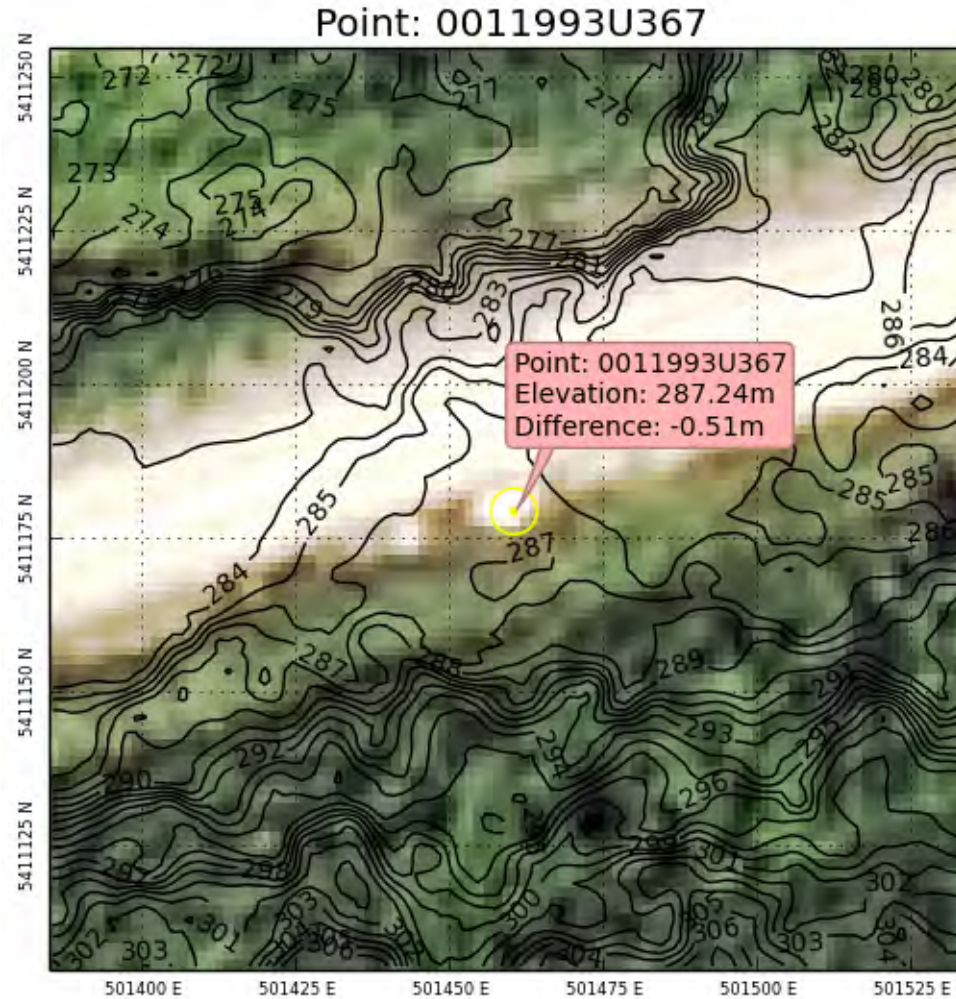
## PhotoSat Stereo Satellite Surveying Project Report:

Point: 0011993U366

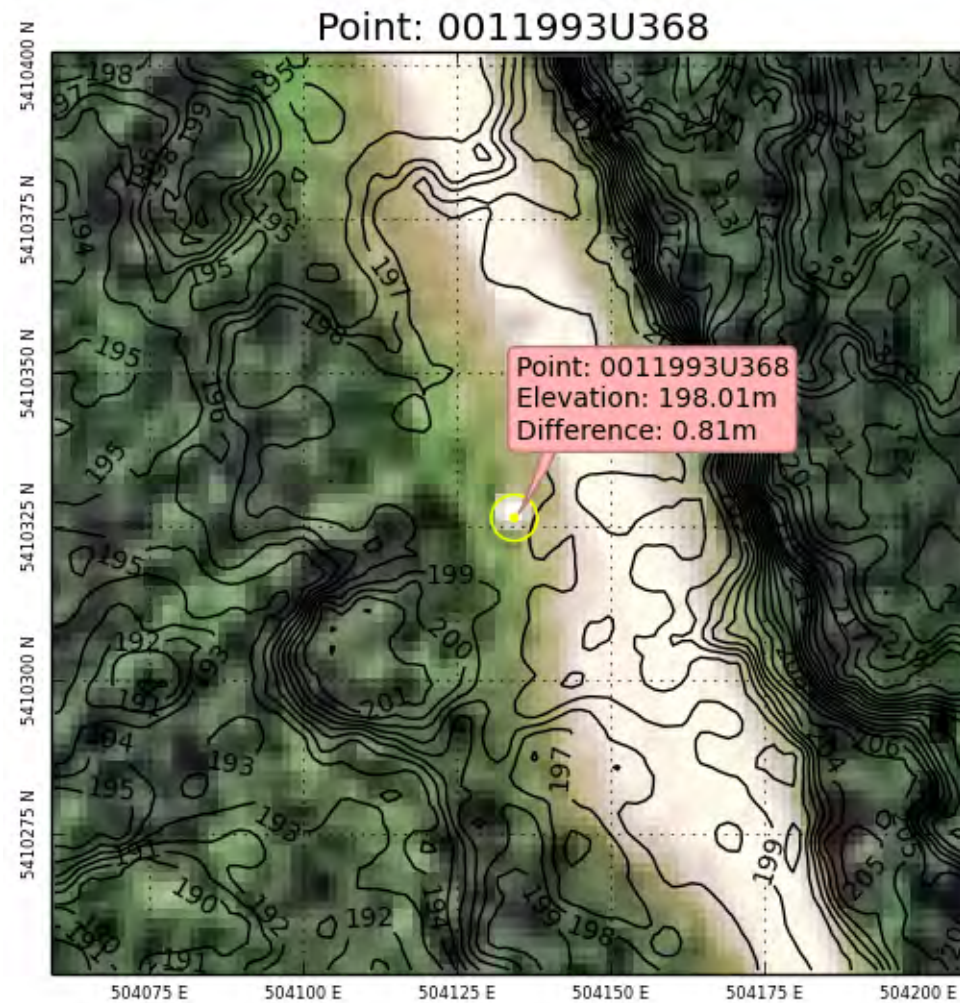




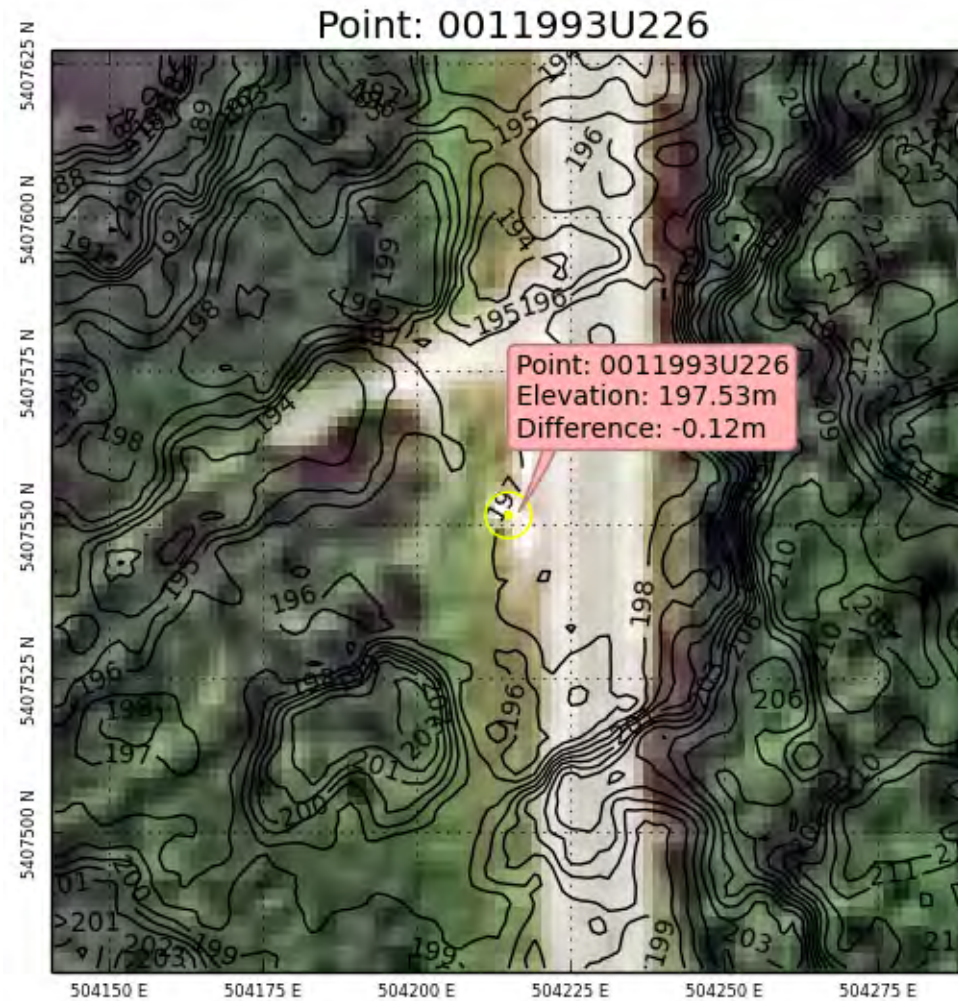
## PhotoSat Stereo Satellite Surveying Project Report:



## PhotoSat Stereo Satellite Surveying Project Report:



## PhotoSat Stereo Satellite Surveying Project Report:



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## PhotoSat Stereo Satellite Surveying Project Report:

### Appendix: Listing of delivered files

- 3m\_dsm\_grd/
  - jackfish\_3m\_dsm (.grd)
- 3m\_dsm\_ers/
  - jackfish\_3m\_dsm (.ers)
- 3m\_dsm\_mig/
  - jackfish\_3m\_dsm (.mig, .tab)
- 3m\_dsm\_images/
  - jackfish\_3m\_colour\_elevation (.tif, .tfw, .txt, .tab)
  - jackfish\_3m\_colour\_elevation\_scalebar.jpg
- 1.5m\_spot/
  - jackfish\_spot\_2017aug15 (.tif, .tfw, .txt, .tab)
- contours/
  - jackfish\_2m\_contours (.dat, .id, .map, .tab)
  - jackfish\_5m\_contours (.dat, .id, .map, .tab)
  - jackfish\_10m\_contours (.dat, .id, .map, .tab)
  - jackfish\_50m\_contours (.dat, .id, .map, .tab)
- Licence files
- Project report

# **A GEOPHYSICAL STEREO SATELLITE ELEVATION MAPPING SYSTEM**

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## **ABSTRACT**

A significant technological advance has been achieved by applying concepts and software developed for oil and gas exploration seismic data processing to produce detailed elevation maps from the new generation of high resolution satellite photos. We call this a geophysical processing system since the system is developed by geophysicists, using geophysical processing tools, including a 3D seismic workstation, and the processors never view the photos in stereo. PhotoSat has recast the stereo satellite elevation mapping problem so that it closely resembles oil and gas exploration seismic processing. Seismic processors have been matching pixels, that they call time samples, to better than 0.01 pixels for many years. Seismic processors routinely match over 100 coincident images at a time to improve signal to noise ratios in their images from less than 10% to over 500%. While seismic processors map subsurface elevation surfaces rather than surface elevations, there are enough similarities in the problems that we are able to use many of the sophisticated seismic processing tools to process the stereo satellite elevations. By substituting profiles of stereo photo correlation amplitudes as a function of elevation for seismic reflection amplitudes as a function of elevation, we are able to use powerful 3D seismic workstations to display and interpret the stereo satellite correlation profiles. The concept of displaying profiles of stereo photo correlation amplitudes as a function of elevation was first published by Nicolas Papanoditis in 2001.

## **INTRODUCTION**

PhotoSat is applying processing and interpretation concepts and software from the fields of oil and gas exploration and mining exploration geophysics to map elevations from stereo satellite photos. These geophysical concepts, algorithms and software were developed for mapping subsurface geological features from seismic, gravity, magnetic, electrical and electromagnetic surveys. We have discovered ways to effectively apply many of these concepts, algorithms and computer programs to the mapping of surface topography from stereo satellite photos with surprising results.

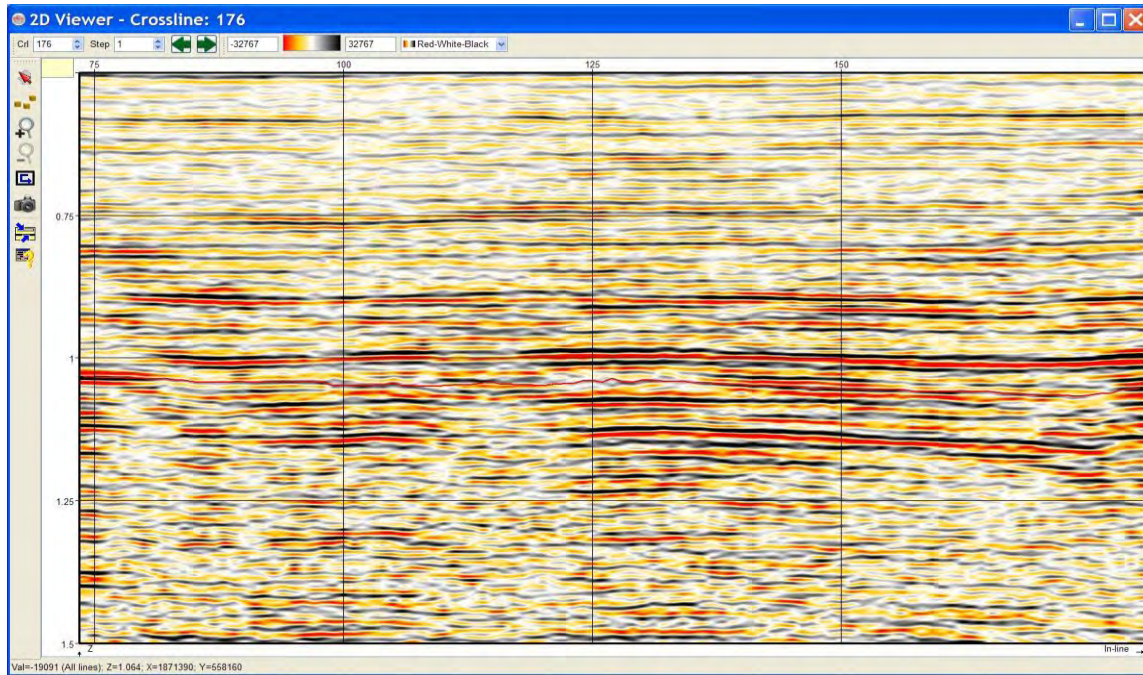
## **GEOPHYSICAL INTERPRETATION PROCESS**

The procedure used by geophysicists to interpret most types of exploration geophysical surveys may be summarized in three broad steps:

1. Plotting the geophysical field data in ways that facilitate geological interpretation,
2. Making geological interpretations of the the geophysical data plots, and
3. Verifying the geological interpretation by comparing data from numerical models to the geophysical field data.

## PLOTTING CONVENTIONS TO FACILITATE INTERPRETATION

To illustrate how geophysicists plot data in ways that facilitate geological interpretation, a plot of a seismic survey “section” is shown in Figure 1. In this plot, the acoustic signals detected by the seismic geophones are plotted at a location midway between the location of each explosive seismic source and each geophone. The acoustic signals are plotted as vertical profiles of the amplitude of the acoustic signal with time increasing downwards. While this is a representation of the seismic data, not a geological cross section, it is quite easy to identify vertical layering in the geological section and horizontal variations in some of the layers.



**Figure 1.** Seismic section showing the amplitudes of the acoustic signals recorded on seismic geophones. The acoustic signals originate from a large number of individual explosive seismic shots. The acoustic amplitude profiles are plotted in colour with the time after the seismic shot increasing downward towards the bottom of the plot. Each acoustic profile is plotted midway between the seismic shot and geophone location. This is not a geologic cross section; it is simply a plotting convention that facilitates the interpretation of the geologic cross section.

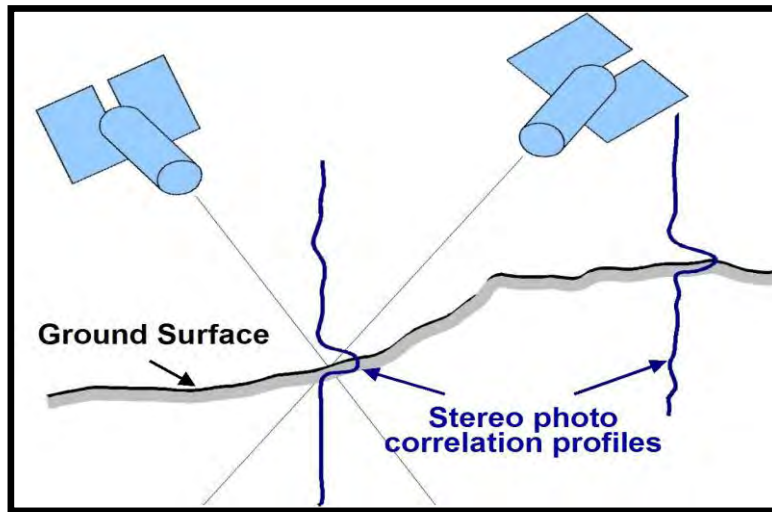
## CROSS SECTIONS OF THE CORRELATIONS BETWEEN STEREO SATELLITE PHOTOS

In order to visualize the relationship between stereo satellite photos in a way that facilitates the interpretation of surface topography, we developed a process to calculate the correlation between the stereo photos as a function of elevation. We believe that profiles of correlation as a function of elevation were first proposed by Nicholas Paparoditis in 2001. This concept is illustrated in Figure 2. The strongest correlation between the photos will usually occur at the elevation of the ground surface at each location.

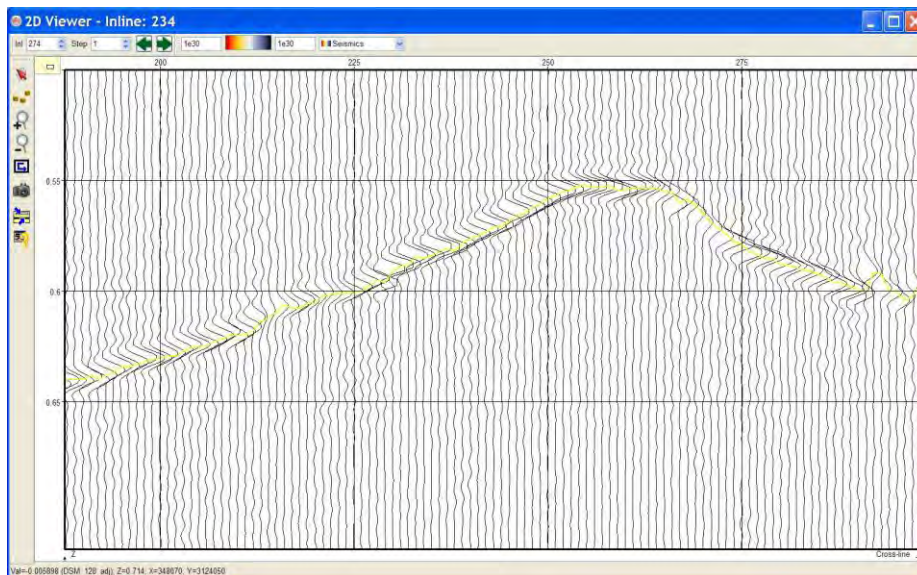
A cross section of stereo satellite correlation profiles for a pair of GeoEye-1 photos across a hill in Northeast Mexico is shown in Figure 3. The hill is readily apparent and easy to interpret in this plot of the stereo satellite photo correlations.

A plot of stereo GeoEye-1 correlation profiles with the correlation amplitudes represented as colours is shown in Figure 4. In this example, there is a bare ground upland and a valley with both bare ground and a grove of trees. It is fairly easy to recognize the strong correlations from the bare ground and the weaker correlations and short wavelength elevation variations from the trees in the valley. This plot is generated with OpendTect, a free, open source 3D seismic workstation.

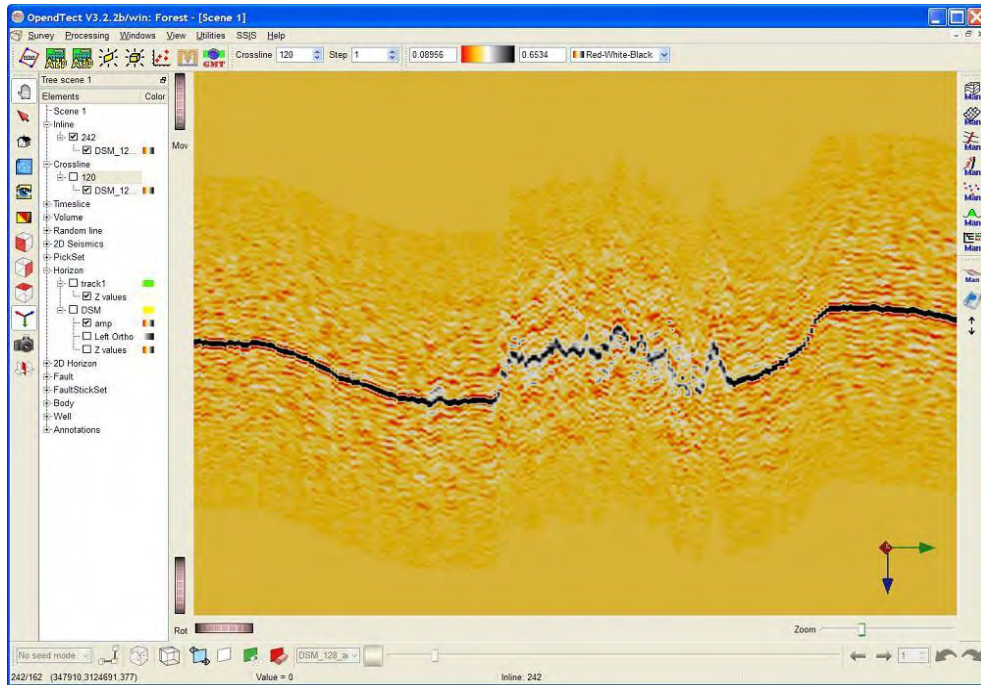
With this development, we believe that we have clearly succeeded in making plots of the stereo satellite photo data that facilitates the interpretation of the topographic surface. We have a display of the data in which we can easily identify the hills, valleys and in some places, trees and buildings, without having done any interpretation.



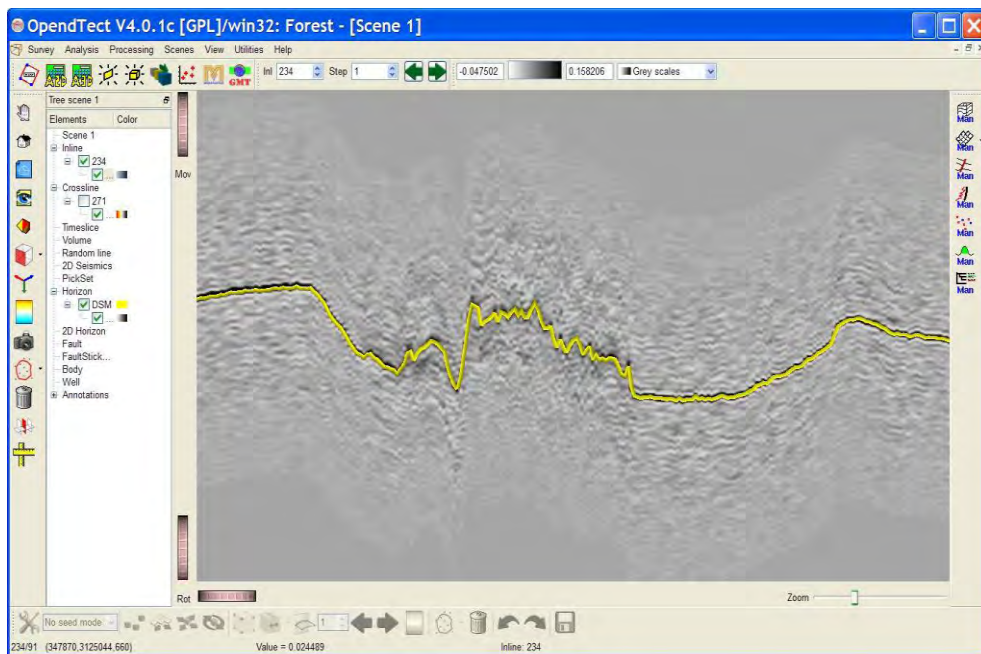
**Figure 2.** The correlations between stereo satellite photos plotted as a profile of the correlation amplitude as a function of the elevation.



**Figure 3.** Cross section of stereo photo correlation profiles from GeoEye-1 stereo photos across a hill in Northeast Mexico. The correlation profiles are displayed in the OpendTect 3D seismic workstation.



**Figure 4.** Cross section of stereo GeoEye-1 correlation profiles for a project in Northeast Mexico displayed in the OpendTect 3D seismic workstation. Strong correlation amplitudes are shown in dark colours and weaker correlation amplitudes are shown in red.

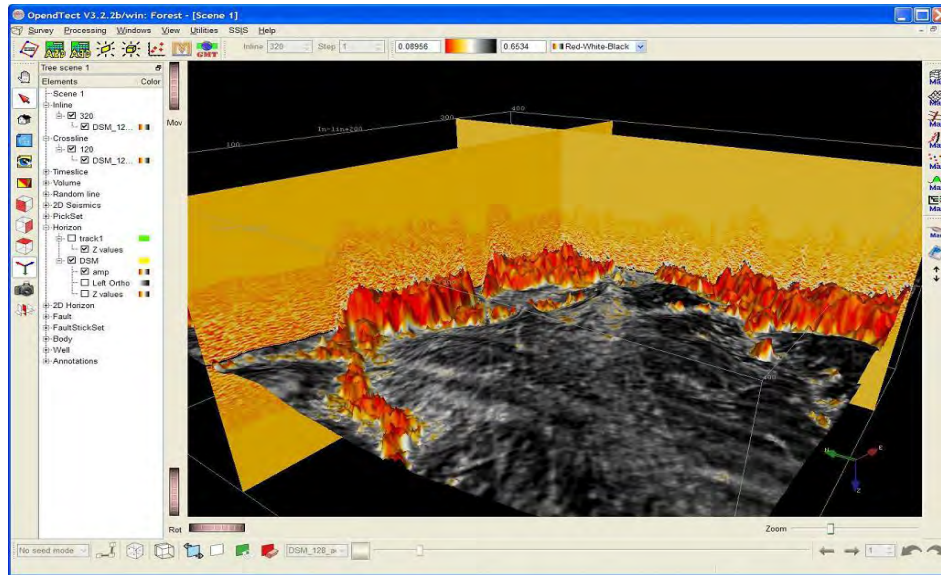


**Figure 5.** Cross section of the correlation profiles in the OpendTect 3D seismic workstation, showing the automatic picking of the highest correlation amplitude on each profile. On most of the correlation profiles, this pick represents the reflective surface, either bare ground or tree and building tops.

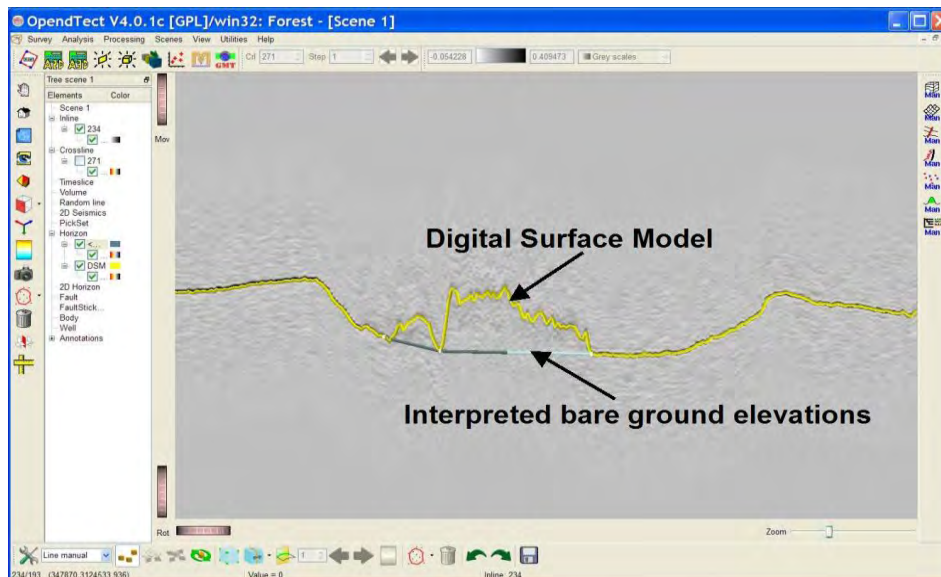


## INTERPRETATION OF THE BARE GROUND TOPOGRAPHIC SURFACE

To make maps of the bare ground elevations in areas of trees and buildings, where the bare ground surface is not visible in the stereo satellite photos, we can interactively interpret the bare ground elevations. Figure 7 shows an example of the interpretation of bare ground elevations through a grove of trees.



**Figure 6.** 3D display of the interpreted reflective surface in the OpendTect 3D seismic workstation. The colours displayed on the surface represent the correlation amplitudes. The combination of the correlation amplitudes and the surface elevations clearly differentiate the trees from the bare ground.



**Figure 7.** Cross section displayed in the OpendTect 3D seismic workstation, showing the interpretation of bare ground elevations.

## **VERIFYING GEOPHYSICAL INTERPRETATIONS**

Geophysical interpretations are commonly verified by comparing numerical models of the interpretation to the geophysical field results. This verifies that the interpreted geological structure will indeed produce the observed geophysical response.

The dilemma for the geophysical interpreter is that, while the model results match the data, there are an infinite number of models of subsurface geology with different geometries and physical properties that will also exactly match the geophysical field data. The modeling process will tell the interpreter that the interpretation is possibly correct but not that it is correct. Usually the only way to determine which model correctly represents the subsurface geology is to drill.

## **VERIFYING STEREO SATELLITE ELEVATION INTERPRETATIONS**

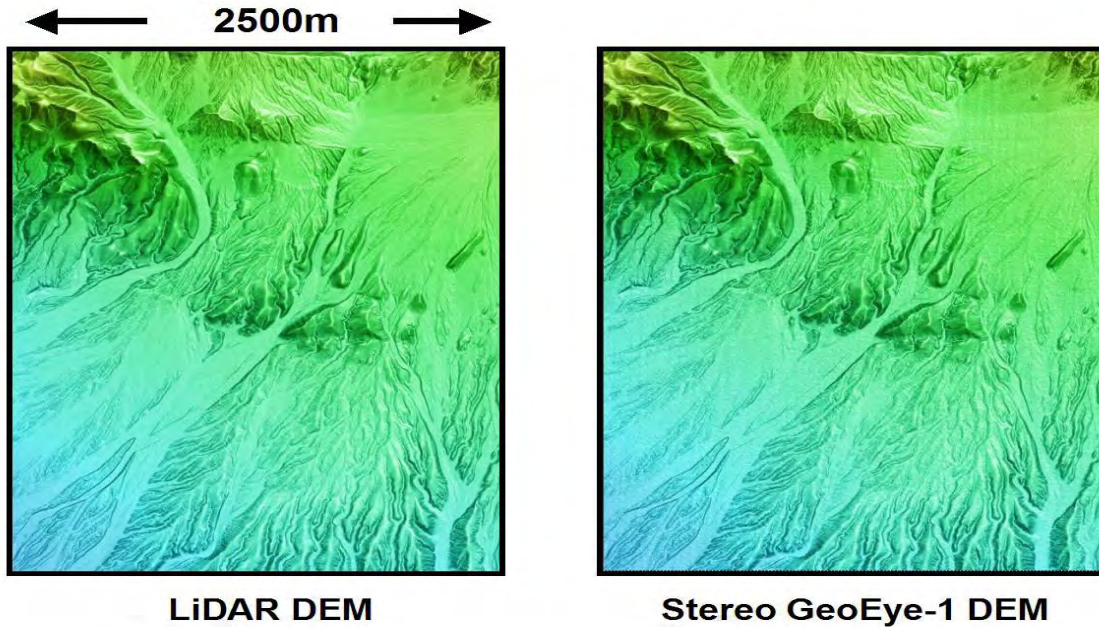
Unlike geophysical interpretation where there is never a unique interpretation, there is always some unique topographic surface that will exactly match each pair of stereo satellite photos. When both photos are projected onto the correct topographic surface, the photos should match each other exactly. Mismatches between the stereo photos when they are projected onto the same topographic surface may be due to errors in the topographic surface, distortions in the photos or errors in the transformation used to project the photos on the surface.

We test the topographic surface produced by our elevation mapping process by projecting the two photos onto the surface and creating a movie that switches the display between the two photos. For a correct digital surface model, there should be no motion in the movie. For a correct digital terrain model, the areas of bare ground should be motionless and the trees and building should flicker back and forth as the photos switch.

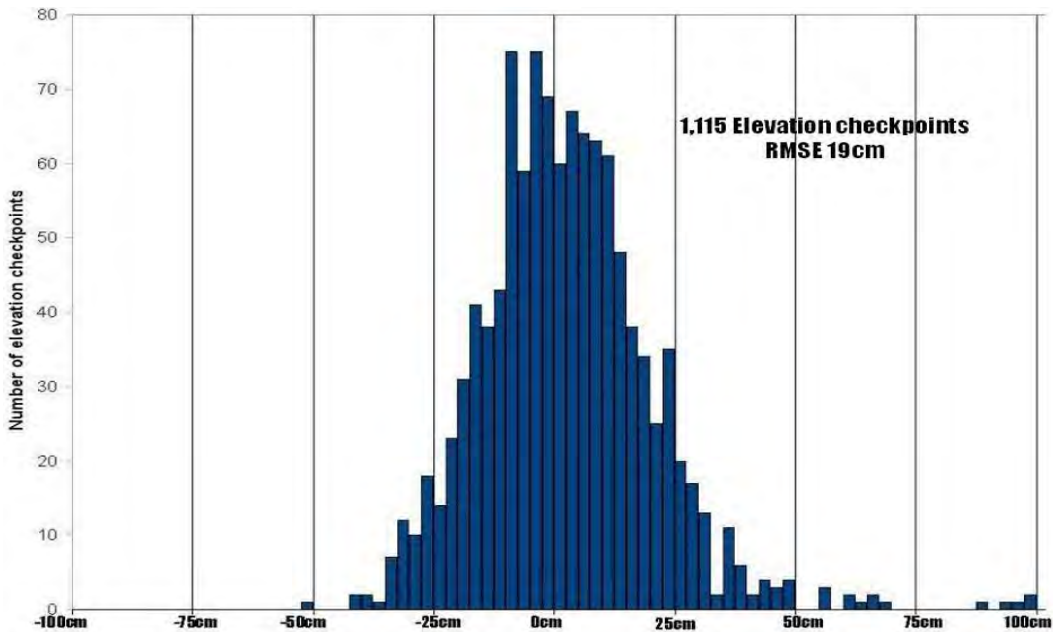
## **RESULTS**

Since we began developing the Geophysical Stereo Satellite Elevation Mapping System in Q4 2007, PhotoSat has completed over 50 stereo satellite elevation mapping projects using the system. In December 2009, we did a direct comparison of stereo GeoEye-1 elevation mapping and LiDAR elevation mapping in Southeast California. Figure 8 shows the comparison of the LiDAR Digital Elevation Model (DEM) and the stereo GeoEye-1 DEM for this area. The standard deviation of the elevation differences between these DEMs is 25cm.

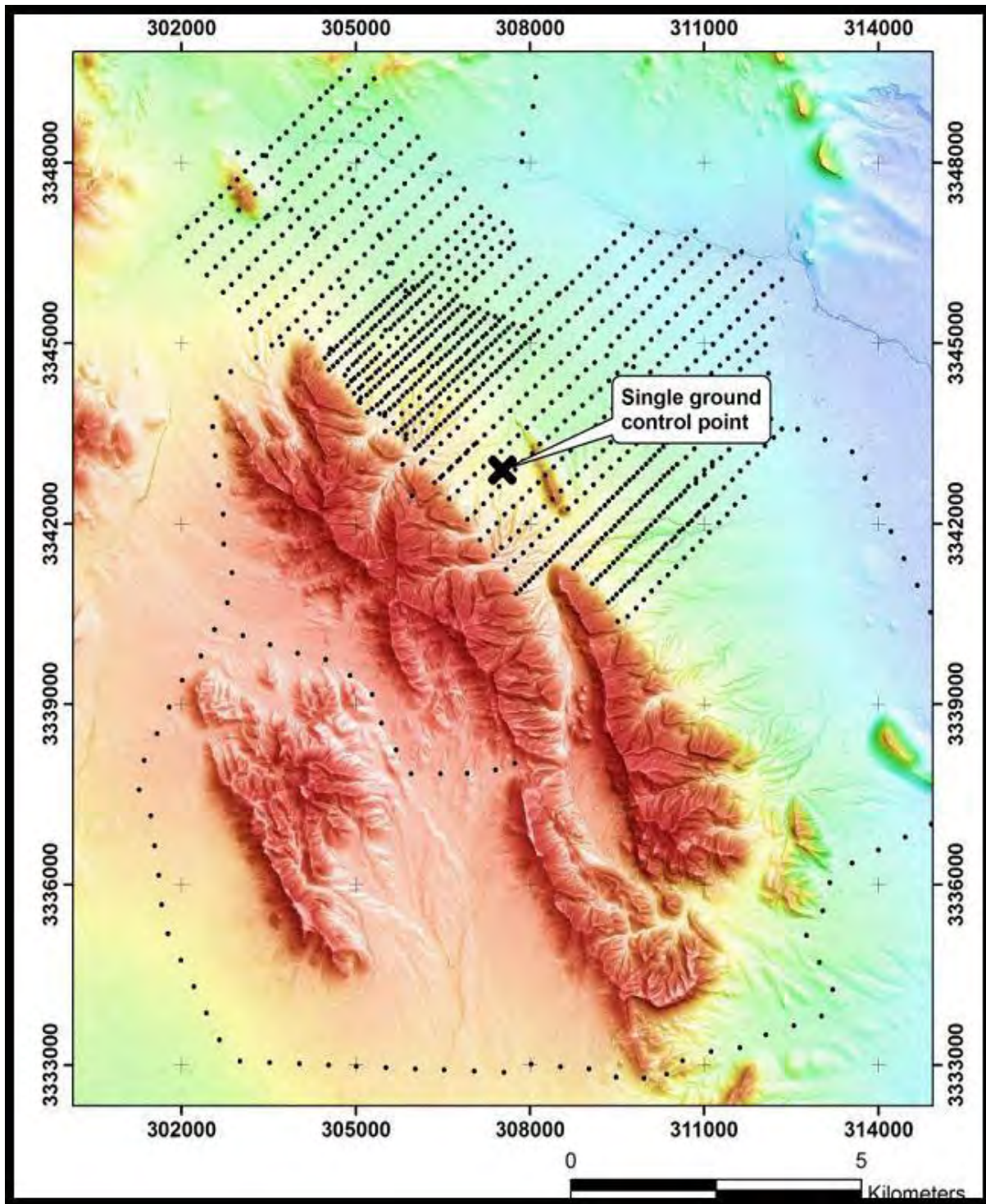
We have also carried out quantitative accuracy assessments for stereo pairs of IKONOS, GeoEye-1, WorldView-1 and WorldView-2 photos. The results of an elevation mapping accuracy assessment for a 260 km<sup>2</sup> stereo WorldView-1 elevation mapping project in Chihuahua Mexico are shown in Figures 9, 10 and 11. On the Chihuahua project, using a single ground control point and 1,115 independent elevation checkpoints, the stereo satellite elevation mapping accuracy is 19cm Root Mean Square Error (RMSE).



**Figure 8.** Images of a 1m LiDAR DEM and a 1m stereo GeoEye-1 DEM from the same area in Southeast California. The LiDAR DEM was produced by OpenTopography and is available from the OpenTopography.org website. The standard deviation of the elevation differences between these two DEMs is 25cm.



**Figure 9.** Histogram of the elevation differences between the stereo WorldView-1 elevation mapping and the 1,115 elevation checkpoints for the 260 km<sup>2</sup> project in Chihuahua, Mexico, shown in Figure 10. RMSE 19cm.



**Figure 10.** Image of a 1m DEM for the 260 km<sup>2</sup> stereo WorldView-1 elevation mapping project in Chihuahua, Mexico. The entire mapping project was referenced to a single ground control point shown in the figure. The elevation mapping accuracy of 19cm RMSE was determined by the 1,115 elevation checkpoints shown in the figure.



**Figure 11.** The single ground control point used to reference the 260 km<sup>2</sup> stereo WorldView-1 elevation mapping project in Chihuahua, Mexico.

## REFERENCES

Fraser, C. and Ravanbakhsh, M., 2009. Georeferencing Accuracy of GeoEye-1 Imagery. *PE & RS*. 75(6): 634-638.

OpenTect. Open Source Seismic Interpretation System. <http://opentect.org>

OpenTopography. Standard DEMs. <http://opentopo.sdsc.edu/gridsphere/gridsphere?cid=standarddems>

Paparoditis, N., 2002. 3D Data Acquisition From Visible Images. *In: Digital Photogrammetry*, Taylor & Francis, New York, pp. 168-220.