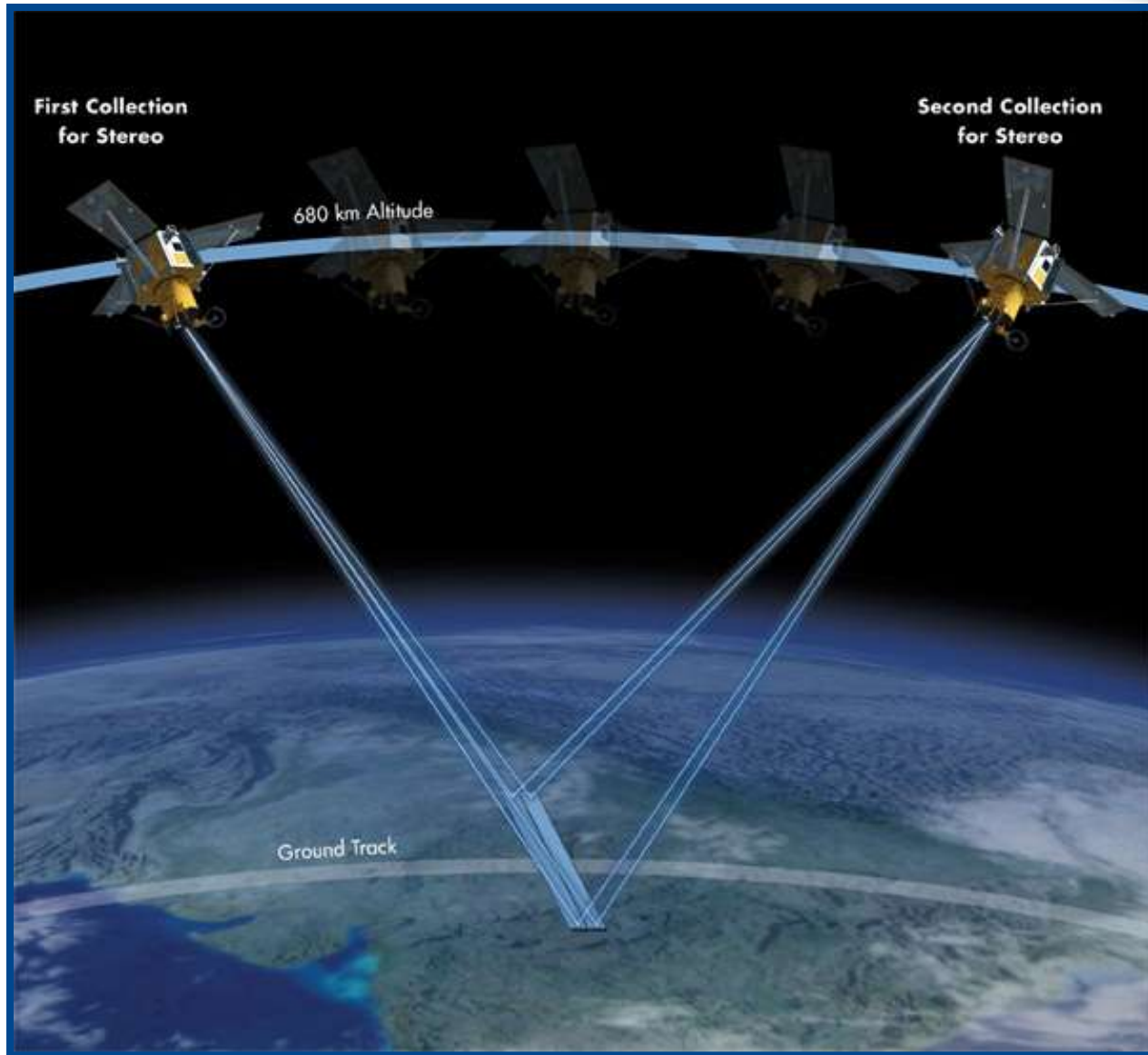


Session ID: GEO-6307
Mapping and Monitoring
for Suncor's Oil Sands Tailings
Reduction Operation process
using GPS surveying and
PhotoSat satellite topography.

Paul Lomond, Suncor Energy Inc.

Jim Turner, PhotoSat



Stereo satellite photos used to map Suncor Tailings

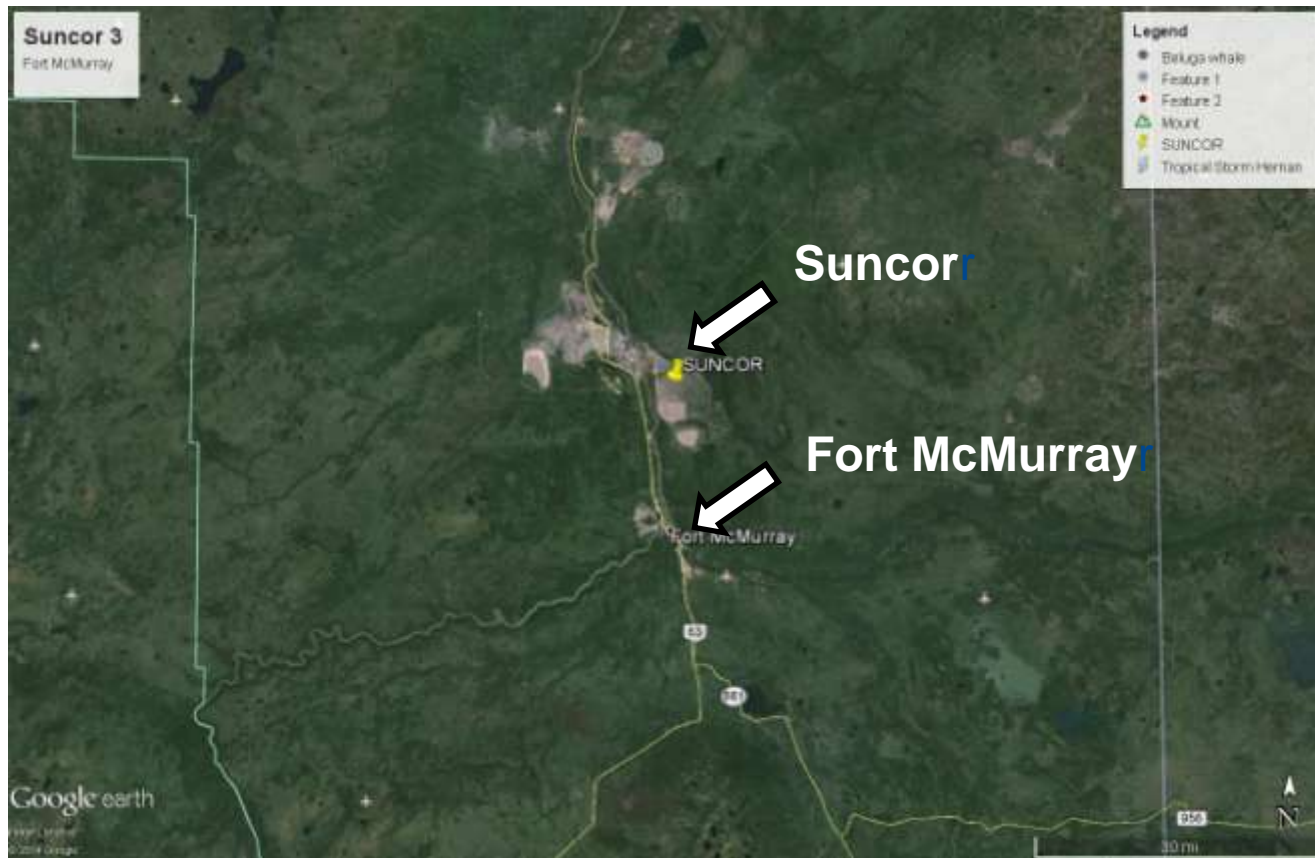
Where is Suncor Oilsands?

- Alberta, Canada



Where is Suncor Oilsands?

- Athabasca Oilsands, near Fort McMurray



How large is the Suncor Oilsands Operation?

- **Total Mapping Area**
 - About 271 km² (66,974 acres)
- **Mining**
 - Total - Over 1,000,000 t/day
 - Oilsand - Over 400,000 t/day
- **Extraction**
 - Bitumen – Over 275,000 bbls/day
- **Tailings Ponds**
 - About 31.5 km² (7,783 acres)



What is TRO?

- **Tailing Reduction Operation**
 - Reducing the need to build more Tailings Ponds
 - Accelerating reclamation
 - Reducing existing MFT inventory
(Mature Fine Tailings)



How Large is the Suncor TRO Operation?

- **Designated Drying Areas (DDA)**
- Total Surface Area 7,550,000 m² (1,866 acres)
- Tailings Sand Deposit 10,872,000 m³ /year
- 697 Tailings Cells
- 2788 Discharge Locations

- **System 7 – Field D**
 - 216m x 902m
 - 14 Cells (216m x 64m)
- **Seasonal Operation**
 - April - October



How Large is the Suncor TRO Operation?

- **Sand Dump 8 (SD8)**
- **Total Surface Area 4,053,693 m² (1,002 acres)**
- **Tailings Sand Deposit 39,015,877 m³ /year**
- **74 Tailings Cells**
- **74 Discharge Locations**
- **Operates 12 months / year**



In 2012

- Survey Department was given the challenge to do monthly topo surveys on all TRO cells.

Trimble R8 GNSS



Trimble VX



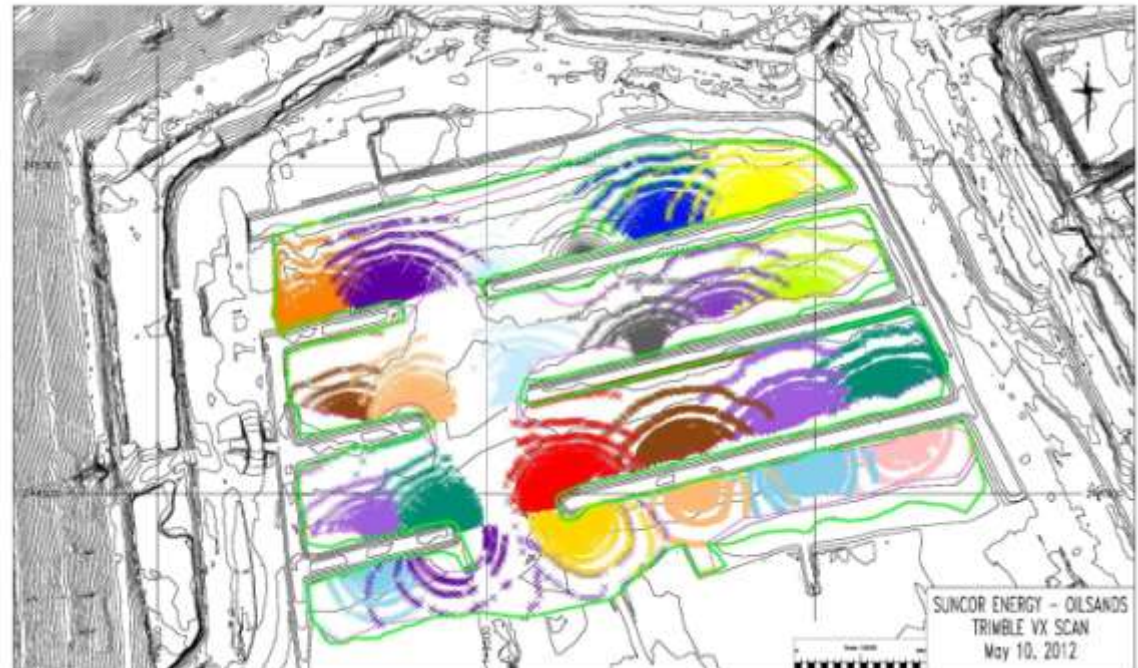
In 2012

- **Trimble GPS equipment was used on compacted areas of Sand Dump 8.**
 - **<20% of total area was accessible.**



In 2012

- **Trimble VX was used to scan DDA Cells.**
 - Very slow
 - Multiple set-ups
 - Sparse data



In 2012

- **Survey Department was given the challenge to do monthly topo surveys on all TRO cells.**
- **Trimble GPS equipment was used on compacted areas of Sand Dump 8.**
 - < 20% of total area was accessible
- **Trimble VX was used to scan DDA Cells.**
 - Very slow, multiple set-ups, sparse data
- **Aerial LiDAR was used for all TRO Cells.**
 - Huge point clouds
 - Slow data delivery

In 2012 - November

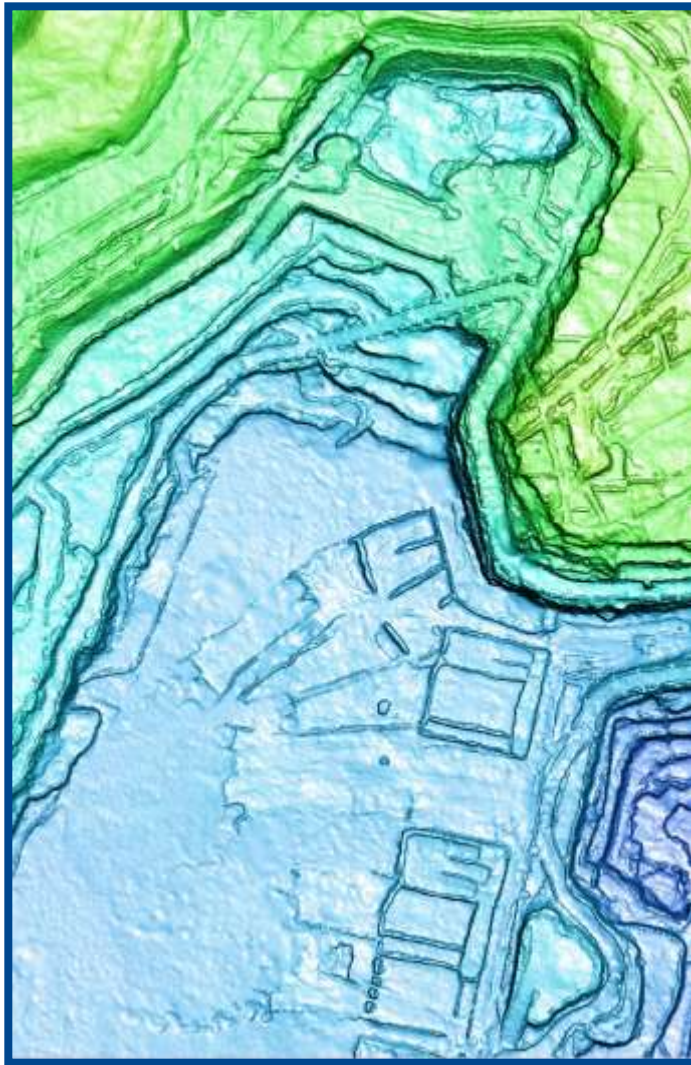
- **Trimble Dimensions**
 - **Digital Globe**
 - **Satellite Remote Sensing for Mining**
 - **Using Satellite Imagery to produce DEM data**

 - **Digital Globe – PhotoSat**
 - **PhotoSat was already producing monthly Satellite Orthophotos for Suncor**

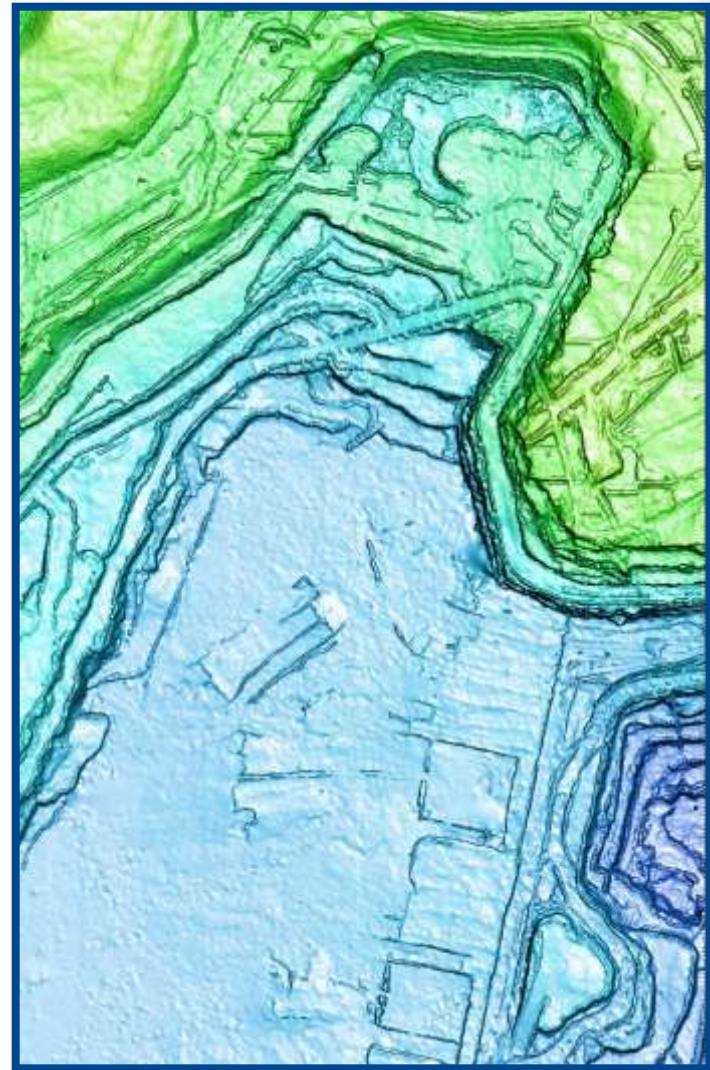
In 2013

- **PhotoSat began collecting monthly Satellite Imagery of Sand Dump 8 and delivering DEM data.**
- **This project expanded to include all TRO areas.**





Jan 20, 2013



Feb 23, 2013

Many features visible in the Jan 20 satellite topography have been buried by tailings by Feb 23.

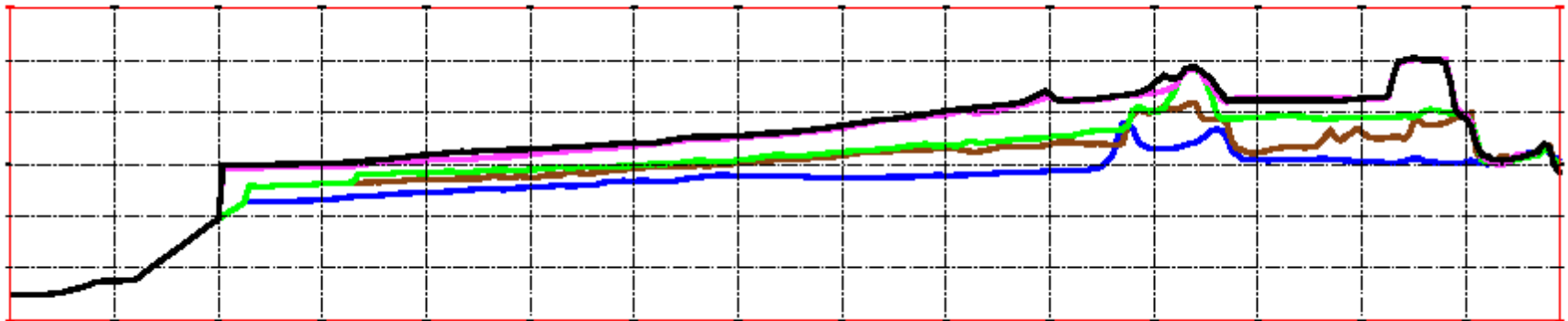


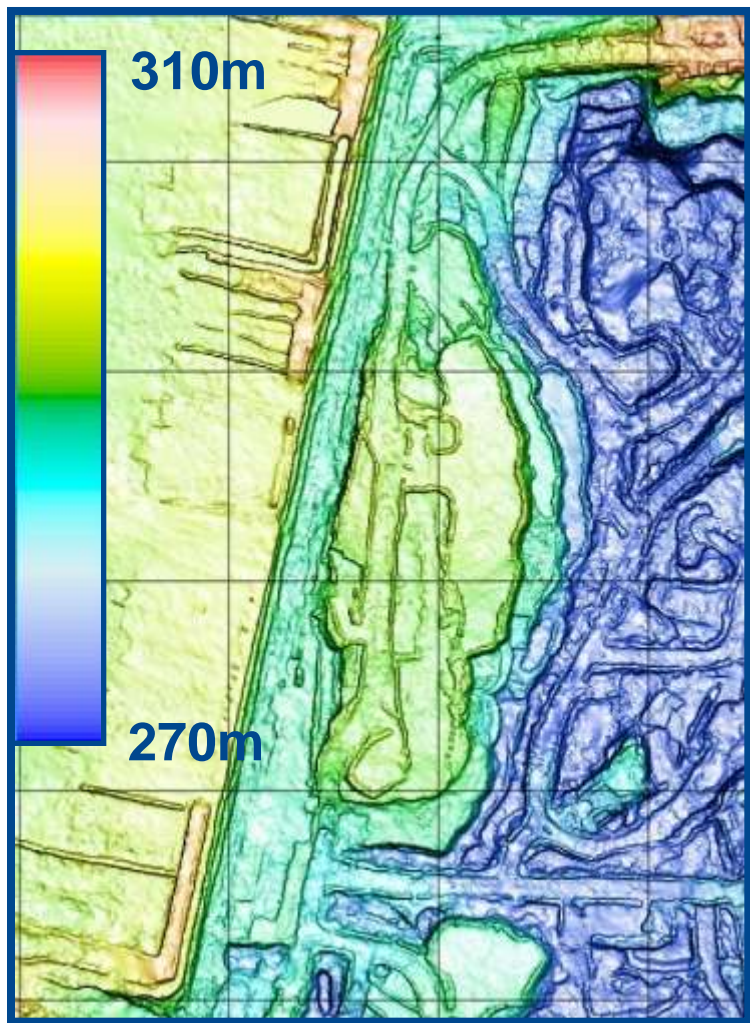
← Cross-Section

**50 cm tailings thickness contours
Jan 20 to Feb 23, 2013**

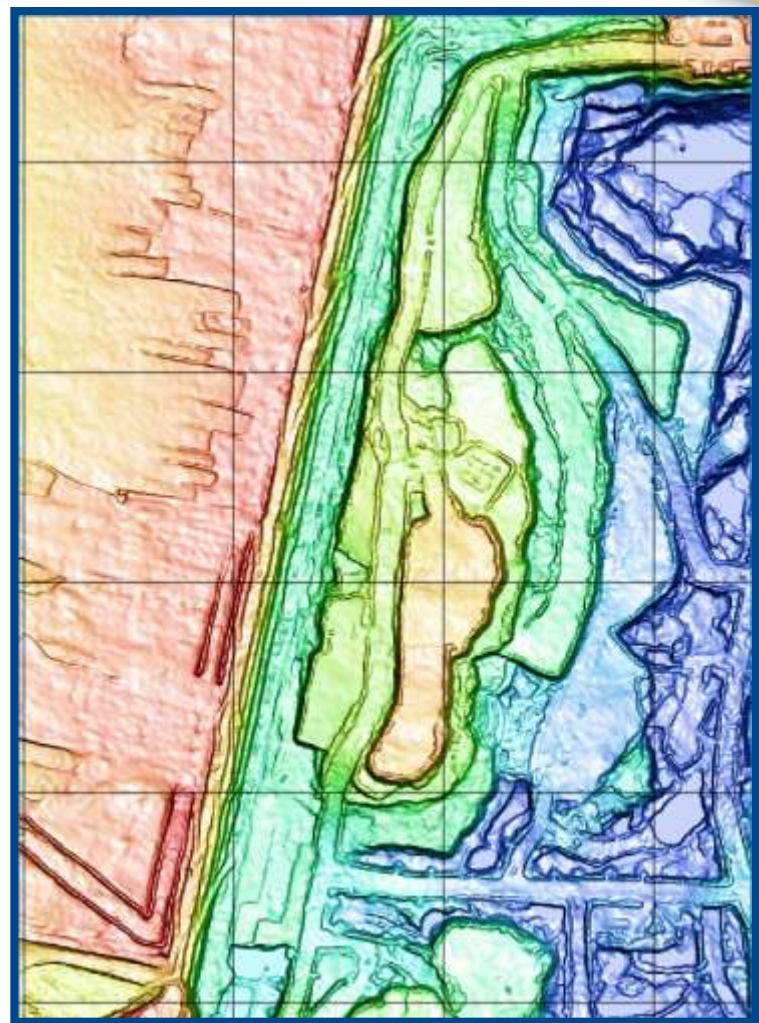
Cross-section at Sand Dump 8

- **First 5 surfaces from PhotoSat (2013)**
 - January 11 - Blue
 - February 23 - Brown
 - March 23 - Green
 - April 15 - Magenta
 - April 24 - Black

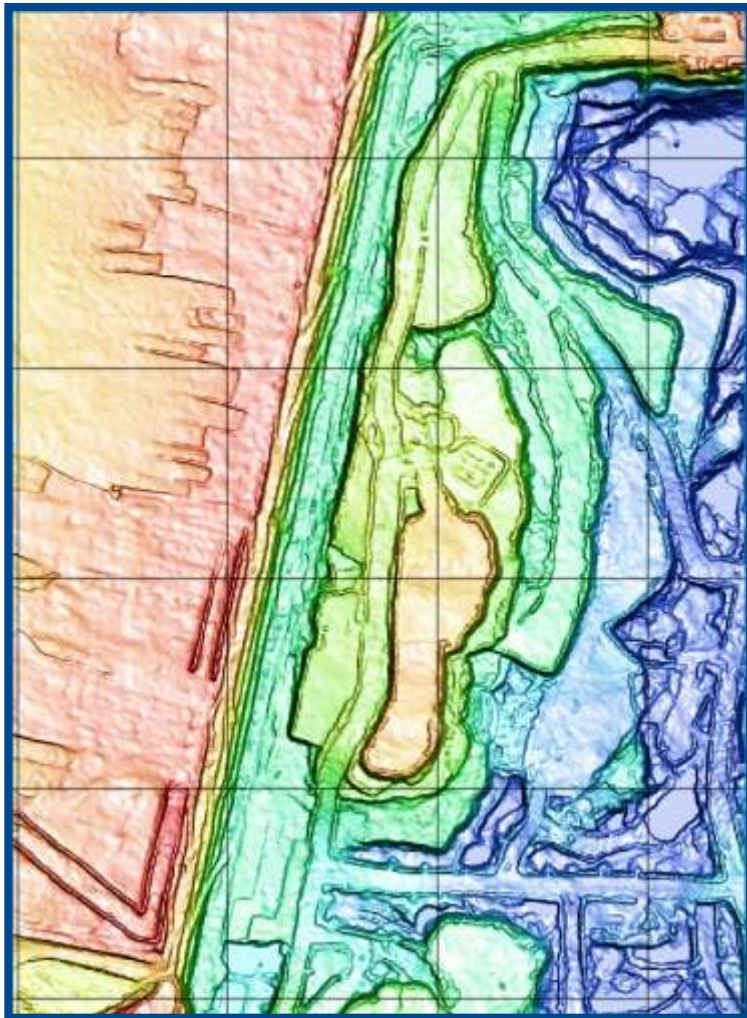




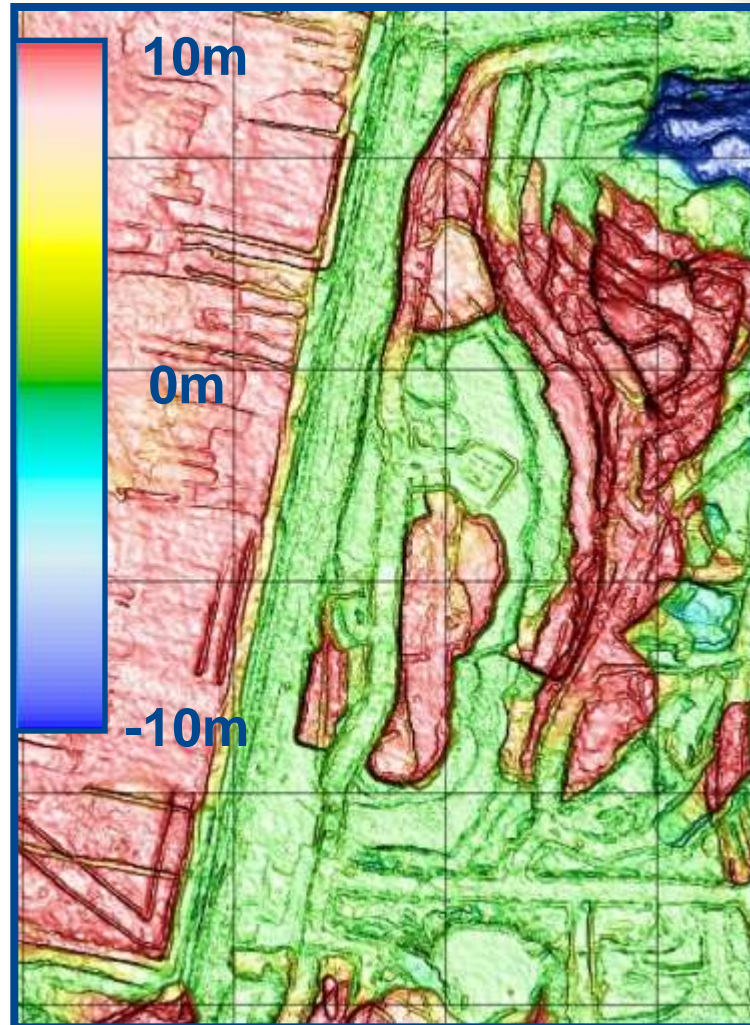
Dec 30, 2013



July 29, 2014



July 29, 2014



**Thickness Dec 30, 2013
to July 29, 2014**

Pond 6 Beach Excavation Survey

GPS and satellite mapping match to ½ inch

■ Pre Excavation Survey

- GPS Data - Blue 1' contours
- PhotoSat Data - Black 1' contours

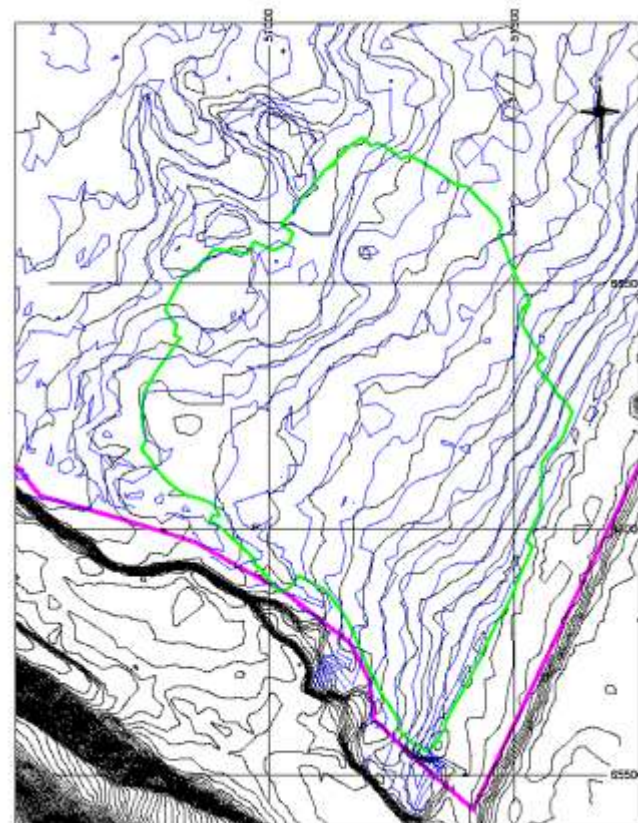
■ Excavation Survey

- GPS Data

- GPS surface – Excavation surface 77,982 yds³
- PhotoSat surface – Excavation surface 77,041 yds³
- Difference (1.2%) 941 yds³

- $941 \text{ yds}^3 / 70,134 \text{ yds}^2 = 0.0134 \text{ yds} = \frac{1}{2} \text{ inch}$

- On average, the PhotoSat data was lower than the GPS data by ½ inch.



Millennium Pit

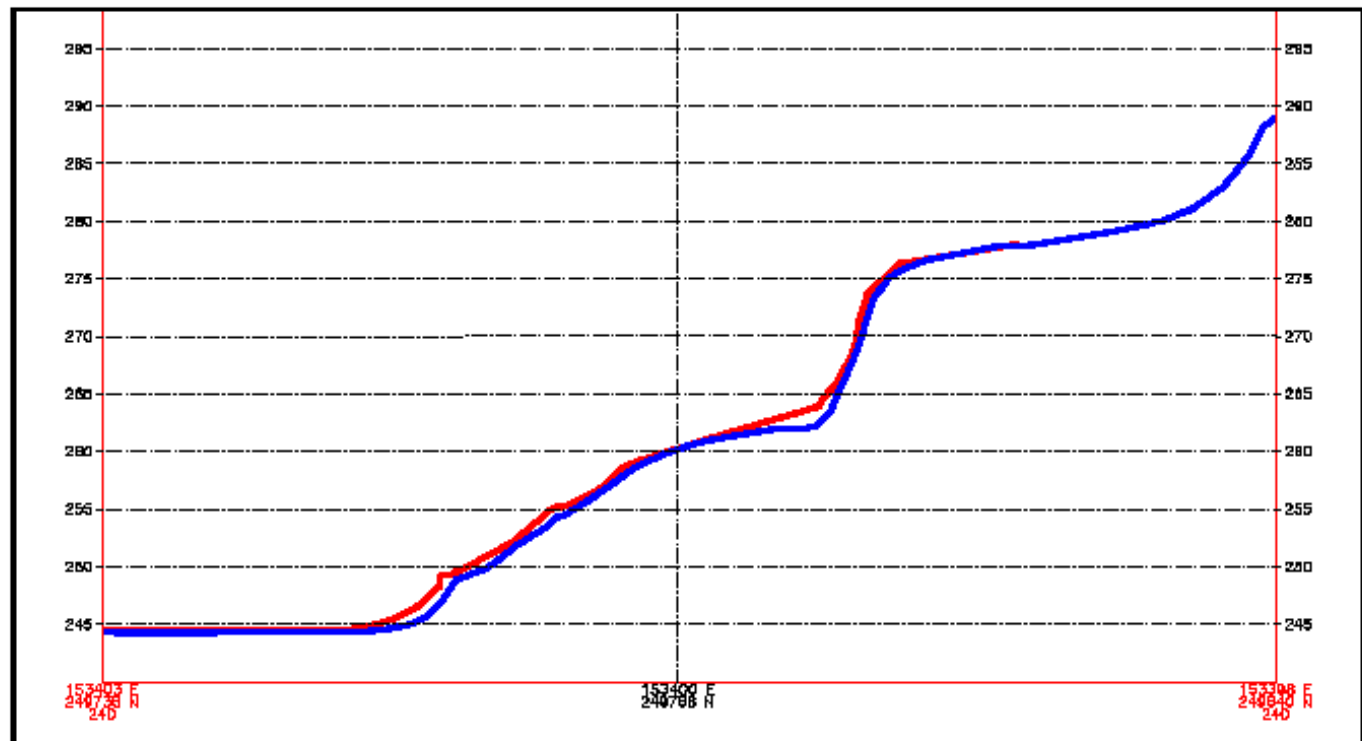
Trimble VX and GPS vs. PhotoSat Data

- **Cross Sections**
 - North Pit Wall
 - Overburden Top Cut



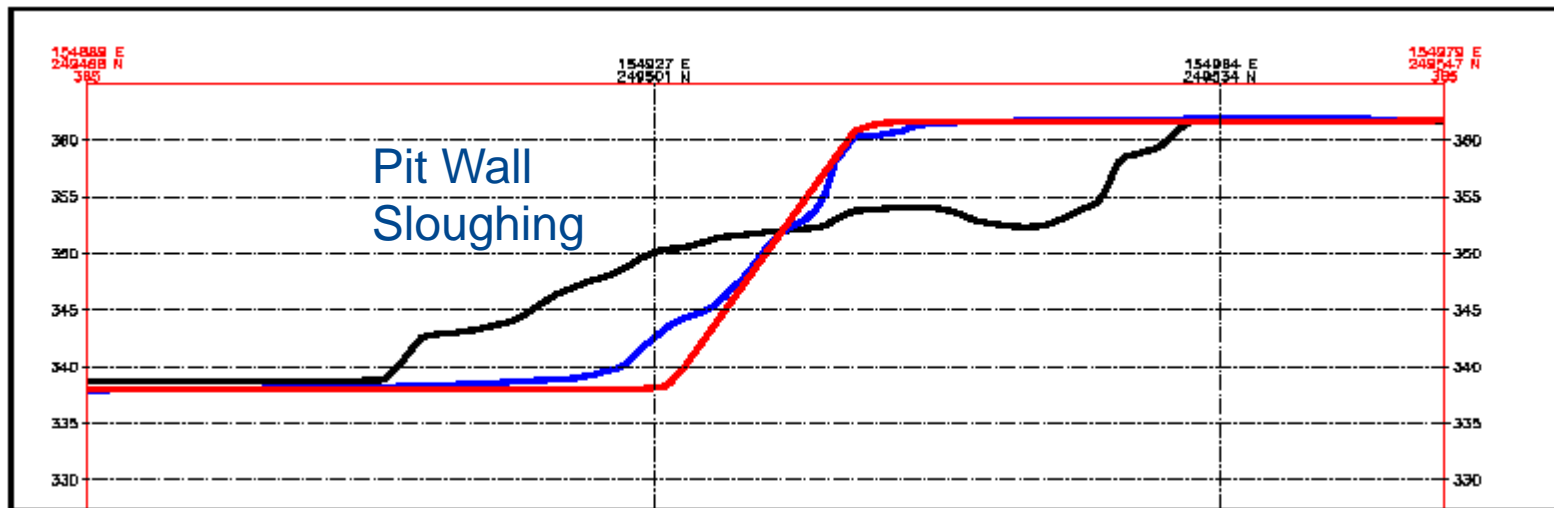
Millennium Pit – Cross Sections

- Blue Line - PhotoSat Data
- Red Line – Trimble VX Scan Data



Millennium Pit – Cross Sections

- Overburden Top Cut
 - Red Line – GPS Survey Data – March 9
 - Blue Line – PhotoSat Data – March 7
 - Black Line – PhotoSat Data – April 3
 - PhotoSat captured sloughing which is unsafe to survey with GPS.



PhotoSat Customized Data

- **Convert DEM data and Orthophotos to Suncor's Local Mine Grid Coordinates**
- **Filter DEM data**
 - Reduce density of point cloud in flat areas.
- **Create Break Lines (Crests and Toes)**
 - Used for visual reference on maps with and without contours.

PhotoSat Challenges

- **Limitations of satellite mapping**
 - **Shadows**
 - **Black Surfaces**
 - **Petroleum Coke Stockpile**
 - **Active Oilsands Pits**
 - **Tree Cover**
 - **Snow Cover**
 - **October – March**
 - **Cloud cover**



Suncor stereo satellite topographic mapping dates 2013-2014

2013		2014	
1.	January 11	1.	February 5
2.	January 20	2.	March 7
3.	February 23	3.	April 4
4.	March 7	4.	May 14
5.	March 24	5.	June 8
6.	April 4	6.	June 29
7.	April 14	7.	July 13
8.	April 24	8.	July 27
9.	May 10	9.	August 24
10.	June 4	10.	September 11
11.	July 17	11.	September 21
12.	August 18		
13.	September 15		
14.	October 14		
15.	November 18		
16.	December 30		

In 2014

- **Suncor Survey Department continues to use Trimble GPS equipment for weekly surveys of accessible areas in**
 - **Mine Pit Advance**
 - **Overburden Dykes and Dumps**
 - **Tailings Construction**
 - **Tailings Reduction Option**
 - **Tailings Dykes**
- **For survey areas that not accessible...**

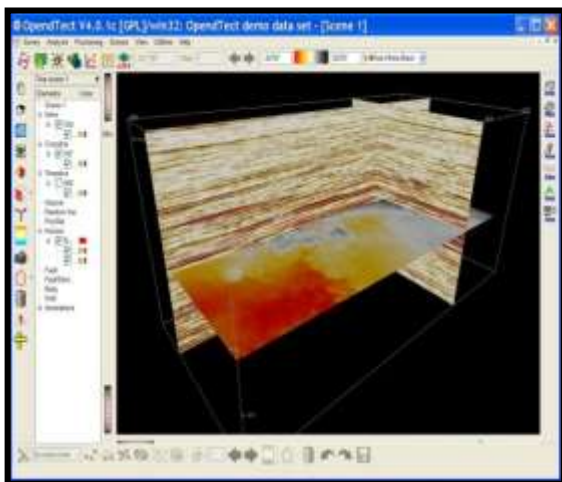
In 2014

- **Suncor has been using PhotoSat data for surface updates twice per month in**
 - **Tailings Reduction Operations (TRO)**
 - **Sand Dump 8**
 - **DDA Systems**
 - **Tailings Pond Beaches**
- **Suncor has been using PhotoSat data for surface updates once per month in**
 - **Mine Pit Advance**
 - **Overburden Dumps**

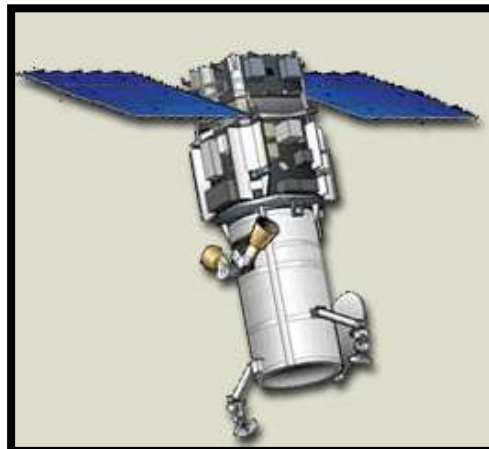
PhotoSat Technology Background

Four key technical components enabling 15cm accuracy mine tailings mapping from space

Adaptation of seismic processing systems



High resolution stereo satellite photos

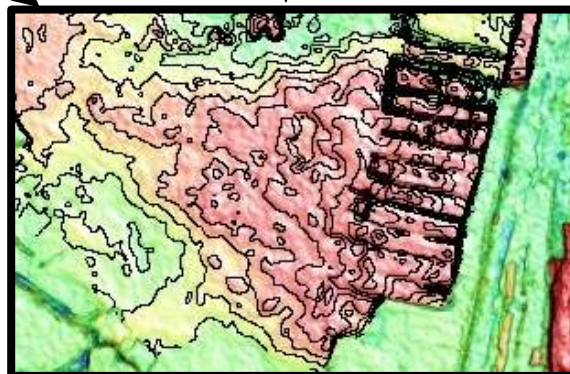


Graphics Processing Units (GPUs)



Oil sands surveying and 450+ other projects

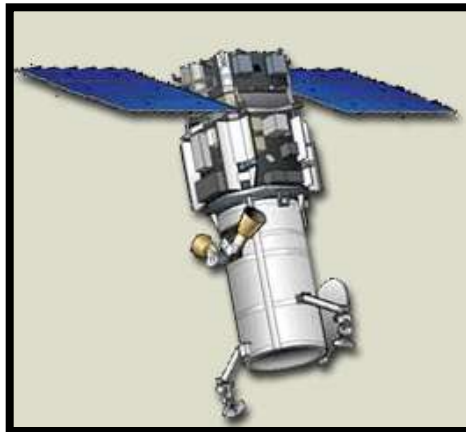
Characterize the satellites and optimize the process



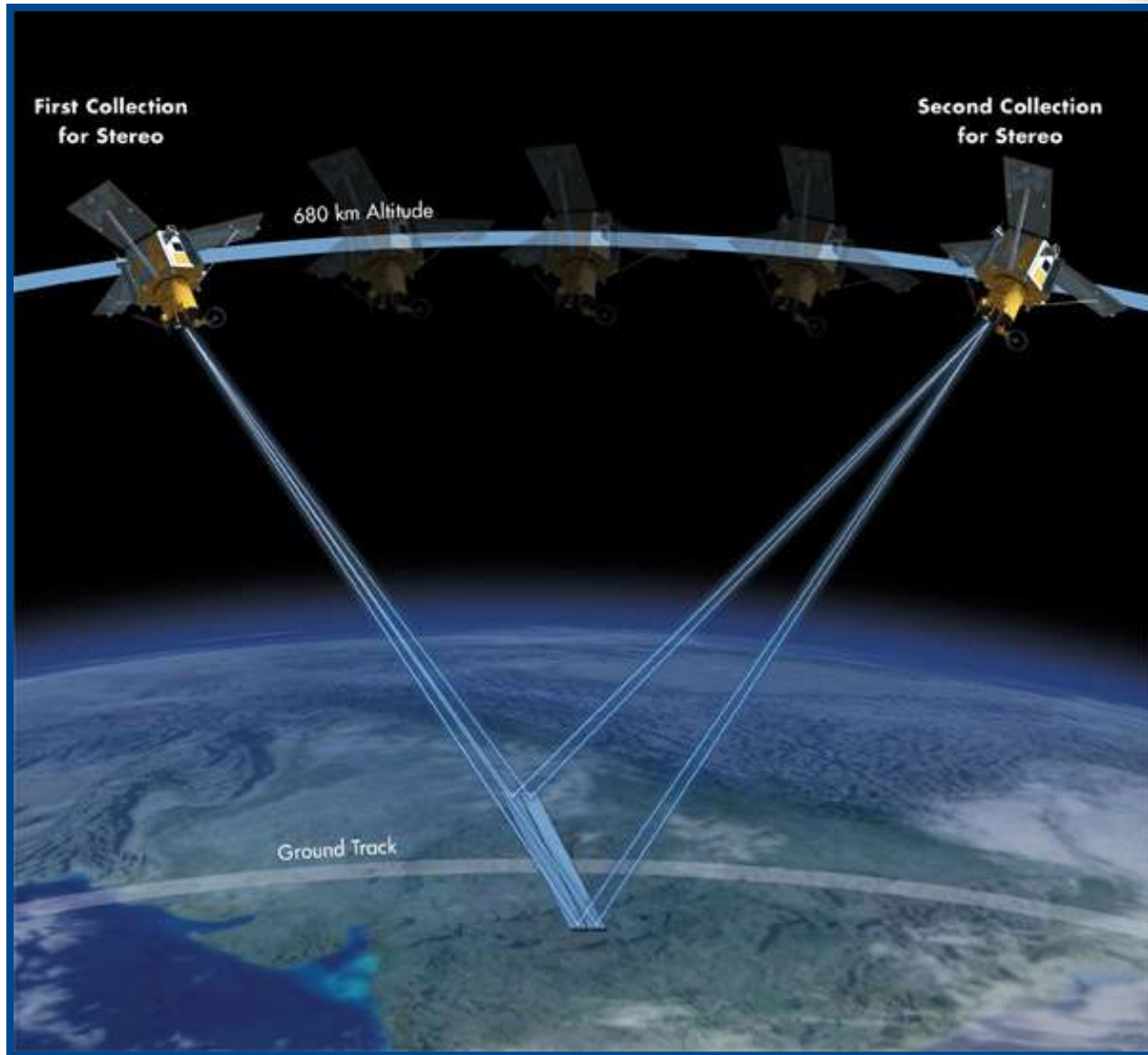
High resolution stereo satellites



**WorldView-1 50cm greyscale
2008**

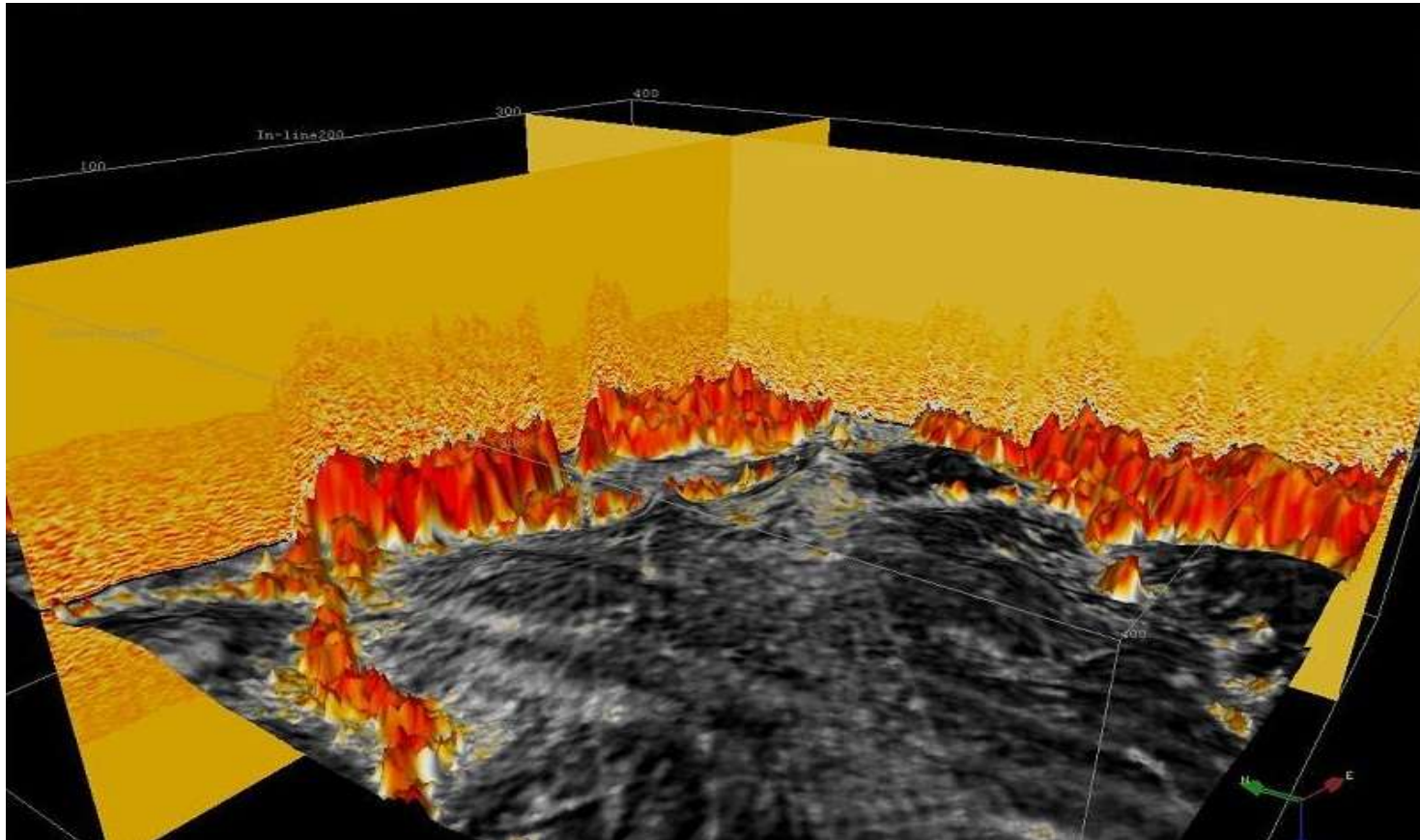


**WorldView-2 50cm colour
2010**



Ground elevations are measured from the parallax of the satellite stereo pairs.

“Seismic” processing of stereo satellite photos

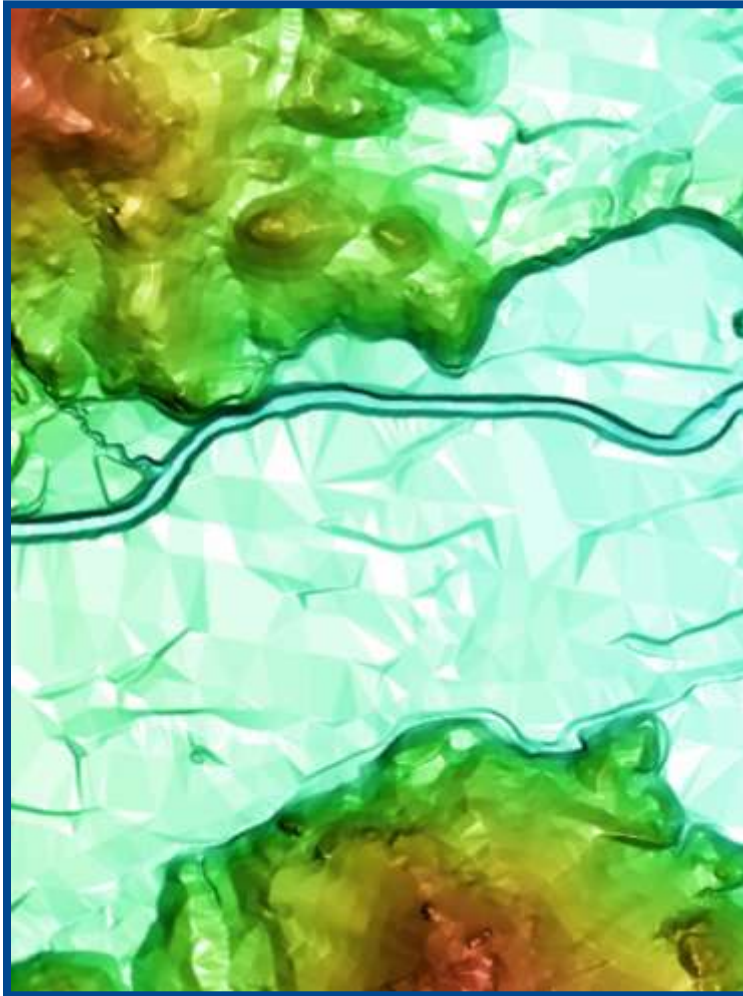


Satellite topographic surface displayed in a 3D seismic workstation.

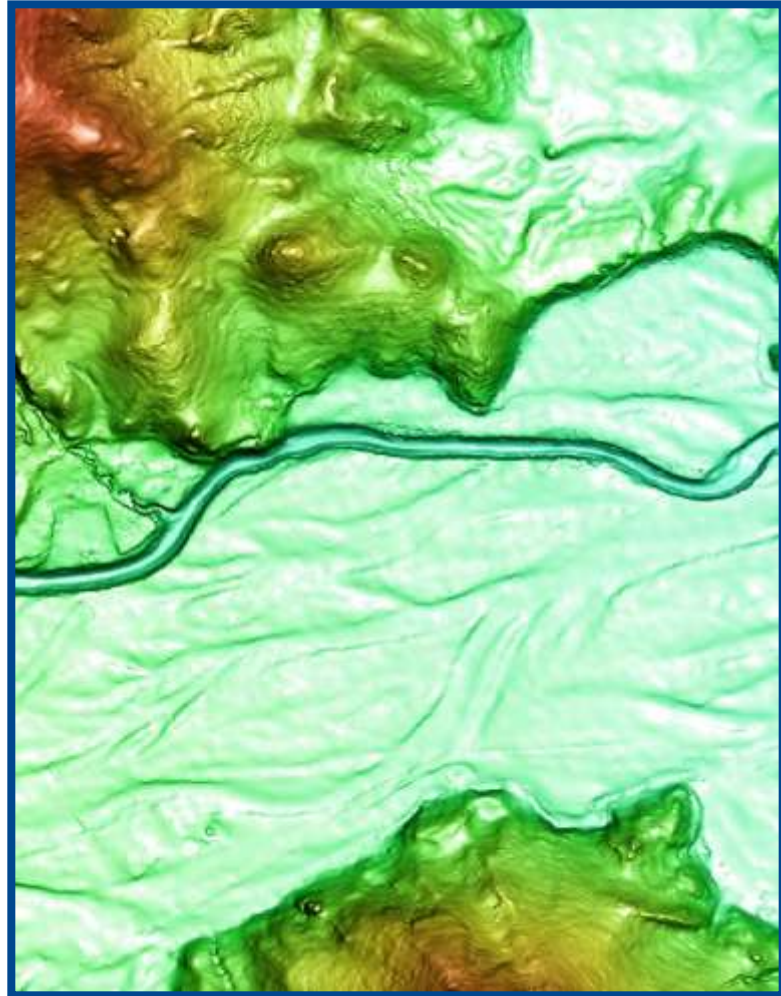


***PhotoSat 3D stereo satellite
processing and visualization system***

Better topographic detail

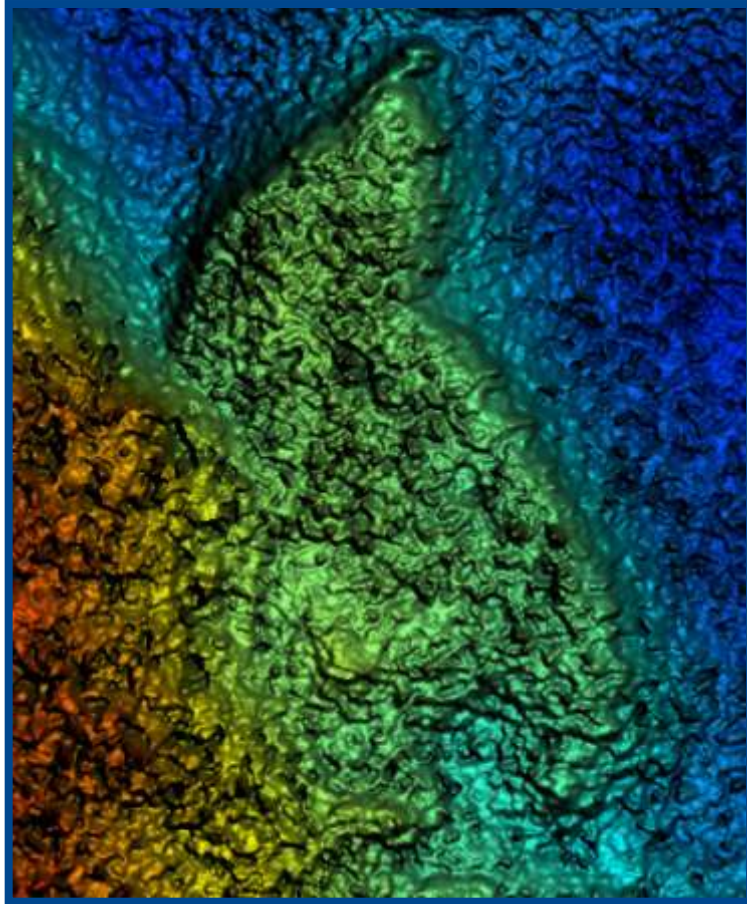


**Conventional
Photogrammetric mapping**

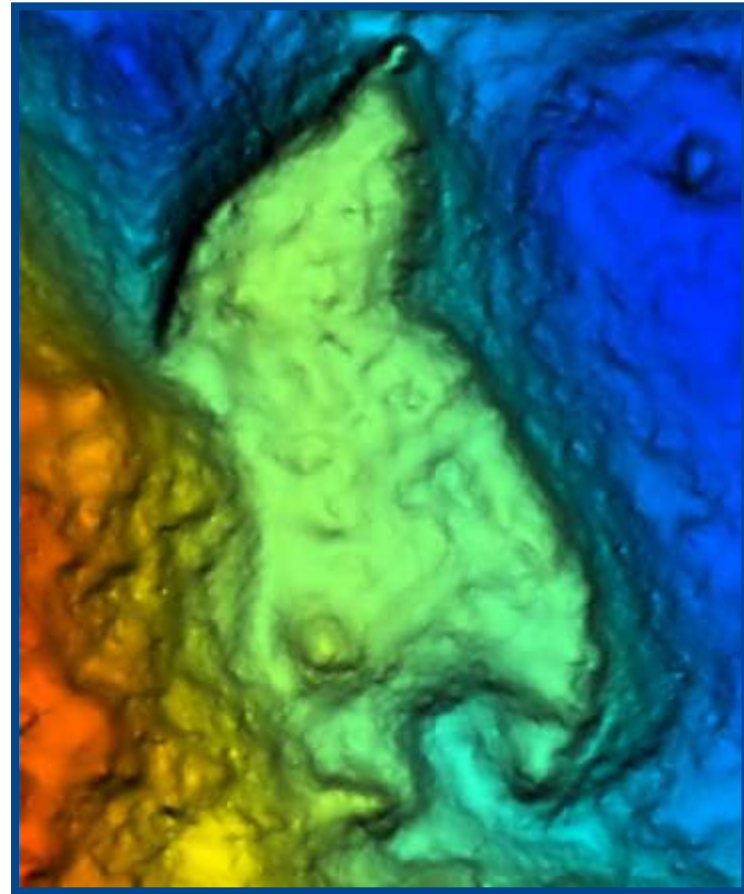


PhotoSat mapping

Lower topographic noise

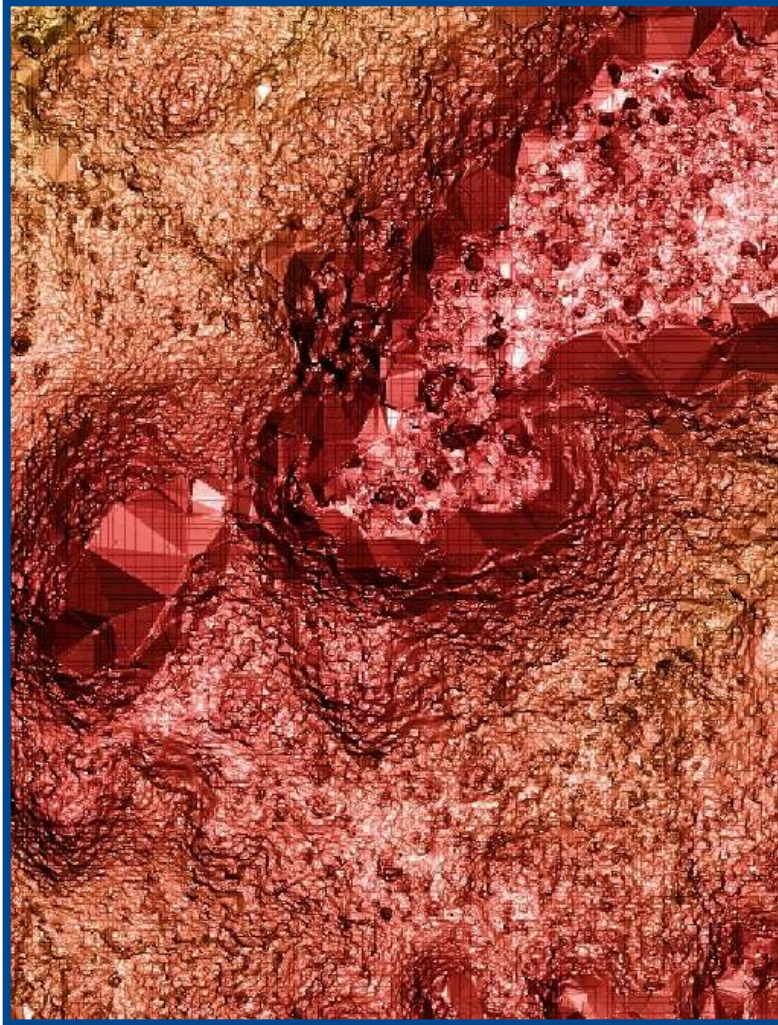


Photogrammetric mapping

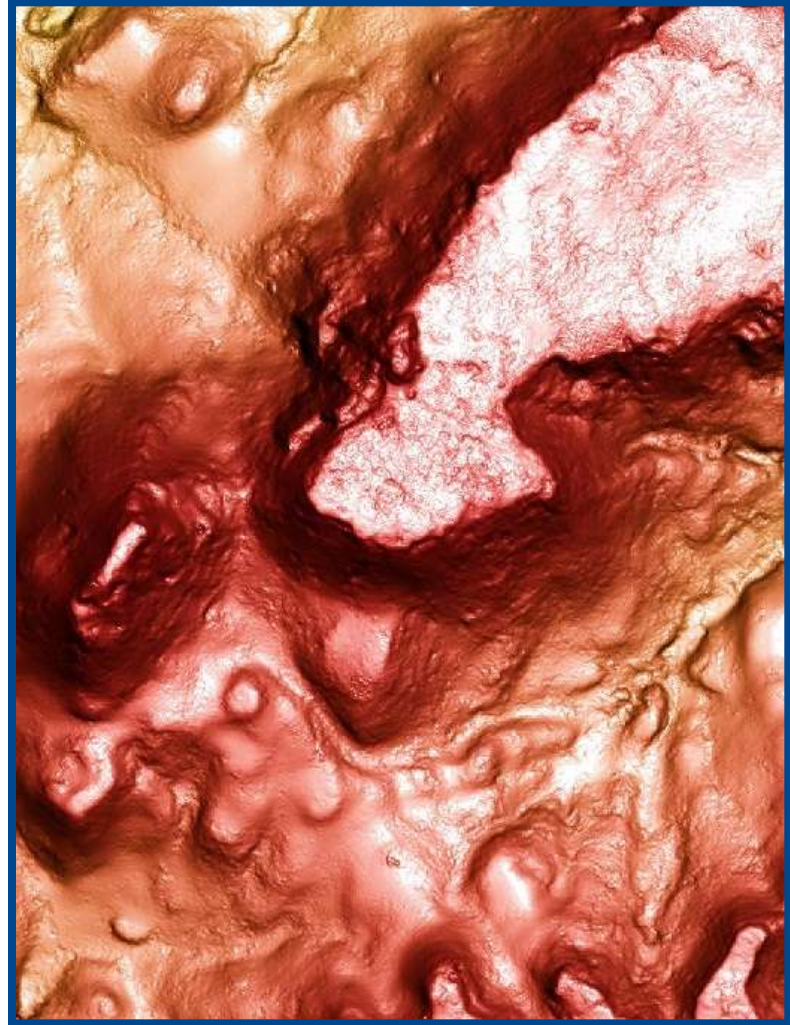


PhotoSat mapping

Better resolution of steep slopes



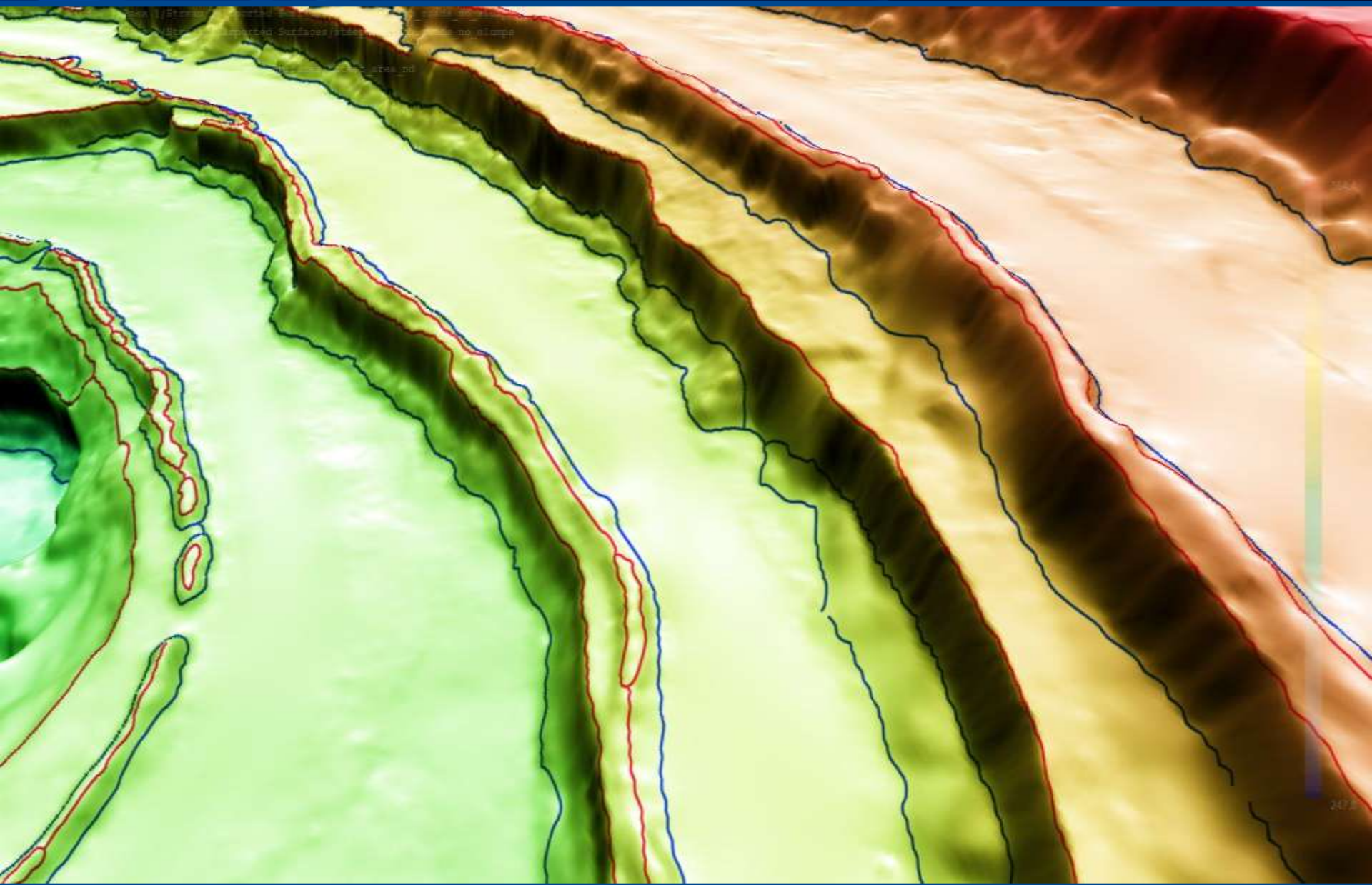
Photogrammetric mapping



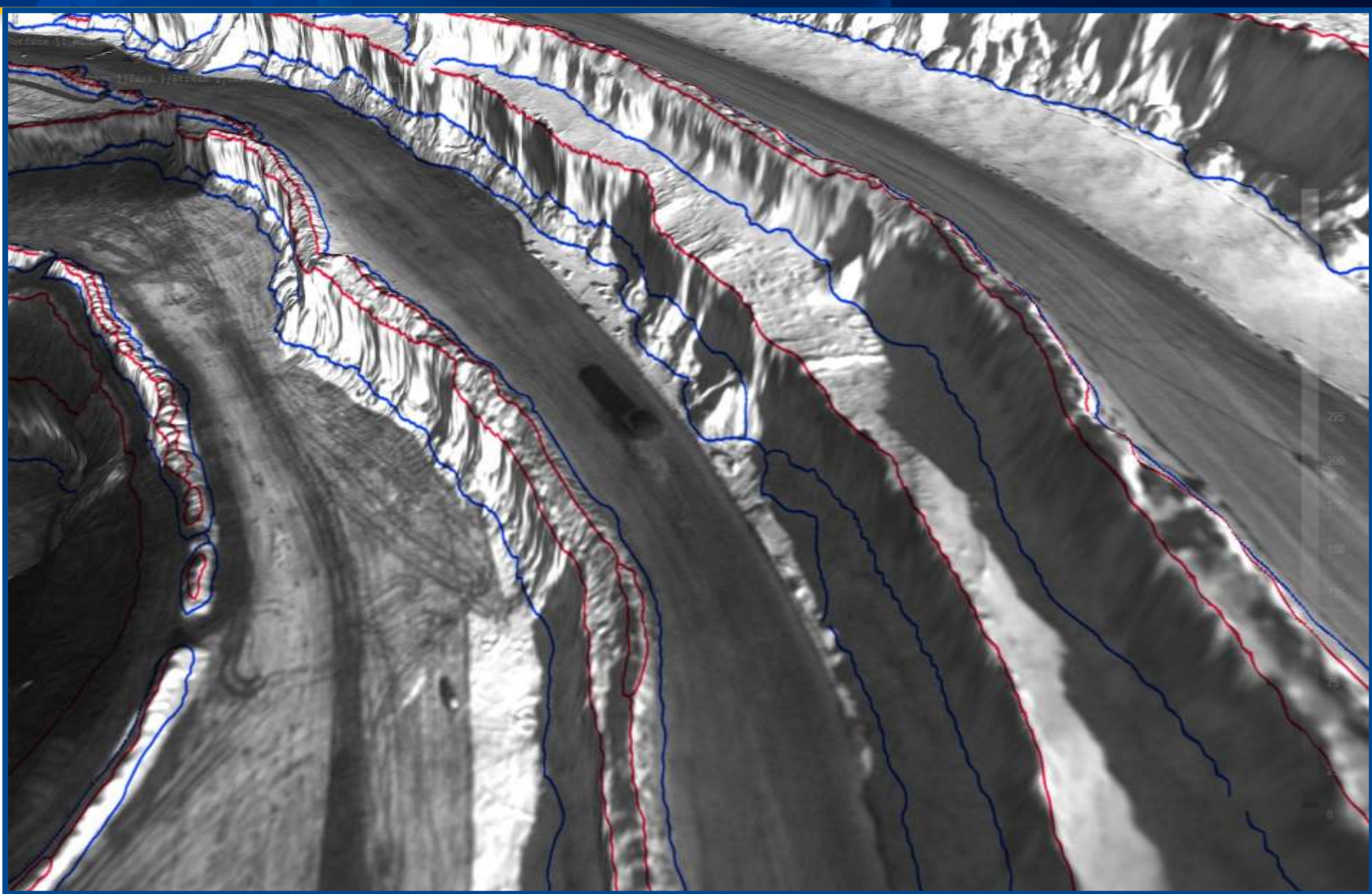
PhotoSat mapping

In collaboration with Suncor PhotoSat developed a process for automatically mapping the mine site toes and crests.

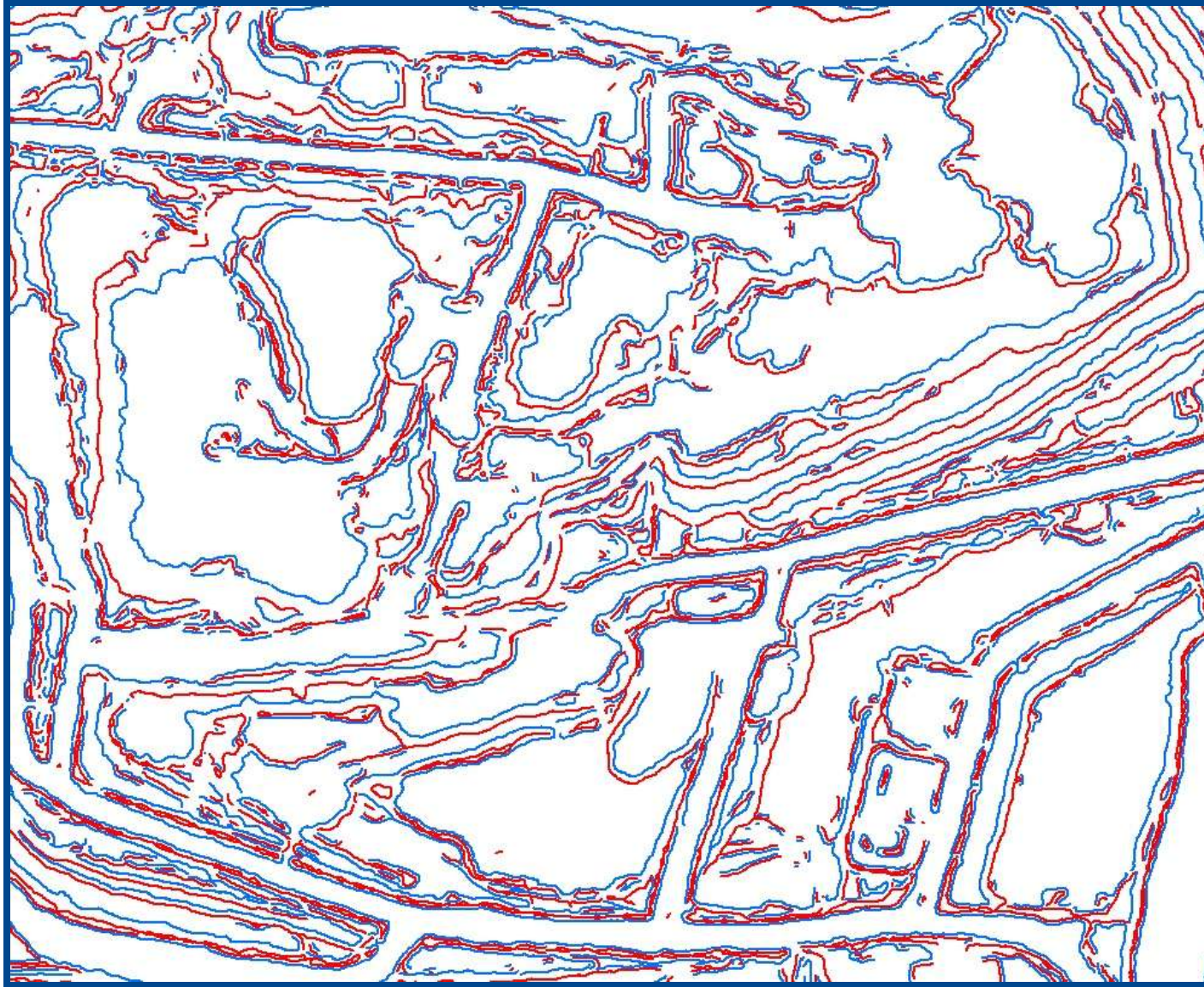
We have been contracted to provide this service every 2 weeks for the balance of 2014.



Millenium Toes and Crests



Millenium Toes and Crests

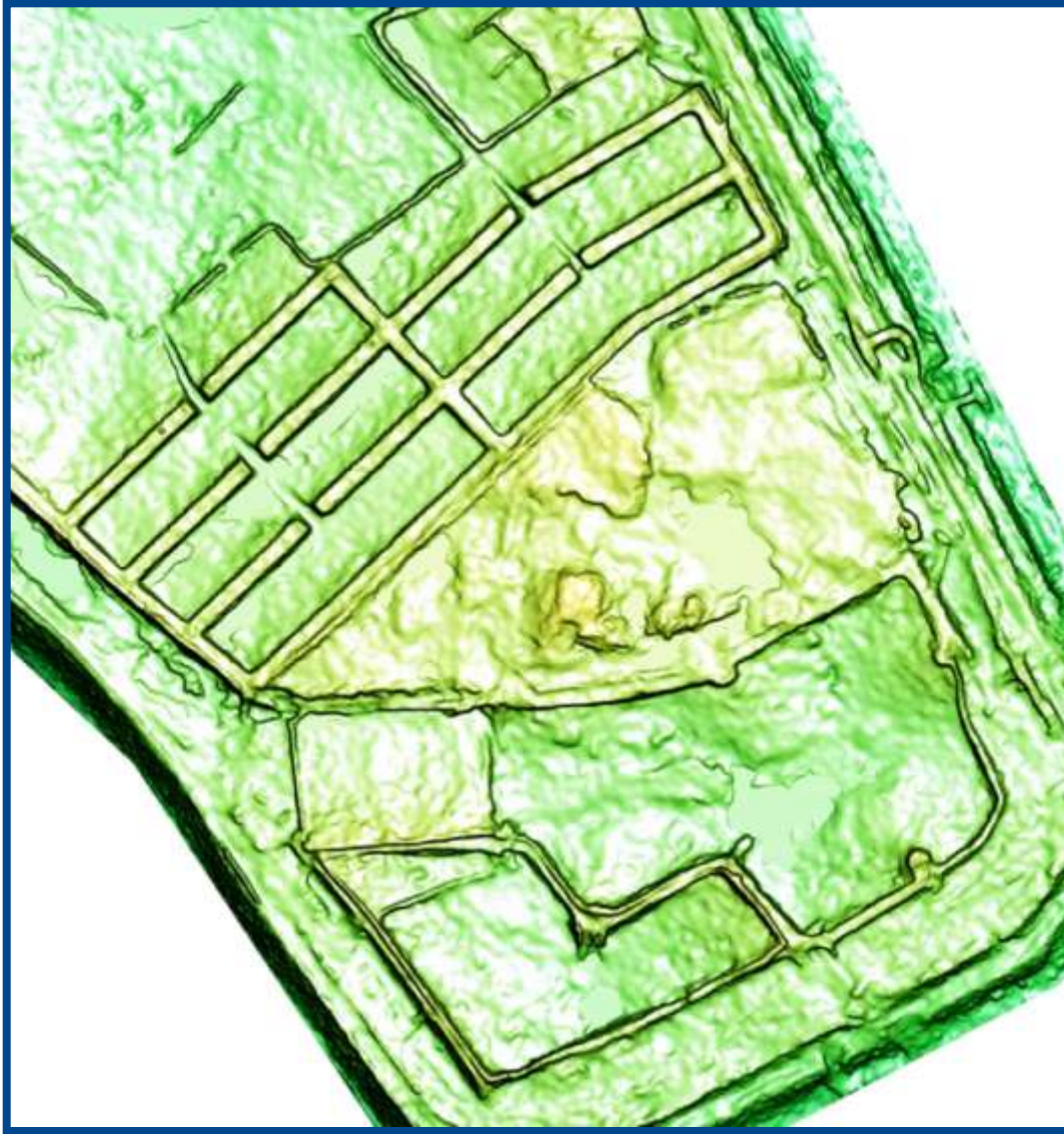


Millenium Mine Toes and Crests

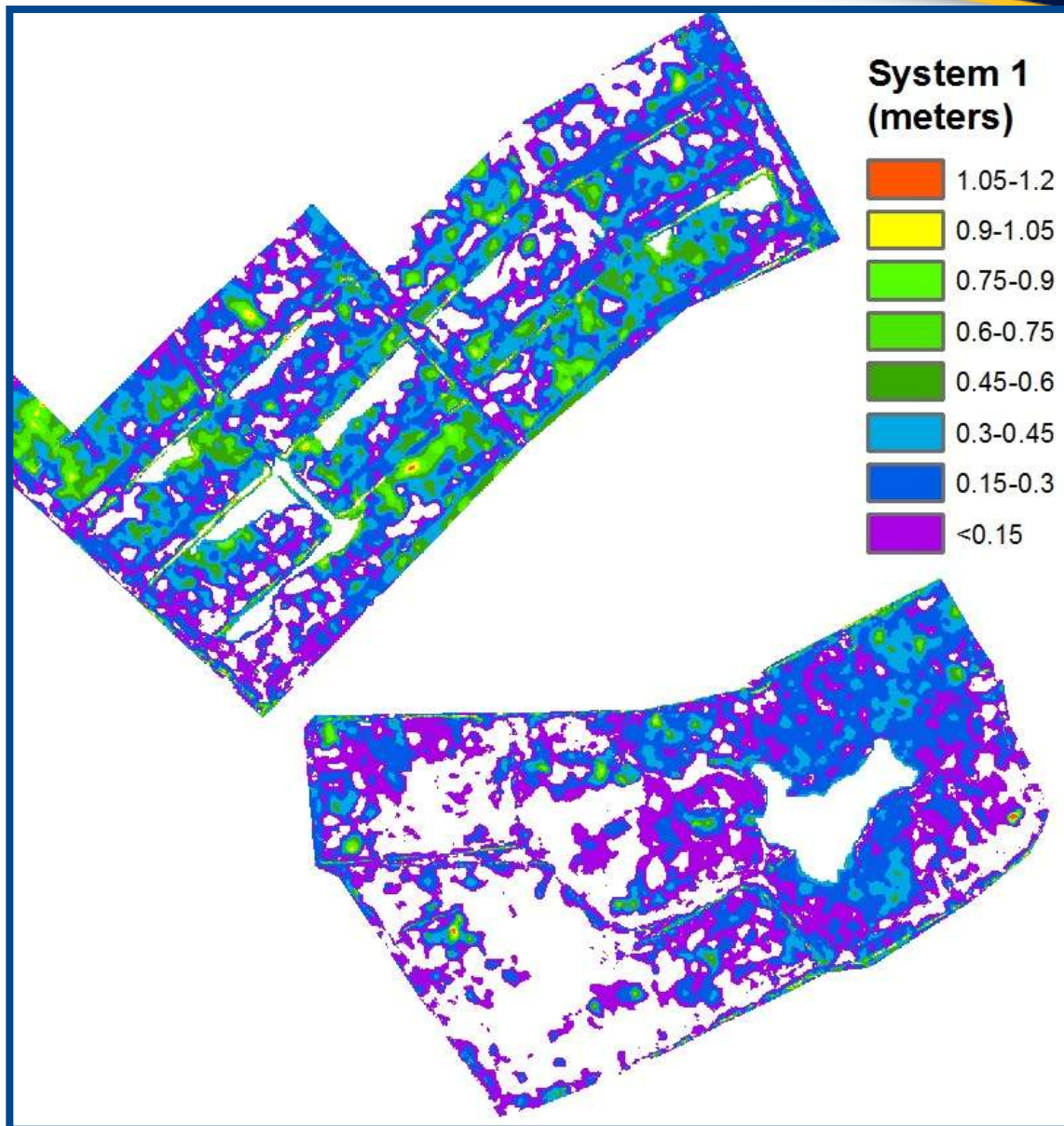
In collaboration with Suncor PhotoSat is developing a process for automatically mapping the thickness of the Mature Fine Tailings dewatering cells between satellite mapping passes in increments of 15cm thickness.



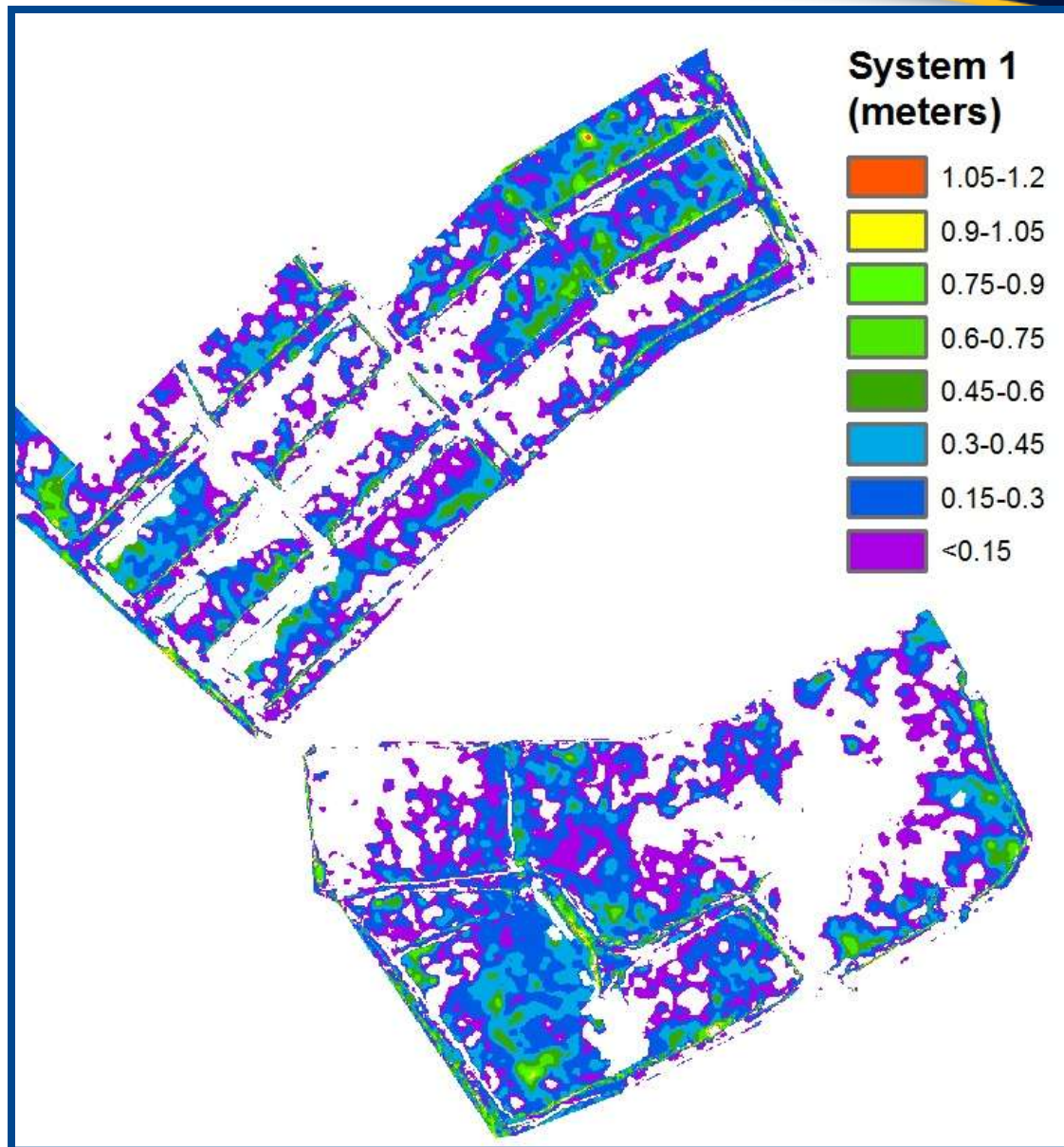
Millenium MFT System 1, July 27



Millenium MFT System 1, July 27



System 1, Isopach June 29 to July 13



System 1, Isopach July 13 to July 27