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MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

South Wall Buttress As-built Report

January 2015

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1 Introduction

This report presents as-built drawings and performance measurements of the South Wall Buttress, built to stabilize the Main Pit's south wall following a significant slope failure in April 2011.

The Main Pit was Minto Mine's sole source of ore from startup in 2007 through its completion in April 2011. The pit was mined in five stages, each enlarging it to access deeper ore. The south wall of the pit intersected a paleochannel of permafrost soil overburden with significant ice content. Each stage of mining (except for Stage 4) pushed the southern extent of the pit further, increasing the height of the exposed overburden slope: at the completion of Stage 5, it measured 67m high at its deepest point.

In their design report for the South Wall Buttress, EBA provided the following description of the slope:

> *The south wall consists of between 50 and 70 m of soil overlying bedrock. The following general stratigraphy is extrapolated from available borehole information:*
>
> - *0 to 5 m depth - Various fill materials, and native Silt (Till-like) material;*
> - *5 m to 45m depth – Silt/Sand (Till-like) soils;*
> - *45-50 m depth – Ice-rich Permafrost Clay, observed to contain substantial warm segregated ground ice;*
> - *50-55 m depth – Sand derived from weathered bedrock (Residuum);*
> - *55 m depth – Granodiorite Bedrock*
>
> *Based on movement data, failure is confined to a relatively weak zone within the overburden located at a depth of about 40 m to 50 m. This weak zone correlates with a layer of ice-rich permafrost clay. The inclinometer data indicates that a large block of the overburden above this weak zone is creeping slowly towards the pit. The mechanism of failure is analogous to ice near its melting point at the base of a glacier.*

1.1 Background

Movement along a plane above the overburden / bedrock contact had been observed during the mining of the Stage 3 pushback in April of 2009; this movement eventually led to a failure of the south wall on May 5, 2009.

After the completion of Stage 3 in March 2010, a small (approx. 210,000 m^3) buttress was dumped in up to the 766m elevation to prevent movement near the toe of the overburden layer. This interim measure, having successfully stabilized the Stage 3 wall, was removed in the course of Stage 5 mining.

With the failure of the south wall during the mining of Stage 3, the Stage 5 pushback design was created with a large unloading cut at the 810m elevation and 30° slopes in overburden. Mining of Stage 5 began in summer of 2010 and finished in April 2011.

Prior to mining, it was recognized that the Stage 5 south wall would need to be supported by a buttress of 850,000 m^3, which would have formed a layer of approximately 40m thickness over the slope. This was intended to prevent localized failure of the overburden layer. Several variations on this design were created, with some, such as that appearing in the *Preliminary Phase IV Waste Management Plan* submitted as part of the Phase IV environmental assessment application, measuring as much as 1.30 Mm^3.

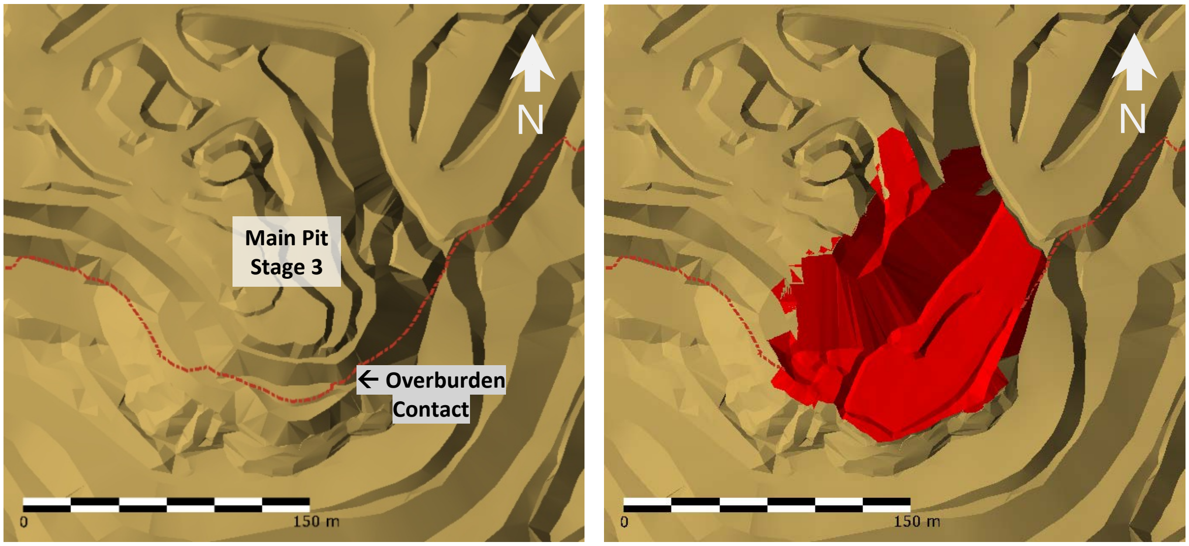


Figure 1-1: Completed Stage 3 pushback (left) and temporary buttress constructed to stabilize the slope (right).

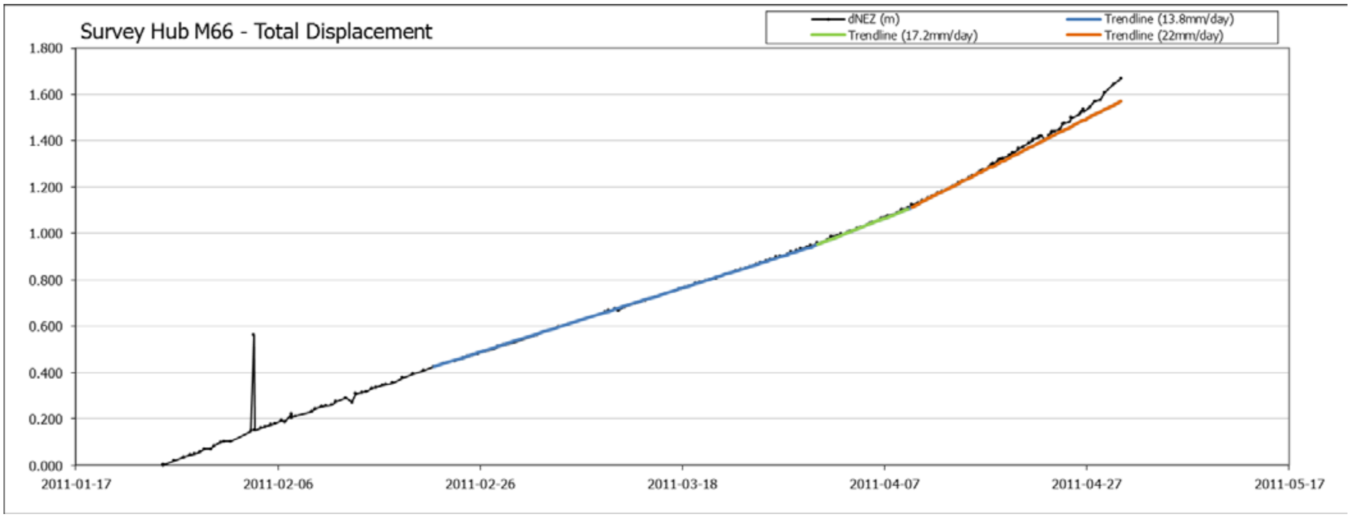
Figure 1-2: Movement along failure plane in overburden, south wall, Main pit, Stage 3 pushback, April 2009.

Figure 1-3: Displacement along the plane of movement: south wall, Main pit, Stage 3 pushback, April 2009.

Figure 1-4: Main pit, Stage 3, May 2009 south wall failure. Looking south-southwest, camera positioned at bottom of pit.

Figure 1-5: South wall failure, Main pit, April 2011. Aerial photo, looking southwest. Start of buttress construction visible at bottom left corner of the photo.

Monitoring via inclinometers and survey hubs during the mining of Stage 5 in the winter of 2010/2011 suggested a larger-scale translational failure. The graph below shows movement data for one such survey hub.



Analysis showed that the bulk of a 50m-thick silty / sandy overburden layer was sliding into the pit along a thin layer of ice-rich permafrost clay. After several months of accelerating movement, this translational failure resulted in a substantial piece of the slope sliding into the pit on April 30, 2011, bounded at the back by a large tension crack. This created an over-steepened overburden face that underwent a progressive failure, sloughing continuously throughout the summer of 2011 until winter conditions halted further degradation of the slope.

The volume of the failure initially measured 83,000 m^3; by the end of the summer, the volume lost from the South Wall had increased to 302,000 m^3. The following, quoted from EBA's *Area 1 South Wall Buttress Design Report*, describes the material that comprised the failure:

> *The majority of the in-situ overburden was in a permafrost condition and the failed material included significant remnant chunks of frozen material. Following the initial failure and subsequent failures, the resulting run-out of the failed material extended approximately 150 m from the toe of the original slope. Depending on the level of thaw, the material was deposited at an angle of between 10 and 15 degrees. Subsequent observations indicated that the failed material has continued to melt and the angle of the run-out material has further decreased.*

Construction of the buttress to the original design began shortly before the slope failure and continued until May 30, 2011, at which time the buttress advanced to a point where it could not be safely constructed using the original design. This, and concerns about the ability of the design to stabilize the slope, necessitated a new analysis of the data and a new design, which EBA performed in July of 2011.

This analysis showed that a buttress considerably larger than the original design would be required to halt the movement of the overburden slope.

2 Buttress Design

EBA's analysis concluded that a 2.65 Mm^3 buttress with a 4:1 front face slope, the toe of which would butt up against existing rockfill in the pit, would stabilize the south wall. The side slope of the buttress was designed at 1.5:1 H:V. The figure below shows an overview of the design; sections are available in the Section 4 of this document and in EBA's design report.

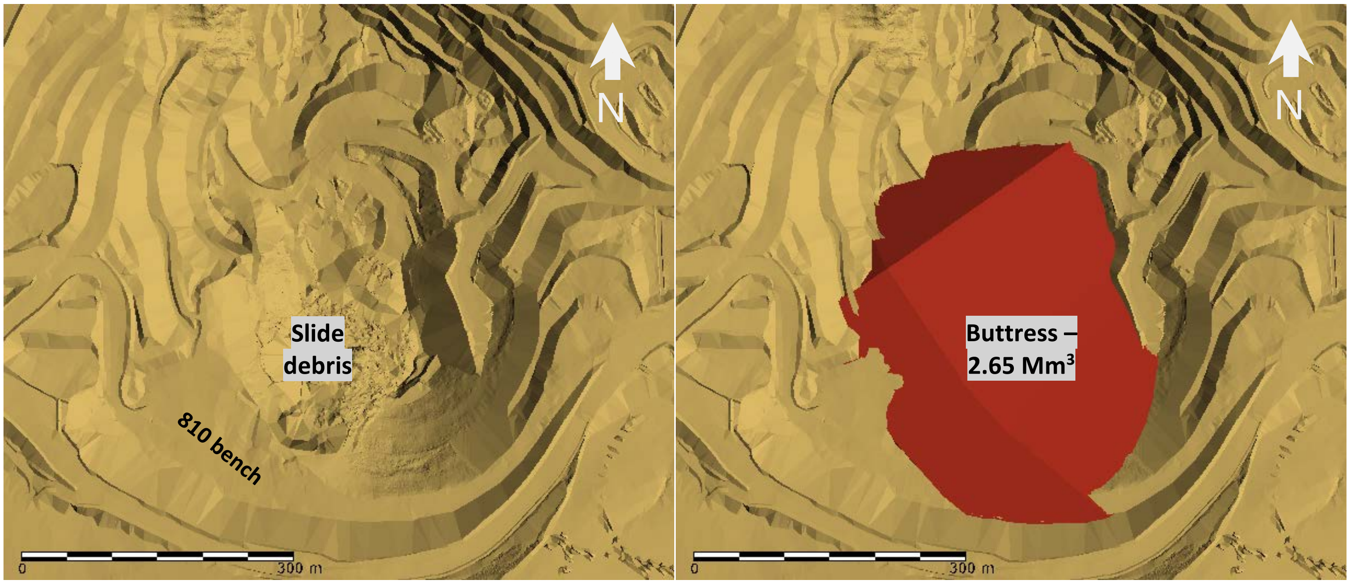


Figure 2-1: Post-failure survey of the Main pit (left) and final buttress design for the south wall of the Main pit (right).

The intersection of the overburden contact with the final pre-failure as-built of the south wall is shown in Figure 4. It can be seen that the overburden contact intersects the south wall as low as 740m at the south corner of the pit, and as high as the 770m elevation at the west corner of the pushback.

This is also illustrated in a section view of the buttress, shown in Figure 5.

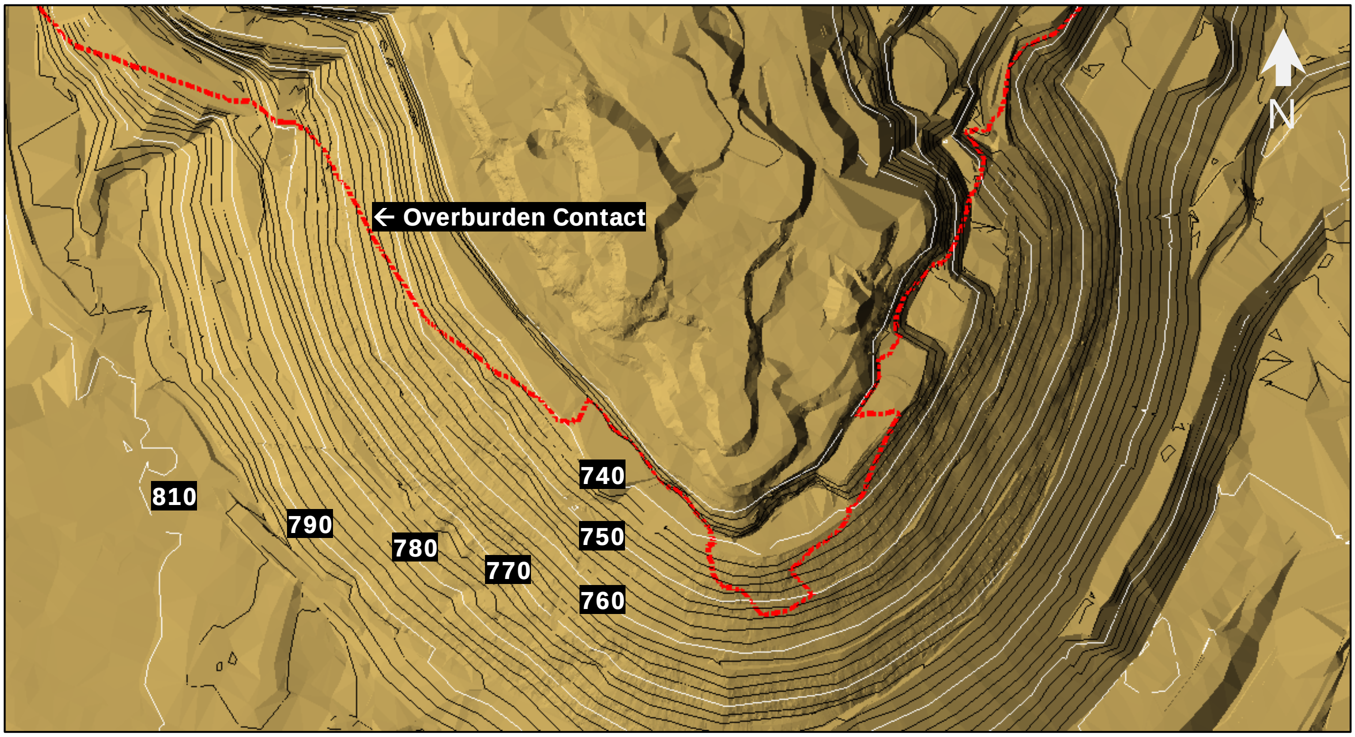


Figure 2-2: Overburden contact (red) where it intersects the final pre-failure as-built of the south wall.

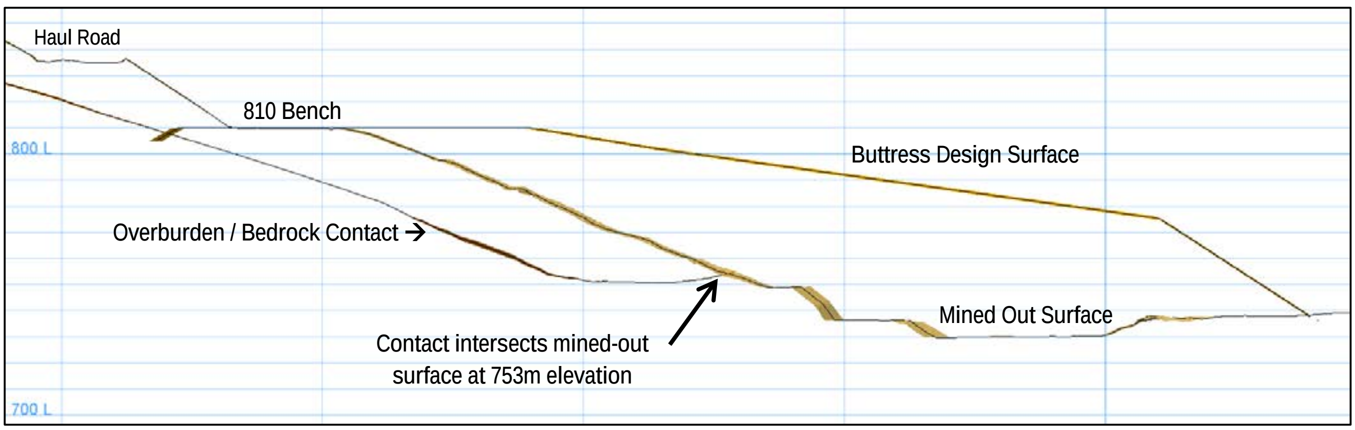


Figure 2-3: Section (0° azimuth) through centerline of buttress, looking west.

3 Construction Sequence

Dumping of material as per the original pre-failure buttress design began on May 28, 2011, shortly before the wall failure, by end-dumping from the 765 elevation. The photo below shows this initial dumping as of June 15. Dumping continued until June 2, at which time the toe was largely resting upon the slide debris and it was no longer considered safe to proceed. Minto contracted EBA to carry out a redesign of the buttress at this time.

Figure 3-1: Main Pit, looking southeast, June 15. Dumping based on the original wraparound buttress design is shown.

Dumping resumed on July 11 based on the new design. The construction plan called for three stages, the first of which was a toe berm across the pit on ground considered likely to be beyond the toe of the slide debris (due to the water level in the pit and Minto's inability to discharge water at that time, this could not be verified). This served to provide a stable toe for the buttress and to contain slide debris. The toe berm was dumped from the 754m elevation, which was chosen to ensure that natural segregation would leave coarse material at the toe of the structure, and to stay safely above the level of the slide debris. The water level in the pit was also a significant factor, being at approximately 750-753m elevation during the construction Stage 1.

The three sections shown in Figures 3-2 through 3-4 show the planned construction sequence.

Stage 2 padded over the slide debris from two separate faces. This approach was chosen so that dumping could advance from a stable base to cover the slide debris while maintaining sufficient dump height to permit safe travel of haul trucks on the dump surface. Stage 2, as well as the completed Stage 1 toe berm, are shown in Figures 3-5 and 3-6.

Following the completion of Stage 2, further construction took place in lifts of 2m thickness, each of which was compacted using a vibratory smooth-drum compactor, until the buttress reached the 784 elevation in March 2012. At this time, effort shifted to the Mill Valley Fill Extension.

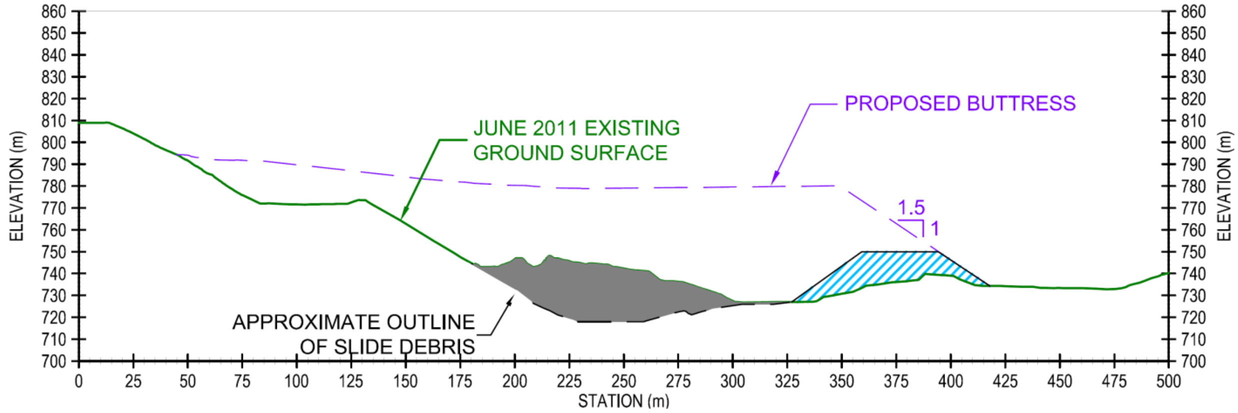


Figure 3-2: Stage 1 of buttress construction, shown hatched in blue.

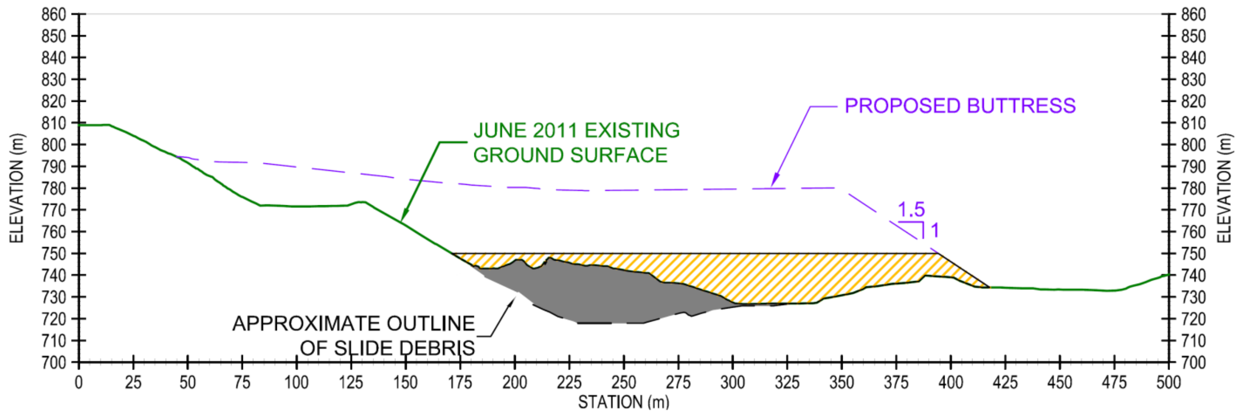


Figure 3-3: Stage 2 of buttress construction, advancing the buttress flat to pad over slide debris.

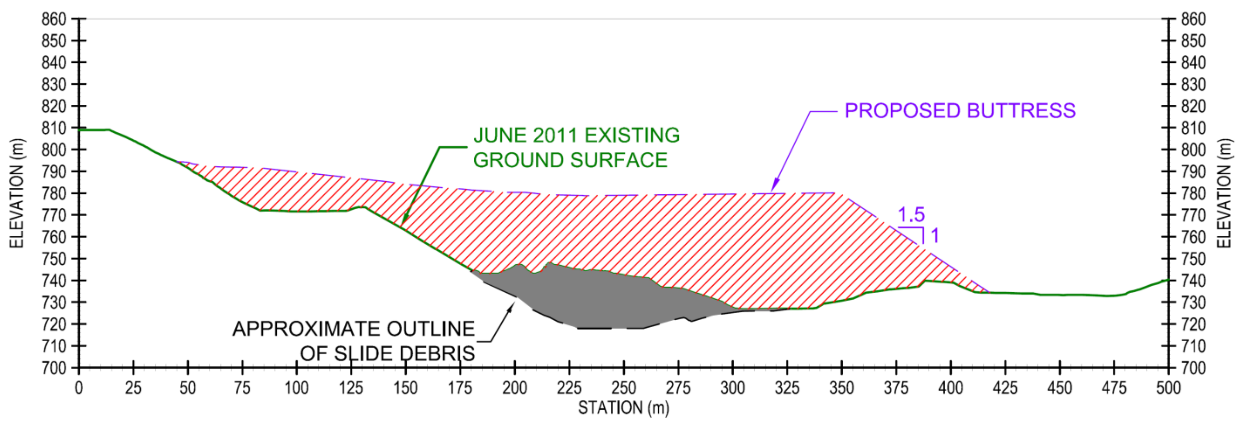


Figure 3-4: Stage 3 of buttress construction: bulk fill.

Figure 3-5: Photo showing Stages 1 and 2 of buttress development. September 17, 2011, looking S-SE.

Figure 3-6: Buttress development, October 2, 2011, looking E-SE.

Figure 3-7: Aerial ortho-photo of South Wall Buttress, August 14, 2012.

Figure 3-8: Aerial ortho-photo of South Wall Buttress, August 11, 2013.

Figure 3-9: Aerial ortho-photo of South Wall Buttress, September 9, 2014.

Work resumed in September 2012 by dumping a road on top of the South Wall Buttress's front face; this expanded the dump beyond the original EBA design and was intended to serve as a bench along which a tailings line would run.

The development of this additional bench coincided with Minto's decision to separate so-called "SAT waste" from the Area 2 pit, this being waste rock with an NP:AP ratio less than 3.0, a sulfide sulfur content greater than 0.30%, or a paste pH of less than 5.0. It was determined that this material should be stored under saturated conditions after the closure of the mine. To minimize re-handling costs at closure, dumping of SAT waste rock from the 786m elevation, beyond the design of the South Wall Buttress and beneath the spill elevation of the pit, began at this time and continued until April 2013.

To conserve pit volume for the mine's water and tailings storage needs, dumping of SAT waste then began on top of the buttress pad.

Simultaneously, a new haul road was built from low-grade waste rock to compensate for the loss of the previous haul road mined out by the northwest corner of the Area 2 pit (see Figure 3-8). The thawing overburden on the 810 bench was covered: this low-grade waste rock fill was only partly within the buttress footprint. Finally, work resumed on raising the lower pad of the South Wall Buttress in lifts until it reached its present level at the 800m elevation.

4 As-Built Drawings and Volumes

As-built drawings are shown in the following figures. The sections were chosen to approximately match those in Figure 4 of EBA's design report.

In some section views, the profile of the slide debris shows vertical discontinuities, as it was created as a composite of several surveys taken over a period of months. As the south wall overburden thawed and sloughed, the volume of slide debris in the pit increased, flowing over the fill being placed at the time. Simultaneously, rock fill was being placed on top of slide debris. The point at which the slide debris met the rock fill was observable on each survey surface, but it was not possible to determine the nature of the contact beneath. The contact point on surface was therefore projected downward.

4.1 Volumes

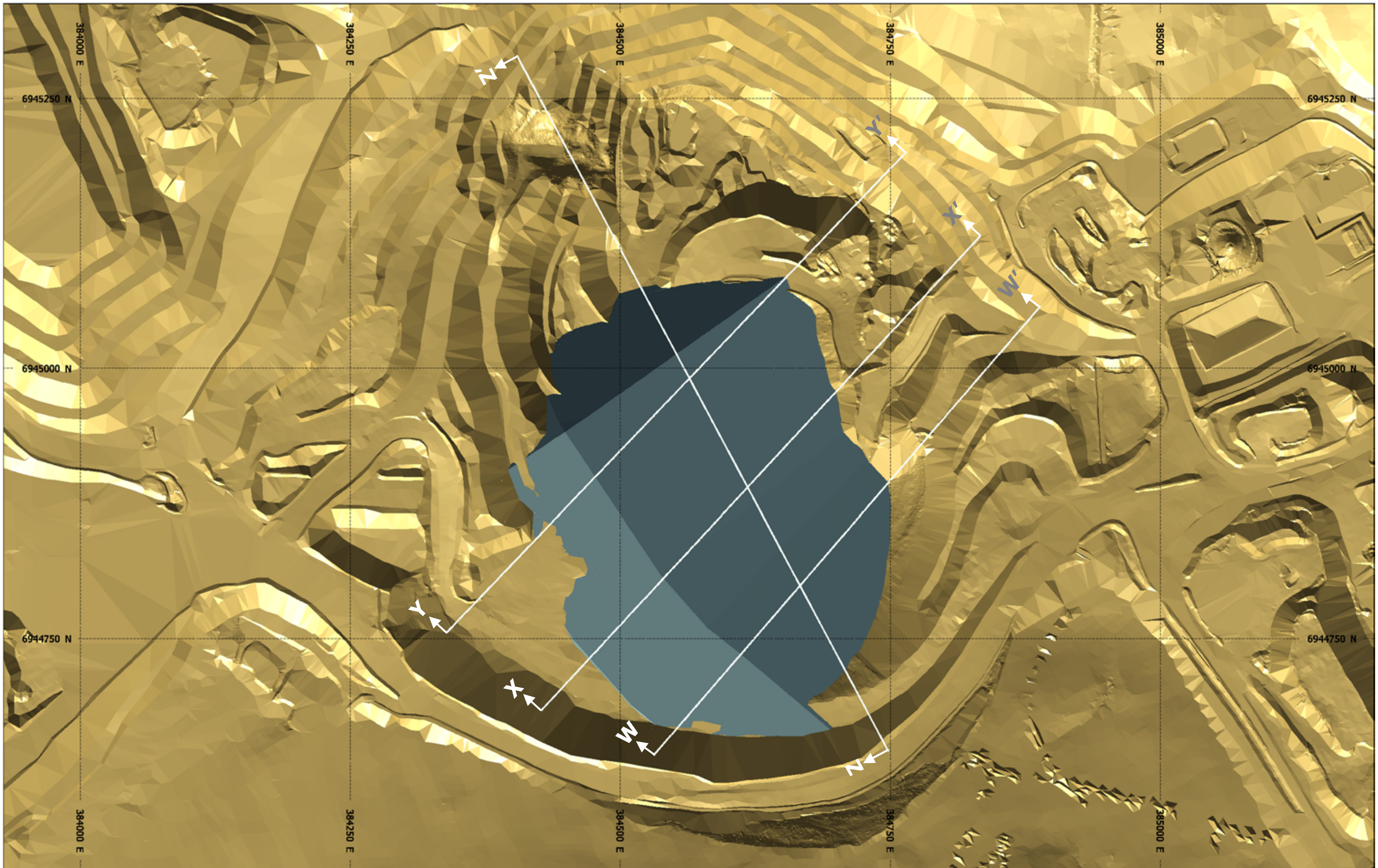
The combination of the South Wall Buttress, the in-pit SAT dump, and the dumping completed to establish the new east-west haul road (shown in Figure 3-7) measures 4.63 Mm^3 (as of October 2014).

There are a few small areas in which the South Wall Buttress was not dumped out to the design crest; the volume of these under-built areas measures 53,000 m^3.

4.2 SAT Volume

The following table describes the quantity of SAT waste present below a given elevation.

From	To	SAT Volume Within Interval (m^3)	Cumulative SAT Volume Below Elevation (m^3)
811	812	2390	2390
810	811	5460	7850
809	810	10637	18487
808	809	12439	30926
807	808	12747	43673
806	807	13232	56905
805	806	13805	70710
804	805	14357	85067
803	804	14884	99951
802	803	15439	115390
801	802	16603	131993
800	801	21206	153199
799	800	34753	187952
798	799	48997	236949
797	798	52350	289299
796	797	52278	341577
795	796	52344	393921
794	795	55821	449742
793	794	57993	507735
792	793	58193	565928
791	792	58034	623962
790	791	57698	681660



DESCRIPTION:	South Wall Buttress design superimposed upon April 2011 site as-built survey
DATE PLOTTED:	2015/01/17

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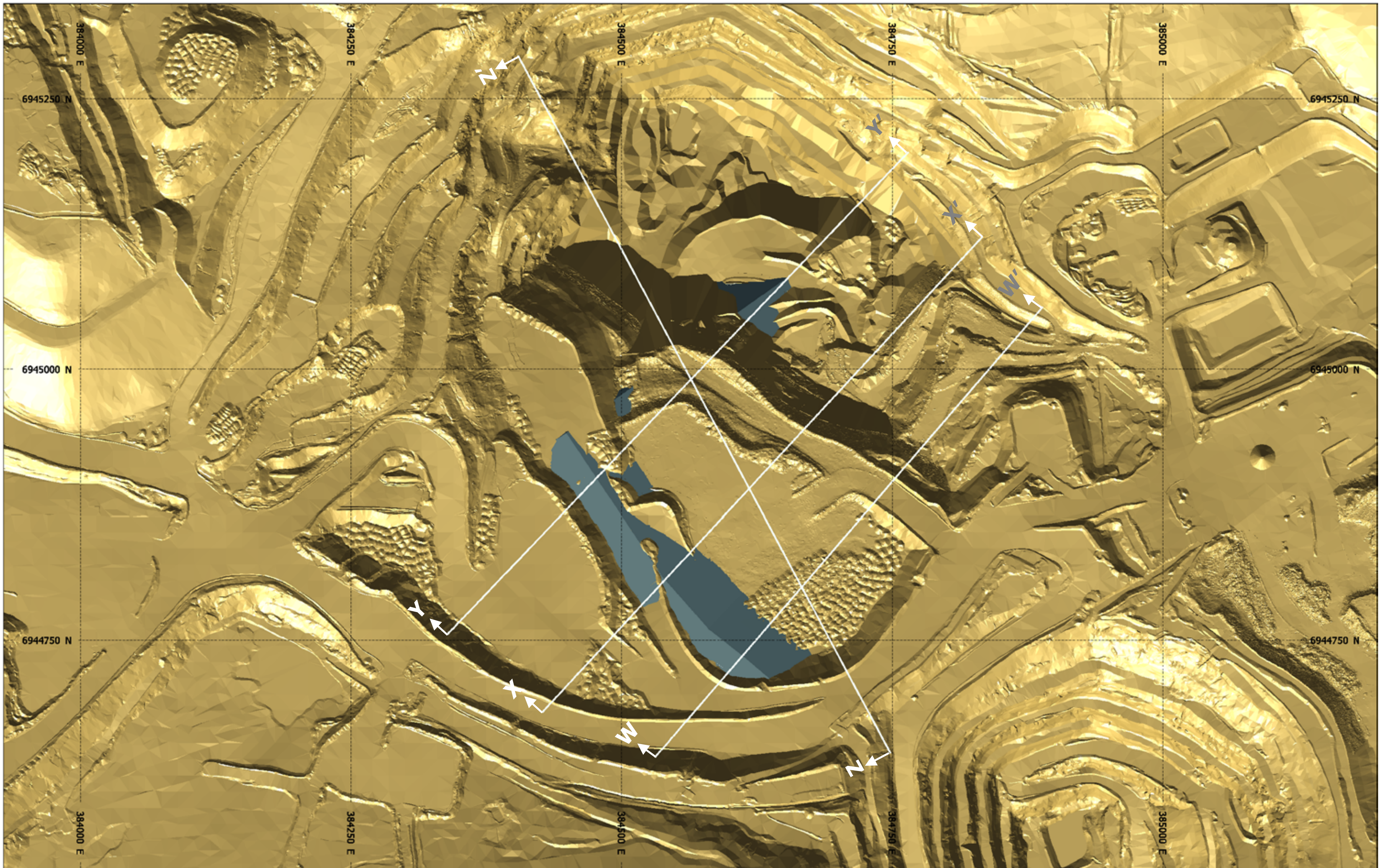

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DESCRIPTION:	South Wall Buttress design superimposed upon January 2015 site as-built survey
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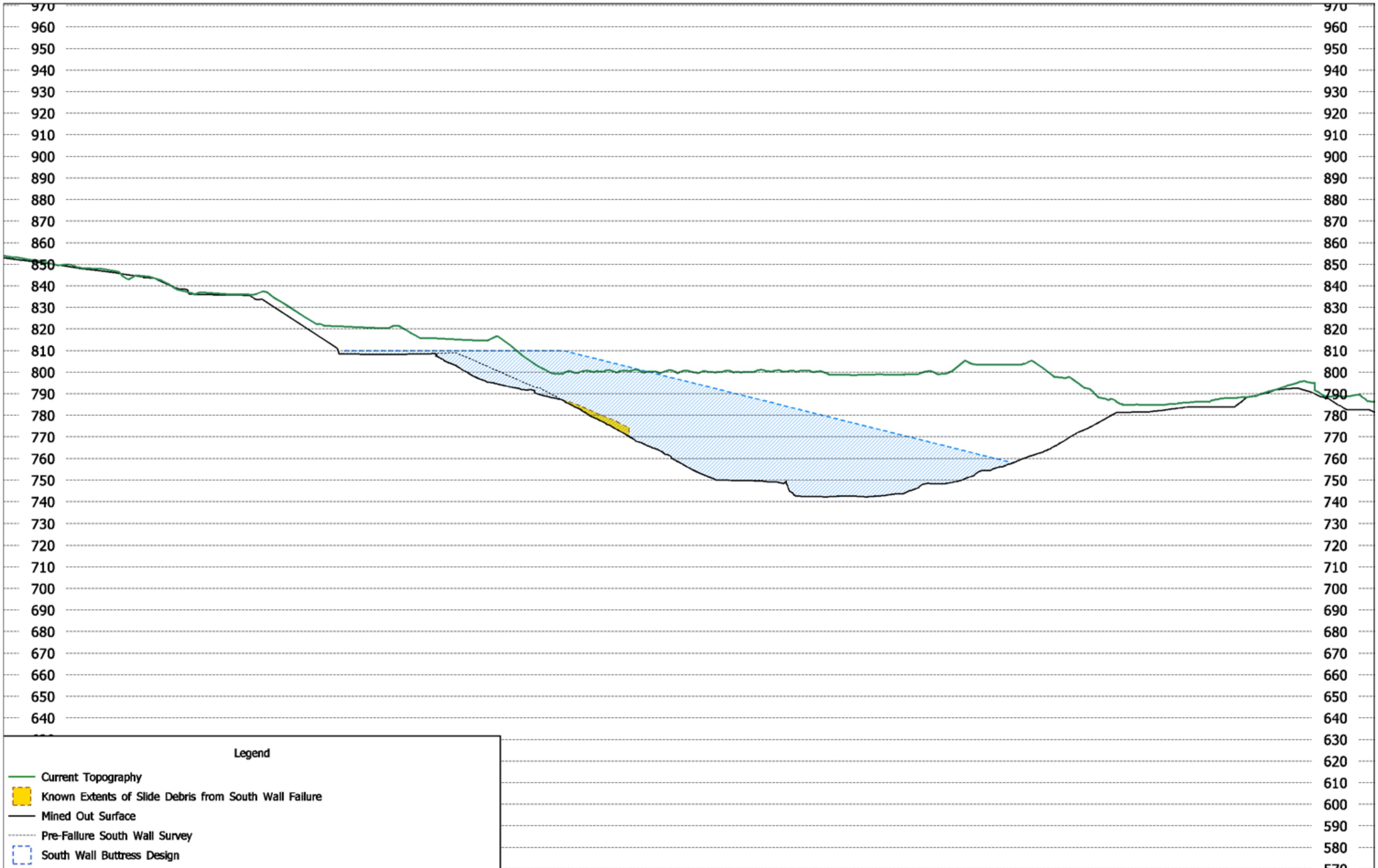

1 : 2500

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DESCRIPTION:	South Wall Buttress As-Built
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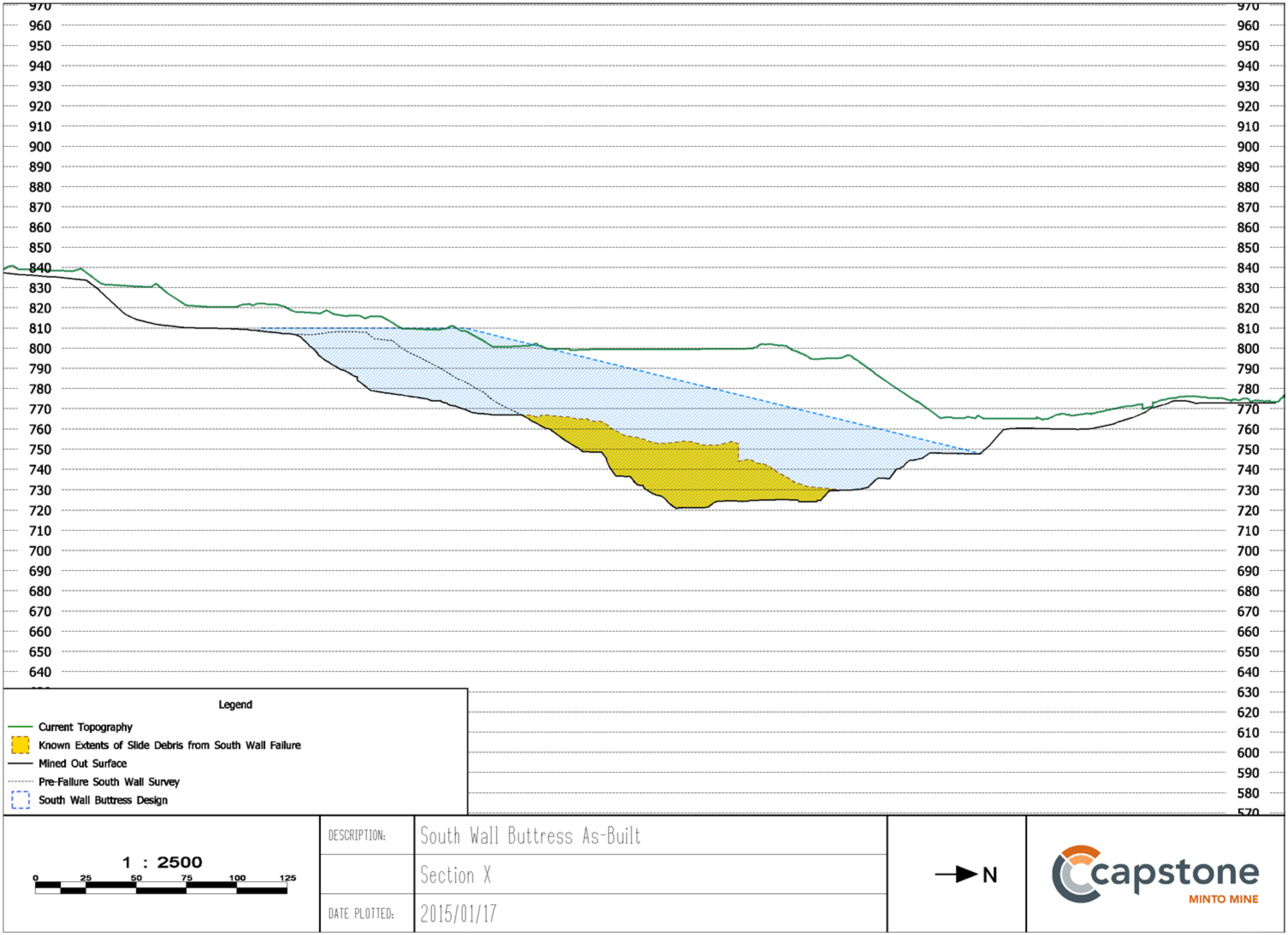
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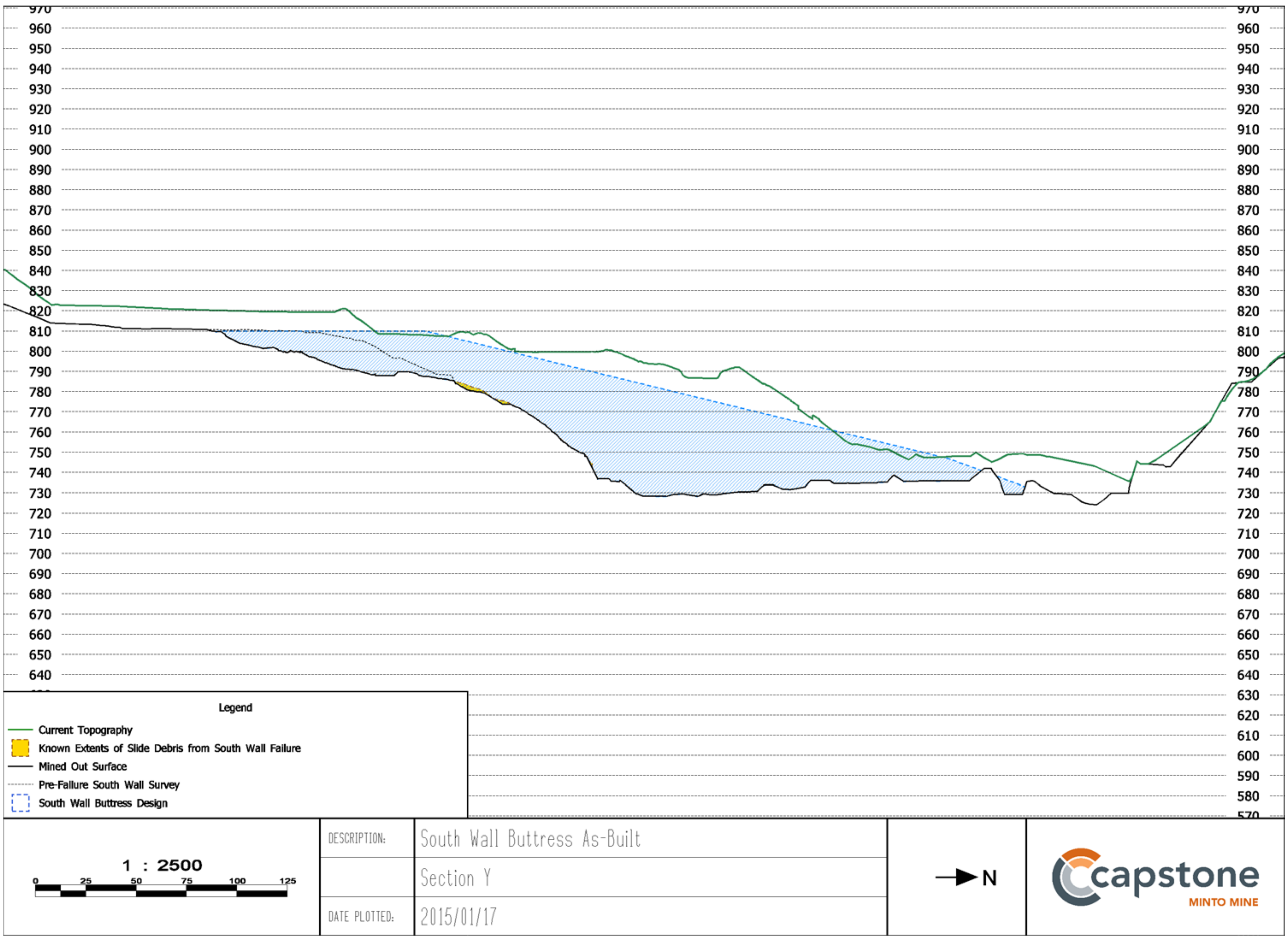
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5 Buttress Performance and Monitoring

Monitoring of the buttress consists of a combination of surface instrumentation and visual inspections. Inspections of the pit and buttress are carried out quarterly as part of site wide geotechnical reviews. Three of the quarterly inspections are done internally by Minto's geotechnical engineers and one is done by an external geotechnical engineering consultant.

Instrumentation consists of series of survey hubs around the south perimeter of the pit/buttress, shown in Figure 5-2, which have been surveyed regularly since the start of dumping in early 2011. Hubs are constructed by drilling holes in the rock fill of the dump, inserting steel posts approximately 2m into the ground, and cementing them into place. Affixed to each post is a base plate on which an RTK-corrected GPS instrument is attached. At the time of this report, readings are taken bi-weekly.

Movement rates, shown in Figure 5-1, indicate gradually decreasing movement during construction of the buttress in 2011 and 2012. By mid to late 2013, movement had decreased significantly, at which point construction of the buttress had been completed nearly to design. At the time of this report, movement has essentially stopped, with the exception of small movement (<1 mm/day) rates still recorded in mid to late 2014 on the west side of the buttress (hubs M69, M73 and M74). Hub M74 in particular has been damaged by frost heaving and there is some question if the movement being recorded is representative of ground movement or heaving/leaning of the hub post. A replacement hub is planned for this location to verify the results of M74.

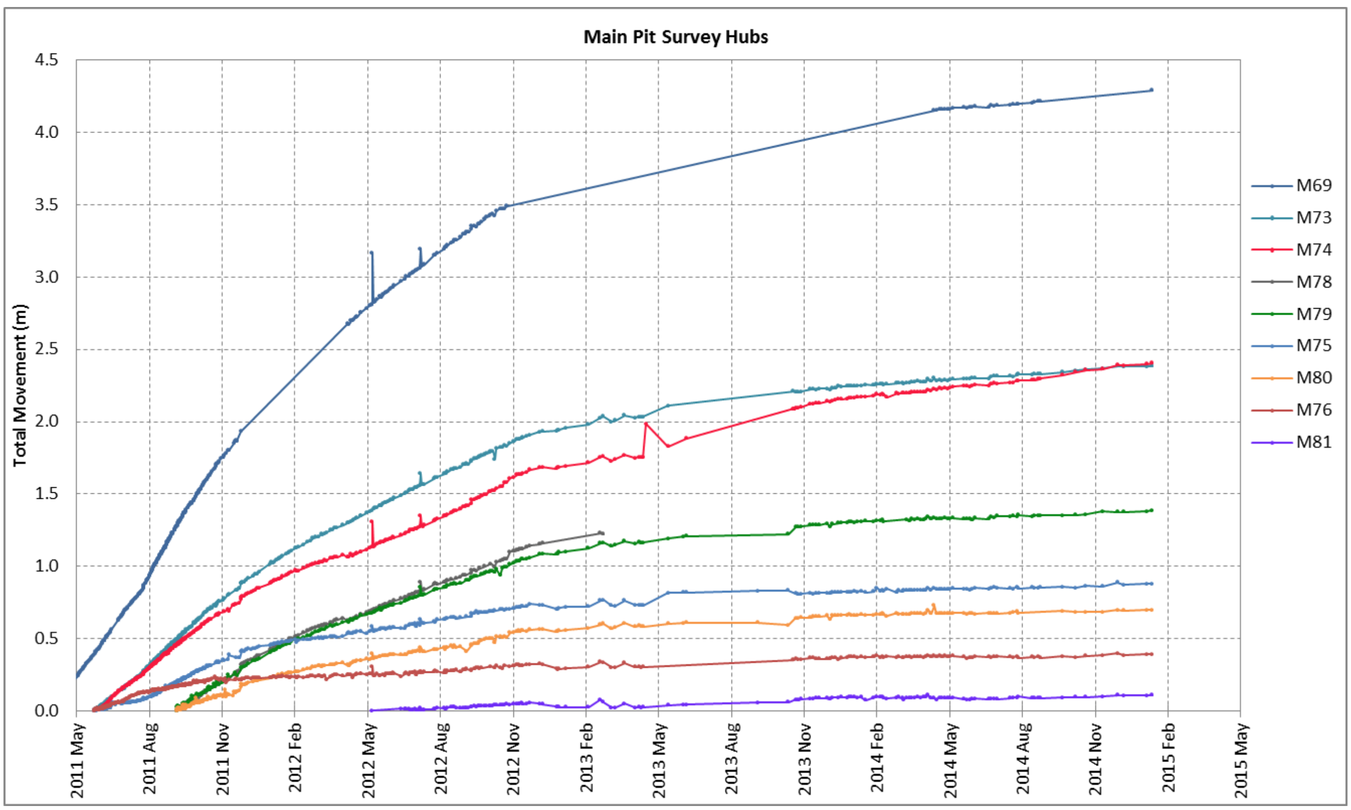

Figure 5-1: Main Pit survey hub total displacement data.

In January 2015, three additional hubs, M82 (behind tension cracks), M83 and M84 (near crest within tension cracked area at the northwest corner) were installed on the west side of the buttress to monitor tension cracking on the 810 bench of the in-pit dump. Although data is only available for a short time period, early results indicate movement is no longer occurring, or is very marginal.

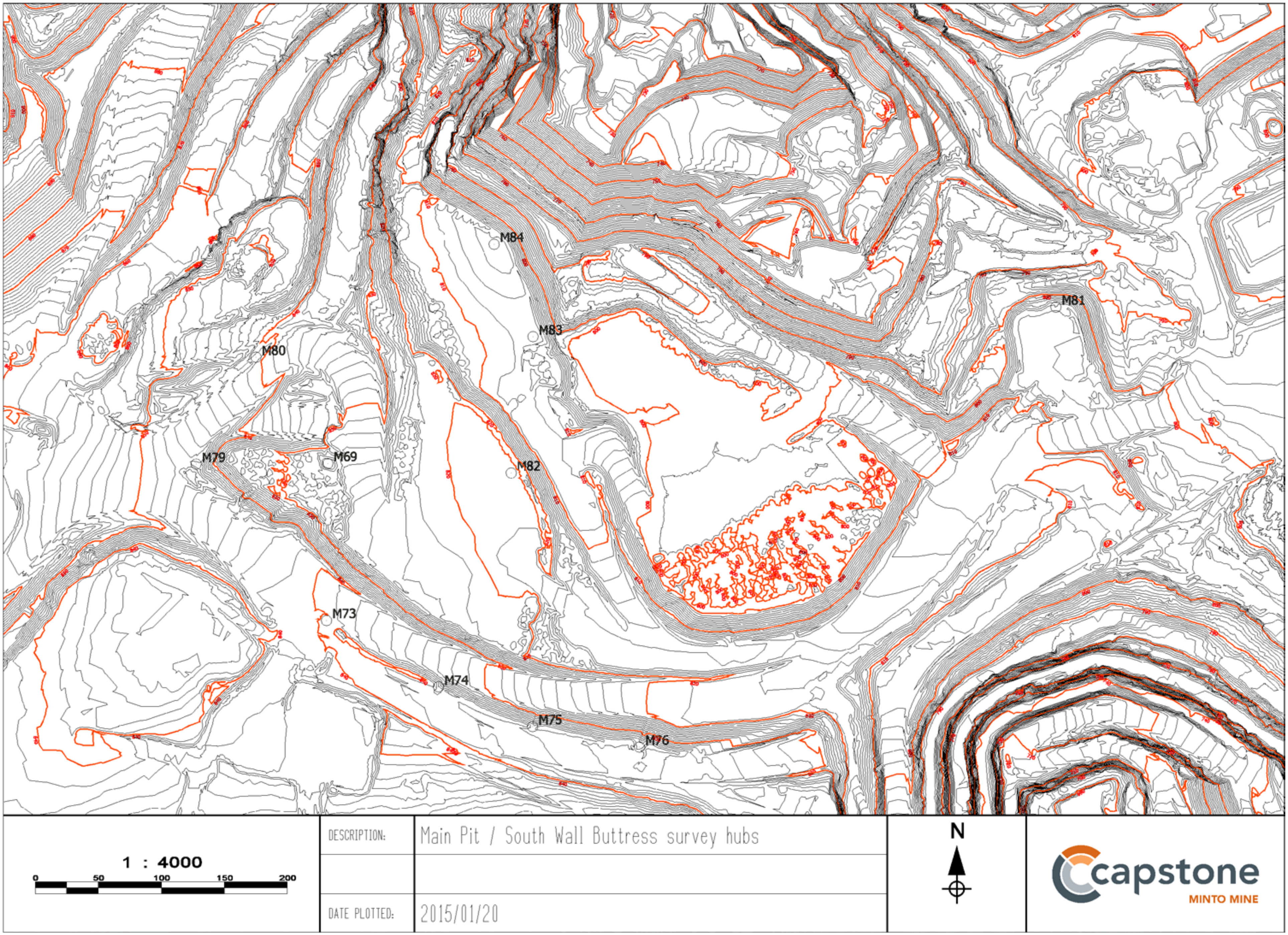

Figure 5-2: South Wall Buttress survey hubs