2018 CASE STUDY

Problem Statement:

A review of exploration in Canada clearly shows new ore bodies are continually found at depth and are increasingly difficult to define using current drilling practices Typically, the deeper the ore body, the greater the capital and operating cost.   With depth, exploration drilling accuracy is challenging, resulting in inaccurate ore definition, large swings in grade, ounces produced and forecasting inaccuracy. However, Mother Nature doesn't connect greater ore grades with depth. As a result, mining companies continually need to find ways to improve geological data accuracy thereby reducing costs and increasing efficiencies. Even with improvements, savings are typically offset by increased costs associated with shaft sinking, ventilation requirements and, more often of late, cooling plants – a step change in capital and operating cost.

Innovation is key to overcoming issues at depth. New thinking is required, in terms of ore body access development, mining methods, extraction and technologies. Innovative technologies can also make mining tasks safer and more appealing to diverse demographics like Indigenous people and women. In Ontario, Aboriginal employment accounts for 11.2% of total mining jobs, while women currently represent only 17% of the mining workforce. The industry is interested in attracting a diverse workforce, recognizing that inclusivity results in better decision making and problem solving, more creativity, and breakthrough innovations.

One current key change in mining is the focus on battery electric mobile equipment to reduce ventilation and cooling requirements. Due to companies' interest and focus in this area, a number of equipment manufacturers are developing battery electric equipment to meet industry requirements. Automation and tele-remote equipment, combined with increased bandwidth, are allowing workers to operate equipment from surface, or even from hundreds of kilometers away.

One of the driving forces to innovation is the need to increase productivity in mining, which has been declining over the past few decades. According to McKinsey & Company, mining's productivity is at a 30 year low, and dropping 5-6% per annum. If operating costs increase by 5% every year, we need to be 5% more effective every year simply to preserve the status quo. Stope mining rates are a key aspect to improving productivity.

A significant number of mines in Canada utilize long hole mining for a number of reasons – less miner exposure to hazards per tonne of ore mined, is a relatively "fast" mining method when compared to cut and fill, and has improved flexibility if deposit strike and thickness are reasonable. Additionally there is a strong knowledge and comfort base due to historic use of this method. However continuous mining processes have been shown to increase productivity (eg. no need for blast clearing between shifts) and should not be discounted. Continuous mining is also seen as a more ‘manufacturing’ type approach to production.

The long hole process typically consists of driving an overcut and undercut based on a predetermined stope height, often governed by geotechnical considerations (particularly at depth), followed by drilling off predetermined sized panels, establishing a slot raise, and blasting out sufficient void to allow for a final blast(s) to fully break the panel. The ore is then mucked out utilizing LHD’s (size dependant on size of stope and access drift size). Once mucked out, fill fences are constructed in the U/C and the stope filled with waste rock/hydraulic fill/paste fill, or a combination. Stopes are not typically left open at depth. This process time varies considerably depending on the size of stope, size of equipment and dump location distance and system configuration.

Stope production rates vary considerably as well. However if we consider mid to large ore bodies with typical stope sizes of 15m wide by 25m high (back of U/C to floor of O/C) and panel lengths of 20m, mucked with 8yd LHD’s - we typically see mucking rates from 700 to 1,000 tonnes per day. When this is averaged over the full stope cycle it equates to approximately 325 tonnes mined per day. In order to “compensate” for the additional costs associated with mining at depth, companies are looking at increasing this rate 3-4 fold. One European company has recently been able to increase their production rate 3 fold.

Solutions that will drastically disrupt mining are just around the corner. In a recent mining trends report by Deloitte, the firm highlighted the need for miners to unlock productivity through innovation and digital thinking: going beyond driverless trucks, sensors and advanced analytics to reduce cost, streamline equipment maintenance and prevent safety incidents. New technology such as drones, real-time modeling and geo-coding, to name a few, are driving the next wave of productivity gains. In addition there are technologies used in oil and gas that could take mine planning and virtual interaction to a whole new level.

The question to be answered is:

How can production rates be increased 3 fold through improvements/changes to mining methods and/or stope cycle time through the use of technology?

Outcomes of analysis:

1. Improved health and safety performance - impact on H&S performance due to proposed solution
2. Increased productivity – minimum of 3 fold
3. Change in mine design (if required) to meet 3 fold production increase
4. Impact of technology on ore definition, mining efficiency and production increase
5. Trade-off of capital for reduced overall operating costs (with minimal impact on overall capital expenditures depending on technology introduced) and increased productivity
6. Environmental footprint reduction – impact of solution on the environment
7. Increase in employee engagement – consideration of diversity, skill set in modern mine, work environment

Boundary Limits:

1. Health and safety is paramount – no compromising on this number one priority
2. Adhere to applicable regulations
3. Infrastructure design is critical

a. Consider geotechnical parameters at depth
b. Consider ventilation and cooling parameters at depth

Case Study:

Jedi Project is a brownfields deposit located in a well-known mining district of Northern Ontario. Diamond drilling has discovered a deposit of approximately 11M tonnes below an existing mine, approximately 2300-2600m below surface. NewTech Mining Company has determined that applying a Longhole mining method will provide the necessary health and safety requirements for such a deep deposit. However, the company is exploring some novel technologies that can also increase the rate of production. At present, the standard mucking configuration and rate (1000T/day while mucking) does not provide sufficient revenue to meet their economic hurdle rate. The accompanying level plans are based on the current longhole design. However solutions which improve the production rate do not necessarily require the mining method to remain the same – innovative alternative mining methods may be required to create the 3 fold increase in production, and should be explored.

For consideration, and based on the current longhole design (see accompanying level plans), geotechnical evaluations have restricted panel sizes to 15m wide by 25m high (U/G back to O/C floor) by 20m long. Additionally, the deposit dips at 30 degrees, so larger panels will result in too much dilution to be economic. The deposit is approximately 300m high and varies in thickness from 25m to 100m thick over a strike length that also varies from 150m to 350m, with the majority of the deposit approximately 250m on strike.

Any change in mine design must recognize and address impact on dilution and recovery. At depth and with an internal winze, the cost to hoist waste is considerable, so minimizing dilution plays a role in project economics. Additionally, maximizing recovery is important since much of the cost to get to the ore is fixed, and therefore any increase in recovery has a significant impact on overall project economics.

The existing mine closed 8 years ago, after producing consistently at 1.1M tonnes of ore per year. It has been kept on care and maintenance since closure, so the primary infrastructure is known to be in good condition. The existing shaft is capable of hoisting 1.5M tonnes of muck, as well as supporting the material and personnel to achieve such a rate through its independent cage and single skip (10T capacity) configuration.

NewTech Mining has determined an underground winze will be required to reach the new deposit. The winze design is matched to the hoisting capacity of the existing shaft to maintain compatibility. A mine design incorporating technology is required to allow increased productivity – 3,000T per day mucking rate from the designed stopes. They are also evaluating technology solutions that could increase up-time for equipment or improve the diversity of their workforce. Connectivity in a mine can improve communication, response, and productivity. Creating a mobile-enabled workforce supported by digital identification, tracking and monitoring of personnel and equipment is being considered, though the required investment in technologies is significant. Enhancing ventilation could decrease the amount of ventilation required by as much as 50%.

Current mine plans call for 5m by 5m sized drifts, stope accesses and O/C's. Since the entire mines' mobile fleet will be battery electric, and there are geotechnical concerns regarding the ability to maintain ore passes for life of mine (LOM), all muck will be moved to rock breakers via trucks. As the study matures, alternatives to this approach will be examined, and will be influenced by available technology.

All waste produced is assumed to be hoisted to surface, however opportunities to internalize waste are being considered in order to reduce hoisting costs as well as minimize impact on the environment. Additionally, although infrastructure exists to dispose of tailings, opportunities to reduce their impact on the environment are to be considered.

Mine Conditions:

The ore deposit crosses a property boundary with a neighbouring company. As a result, access design is from the hanging wall. No access or ramping may occur on the neighbouring company's property. Ramps are designed ±15% grade with the rock dump location near the bottom of the ore zone, such that the majority of muck is moved down grade. This method optimizes the regenerative capability of the battery electric equipment.

An evaluation of ventilation conditions has determined U/G workings will be in excess of 28^0C WBGT and therefore a cooling plant is required. The temperature also aided in the decision to move to a full battery electric fleet underground.

Relationships:

NewTech is an employer committed to diversity. One example is an IBA agreement with their indigenous partners which can involve Joint Ventures to deliver technology and jobs and training. Any new development, at surface or underground, requires consultation with First Nations. Government's nation-nation relationship with FN communities means that the ability to secure a social license to operate is very much connected to the strength of NewTech's relationship with FN's. NewTech values this relationship, along with gender diversity, as they see a collaborative approach will generate innovative thinking as the project develops.

Primary Mobile Equipment:

NewTech's high level evaluation of equipment requirements has determined the following battery electric fleet will be required to meet the production requirements, (based on a longhole mining method – other methodologies may change this profile). Additional support vehicles are not shown, but are all battery electric.

Equipment (all battery electric)	Size	Quantity
LHD	8yd – 14 Tonne	9
Trucks	40T	6
2 boom jumbo	Dev & Overcuts	4
Production Drill	Top Hammer	2
Production Drill	ITH	1
Cable Bolter	Primarily for brows	1
Blockholer	For large muck	1
Raisebore	For panel slots	1

Level Plans:

The following level plans depict the current mine design on 25m level intervals based on longhole mine design parameters as set out above. All grids are metric and elevation is noted as metric depth below surface.

APPENDIX A

LEVEL PLANS

APPENDIX B

ISOMETRIC VIEW AND SELECTED LEVEL PLANS SHOWING ORE OUTLINE

Appendix A

Level Plans

DWG. No.	DESCRIPTION	MK	YYYY/MM/DD DATE	DESCRIPTION	REV. BY	P. ENG. NAME	P. ENG. COMPANY
REFERENCES		REVISIONS AND ISSUES					

1440 LEVEL

DRN BY	CHKD	APP'D	DRAWING No.	SHEET	REV.
DATE YYYY/MM/DD	SCALE			CONT'D ON	

PROJECT No.

FILE ID.

DWG. No.	DESCRIPTION	MK	YYYY/MM/DD DATE	DESCRIPTION	REV. BY	P. ENG. NAME	P. ENG. COMPANY
REFERENCES		REVISIONS AND ISSUES					

1915 LEVEL
COOLING & SERVICE LEVEL

DRN BY	CHKD	APP'D	DRAWING No.	REV.
DATE YYYY/MM/DD	SCALE		SHEET CONT'D ON	

PROJECT No. FILE ID.

DWG. No.	DESCRIPTION	MK	YYYY/MM/DD DATE	DESCRIPTION	REV. BY	P. ENG. NAME	P. ENG. COMPANY
REFERENCES		REVISIONS AND ISSUES					

2280 LEVEL

DRN BY	CHKD	APP'D	DRAWING No.		REV.
DATE YYYY/MM/DD	SCALE			SHEET CONT'D ON	

PROJECT No.

FILE ID.

DWG. No.	DESCRIPTION	MK	YYYY/MM/DD DATE	DESCRIPTION	REV. BY	P. ENG. NAME	P. ENG. COMPANY
REFERENCES		REVISIONS AND ISSUES					

2300 LEVEL

DRN BY	CHKD	APP'D	DRAWING No.	SHEET	REV.
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PROJECT No.			FILE ID.		


3200E
3300E
3400E
3500E
3600E
3700E
3800E
3900E
4000E
4100E
600N
500N
400N
300N
200N
NORTH
MINERALIZED OUTLINES
RED CLAY FAULT
BACKFILL SUMP
LEVEL SUMP
LEVEL ACCESS
CHARGING STATION
ELECTRICAL STATION
EGRESS TO 2340L
RAMP TO 2300 LEVEL
RAMP FROM 2340 LEVEL
PRODUCTION WINZE
EGRESS RAISE
BACKFILL ACC.
TRUCK LOADOUT/ LHD CHARGING
RAR TO 2300L
EGRESS TO 2300L
RAR FROM 2340L
BOUNDARY
DWG. No.
DESCRIPTION
MK
YYYY/MM/DD DATE
DESCRIPTION
REV. BY
P. ENG. NAME
P. ENG. COMPANY
REFERENCES
REVISIONS AND ISSUES
2320 LEVEL
DRN BY
CHKD
APP'D
DRAWING No.
REV.
DATE YYYY/MM/DD
SCALE
SHEET
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PROJECT No.
FILE ID.

DWG. No.	DESCRIPTION	MK	YYYY/MM/DD DATE	DESCRIPTION	REV. BY	P. ENG. NAME	P. ENG. COMPANY
REFERENCES		REVISIONS AND ISSUES					

2340 LEVEL

DRN BY	CHKD	APP'D	DRAWING No.	REV.
DATE YYYY/MM/DD	SCALE		SHEET CONT'D ON	

PROJECT No. FILE ID.

DWG. No.	DESCRIPTION	MK	YYYY/MM/DD DATE	DESCRIPTION	REV. BY	P. ENG. NAME	P. ENG. COMPANY
REFERENCES		REVISIONS AND ISSUES					

2360 LEVEL

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DATE YYYY/MM/DD	SCALE		SHEET CONT'D ON	

PROJECT No.

FILE ID.

DWG. No.	DESCRIPTION	MK	YYYY/MM/DD DATE	DESCRIPTION	REV. BY	P. ENG. NAME	P. ENG. COMPANY
REFERENCES		REVISIONS AND ISSUES					

2380 LEVEL

DRN BY | CHKD | APP'D | DRAWING No. | REV.

DATE YYYY/MM/DD | SCALE | SHEET | CONT'D ON

PROJECT No. FILE ID.

DWG. No.	DESCRIPTION	MK	YYYY/MM/DD DATE	DESCRIPTION	REV. BY	P. ENG. NAME	P. ENG. COMPANY
REFERENCES		REVISIONS AND ISSUES					

SUDBURY
INTEGRATED NICKEL
OPERATIONS
A GLENCORE COMPANY

2405 LEVEL

DRN BY | CHKD | APP'D | DRAWING No. | REV.

DATE YYYY/MM/DD | SCALE | SHEET | CONT'D ON

PROJECT No. | FILE ID.

DWG. No.	DESCRIPTION	MK	YYYY/MM/DD DATE	DESCRIPTION	REV. BY	P. ENG. NAME	P. ENG. COMPANY
REFERENCES		REVISIONS AND ISSUES					

2430 LEVEL

DRN BY | CHKD | APP'D | DRAWING No. | SHEET | REV.

DATE YYYY/MM/DD | SCALE | CONT'D ON

PROJECT No.

FILE ID.


3200E
3300E
3400E
3500E
3600E
3700E
3800E
3900E
4000E
500N
400N
300N
200N
100N
0N
NORTH
BOUNDARY
MINERALIZED OUTLINES
RED CLAY FAULT
PRODUCTION WINZE
EGRESS RAISE
LEVEL SUMP
BACKFILL SUMP
REFUGE STATION
OREPASS TO 2555L
BACKFILL ACCESS
EGRESS
RAMP TO 2480L
RAMP TO 2430L
CHARGING STATION
ELECTRICAL STATION
TRUCK LOADOUT/ LHD CHARGING
RAR TO 2430L
LATRINE
RAR TO 2480L
RAR TO 1980L
DWG. No.
DESCRIPTION
REFERENCES
MK
YYYY/MM/DD DATE
DESCRIPTION
REV. BY
P. ENG. NAME
P. ENG. COMPANY
REVISIONS AND ISSUES
2455 LEVEL
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CONT'D ON
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REFERENCES		REVISIONS AND ISSUES					

2480 LEVEL

DRN BY | CHKD | APP'D | DRAWING No. | REV.

DATE YYYY/MM/DD | SCALE | SHEET | CONT'D ON

PROJECT No. | FILE ID.

DWG. No.	DESCRIPTION	MK	YYYY/MM/DD DATE	DESCRIPTION	REV. BY	P. ENG. NAME	P. ENG. COMPANY
REFERENCES		REVISIONS AND ISSUES					

2505 LEVEL

DRN BY | CHKD | APP'D | DRAWING No. | SHEET | CONT'D ON | REV.

DATE YYYY/MM/DD | SCALE

PROJECT No. | FILE ID.

DWG. No.	DESCRIPTION	MK	YYYY/MM/DD DATE	DESCRIPTION	REV. BY	P. ENG. NAME	P. ENG. COMPANY
REFERENCES		REVISIONS AND ISSUES					

2515 LEVEL

DRN BY	CHKD	APP'D	DRAWING No.	SHEET	REV.
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PROJECT No.

FILE ID.

DWG. No.	DESCRIPTION	MK	YYYY/MM/DD DATE	DESCRIPTION	REV. BY	P. ENG. NAME	P. ENG. COMPANY
REFERENCES		REVISIONS AND ISSUES					

2530 LEVEL

DRN BY | CHKD | APP'D | DRAWING No. | SHEET | CONT'D ON | REV.

DATE YYYY/MM/DD | SCALE

PROJECT No.

FILE ID.

DWG. No.	DESCRIPTION	MK	YYYY/MM/DD DATE	DESCRIPTION	REV. BY	P. ENG. NAME	P. ENG. COMPANY
REFERENCES		REVISIONS AND ISSUES					

2555 LEVEL

DRN BY | CHKD | APP'D | DRAWING No. | SHEET | REV.

DATE YYYY/MM/DD | SCALE | CONT'D ON

PROJECT No. | FILE ID.

DWG. No.	DESCRIPTION	MK	YYYY/MM/DD DATE	DESCRIPTION	REV. BY	P. ENG. NAME	P. ENG. COMPANY
REFERENCES		REVISIONS AND ISSUES					

2580 LEVEL

DRN BY | CHKD | APP'D | DRAWING No. | REV.

DATE YYYY/MM/DD | SCALE | SHEET | CONT'D ON

PROJECT No. | FILE ID.

DWG. No.	DESCRIPTION	MK	YYYY/MM/DD DATE	DESCRIPTION	REV. BY	P. ENG. NAME	P. ENG. COMPANY
REFERENCES		REVISIONS AND ISSUES					

2605 LEVEL

DRN BY	CHKD	APP'D	DRAWING No.	SHEET	REV.
DATE YYYY/MM/DD	SCALE			CONT'D ON	

PROJECT No. FILE ID.

mining innovation nature energy design

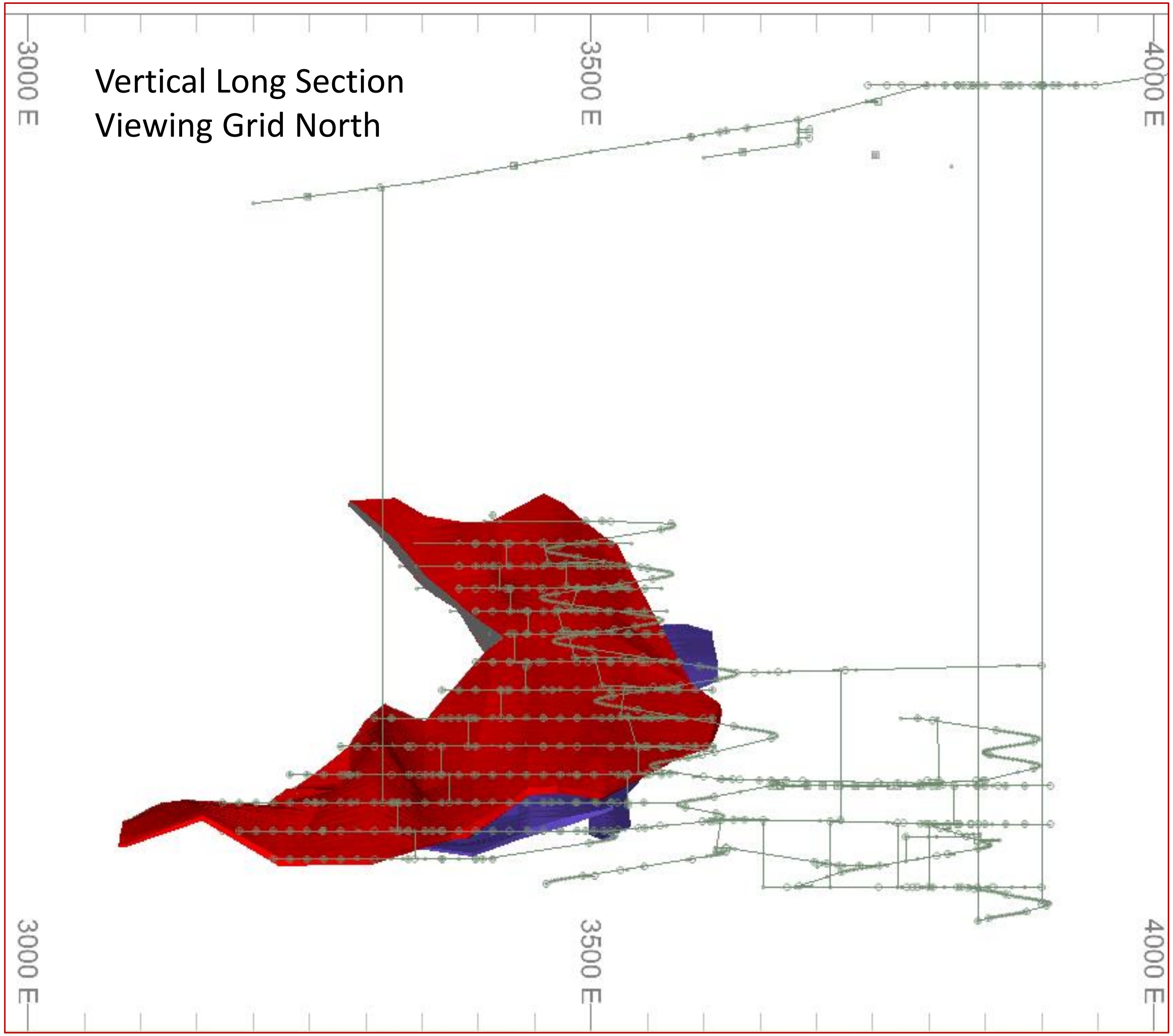
Mined

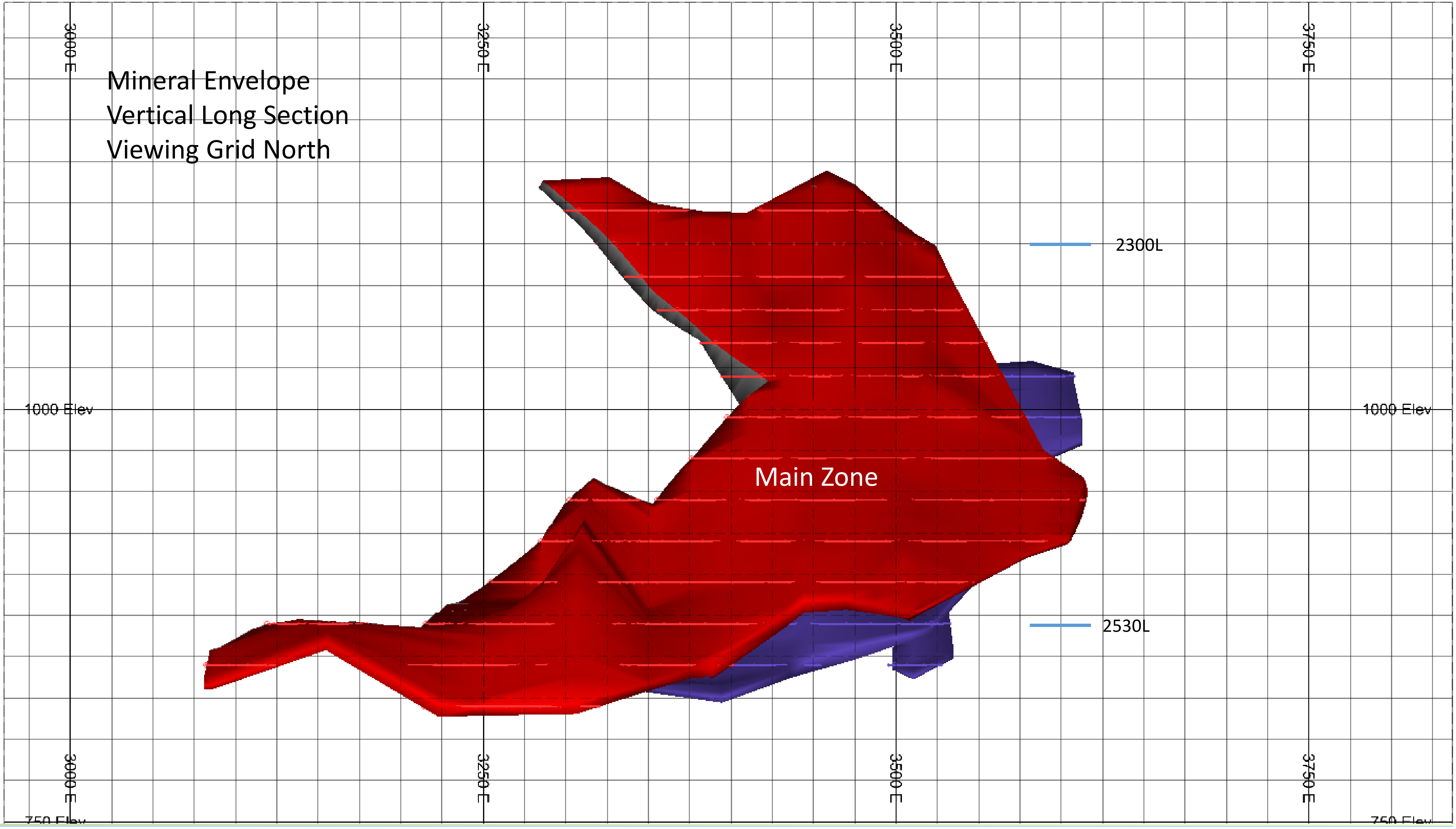
Open Innovation Challenge

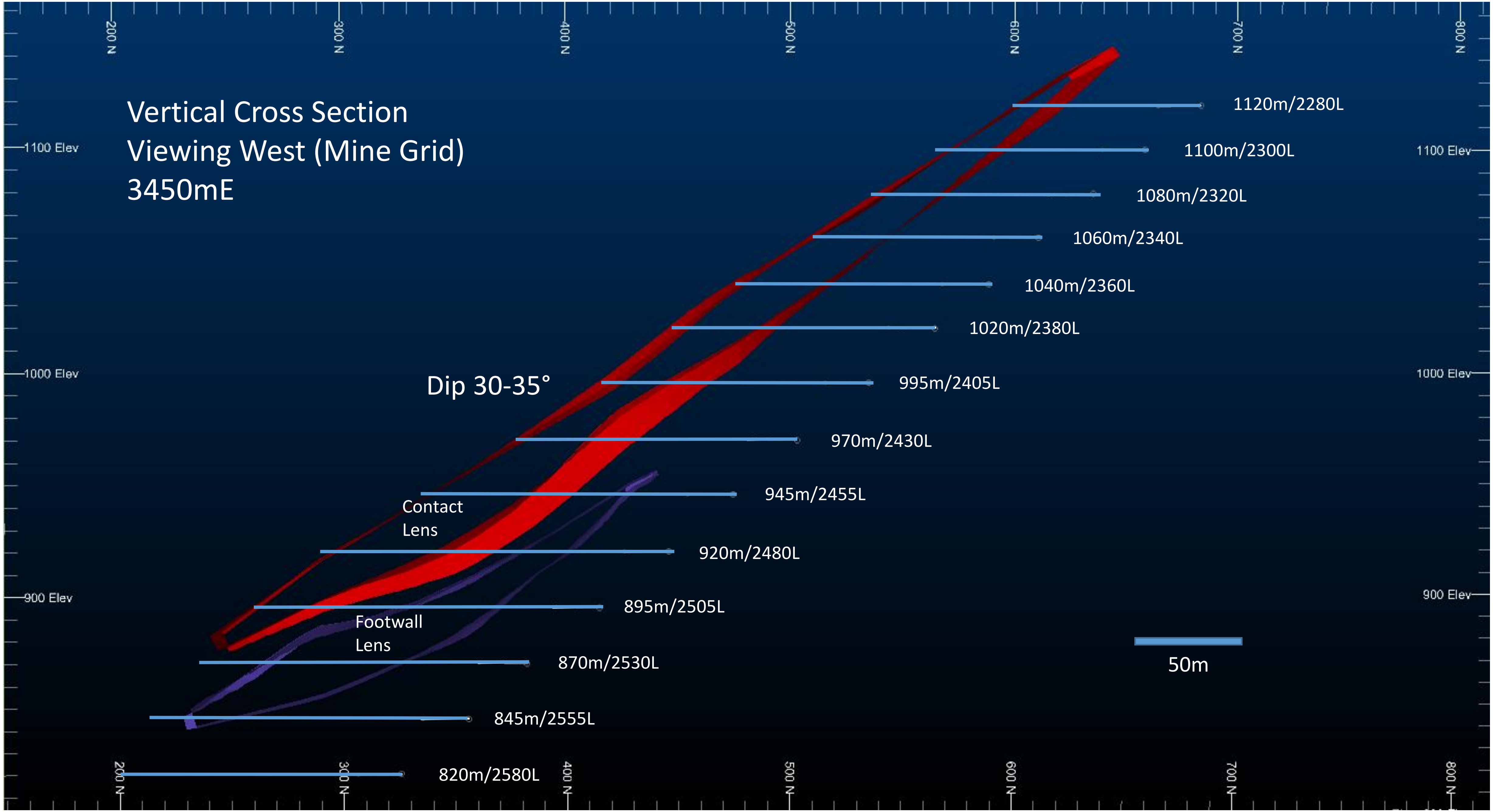
Appendix B

Isometric view and selected level plans showing ore outline

Vertical Long Section
Viewing Grid North




Mineral Envelope
Vertical Long Section
Viewing Grid North
3000 E
3250 E
3500 E
3750 E
1000 Elev
1000 Elev
2300L
Main Zone
2530L
3000 E
3250 E
3500 E
3750 E



Vertical Cross Section
Viewing West (Mine Grid)
3450mE
Dip 30-35°
Contact
Lens
Footwall
Lens
1120m/2280L
1100m/2300L
1080m/2320L
1060m/2340L
1040m/2360L
1020m/2380L
995m/2405L
970m/2430L
945m/2455L
920m/2480L
895m/2505L
870m/2530L
845m/2555L
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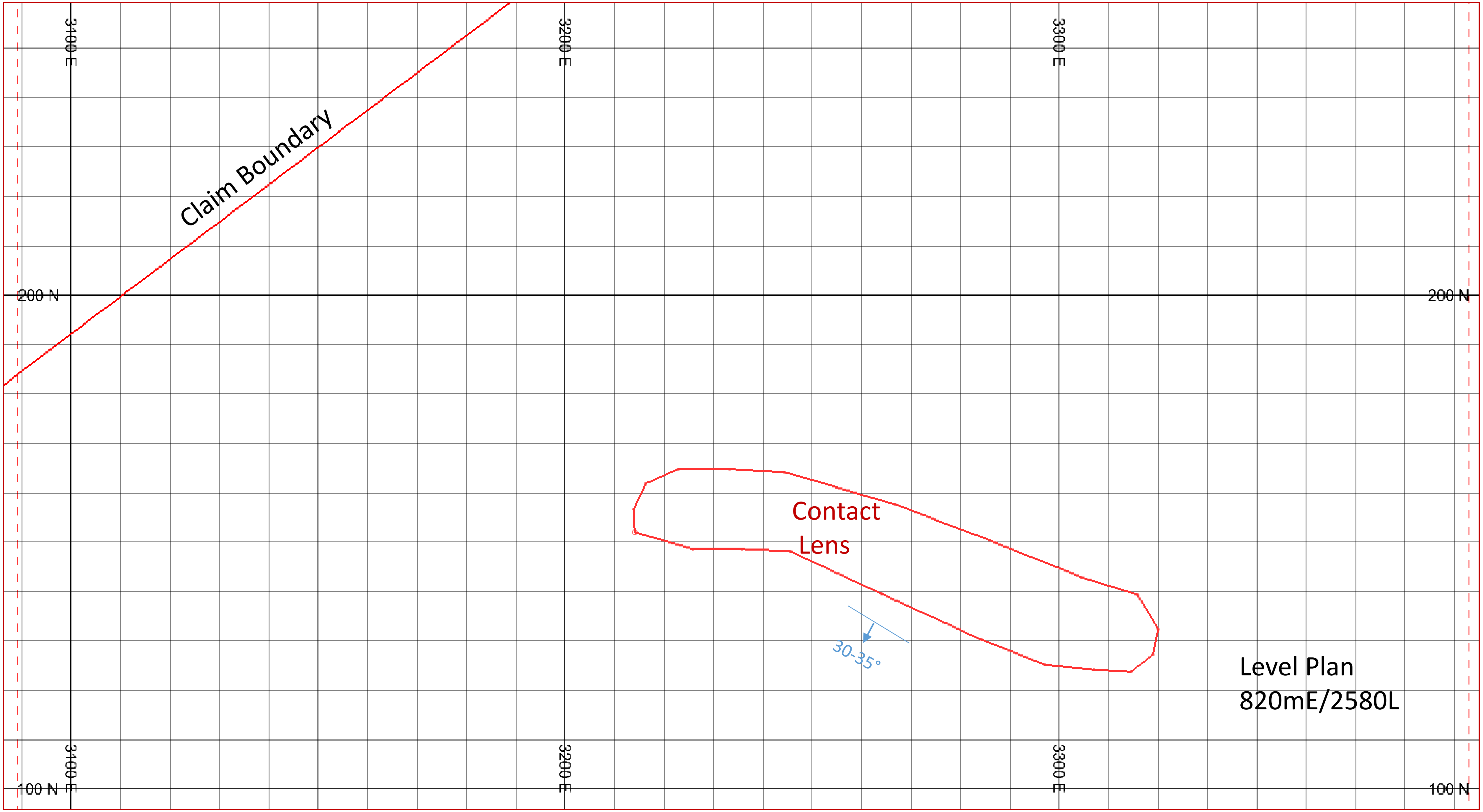
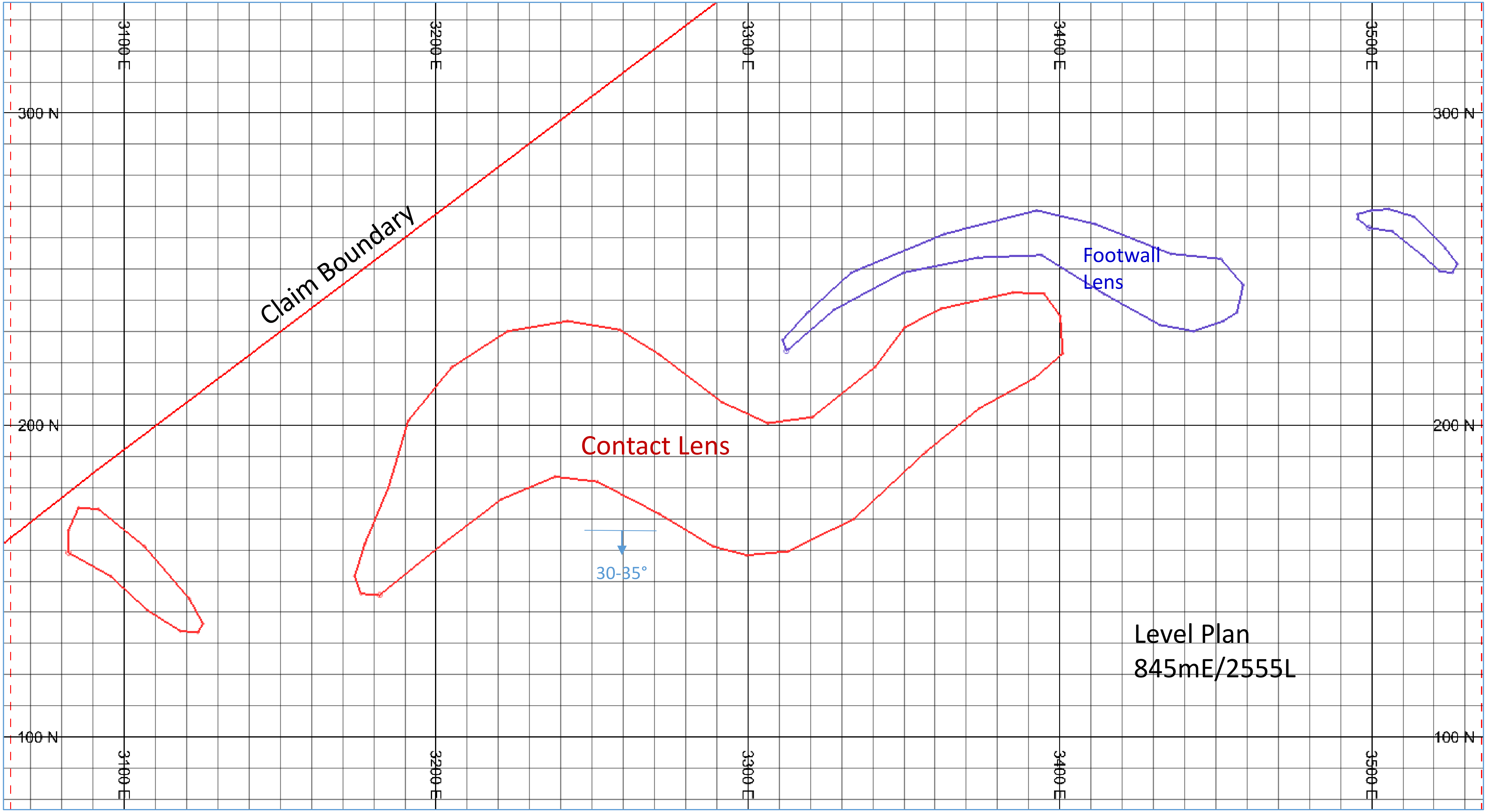
500 N
600 N
700 N
800 N



3100 E
3200 E
3300 E
200 N
200 N
Claim Boundary
Contact Lens
30-35°
Level Plan
820mE/2580L
3100 E
3200 E
3300 E
100 N
100 N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Footwall
Lens
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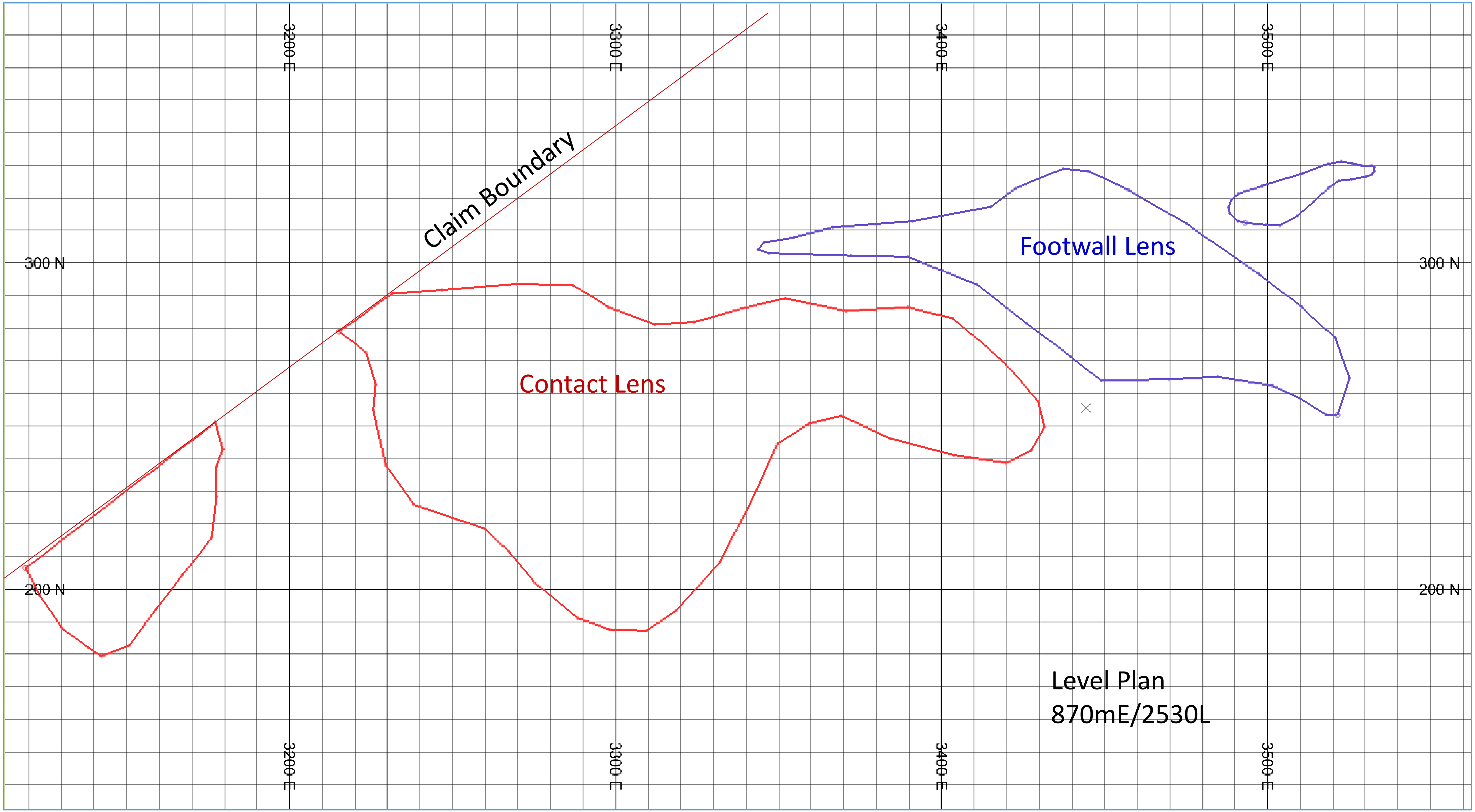
30-35°
Level Plan
845mE/2555L



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3500 E
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200 N
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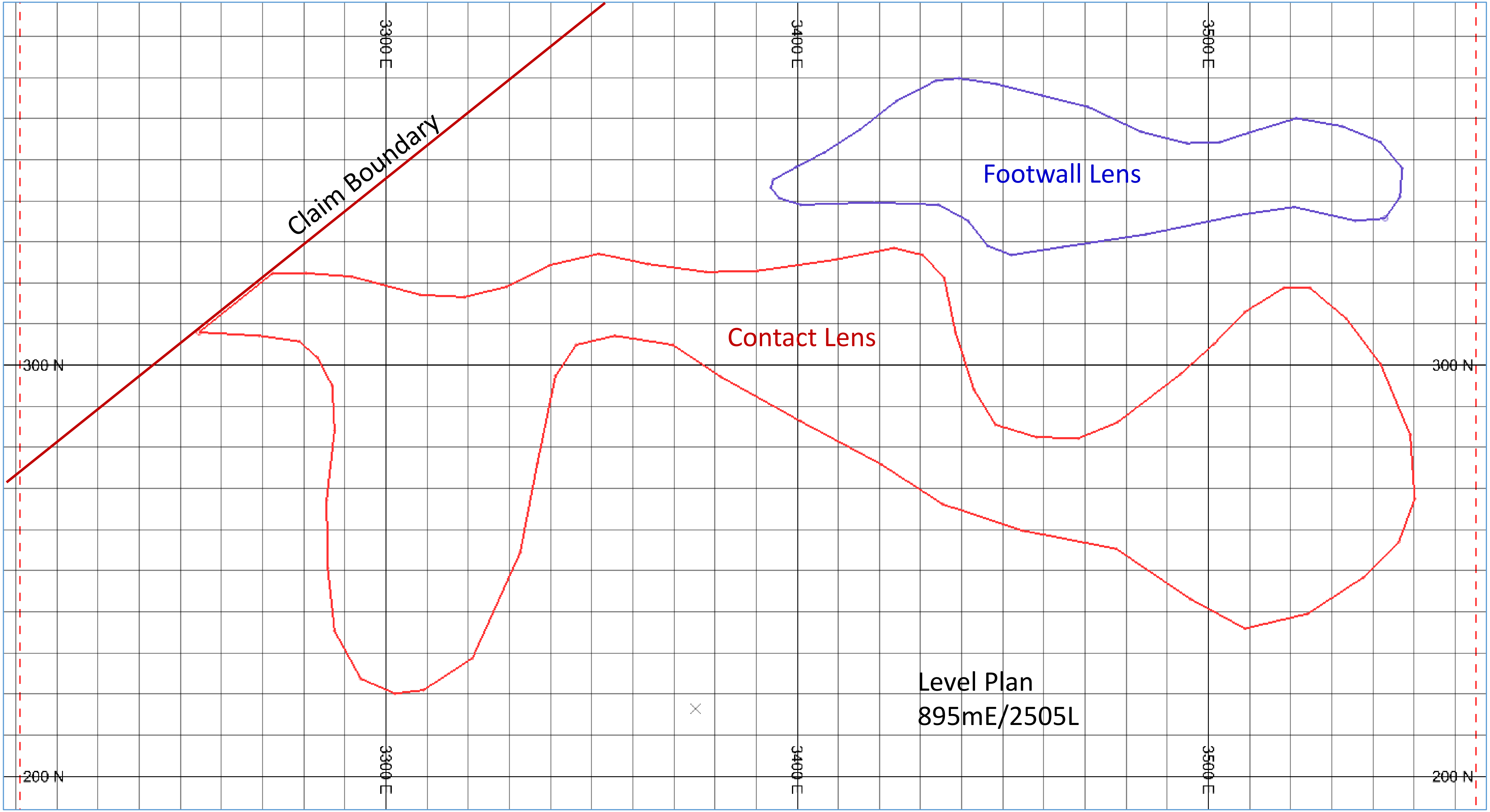
Footwall Lens
Contact Lens
Level Plan
870mE/2530L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3500 E
Claim Boundary
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Contact Lens
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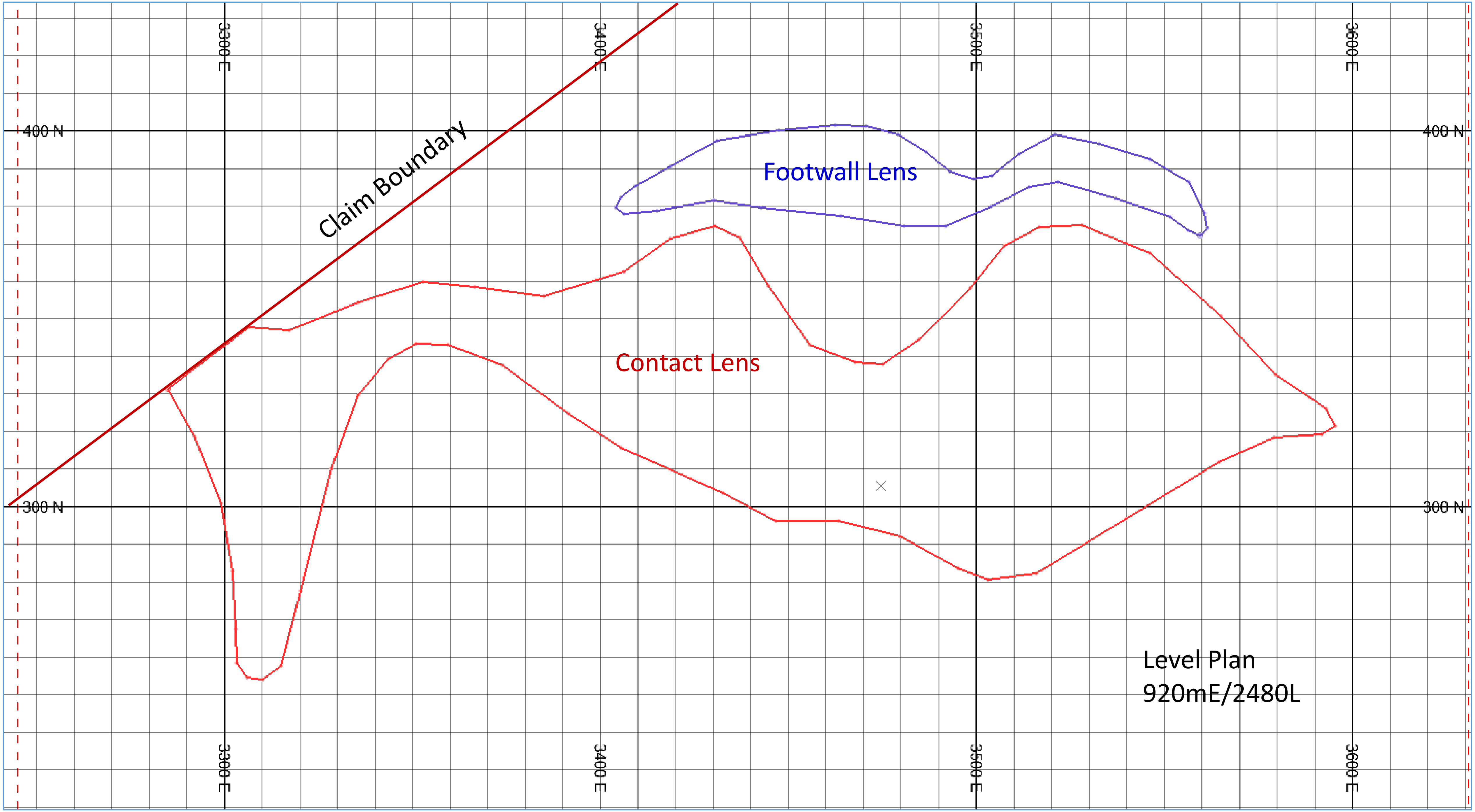
3300 E
3400 E
3500 E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3600 E
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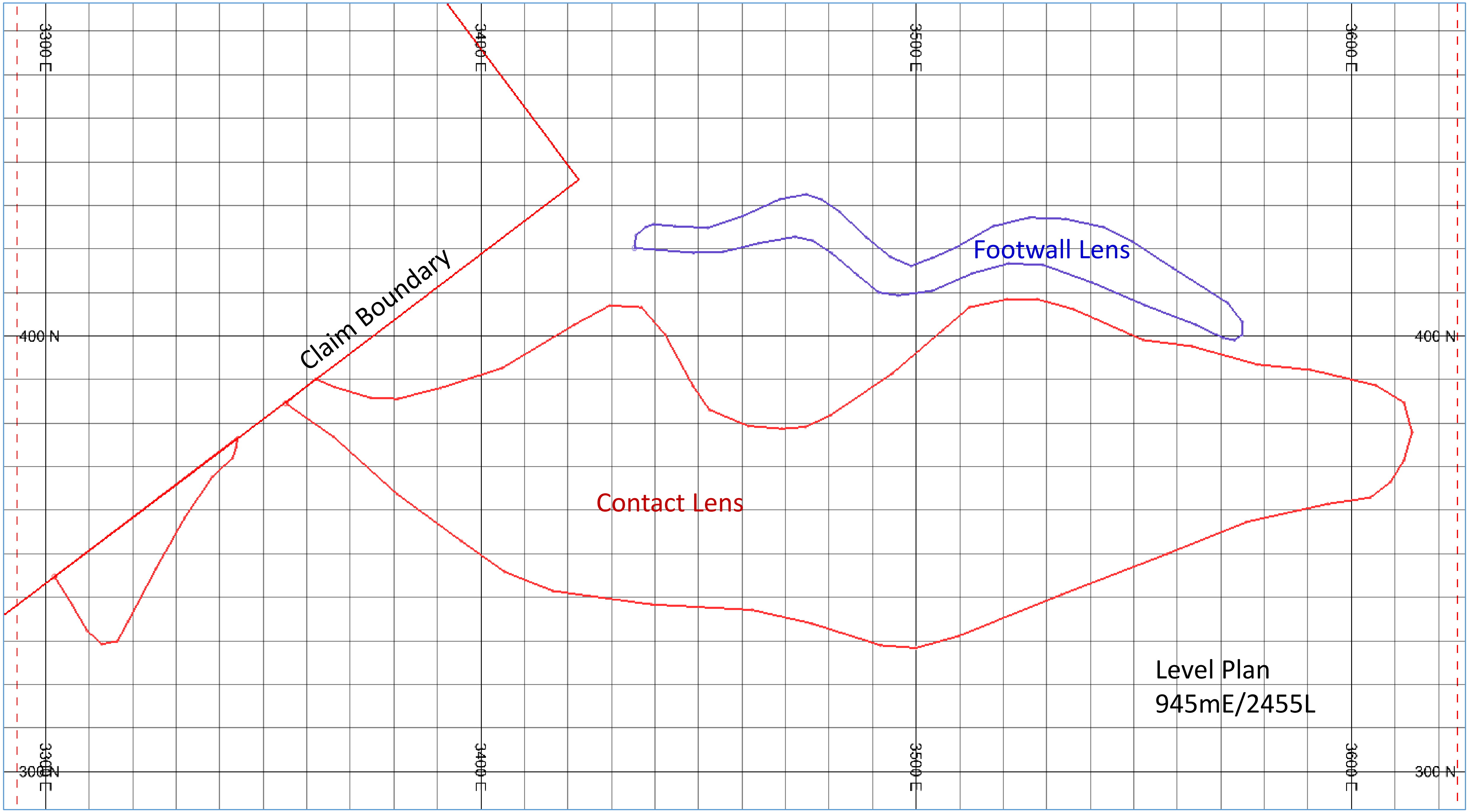
300 N
Claim Boundary
Footwall Lens
Contact Lens
Level Plan
920mE/2480L



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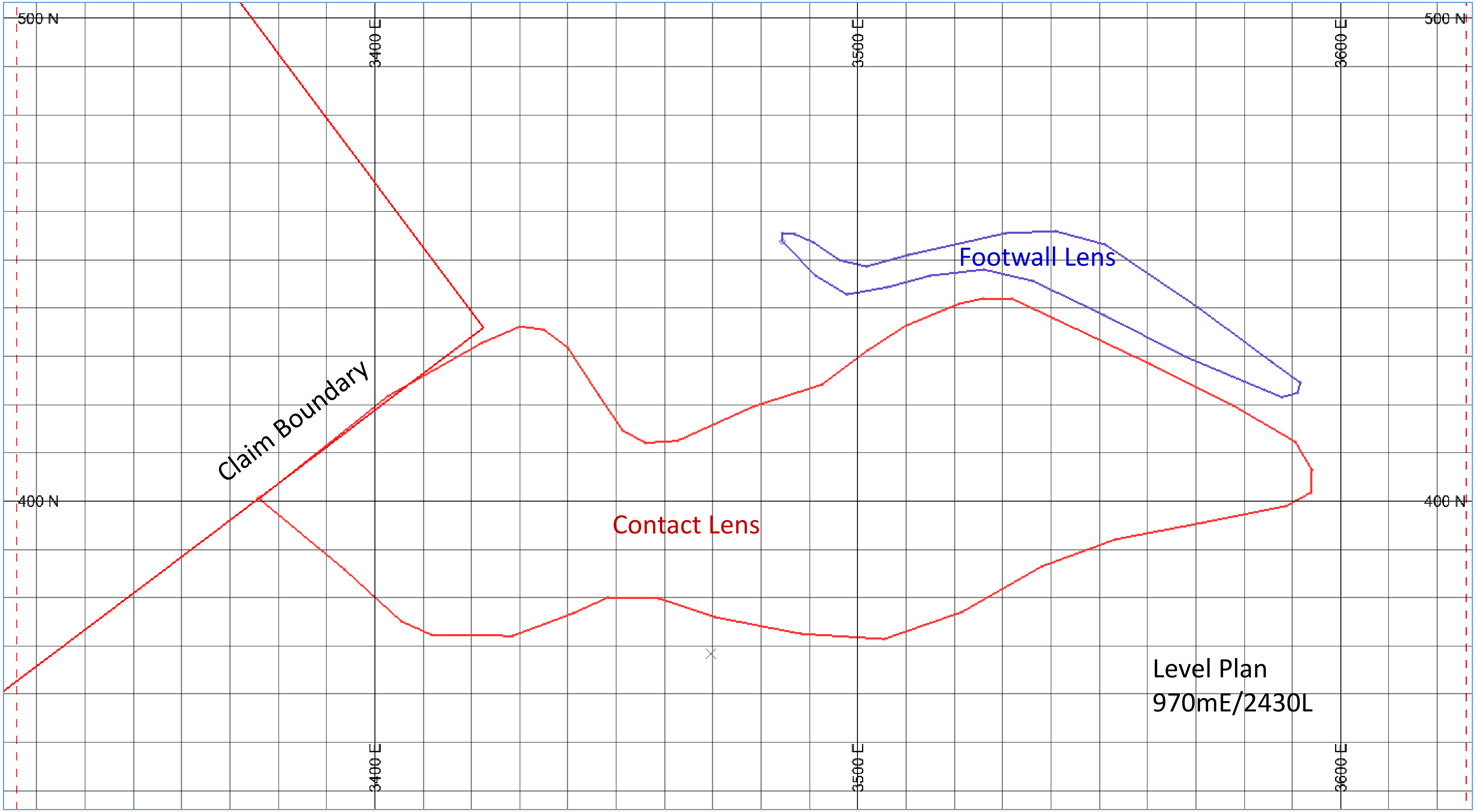
Contact Lens
Level Plan
945mE/2455L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3500 E
3600 E
500 N
Footwall Lens
Claim Boundary
400 N
Contact Lens
400 N
Level Plan
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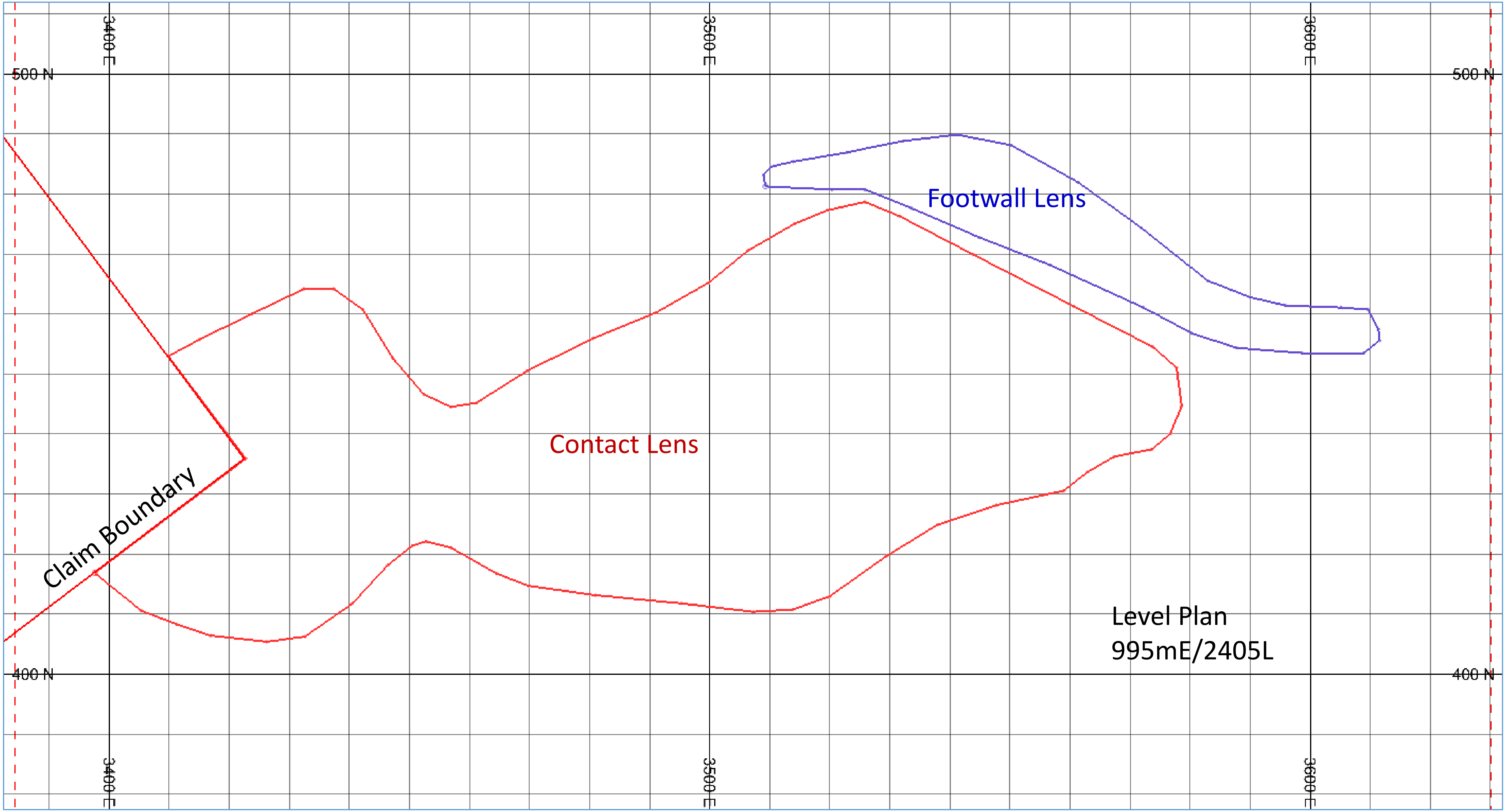
3400 E
3500 E
3600 E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3500 E
3600 E
500 N
500 N
Footwall Lens
Contact Lens
Claim Boundary
Level Plan
995mE/2405L
400 N
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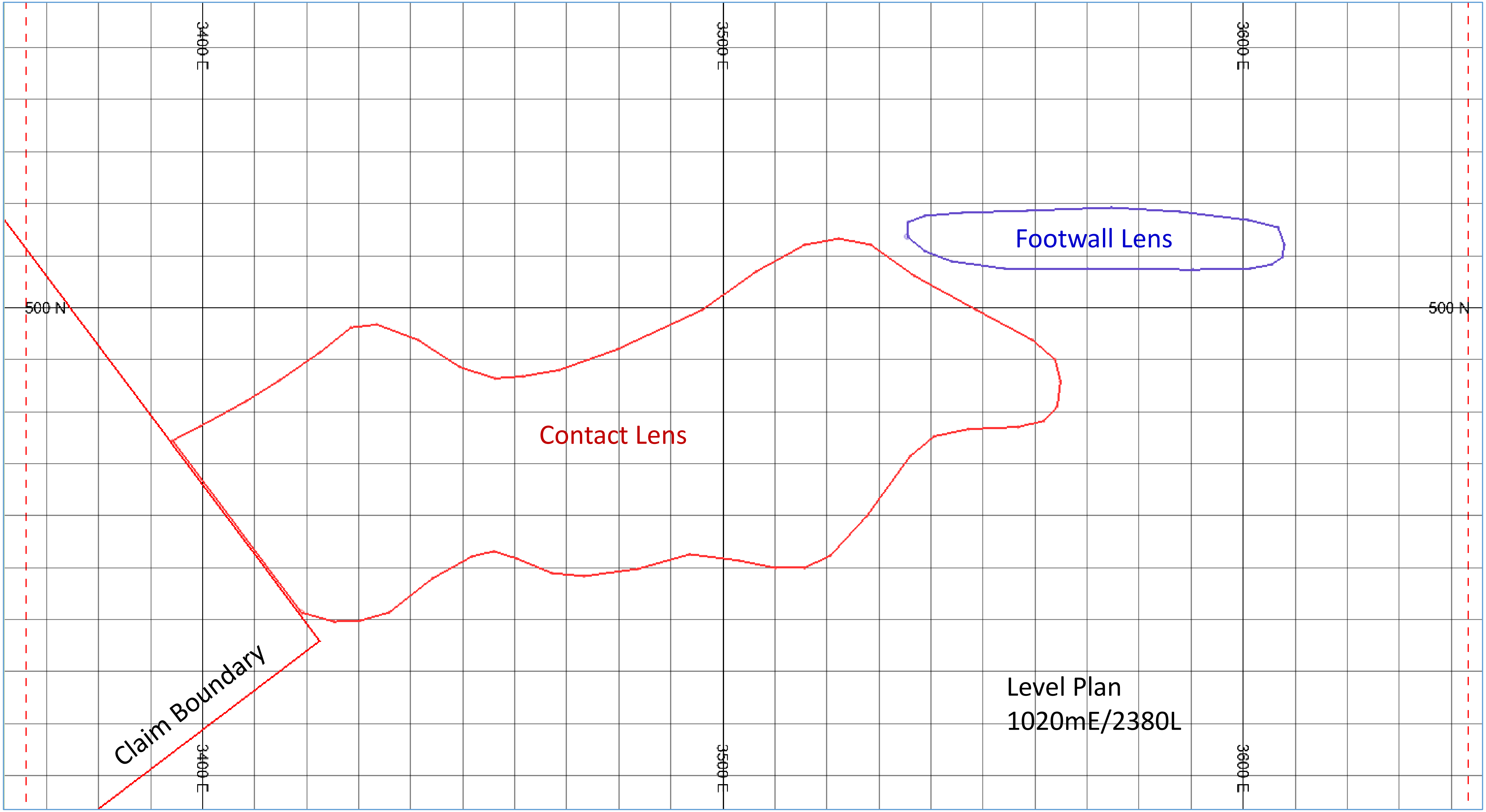
3400 E
3500 E
3600 E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3500 E
3600 E
500 N
500 N
Footwall Lens
Contact Lens
Claim Boundary
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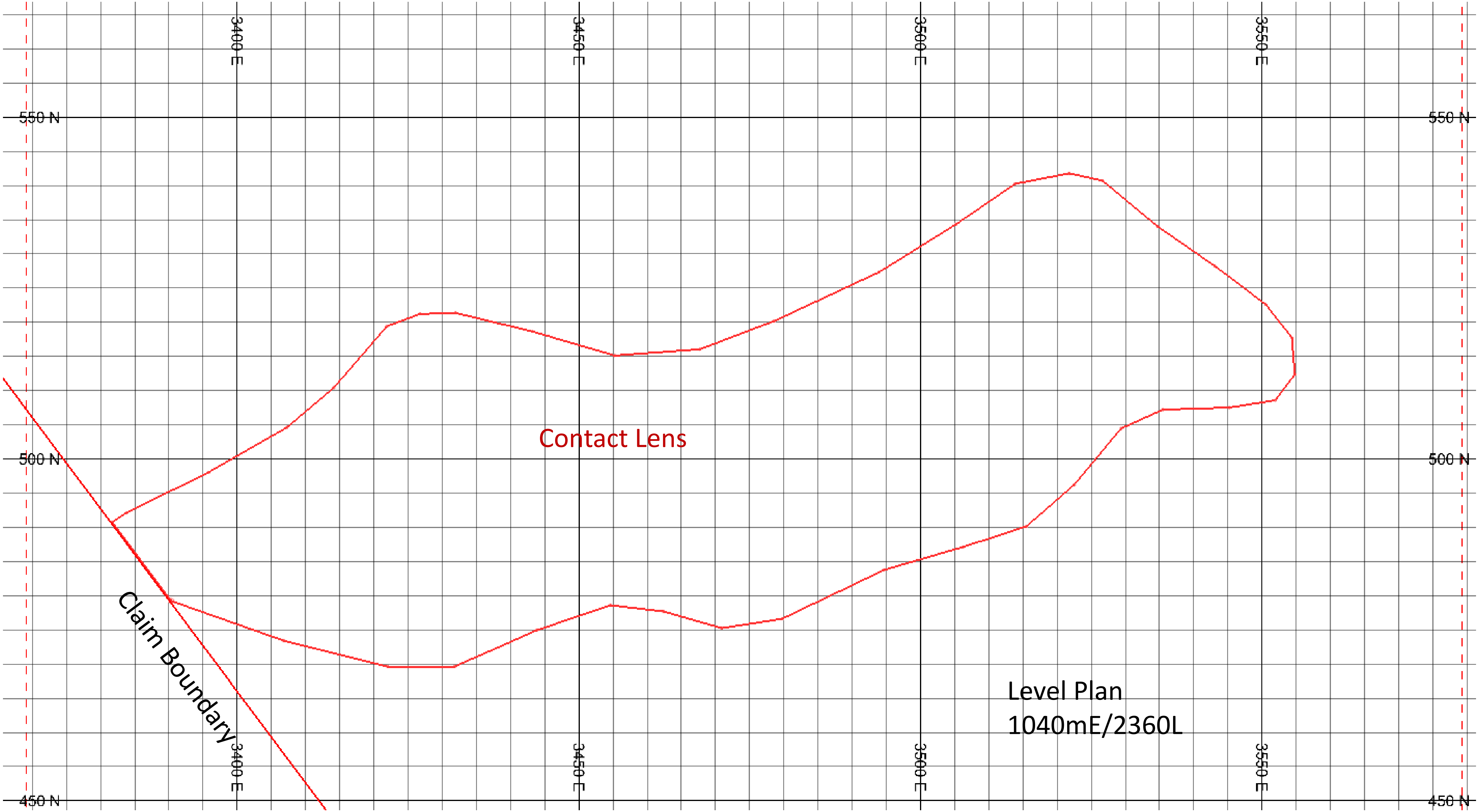
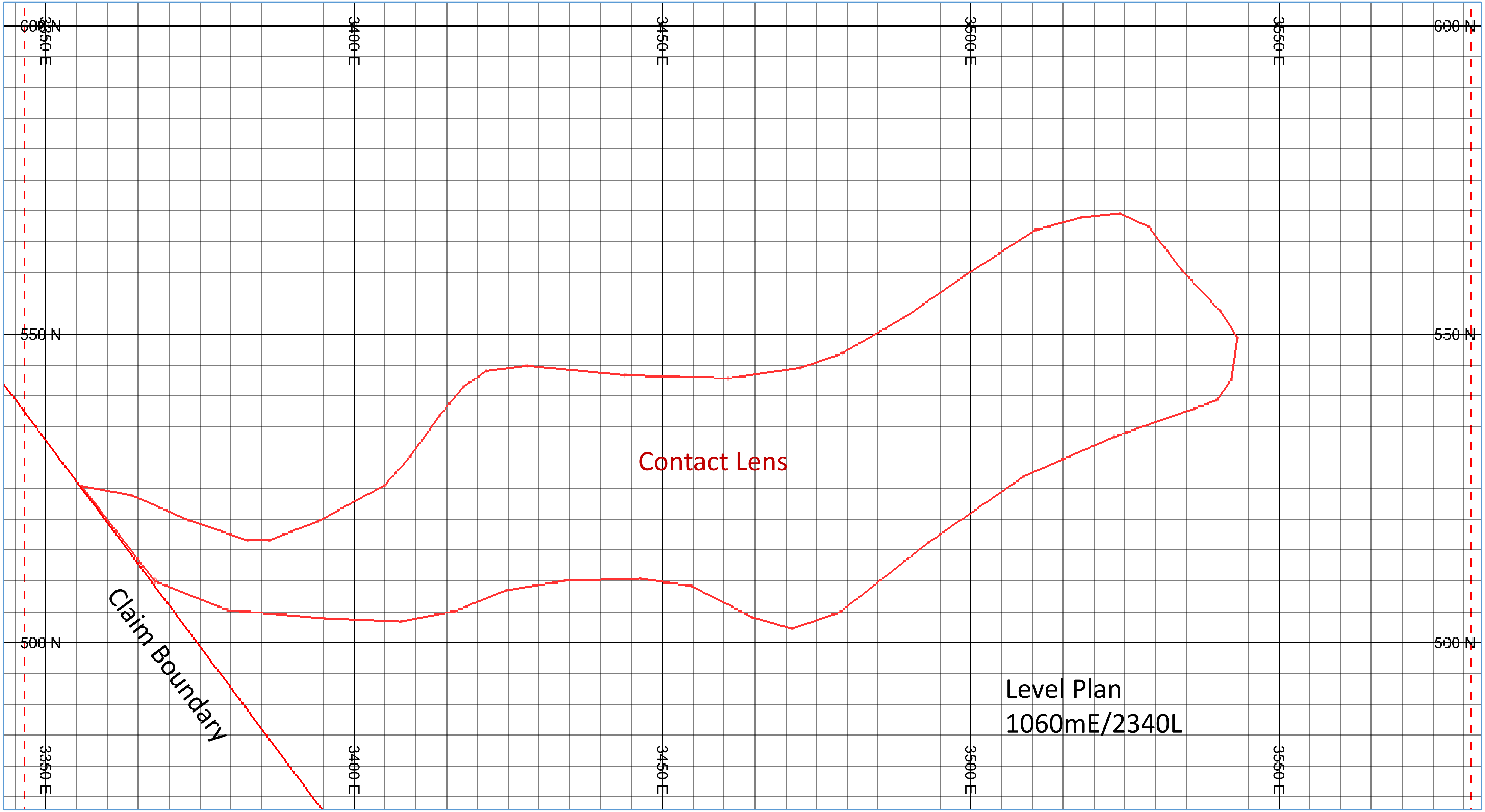
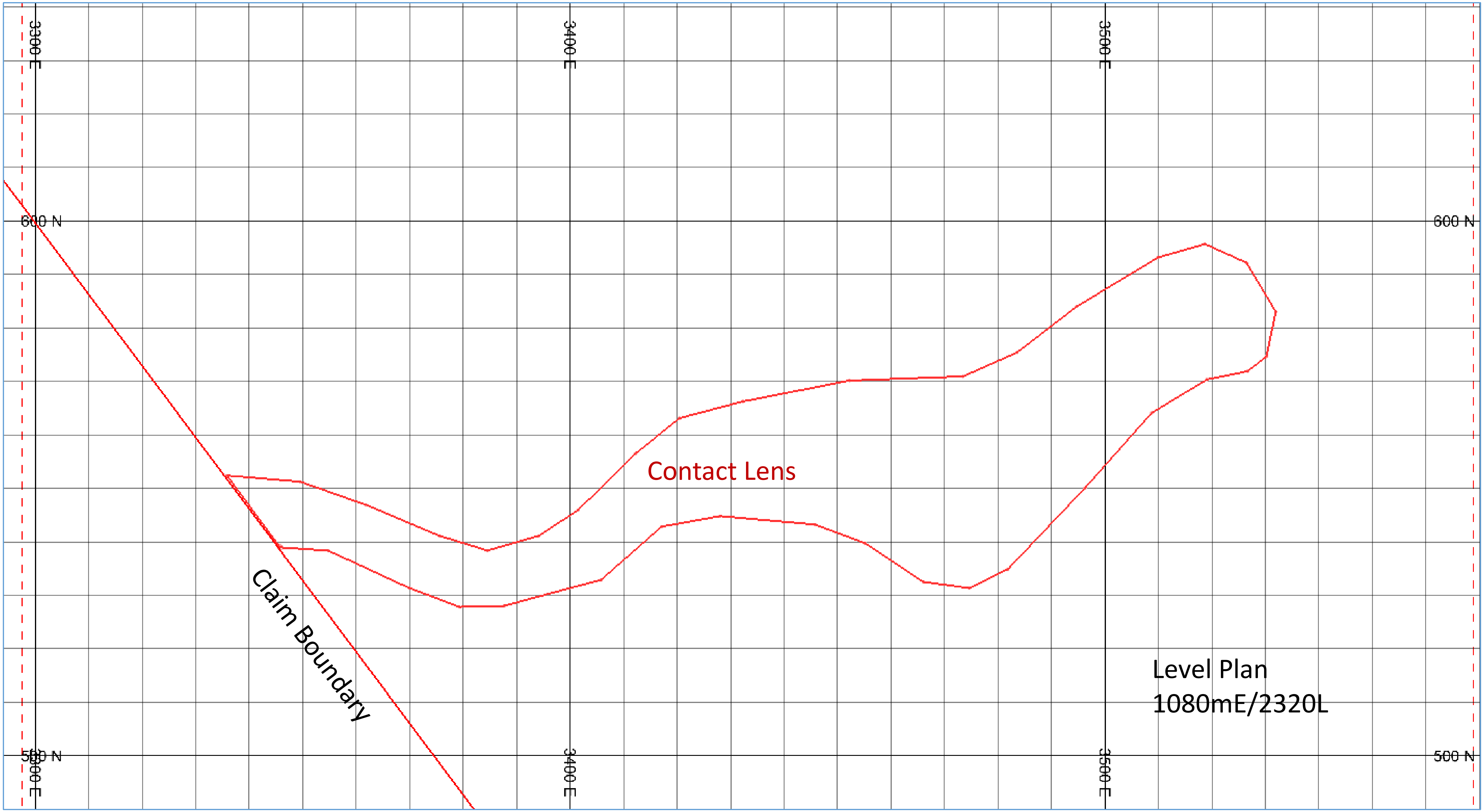
3500 E
3600 E
Level Plan
1020mE/2380L



3400 E
3450 E
3500 E
3550 E
550 N
500 N
450 N
Contact Lens
Claim Boundary
Level Plan
1040mE/2360L



600 N
550 N
500 N
3350 E
3400 E
3450 E
3500 E
3550 E
Contact Lens
Claim Boundary
Level Plan
1060mE/2340L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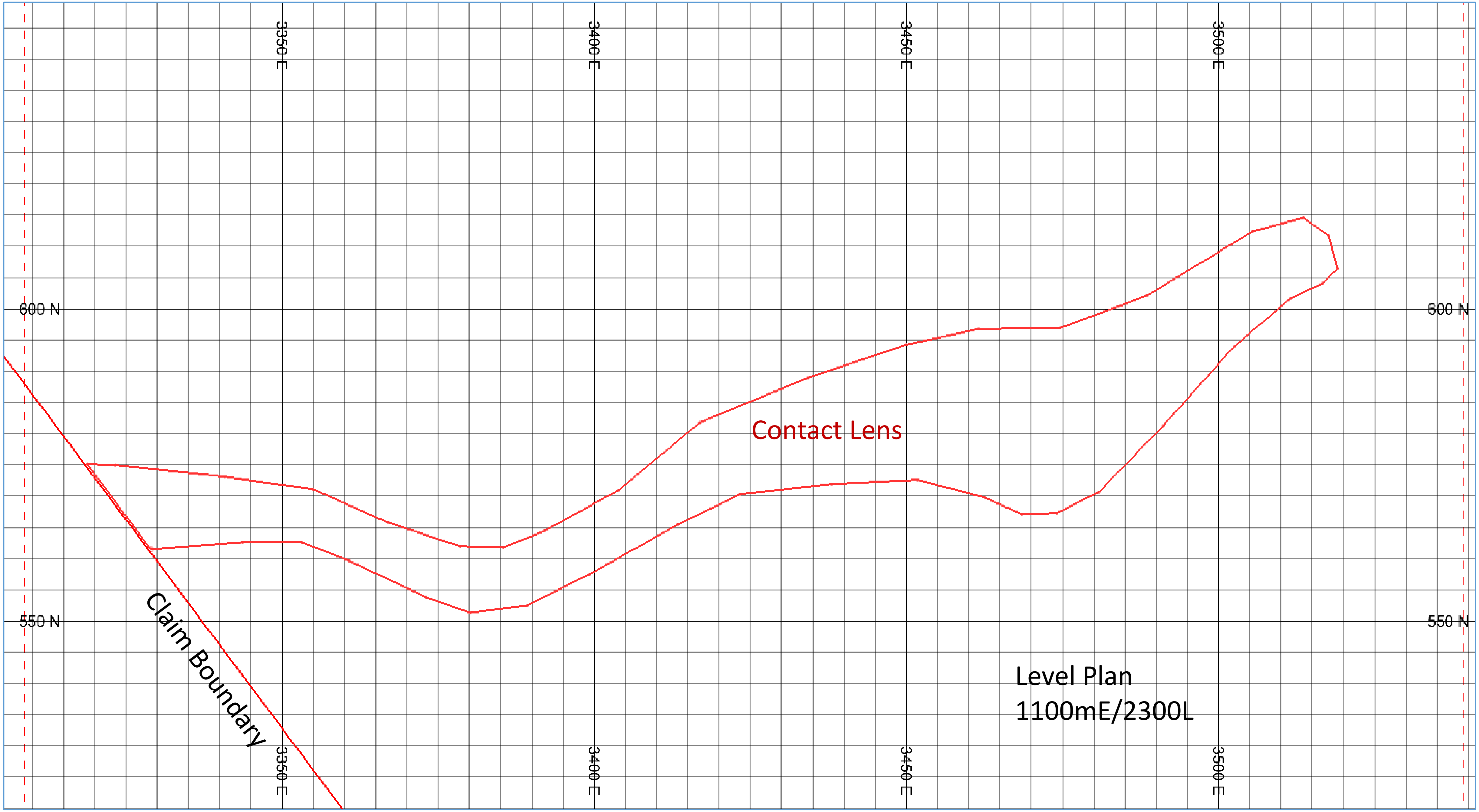
3400 E
3500 E
600 N
600 N
500 N
500 N
Contact Lens
Claim Boundary
Level Plan
1080mE/2320L


3350 E
3400 E
3450 E
3500 E
600 N
600 N
550 N
550 N
Contact Lens
Claim Boundary
Level Plan
1100mE/2300L


3300 E
3350 E
3400 E
3450 E
3500 E
650 N
600 N
550 N
Contact Lens
Contact Lens
Claim Boundary
Level Plan
1120mE/2280L