Golden Minerals Company
350 Indiana Street, Suite 650
Golden, CO 80401
Phone (303) 839-5060 | Fax (303) 839-5907

Preliminary Economic Assessment Update
NI 43-101 Technical Report of the Velardeña Project
Durango State, Mexico

Effective Date: March 1, 2022
Issue Date: May 6, 2022

Prepared by: Guillermo Dante Ramírez Rodríguez, PhD, MMSA QP
Kira Johnson, MMSA QP
Randolph P. Schneider, MMSA QP

TETRA TECH
350 Indiana Street, Suite 500 | Golden, CO 80401
Phone: 303.217.5700 | tetratech.com

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS/ABBREVIATIONS

Abbreviation	Unit or Term
2D	Two dimensional
3D	Three dimensional
AR	Análisis de risegos (Risk analysis)
ASARCO	American Smelting and Refining Company
BAT	Batch amenabilty tests
BIOX	Bio-odixation
CAM	Chlumsky, Armbrust & Meyer, LLC
CCD	Counter current decantation
CFE	Comisión Federal de Electricidad (Federal Electricity Commission)
cm	Centimeter
CONAGUA	Comisón Nacional del Agua (National Water Commission)
cu. Ft.	Cubic feet
CUSF	Cambio de Uso de Suelo Forestal (Change in Forest Land Use)
DMT	Dry metric tonne
ECU	ECU Silver Mining
ERSA	Ensayes y Representaciones, S.A.
ETJ	Estudio Téchnico-Justificativo (Technical Justification Study)
ft.	Feet
g/cm^3	Grams per cubic centimeter
g/t	Grams per tonne
Golden Minerals	Golden Minerals Company
ha	Hectare
HP	Horsepower
hr	Hour
ID	Identification
IDW	Inverse distanced weighted
IMMSA	Industrial Minera de México S.A
in.	Inch
INAH	Instituto Nacional de Antropología e Historia (National Institute of Anthropology and History)
INEGI	Instituto Nacional de Estadística, Geografía e Informatica (National Institute of Statistics and Geography)
IRR	Internal rate of return
k	Thousand
kg	Kilogram
km	Kilometer

Abbreviation	Unit or Term
kt	Thousand tonnes
kWh	Kilowatt-hour
LAU	Licencia ambiental única (Unique environmental license)
lb.	Pound
LCY	Loose cubic yard
LGDFS	Ley General de Desarrollo Forestal Sustentable (General Law for Sustainable Forest Development)
LGEEPA	Ley General del Equilibrio Ecológico y la Protección al Ambiente (General Law of Ecological Equilibrium and Environmental Protection)
LGPIR	Ley General para la Prevención y Gestión Integral de los Residuos (General Law for the Prevention and Integral Management of Waste
LHD	Load-haul-dump
LOM	Life of mine
m	Meter
M	Million
m3/d	Cubic meters per day
m3/yr	Cubic meters per year
MIA	Manifestación de Impacto Ambiental (Environmental Impact Assessment)
Micon	Micon International Limited
Minera Labri	Minera Labri S.A. de C.V.
Minera William	Minera William S.A. de R.L. de C.V.
mm	Millimeters
Mt	Million tonnes
MXN	Mexican pesos
mya	Million years ago
NEAP	National Environmental Auditing Program
NPV	Net present value
NSR	Net smelter return
oz	Troy ounce
PEA	Preliminary Economic Assessment
PLS	Pregnant liquor solution
PPA	Programa para la prevención de accidentes (Accident prevention program)
QA/QC	Quality assurance/quality control
QP	Qualified Person
ROM	Run of mine
SEDENA	Secretaría de la Defensa Nacional (Secretariat of National Defense)
SEMARNAT	Secretaria del Medio Ambiente y Recursos Naturales (Secretariat of Environment and Natural Resources)
SGM	Servicio Geológico Mexicano (Mexican Geological Survey)

Abbreviation	Unit or Term
t	Tonnes
tpd	Tonnes per day
tpy	Tonnes per year
TSF	Tailings storage facility
USD	United States dollars
yd.	Yard
yr	Year

1. SUMMARY

This report has been prepared as a Preliminary Economic Assessment (PEA) Technical Report for Golden Minerals Company (Golden Minerals) for the Velardeña Project in Durango, México; the Project is held by Minera William S.A. de R.L. de C.V. (Minera William) a wholly owned subsidiary of Golden Minerals.

This report is prepared as an update of a previous PEA technical report prepared by Tetra Tech for Golden Minerals dated May 8, 2020 with effective date of April 2020.

This PEA incorporates additional information developed by Golden Minerals since the May 2020 report. This includes updated pricing and investigates the potential minability of Measured, Indicated, and Inferred Sulfide Mineral Resources for the principal veins.

Following the success of two series of metallurgical tests to evaluate the amenability of Velardeña Au- and Ag-bearing concentrate to bio-oxidation, this updated PEA includes a circuit to oxidize the pyrite concentrate from Plant 1 for recovery of the contained Au and Ag to doré on site.

1.1 Location, Property Description, and Ownership

The Project is located in the Velardeña mining district, within the municipality of Cuencamé, in the northeastern portion of the State of Durango, Mexico. The property is situated approximately 65 km south-southwest of the city of Torreón in the State of Coahuila, and 150 km northeast of Durango City, capital of the State of Durango. The location of the Project is shown in **Figure 1-1**.

Figure 1-1: General location map

1.2 Geology and Mineralization

Regional geology is characterized by a thick sequence of limestone and minor, calcareous clastic sediments of Cretaceous age, intruded by Tertiary plutons of mostly felsic to intermediate composition. During the Laramide geologic event, sediments were subject to an initial stage of compression which resulted in formation of large amplitude, upright to overturned folds generating the distinctive strike ridges of limestone, which dominate local topography. Fold axes trend northerly in the northern part of the region but are warped or deflected to west northwest azimuths in the south. The northeast trending hinge line or deflection which controls this fundamental change in strike passes through the Velardeña district.

1.3 Exploration, Sampling, and QA/QC

The Project has been extensively explored from the surface using geologic mapping, vein mapping and vein sampling. Underground exploration consisted of geologic mine level mapping, vein level mapping, vein sampling, drilling, drifting and stope development. Mining and metallurgical testing and small-scale production have been carried out throughout the long historical development along some of the numerous mineralized structures.

Sample preparation, analyses, and security procedures followed by Minera William staff meet industry best practice standards and are sufficient to support the estimation of Resources. The quality control sampling results are typical of an operation given the amount of throughput and data handling. Previous quality control procedures and results have been reviewed by previous authors, and those reviews resulted in improved protocols and performance, but previous authors ultimately concluded the data was sufficient to support estimation of Resources.

Current drill hole analysis is completed by ALS Chemex in Vancouver, Canada and mine channel and mill samples are tested at the onsite laboratory facility constructed in 2013. ALS Chemex in Vancouver is independent of the issuer and is ISO 17025 accredited, and the accreditation of ALS Vancouver encompasses preparation processes completed at ALS Chihuahua. The onsite laboratory is not independent of the issuer and is not accredited; however, it is well qualified and maintains regular checks with standard reference material, duplicate, and blank samples with the certified and accredited laboratory SGS-Durango-Vancouver, as well as ALS Chemex. Tetra Tech's QPs inspected the onsite laboratory in January 2022 and found the facility and procedures appropriate and following the procedures to be of industry best practice standards. Velardeña's laboratory also performs metallurgical test investigations.

1.4 Mineral Processing and Metallurgical Testing

There are two processing plants at the Project. Plant 1 is designed to treat sulfide material by conventional crush, grind, and differential flotation to produce Pb, Zn and pyrite concentrates. Process Plant 2 is an agitated cyanide leach plant that produces Au-Ag doré by using a Merrill-Crowe circuit.

Operation of Plant 1 was discontinued in late 2015 due to a combination of low metal prices, dilution, and metallurgical challenges. Plant 2 was leased to Hecla Mining Company from July 2015 through November 2020, after which the lease expired. Mineralized material from the Golden Minerals Rodeo Project has been processed through Plant 2 since January 2021.

Because of the historical production for Plant 1, the liberation characteristics of the material and subsequent response to differential flotation are within typical design criteria and known by the operations personnel. There are no geological, lithological, or mineralogical changes in the process plant feed anticipated for the envisaged future production as compared to previous operations. Historical operational results support the existing process flowsheet for potential future production at Plant 1. Further, the use of existing and refurbished equipment within the pre-existing facilities is Golden Minerals' preferred method of future treatment.

In 2007 the potential to increase Au recovery from Plant 1 and improve project economics by installing a bio-oxidation circuit to treat pyrite concentrates on site and recover Au and Ag to doré was explored by sending samples to SGS in South Africa for test work. Since then, in 2019 and 2020, two additional sets of representative Au-bearing iron pyrite concentrate samples were sent to Outotec in South Africa to confirm uniformity of the BIOX® process results and to further define the bio-oxidation residence time required for subsequent Au recovery by cyanide leaching. The Metso Outotec BIOX® process for the treatment of refractory Au concentrates has been in commercial operation for over 30 years with 13 successful plants commissioned worldwide. To date, over 22 million ounces of gold have been produced through this process. SGS and Outotec are independent of Golden Minerals.

1.5 Mineral Resource Estimation

Resources have been estimated independently for 60 vein surfaces representing main veins, fault offsets and splits of 39 known veins. Intervals were evaluated and recoded by vein as necessary for construction of vein wireframes. These veins are CC, C1, A4, F1, G1, San Mateo, Roca Negra, Hiletas, Terneras, Chicago, and Escondida. Attributes have been estimated using inverse distance to a power of 2.5.

Estimated Mineral Resources for the Velardeña project are shown in **Table 1-1** below, as well as the mineral type portions for each Resource class. Resources were calculated as diluted to a minimum of 0.7 m and are reported at a $175 NSR cutoff.

Table 1-1: Velardeña Project Mineral Resources

Classification	Mineral Type	NSR Cutoff	Tonnes	Grade Ag g/t	Grade Au g/t	Grade Pb%	Grade Zn%	Ag oz	Au oz	Pb lb.	Zn lb.
Measured	Oxide	175	128,800	268	5.69	1.74	1.53	1,108,000	23,500	4,936,000	4,333,400
Indicated	Oxide	175	280,300	262	5.06	1.73	1.45	2,361,200	45,600	10,681,500	8,936,600
Measured + Indicated	Oxide	175	409,100	264	5.26	1.73	1.47	3,469,200	69,100	15,617,500	13,270,000
Inferred	Oxide	175	351,400	417	4.95	2.55	1.45	4,714,600	56,000	19,729,500	11,248,200
Measured	Sulfide	175	256,200	357	5.52	1.56	1.91	2,942,800	45,500	8,819,300	10,769,700
Indicated	Sulfide	175	603,500	341	4.79	1.46	1.91	6,619,400	92,900	19,475,600	25,408,900
Measured + Indicated	Sulfide	175	859,700	346	5.01	1.49	1.91	9,562,200	138,400	28,294,900	36,178,600
Inferred	Sulfide	175	1,357,700	348	4.76	1.52	1.97	15,179,000	207,800	45,534,200	58,952,900
Measured	All	175	385,000	327	5.58	1.62	1.78	4,050,800	69,000	13,755,300	15,103,100
Indicated	All	175	883,800	316	4.88	1.55	1.76	8,980,600	138,500	30,157,100	34,345,500
Measured + Indicated	All	175	1,268,800	319	5.09	1.57	1.77	13,031,400	207,500	43,912,400	49,448,600
Inferred	All	175	1,709,200	362	4.80	1.73	1.86	19,893,600	263,800	65,263,700	70,201,100

Notes:
1. *Resources are reported as diluted tonnes and grade to 0.7 m fixed width*
2. *Metal prices for NSR cutoff are: $23.70/oz-Ag, $1,744/oz-Au, $0.97/lb.-Pb, and $1.15/lb.-Zn*
3. *Columns may not total due to rounding*

Block attributes were estimated in three passes from small to large. Estimation was completed using anisotropic inverse distance weighting for each block in the model. **Table 1-2** details the search ellipse sizes, orientations along with sample selection criteria, and classification. Resource classification was assessed by pass (maximum search), number of samples and the nearest composite and average distance. Measured or Indicated classification was only permitted in pass one, 75 m maximum search, and was primarily, but not exclusively, defined within blocks haloing the existing drifts and stopes.

Table 1-2: Pass parameters and classification

Pass	Method	Max Search	Ratio 1st:2nd:3rd	Sectors	Max Per Sector	Comp Min	Comp Max	Classification
First	IDW 2.5	75	See vein parameter table	4	2	1	8	Inferred, Indicated if; comps >=3 and nearest comp <= 50 m, Measured if; comps >=4 and nearest comp <= 16 m and average comp distance <= 25
Second	IDW 2.5	150	1:0.25:0.5	1	2	1	2	Not classified, Inferred if; nearest comp <= 125 m
Third	IDW 2.5	200	1:0.5:0.5	1	2	1	2	Not classified

1.6 Mining Methods

The Project is currently in care and maintenance. It is planned to be continued as an exclusively underground operation. The current conceptual mine plan includes only the sulfide material in the principal veins.

A site visit was conducted by Tetra Tech personnel on December 10, 2019. Cut and fill stoping was observed to be the primary method of extraction, along with resue stoping. These methods are suitable to the steeply dipping veins found at the Project. Test mining has been conducted while the operations at the mine have been suspended to prove mining methods and selective mining widths, and to control dilution during mining. These tests were successful at a minimum selective mining width of 0.7 m.

Conceptually planned stopes for mining are based on Measured, Indicated and Inferred Resources which total 1.237 million tonnes for mining over 11 years, from stopes and stope development. **Table 1-3** details the tonnes and grade of the conceptual mine plan.

Table 1-3: Preliminary mine plan numbers

Category	Total/Avg
Tonnes (kt)	1,237
NSR ($M)	506
Ag (g/t)	344
Ag (koz)	13,678
Au (g/t)	5.30
Au (koz)	210
Pb (%)	1.34
Pb (klb.)	36,586
Zn (%)	1.64
Zn (klb.)	44,731

1.7 Recovery Methods

There are two existing process plants, Plant 1 and Plant 2, at the Project. Plant 1 is designed to treat sulfide material to produce Pb, Zn, and pyrite concentrates, and is located near the village of Velardeña, approximately eight kilometers from the mining operations.

Plant 1 has an operating capacity of 340 tpd with effective capacity of 325 tpd, equal to 112,775 tonnes per year on a 347-day operating schedule. Plant 2 is a process plant with 550-tpd capacity for treating Au-Ag ore with the capability to separate sulfide material from oxide material and produce bulk Au-Ag rich flotation concentrate and Au-Ag doré. Plant 2 was purchased by William Resources in 1996. Operations were suspended at both plants in June 2013. During the shutdown, Golden Minerals completed several capital projects at Plant 1 prior to its restart including: Overhauling the electrical system, installing new concentrate filters, and refurbishing the flotation cells.

In July 2014, Golden Minerals restarted mining operations to feed Plant 1, which resumed production on November 3, 2014. Operation of Plant 1 was discontinued in late 2015 due to a combination of low metal prices, dilution, and metallurgical challenges.

Plant 2 was leased to Hecla from July 2015 through December 2020. Material from the Golden Minerals Rodeo Project has been processed through Plant 2 since January 2021 at a rate increasing to more than 500 tpd.

A BIOX® circuit would be constructed adjacent to Plant 2. Thickened pyrite concentrate from Plant 1 would be trucked to Plant 2, transferred to a stock tank, and subsequently to the BIOX® reactors. Oxidized concentrate, BIOX® residue, would be leached in the existing Plant 2 circuit.

1.8 Infrastructure

Infrastructure facilities at the Project include the following:

- Access roads
- Power line
- Ancillary buildings
- Water wells

The Project is in the Mexican state of Durango, approximately 65 km southwest of the city of Torreón and 150 km northeast of the city of Durango. A major 4-lane highway, Highway 40, connects these cities. The Velardeña Plant 1 is located adjacent to the village of Velardeña, which is approximately 500 m west of Highway 40D. The Velardeña mines are located approximately eight kilometers from Plant 1 via a gravel road. Plant 2 is located approximately 3.5 km from the Velardeña mine, also via gravel roads. Personnel working at the Project reside in the town of Velardeña and surrounding communities.

1.9 Market Studies and Contracts

Detailed market studies have not been performed for the Velardeña project. Markets for the Pb and Zn concentrates include metal brokers and direct sales to smelters. Doré produced at Plant 2 can be sold to downstream metal refiners. The concentrates and doré produced are typical within the Mexican mining industry and the concentrate and doré markets within Mexico and worldwide are liquid. For purposes of this study, it is assumed that Golden Minerals will be successful in securing buyers for its concentrates and doré.

1.10 Environmental Permitting

In early 2012, Golden Minerals applied for and was accepted into the Mexican National Environmental Auditing Program (NEAP). Under NEAP, Golden Minerals participated in an audit program to verify compliance with existing regulations and identify non-regulated potential issues that could result in environmental contingencies. Golden Minerals holds various permits required for conducting their current operations at the Velardeña properties, and their participation in NEAP allows them to continue their current operations during the remediation of any potential non-compliance matters. Prior to the suspension of operations at Plant 1 in 2014, Golden Minerals had achieved 85% compliance at the plant.

Golden Minerals is required to update their environmental licenses and environmental impact assessments for any expansion of or modification to any of the existing two plants. The construction of new infrastructure beyond the current plant facilities would require additional permitting, including environmental impact assessments and possibly land use permits. Golden Minerals does not expect to have difficulty obtaining additional permits or environmental impact assessments.

Tetra Tech is unaware of any outstanding environmental liabilities attached to the Velardeña properties and is unable to comment on any remediation, which may have been undertaken by previous companies.

1.11 Capital and Operating Costs

Capital costs for the Velardeña Project are summarized in **Table 1-4**.

Table 1-4: Capital costs

Capital Costs	Pre-Production	LOM	Full LOM
Mine Development	$778	$0	$778
Process Plant	$14,498	$2,750	$17,248
Contingency and Other	$1,755	$1,375	$3,130
Total (1)	**$17,041**	**$4,124**	**$21,166**

[1]Totals may not sum due to rounding

Operating costs for the Project are summarized in **Table 1-5**.

Table 1-5: Operating costs

Item	Total ($000s)	Unit Cost ($/t)
Mining Costs - Stoping	$131,261	$106.09
Mining Costs - Development	$33,653	$27.20
Milling costs	$105,234	$85.05
Mine and Process	**$270,148**	**$218.34**
Contingency and Other	$27,015	$21.83
Federal Precious Metal Royalty	$2,532	$2.05
Total Operating	**$299,695**	**$242.23**

1.12 Economic Analysis

An economic model was prepared for the Project using Measured, Indicated and Inferred Mineral Resources. Mineral Resources are not Mineral Reserves and do not have demonstrated economic viability. This PEA also considers Inferred Mineral Resources that are too speculative for use in defining Reserves. Results of the economic analysis are:

- Mine Life: 11 years
- Pre-tax $NPV_{8\%}$: $119M; IRR: 114%
- Payback: One year
- Federal Precious Metal Royalty: $2.53M

1.13 Interpretations and Conclusions

1.13.1 Geology and Resources

Drill hole and channel samples have been collected and analyzed using industry standard methods and practices and are sufficient to support the characterization of grade and thickness and to further support the estimation of Measured, Indicated, and Inferred Mineral Resources.

1.13.2 Mining

Results of the PEA indicate mining is potentially economically viable. However, due to the thin-veined nature of the mineralization and the scale of the operations, extensive Resource drilling of the deposit is not planned at this time. Conceptual stope outlines have been used for the purposes of this PEA.

The Project is sensitive to mining dilution, which could increase the costs of saleable products, but also provides opportunity as any potential reductions in dilution from the mining would greatly benefit the Project. Recent test mining at the site has confirmed a minimum selective mining width of 0.7 m is achievable, which can contribute to reducing dilution.

1.13.3 Metallurgy and Process

There are no geological, lithological, or mineralogical changes in the process plant feed anticipated for the envisaged potential future production as compared to previous operations. Existing legacy operational data supports the existing process flow sheet for future production at Plant 1.

The use of existing and refurbished equipment within the pre-existing facilities, and the production of marketable concentrates, is Golden Minerals' preferred method of treating potential future production. A new BIOX® plant would be constructed to treat the pyrite concentrates if further testing confirms the potential for increased Au recovery.

1.14 Recommendations

1.14.1 Geology and Resources

- Continue to collect specific gravity measurements and refine current estimations of specific gravity; additional measurement should ideally be made with a paraffin wax or epoxy coating
- Implement procedures of duplicate channel sampling of drifts by secondary sampling teams prior to stope development to ensure grade and thickness characteristics, and to serve as field duplication of channel samples

- Setup of strict control sample review procedures and tolerances involving review of control sample failure on receipt of each batch's results, and automatic triggering of batch re-analysis immediately after being alerted to failures
- Improve sample data transcription methods to reduce control sample labeling errors and immediately resolve errors when encountered
- Perform a detailed model reconciliation on a completed stope early in the proposed mine life and alter the estimation methods if the result of the reconciliation suggest refinements should be made
- Continue to advance exploration drilling down dip of current Inferred Resources as new levels are established; preferentially target the Terneras, San Mateo, Roca Negra, and A4 veins

1.14.2 Mining

It is recommended that Golden Minerals implements cut and fill mining where waste and vein material are blasted separately to reduce ore dilution. This practice would consider more total tonnes blasted in each section. Vein tonnes would be reduced, but the resulting grade would be higher. Recent tests on selective mining widths of 0.7 m have proven to be achievable. Because this practice requires efficient operations control, Tetra Tech recommends having detailed control in drilling and blasting.

The mine plan developed for the PEA should be optimized and undertaken at a more detailed level, which will enable a greater understanding of mining constraints, costs, and resulting mill feed. Additionally, the oxide Resource should be evaluated for inclusion into future mine plans.

1.14.3 Metallurgy and Process

Antimony and arsenic are penalty elements in the Pb and Zn concentrates and could be added to the database and spatially modeled. Additional metallurgical test work is recommended to investigate the depression of antimony and arsenic from the final Pb and Zn concentrates, and Zn from the pyrite concentrate.

The potential of a new bio-oxidation plant to improve Au recovery warrants further test work to confirm previous encouraging results.

1.14.4 Economic Analysis

Currently, it is anticipated that the salvage sale of equipment will cover the reclamation costs. However, the salvage value of the mine equipment at the end of the LOM has not been estimated. It is recommended that an estimate of the salvage value of the Project's assets be determined and incorporated into the economic analysis alongside the closure cost estimates to increase the resolution of the Project's economics.

2. INTRODUCTION

This report has been prepared for Golden Minerals Company (Golden Minerals) for the Velardeña Project (the Project) held by Minera William S.A. de R.L. de C.V. (Minera William) a wholly owned Mexican subsidiary of Golden Minerals. Minera William holds the title to the mines and the oxide mill and processing facility (Plant 2). Additionally, Minera Labri, S.A. C.V. (Minera Labri), is a wholly owned Mexican subsidiary company of Golden Minerals which holds title to the sulfide mill and floatation processing facility, Plant 1. Plant 1 and Plant 2 are constructed and operate within private property.

This Preliminary Economic Assessment (PEA) was prepared to fulfill Golden Minerals' obligation to file a Technical Report in accordance with Section 4.2(1)(j)(ii) of Canadian National Instrument 43-101 – Standards of Disclosure for Mineral Projects (NI 43-101). This report has been prepared by Qualified Persons employed by Tetra Tech, and updates a previous PEA for the Project, *Preliminary Economic Assessment NI 43-101 – Technical Report of the Velardeña Project*, produced by Tetra Tech, with an effective date of April 2020.

This updated PEA has been prepared for the purpose of detailing updated pricing and costs since the previous Technical Report. This PEA investigates the potential minability of Measured, Indicated, and Inferred sulfide Resources for the principal veins, which include the following four areas:

- Santa Juana (A4, CC, C1, F1, and G1 veins)
- San Mateo
- Terneras (Terneras, Hiletas, and Roca Negra veins)
- Chicago (Chicago and Escondida veins)

Golden Minerals is a Delaware corporation based in Golden, Colorado, USA. Golden Minerals' shares are listed on the NYSE-American and the Toronto Stock Exchange under the symbol AUMN.

2.1 Sources of Information

The information contained in this PEA is based on information contained within previous technical reports and other publications listed in **Section 27**. Where applicable and appropriate, content has been updated based on additional work performed by Tetra Tech or by Golden Minerals personnel. Tetra Tech has reviewed the procedures and methodologies used to generate this data and have found it to meet industry standards.

Golden Minerals personnel have contributed the following data and inputs in support of this Technical Report:

- Drill hole and channel database information
- Initial interpretations of veins
- Geologic and vein level and surface maps
- Resource block models
- Existing ramp and level development and mined cavities
- Production reports
- Mill cost reports
- Mineral processing flowsheets, equipment lists, and facility layouts for both Plant 1 and Plant 2
- Freshwater well and infrastructure data
- Smelting and refining contract terms for Pb, Zn, and pyrite concentrates
- Capital and operating cost estimates
- Royalty terms for economic analysis

- Affected environment baseline data, current permit statuses and requirements, and the environmental monitoring program
- Community relations and social responsibility obligations
- Closure and reclamation plans and associated costs

2.2 Property Inspection

Tetra Tech Qualified Persons (QPs) Dr. Guillermo Dante Ramírez-Rodríguez, Mr. Randolph P. Schneider, and Ms. Kira Johnson visited the site on December 10, 2019. The visit included observations of geologic interpretations, mining, exploration drilling, channel sample locations, survey locations, underground mine accesses, the Santa Juana vein (San Mateo ramp), the Chicago veins (Chicago ramp), drifts and stopes, stockpiled material, processing Plants 1 and 2, Golden Minerals' laboratory, and surface infrastructure. Tetra Tech's QPs also visited the Golden Minerals office in Torreón, Coahuila and had discussions with Golden Minerals personnel regarding past estimation methods, database structure, and vein interpretations.

From January 18-21, 2022, Dr. Ramírez-Rodríguez and Ms. Johnson visited the assay laboratory, Plant 1, and Plant 2.

2.3 Units of Measure

All references to currency in this report are to United States dollars (USD) unless otherwise noted. Distances, areas, volumes, and masses are expressed using metric units unless indicated otherwise.

For this report, common measurements are given in metric units. All tonnages shown are in tonnes of 1,000 kilograms, precious metal grade values are given in grams per tonne (g/t), and precious metal quantity values are given in troy ounces (oz.).

3. RELIANCE ON OTHER EXPERTS

Tetra Tech is relying on statements and information provided by Golden Minerals concerning legal, environmental, tax, and royalty matters included in this report.

Tetra Tech is relying on statements and documents provided by Warren Rehn, CEO of Golden Minerals, Robert Vogels, CFO of Golden Minerals, and Telésforo Martínez, Country Manager, Mexico Operations of Golden Minerals, and Aaron Amoroso, Mineral Resource Manager of Golden Minerals regarding:

- Royalty and tax obligations (Sections 4 and 22)
- Status of environmental permits (Section 20)
- Material contracts (Section 20)

A Title Opinion was provided by VHG, Servicios Legales, S.C., regarding the current legal status of the Project concessions. Tetra Tech is relying upon this legal opinion for Section 4.

4. PROPERTY DESCRIPTION AND LOCATION

The Project includes 28 mining concessions covering the Velardeña and Chicago mines controlled by Golden Minerals through its Mexican subsidiary Minera William and located within the Velardeña mining district. Processing Plants 1 and 2 are located within land owned by Golden Minerals. Surrounding ejido-owned land contains some of the associated installations and infrastructure.

4.1 Location

The Project is in the Velardeña mining district, within the municipality of Cuencamé, in the central-eastern portion of the State of Durango, México. The property is situated approximately 65 km south-southwest of the city of Torreón in the State of Coahuila, and 150 km northeast of Durango City, capital of the State of Durango. The location of the Project is shown in **Figure 4-1**.

Figure 4-1: General location map

4.2 Property Description

The Project is comprised of two properties:

- The Velardeña property is centered on UTM grid coordinates 2774300 N and 632200 E (WGS 84 datum, zone 13). This property contains the Santa Juana mine which has been the focus of mining efforts since 1995, as well as the historical Terneras, San Juanes, and San Mateo mines.
- The Chicago property is located approximately 2 km south of the Velardeña property and is centered at UTM grid coordinates 2772480 N and 631867 E (WGS 84 datum, zone 13). This property contains the historical Los Muertos-Chicago mine.

4.3 Mineral Tenures

4.3.1 Claims

The Project consists of 28 claims covering the Velardeña and Chicago properties controlled by Golden Minerals through its Mexican subsidiary Minera William. Golden Minerals holds 315.51 hectares within all the concessions. **Table 4-1** details the list of concessions, title numbers, dates of registration and expiration, and their respective areas.

Table 4-1: Project mineral concessions

Location	Claim Name	Claim Owner	Concession Number	Issue Date	Expiration Date	Concessions Area (ha)
Velardeña	Ampl. del Águila Mexicana	Minera William	85580	10/13/1936	10/12/2061	19.86
Velardeña	Águila Mexicana	Minera William	168290	4/2/1981	4/1/2031	18.94
Velardeña	La Cubana	Minera William	168291	4/2/1981	4/1/2031	2.55
Velardeña	Tornasol	Minera William	168292	4/2/1981	4/1/2031	4.00
Velardeña	San Mateo Nuevo	Minera William	171981	9/21/1983	9/20/2033	8.00
Velardeña	San Mateo	Minera William	171982	9/21/1983	9/20/2033	4.61
Velardeña	Recuerdo	Minera William	171983	9/21/1983	9/20/2033	8.23
Velardeña	San Luis	Minera William	171984	9/21/1983	9/20/2033	2.40
Velardeña	La Nueva Esperanza	Minera William	171985	9/21/1983	9/20/2033	9.93
Velardeña	La Pequeña	Minera William	171988	9/21/1983	9/20/2033	1.00
Velardeña	Buen Retiro	Minera William	172014	9/21/1983	9/21/2033	6.09
Velardeña	Unificación San Juan Evangelista	Minera William	172737	6/28/1984	6/27/2034	13.94
Velardeña	Unificación Viborillas	Minera William	185900	12/14/1989	12/13/2039	46.43
Velardeña	Buenaventura No. 3	Minera William	188507	11/29/1990	11/28/2040	6.01
Velardeña	El Pájaro Azul	Minera William	188508	11/29/1990	11/28/2040	15.00
Velardeña	Buenaventura 2	Minera William	191305	12/20/1991	12/19/2041	5.37
Velardeña	Buenaventura	Minera William	192126	12/19/1991	12/18/2041	30.00
Velardeña	Los Dos Amigos	Minera William	193481	12/19/1991	12/18/2041	25.33
Velardeña	Viborillas No. 2	Minera William	211544	5/31/2000	5/30/2050	1.60
Velardeña	Kelly	Minera William	218681	12/3/2002	12/2/2052	3.91
Chicago	Santa Teresa	Minera William	171326	9/20/1982	9/19/2032	22.34
Chicago	San Juan	Minera William	171332	9/20/1982	9/19/2032	8.17
Chicago	Los Muertos	Minera William	171986	9/21/1983	9/20/2033	3.53
Chicago	El Gambusino	Minera William	171987	9/21/1983	9/20/2033	6.65
Chicago	Ampliación San Juan	Minera William	183883	11/23/1988	11/22/2038	10.80
Chicago	Muñequita	Minera William	196313	7/16/1993	7/15/2043	15.45
Chicago	San Agustín	Minera William	210764	11/26/1999	11/25/2049	7.46
Chicago	La Cruz	Minera William	189474	12/6/1990	12/5/2040	7.91

4.3.2 Surface Rights, Agreements, and Obligations

Golden Minerals reports that it has valid agreements with two local ejidos that control surface rights over the claims. The contract with Ejido Velardeña provides surface rights to certain roads and other infrastructure at the Velardeña property of the Project. As part of the contract the company makes payments of $2,000 every quarter. The agreement expired in December 2021; however, Golden Minerals has negotiated a new agreement, which is valid through 2032 and requires quarterly payments of $4,000.

The Chicago property is part of the Vista Hermosa ejido, which controls surface rights. Golden Minerals and the ejido have signed an agreement regarding surface rights and access. The contract with Ejido Vista Hermosa is for 25 years and was signed in March 2013; it provides exploration access and access rights for roads and utilities for the Chicago area of the Velardeña Project properties. As part of the contract the company makes a payment of $400,000 Mexican Pesos (MXN), plus applicable taxes, by March 24th of every year.

Golden Minerals has acquired the surface rights for the land underlying the oxide mill from Vista Hermosa Ejido in addition to the land it already owned containing surface installations at the entrance of the Terneras mine (San Mateo ramp), the sulfide plant, the area containing the concentrates warehouse, and where one of the wells used by the mill is located.

4.3.3 Royalties and Tax

A royalty of 0.5% on precious metal production (Au and Ag) is paid yearly to the federal government for the purpose of returning a portion of production to the local community. There are no other known production royalties. In addition, all operations in Mexico are required to pay a 7.5% special mining tax.

4.3.4 Mineral Property Encumbrances

There is a lien reported in favor of IIG bank on some concession titles within the Velardeña property regarding a loan made to BLM Minera Mexicana S.A. de C.V., an entity owned by ECU (now a part of Golden Minerals). Golden Minerals reports this loan was repaid in 2001; however, the lien notation on the concession titles was never cleared following the repayment and still shows as an active lien in the Mexican Mining Registry. Golden Minerals states it is 100% confident all debts with IIG have been settled and is continuing to pursue the removal of the lien notation with the Mexican authorities.

4.4 Environmental Liabilities

In early 2012, Golden Minerals applied for and was accepted into the Mexican National Environmental Auditing Program (NEAP). Under NEAP, Golden Minerals participated in an audit program to verify compliance with existing regulations and identify non-regulated potential issues that could result in environmental contingencies. After the operation was closed in 2013, the enrollment in NEAP was suspended; however, the company is eligible to re-enroll in the program when operations resume. Golden Minerals holds various permits required for conducting their current operations, and their participation in NEAP allows them to continue their current operations during the remediation of any potential non-compliance matters.

Golden Minerals is required to update their environmental licenses and environmental impact assessments for any expansion of or modification to any of the existing plants. The construction of new infrastructure beyond the current plant facilities would require additional permitting, including environmental impact assessments and possibly land use permits. Golden Minerals anticipates it will be able to obtain any additional permits as required.

Tetra Tech is unaware of any outstanding environmental liabilities attached to the Velardeña properties, and is unable to comment on any remediation, which may have been undertaken by previous companies.

4.5 Permitting

Areas with permitting requirements at the Project include the Velardeña mine, Plant 1, and Plant 2. Golden Minerals personnel report that the Project holds and has retained the necessary permits to operate the mines and plants at Velardeña, and further there are no unresolved issues with the environmental regulatory agencies. They do not anticipate any limitations on the operations due to future inspections or evaluations by the environmental authorities. Details of the permits required, and the status of the permits, are provided in **Section 20.3**.

4.6 Significant Risk Factors

Access to the project is granted through agreements with two ejidos (Vista Hermosa and Velardeña). The relationship between Golden Minerals and the ejidos is positive; however, should Golden Minerals fail to make payments to the ejidos, access to the property could be affected.

5. ACCESSIBILITY, CLIMATE, LOCAL RESOURCES, INFRASTRUCTURE, AND PHYSIOGRAPHY

5.1 Accessibility

The Project is in the State of Durango approximately 65 km southwest of the city of Torreón, in the State of Coahuila, and 150 km northeast of the city of Durango, in the State of Durango. A four-lane toll highway connecting the cities of Torreón and Durango passes approximately 500 m east of the village of Velardeña. The village is connected to the mine site via a 7 km gravel road. An aerial view of the Velardeña Project area is presented in **Figure 5-1**.

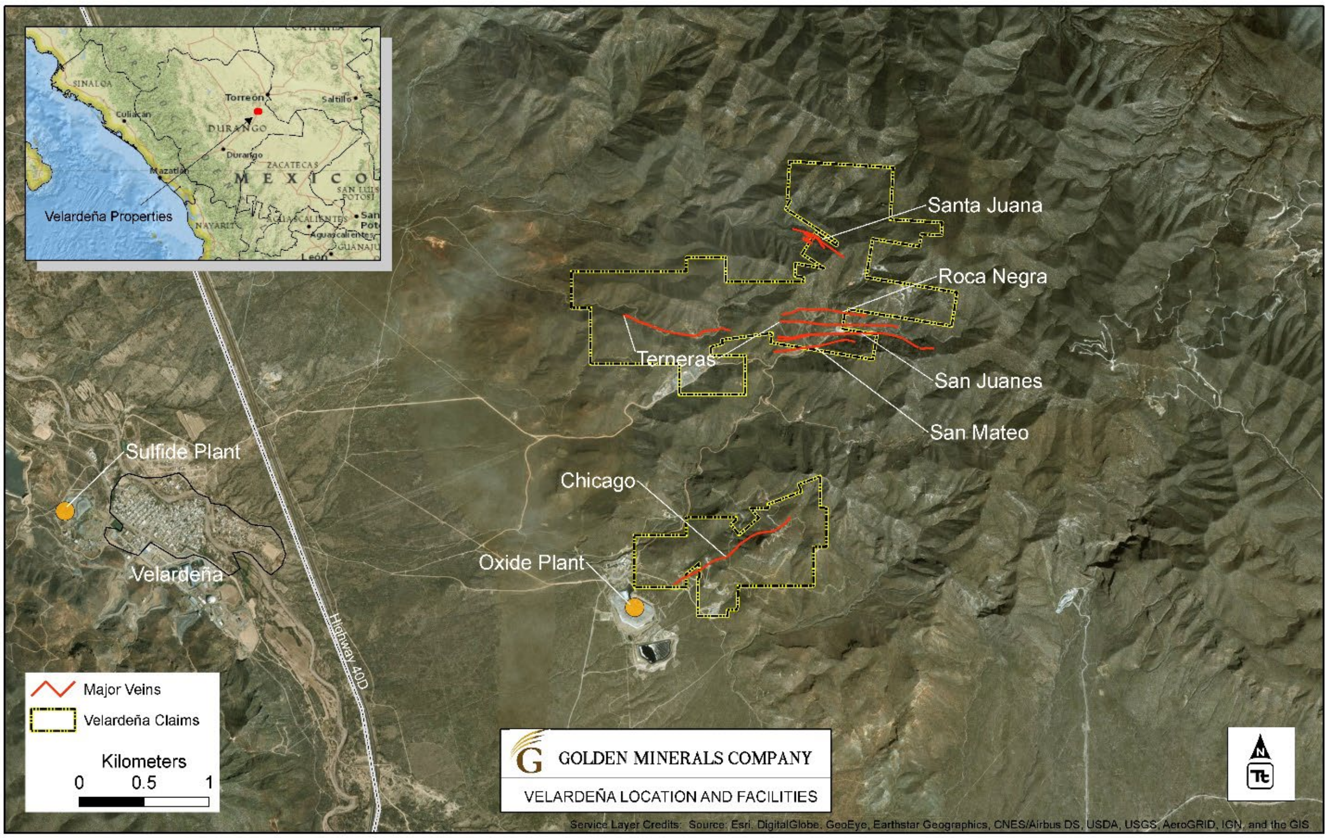


Figure 5-1: Aerial view of the Project

5.2 Climate, Vegetation, Soils, and Land Use

The area in which the Project is situated is semi-arid with a climate predominantly warm and dry, according to the Köppen climate classification (BS_1hw climate), with a mean annual temperature of 21.1°C and rainfall averaging 243.7 mm/yr. Temperatures can drop below freezing in the winter and commonly reach the high 30s (°C), from July through September. The predominant winds are northeast-southwest, with speeds of 8 to 22 km/hr, or 2.1 to 6.0 m/s. The operating season is year-round.

According to INEGI's classification, the type of vegetation where the project is located corresponds to a vegetation type known as desert shrubland *rosetophilous* (rosette-forming vegetation) and sub montane scrub.

There are 106 recorded animal species in the State of Durango: 35 mammals, 13 species of reptiles, and 58 species of birds. The fauna present in the State of Durango represent 19% of the total Mexican fauna, the aviary species represent 32% and the reptilian fauna represent 19% of the total species registered for the country.

5.3 Infrastructure

Torreón was founded in 1907 by cotton growers and cattle ranchers. It is now a major industrial center, which is host to a Peñoles smelter, a coal-fired electricity plant, and one of the largest dairy industries in Mexico. The Francisco Sarabia airport, located in Torreón, is one of the many international airports in Mexico with flights not only to major national hubs, but also to international destinations including Dallas, Houston, and Los Angeles. Torreón has a population of approximately 721,000 according to the 2021 census.

Adjacent to Torreón, within the State of Durango, are the cities of Gómez Palacio and Lerdo de Tejada, which have an extensive industry of manufacturing mining equipment and metallurgical processing plants.

Fresh water for the Velardeña Project is sourced from wells which tap local aquifers. Golden Minerals has a total of six wells - three located near Plant 1 and three near Plant 2. These wells are authorized, regulated, and permitted by the Mexican National Water Commission (Comisión Nacional del Agua, [CONAGUA]). Golden Minerals installed a five-kilometer, 4-in. diameter pipeline for shipping water from Plant 2 to Plant 1; however, the pipeline was removed when operations were suspended, and the pipes are in storage until operations are resumed at Plant 1.

Golden Minerals owns a 340 tpd flotation mill (Plant 1), which produces three concentrates of Pb, Zn and pyrite. This plant is situated near the town of Velardeña and was upgraded in 2014, including the overhaul of the electrical system, installation of new concentrate filters, and refurbishing of the flotation cells. The tailings from the pyrite flotation circuit represents the final plant tailings which are pumped to Tailings Dam 3, which is located adjacent to Plant 1. Tailings Dam 3 has enough capacity to hold the produced tailings from Plant 1. Plant 1 also contains a fully functioning analytical laboratory. 100% of the saleable metals produced in 2014-2015 were processed at this mill.

The company also owns a 550 tpd processing plant for treating oxide Au-Ag ores (Plant 2). This plant is currently processing mineralized material from Golden Minerals' Rodeo mine. The main buildings hosting processing equipment are open to the environment because of the mild climate. Ancillary buildings for warehousing, offices, and maintenance are also present at the plant site. The Velardeña mines, Plant 1, and Plant 2 are connected to the national grid run by the Federal Electricity Commission (Comisión Federal de Electricidad, [CFE]) via a substation located near the entrances of Plant 1 and Peñoles' Velardeña mine.

5.4 Personnel

An experienced labor force is available in the town of Velardeña and in several nearby communities. Supplies and equipment are directly available from Torreón, Monterrey, Chihuahua, and Durango, as well as from specialized suppliers elsewhere in Mexico, Canada, and the USA.

5.5 Physiography

The Project's physiographic characteristics are mature with a mixed topography. Streams within the area drain either to internal drainage systems or tributaries of the Nazas and Aguanaval rivers, which are connected to the Laguna de Mayrán. All streams are intermittent and short lived during the rainy season. A series of water dams were built over the years to control water flows from the two rivers for irrigation and water management purposes. The Francisco Zarco dam, located 25 km to the west, is the closest to the Velardeña properties.

The geomorphology shows characteristics typical of a cycle of arid to semi-arid areas. There is an abundance of valleys and flat alluvial plains variably filled with erosional debris derived from adjacent highlands. The drainage systems are generally dendritic and poorly defined; many channels are not observed when they reach the valley floor due to infiltration into poorly consolidated alluvial sediments.

The Project is located on the northwestern edge of the Mesa Central physiographical province, within the Sierras Transversales sub-province, on the eastern flank of the Sierra Madre Occidental mountain range. The village of Velardeña is in the valley floor set between two northwest trending ranges. To the west is the Sierra Santa María which rises approximately 300 m above the valley floor and, to the east, is the Sierra San Lorenzo rising approximately 750 m from the valley, which hosts the Velardeña and Chicago properties.

6. HISTORY

6.1 Early History of the Velardeña District

Mining in the greater Velardeña District reportedly dates from the late 15th to early 16th century, primarily based on exploitation of oxide mineralization from outcropping or near surface mineralized structures such as the Santa María dome (Gilmer et al, 1988).

In 1888, the Velardeña Mining and Smelting Company was formed, a smelter was installed, and larger scale production began. At this time many of the smaller operations were consolidated within the larger group. According to Pinet (2009), a report written in 1913 recorded that in four years commencing in 1888, the Velardeña District in Durango produced 120,000 kilograms (kg) of Ag, 19,000 t of Pb and 519 kg of Au.

In 1902, the American Smelting and Refining Company (ASARCO) gained control of the operations and installed a new smelter processing 2,500 tpd, principally from the Santa María, Terneras, and Reina del Cobre mines. Both the Terneras and Santa Juana veins were mined on a significant scale by ASARCO during the period from 1902 to 1926. The San Mateo vein supported a small-scale operation by an independent company at about the same time. Several other smaller mining companies were also active in the area such as Salida Mining Co., America Mexico Mining and Development Co., and Mexico Texas Co. (Mexican Mining Journal, 1909).

ASARCO and independent operators worked the mines continuously until 1926, when low metal prices and an unstable political environment contributed to their closure. In addition, the softer oxide ore was diminishing with depth, and the operations were encountering harder sulfide ore that made mining more difficult. After the mine closures, the smelter was dismantled and moved to San Luis Potosí (Pinet, 2009). Old reports indicate that early in the twentieth century, the average grade of the Terneras mineralization was 3.5 g/t Au, 835 g/t Ag and 3.85% Pb. Production statistics for the years 1920 to 1924 show that the Terneras mine produced 138,331 t with an average grade of 4.0 g/t Au, 419.7 g/t Ag, 2.1% Pb, 0.3% Cu and 2.5% Zn (Pinet, 2009, and references therein). In 1924, the Terneras shaft was sunk to the 14th level, and a crosscut was driven to intersect the Santa Juana vein. Also, in 1924, it was reported that production from the Santa Juana vein totaled 37,000 t (in excess of 100 tpd), with an average grade of 5.9 g/t Au and 573 g/t Ag. Lesser production was also reported from the Santa Isabel chimney zone (562 t grading 0.6 g/t Au and 401 g/t Ag) and from the Industrial Minera Mexico S.A. (IMMSA) controlled, El Pilar zone (863 t grading 2.3 g/t Au and 162 g/t Ag) (Pinet, 2009, and references therein).

After 1926, the mines in the district were worked on a small scale by local miners until the advent in 1961 of nationalization by the Mexican government, which precluded foreign ownership of the majority of shares in mining ventures. Therefore, ASARCO became a minority shareholder in IMMSA, who revived their interest in the area and IMMSA consolidated mineral concessions in two areas in the district. Exploration and development work recommenced in the Santa María and Reina del Cobre mines in 1968, and approximately 300,000 t/y were processed by IMMSA in their plant through 2002.

In 1969, IMMSA abandoned several mineral concession blocks, including those underlying the Terneras and San Diego mines. These were acquired by a consortium of individuals headed by Alejandro Gaitán of Torreón. During the 1970’s through the late 1980’s several mines in the district were exploited by *gambusinos* for direct shipping of the Au/Ag ores. Operations by the Gaitán Group on the project area consisted of the removal of material from the old waste dumps and several thousand tonnes of fill left in the stopes from earlier mining. This material was processed in a mill approximately 100 km from the mines. In 1990, Mr. Gaitán purchased a 50 tpd flotation mill located approximately 13 km from the mines. Ores from several veins within the Santa Juana mine were extracted and processed through the mill at a reported average grade of 396 g/t Ag, 5.9% Pb, 7.6% Zn and a mean grade of 4 g/t Au. The mill was operated intermittently at a low throughput due to a lack of mill-feed. The mines and mill were idled in early 1992.

6.2 Mining and Exploration Activities to 2011

In 1994, William Resources acquired the concessions owned by the Gaitán consortium via their Mexican affiliate BLM Minera. During that year, they carried out a Feasibility Study at the Velardeña Mine and commenced pre-production development and mine construction in July 1995. From 1995 to 1997, William Resources carried out a surface mapping and sampling program on the various concessions, as well as an underground sampling program, principally on the Santa Juana vein system. William Resources also drove the Terneras adit, providing access to the 6th level of the Terneras mine, which in turn allowed access to the 12th level of the Santa Juana Mine via a pre-existing crosscut. The Santa Juana winze was deepened 42 m to the 15.5 level, and a ramp was driven to the 17th level.

In 1996, William Resources purchased a 600 tpd processing plant and located it 3.5 km from the mine site. In May of that year, they commenced treatment of dump material, which was mixed with minor quantities of development muck from the Santa Juana mine. William Resources ceased operation in mid-1997. Exploration from 1995 to 1997, apart from underground sampling and drilling, included general geological mapping, sampling of the veins exposed on surface and limited surface drilling.

In December 1997, ECU Gold (the predecessor company of ECU) purchased 93.48% of BLM Minera and 100% of Minera William from William Resources.

ECU restarted operations at Velardeña in January 1998 and the mine has been producing intermittently since that date. Production figures for the period 1998-2008 are summarized in Micon (2009); relevant data for the period 2009-2011 are tabulated in **Table 6-1**.

In 2011, Golden Minerals merged with ECU. Consequently, Minera William became a wholly owned subsidiary of Golden Minerals.

Table 6-1: Summary of production by mine area – Velardeña Project (2009-2011)

Mine Area	Tonnes	Au g/t	Ag g/t	Pb %	Zn %	Cu %	Au Oz	Ag Oz	Ag Eq Oz
Chicago Oxide	39,788	1.66	59.78	1.01	0.92	0.06	2,119	76,477	182,445
San Juanes Oxide	34,344	1.49	135.97	0.52	0.46	0.09	1,650	150,140	232,658
Santa Juana Oxide	209,534	3.61	153.52	0.56	0.54	0.16	24,349	1,034,193	2,251,656
San Mateo Oxide	7,494	2.78	133.07	0.59	0.91	0.06	669	32,060	65,499
Terneras Oxide	13,318	1.05	155.35	1.50	0.57	0.03	448	66,518	88,899
Total Oxides	**304,478**	**2.99**	**138.87**	**0.66**	**0.59**	**0.13**	**29,235**	**1,359,388**	**2,821,156**
Chicago Sulfide	20,982	1.82	82.28	1.67	1.87	0.07	1,227	55,508	116,845
San Juanes Sulfide	17,195	1.44	210.50	1.71	0.53	0.05	797	116,373	156,231
Santa Juana Sulfide	50,652	3.58	185.53	0.71	0.86	0.22	5,834	302,137	593,813
San Mateo Sulfide	756	2.35	156.35	0.65	1.06	0.06	57	3,800	6,660
Terneras Sulfide	3,303	0.66	203.42	1.05	0.84	0.04	70	21,602	25,103
Total Sulfides	**92,888**	**2.67**	**167.23**	**1.12**	**1.03**	**0.15**	**7,985**	**499,420**	**898,652**

Source: Velardeña Mine Geology Department

Exploration statistics for the period 1995-2008 are summarized in **Table 6-2**. These results have been summarized by Micon (2009) and have not been independently verified by Tetra Tech.

Table 6-2: Summary of historic drilling on the Velardeña properties (1995-2008)

Company	Target Area	Drill Program	# Holes	Total Length m
William Resources	Santa Juana	Underground	94	6,438
William Resources	San Juanes	Surface	6	973
William Resources	Terneras	Surface	3	282
William Resources	Other	Surface	6	750
	Total		**109**	**8,443**
ECU	Chicago	Surface	14	8,709
ECU	Santa Juana, Terneras	Underground BQ	11	5,533
ECU	various	Underground EX	59	2,750
	Total		**130**	**16,992**

Data taken and modified from Micon 2009 report.

6.2.1 Exploration Drilling (2009-2011)

Compared to previous exploration programs, relatively little drilling was completed during the period 2009-2011 (**Table 6-3**). The objectives were like previous programs; namely to confirm the continuity of the known veins, to discover new veins, and to test for deep projections of massive sulfide veins in the Santa Juana area. Based on a review of drill cores and data on-site, these objectives were at least partially achieved, notably with the discovery of deep, massive sulfide mineralization down dip of the A4 vein structure (**Figure 6-1**).

Table 6-3: Summary of ECU's drilling programs (2009-2011)

Description	Number of Drill Holes	Total Meters	Total Number of Samples
Surface	0	0	0
Underground (NQ)	3	1,234.6	483
Underground (EX)	35	1,212.1	214
Total	38	2,446.7	697

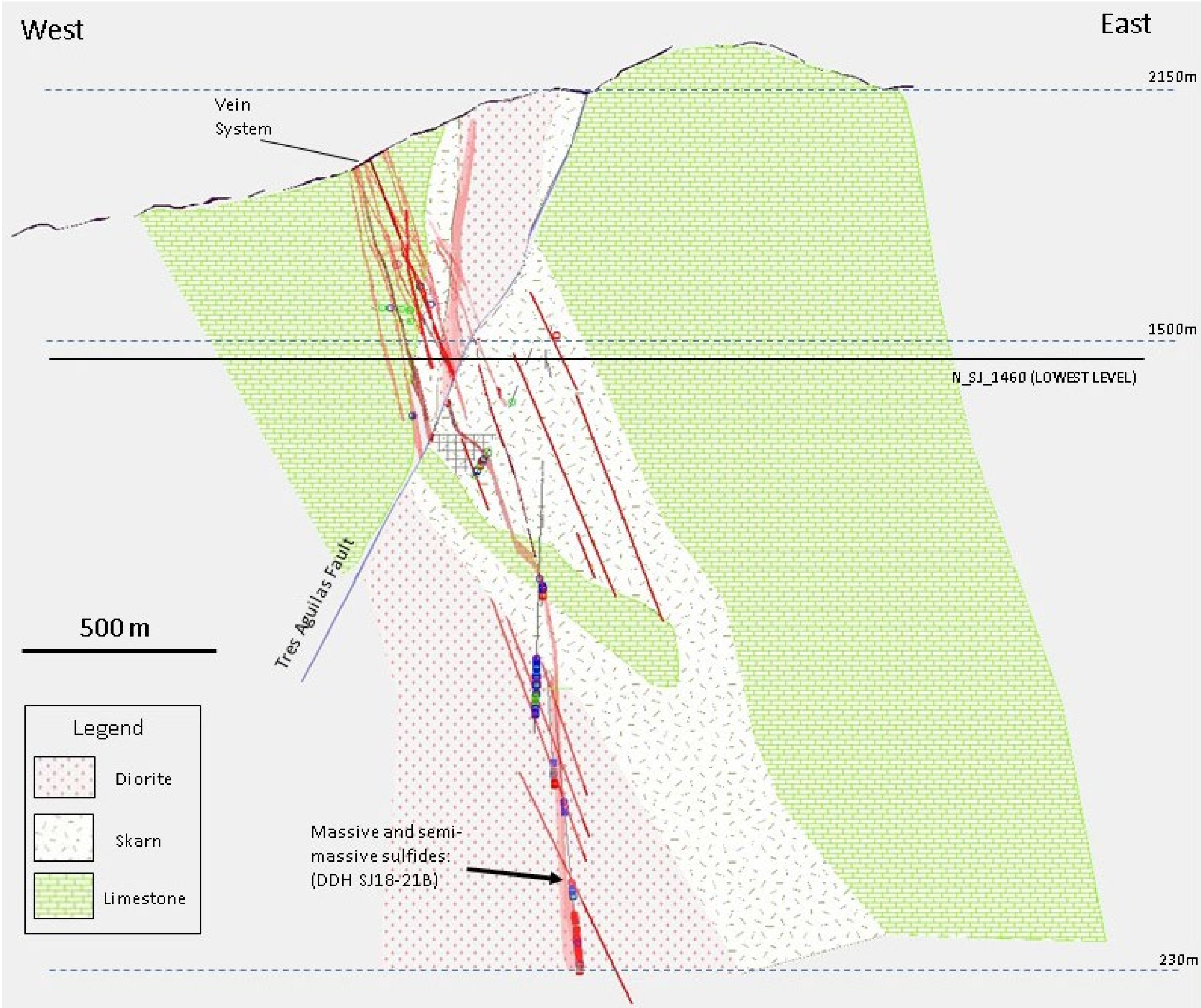


Figure 6-1: Transverse section – Santa Juana geology and vein system

6.2.2 Underground Development (2009-2011)

In addition to drilling programs, ECU drove underground drifts, ramps, and raises to develop the mineralization as well as explore the extent of mineralization. **Table 6-4** summarizes the underground drifting, ramping, and raising completed from 2009 to 2011.

Table 6-4: Summary of underground drifting, ramping, and raising (2009 to 2011)

Year	Drifts & Ramps m	Raises m
2009	3,368.6	770.0
2010	4,442.8	1,381.0
2011	4,218.9	1,457.5

6.3 Production from 2012 to 2014

After the merger with ECU in 2011, Golden Minerals continued production from the Santa Juana, San Juanes, Chicago, and San Mateo mine areas at an approximate rate of 500 tpd operating both Plant 1 and Plant 2 to treat sulfide, oxide, and mixed mineral types.

As a result of the substantial declines in silver prices in early 2013, Golden Minerals decided to temporarily cease mining and processing operations at the end of June 2013. Just prior to ending operations, the San Mateo ramp was successfully connected with the Santa Juana workings on the Santa Juana 20 level, allowing full access to the deeper portions of the Santa Juana vein system without using the internal Santa Juana winze.

During the shutdown period in 2013 and the first half of 2014, exploration drilling was completed from the San Mateo ramp to test the Terneras and San Mateo vein systems. Mining restarted July 1, 2014, with the commissioning of a new ramp to access deeper levels on the Terneras and San Mateo veins, as well as the Roca Negra vein. Mine production rates ramped up over the second half of 2014 approaching the target rate of 285 tpd by year end. Mined material was stockpiled through October 2014 and mill processing recommenced in November 2014 at the newly refurbished Plant 1 flotation mill. **Table 6-5** summarizes yearly production from the Project as presented in the company's annual 10-K filings, with adjusted Ag equivalent values for consistency with Golden Minerals' most recent filings.

Table 6-5: Summary of production by year – Velardeña Project (2012-2015)

Year	Tonnes	Au (g/t)	Ag (g/t)	Pb (%)	Zn (%)	Payable Oz Au	Payable Oz Ag	Payable Oz Ag Eq
2012	185,907	2.02	125	0.28	0.41	6,435	457,265	907,715
2013	72,063	2.56	163	0.36	0.53	2,349	252,256	416,686
2014	14,322	1.57	119	0.76	1.08	194	28,746	42,326
2015	80,736	2.63	160	0.89	1.19	1,976	326,651	464,971

Source: Year-end 10k Filings and Company Documents
Notes: Ag:Au = 70:1

7. GEOLOGICAL SETTING AND MINERALIZATION

7.1 Geological and Structural Setting

The Project is located at the easternmost limit of the Sierra Madre Occidental, near its boundary with the Sierra Madre Oriental (Mesa Central sub-province). The deposits of the Sierra de Santa María and Sierra San Lorenzo, like many other polymetallic, hydrothermal deposits in northern Mexico, are situated along this fundamental boundary which separates thick Tertiary volcanic sequences with Mesozoic basement rocks to the west from Mesozoic carbonates with Paleozoic and older basement to the east.

Regional geology is characterized by a thick sequence of limestone and minor, calcareous clastic sediment of Cretaceous age, intruded by Tertiary plutons mostly of felsic to intermediate composition. During the Laramide event, sediments were subject to an initial stage of compression, which resulted in formation of large amplitude, upright to overturned folds generating the distinctive strike ridges of limestone which dominate topography. Fold axes trend northerly in the northern part of the region but are warped or deflected to west northwest azimuths in the south. The northeast-trending hinge line or deflection, which controls this fundamental change in strike passes through the Velardeña district (**Figure 7-1**).

Tertiary volcanic and semi-consolidated alluvial sediments survive as erosional remnants on earlier basement rocks. The volcanic rocks may have been derived from an eruptive center located west of the pueblo of Velardeña where andesites have yielded age dates of 45 million years ago (mya) (Gilmer et al, 1988).

Tertiary stocks intruded the Cretaceous sediments in the Velardeña area along an axis subparallel to the hinge line described above, resulting in formation of a series of complex limestone domes cored by the younger intrusive rocks (e.g., the Sierra de Santa María, Sierra de San Lorenzo, and San Diego Dome). The Santa María quartz latite porphyry intrusion, west of the town of Velardeña, has yielded a potassium-argon (K-Ar) date of 33.1 mya (Gilmer et al, 1988 and references therein).

Intrusions range in composition from mafic diorite to felsic alaskite and rhyolite. Thermal metamorphism of sediments at and near intrusive contacts is widespread, generating calc-silicates, hornfels, and bleached/marbleized limestone. Higher temperature, calc-silicate rocks are characterized by the prograde assemblage garnet-wollastonite and by the absence of pyroxene. The various mineral deposits of the Velardeña District occur near intrusive centers, contact aureoles, and accompanying alteration zones. Mineralization has been dated at approximately 31 mya (Gilmer et al, 1988), suggesting a genetic as well as spatial association with the intrusions.

Multiple, high angle, northwest trending faults have been mapped throughout the district. These are sub-parallel to the terrain boundary described above and are therefore likely candidates for deep, basement penetrating structures which may have served as magma conduits (Gilmer et al, 1988). Reactivation of the northwest structures and formation of northeast trending faults resulted in a grid of younger, calcite-filled structures which off-set mineralized veins. This is well demonstrated at the Terneras mine where the northeast trending Tres Aguilas fault offsets the mineralized northwest trending Santa Juana veins.

Figure 7-1 illustrates the location of the Velardeña mining district with respect to regional lithologic and structural features.

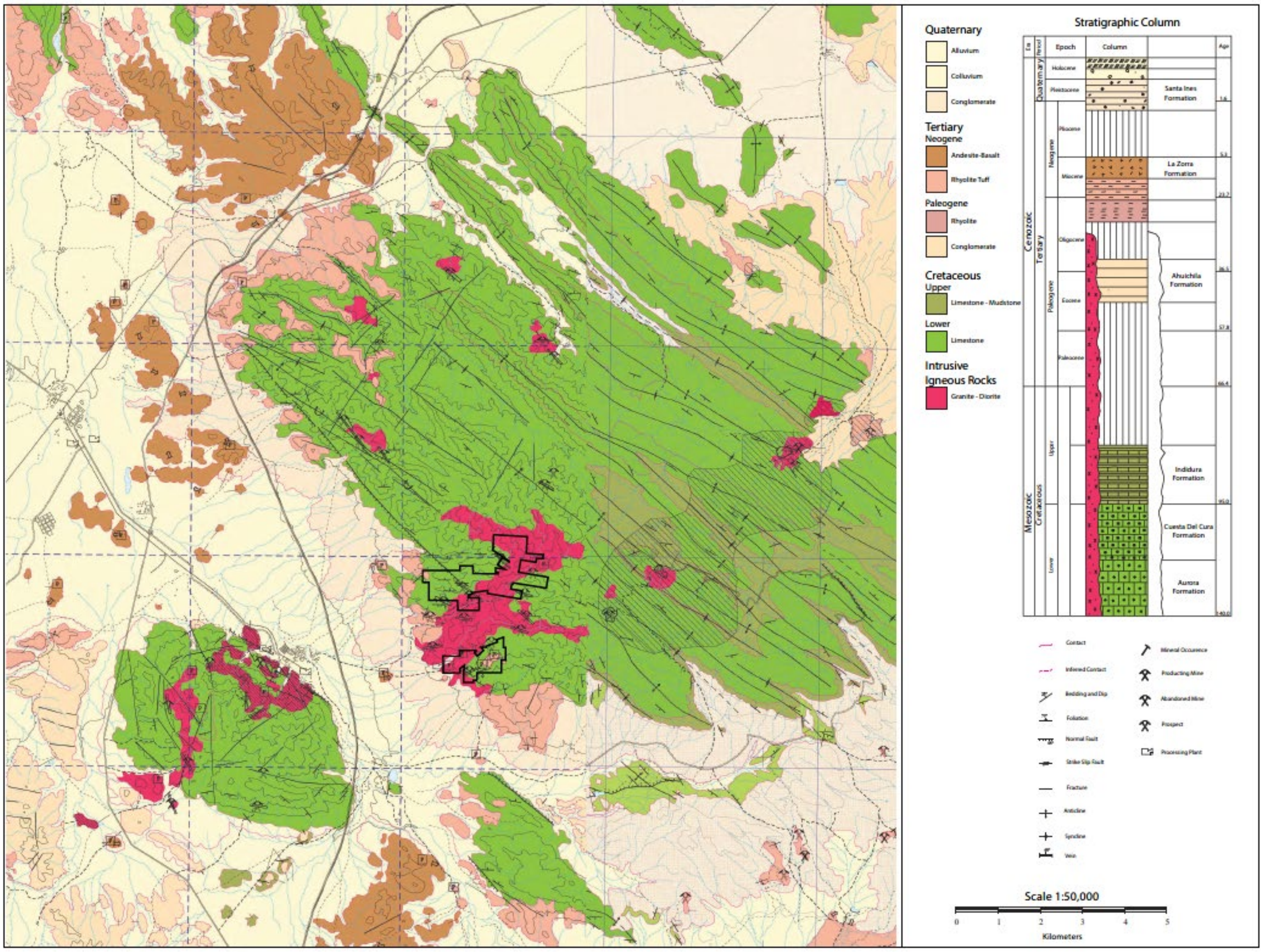


Figure 7-1: Local geology map

7.2 Property Geology

7.2.1 Velardeña Property

Medium to thick-bedded limestone of the Cretaceous Aurora Formation comprises basement rocks in the project area. Limestone was first folded then intruded by the multiphase diorite/monzo-diorite Terneras stock and related dikes of Tertiary age that outcrop over a strike length of approximately 2.5 km. In detail, intrusive contacts range from sharp to broad zones characterized by the presence of numerous large, partially metamorphosed blocks of limestone. Alteration of host carbonates consists of a broad front of bleaching and marble formation, with more localized calc-silicate and hornfels. Although intrusive rocks appear fresh in general, alteration and local endoskarn development occurs near contacts. The diorite stock and the contact zone between limestone and intrusive rock primarily host the veins of the Santa Juana, Terneras, San Juanes, and San Mateo deposits (**Figure 7-2**). Veins extend into relatively unaltered limestone especially in the northwestern portion of the Santa Juana veins and eastern portion of the San Juanes vein.

The Velardeña property is transected by a series of northeast to northwest striking, west dipping, post-mineral normal faults. From east to west these are the Tres Aguilas, Los Bancos, Buenaventura, and Ordenanza faults which are generally characterized by meters-thick banded calcite vein filling. These normal faults demonstrate west-side-down displacements with the result that the western blocks expose higher portions of the hydrothermal system, have a higher calcite content and generally lower precious metal contents.

Two main vein systems are present on the Velardeña property. The first is the northwest striking system found in the Santa Juana deposit, while the second is the east-west trending vein array which includes the Terneras, San Juanes, Roca Negra, and San Mateo deposits. In **Figure 7-2** vein traces are projected to surface and do not cut alluvium.

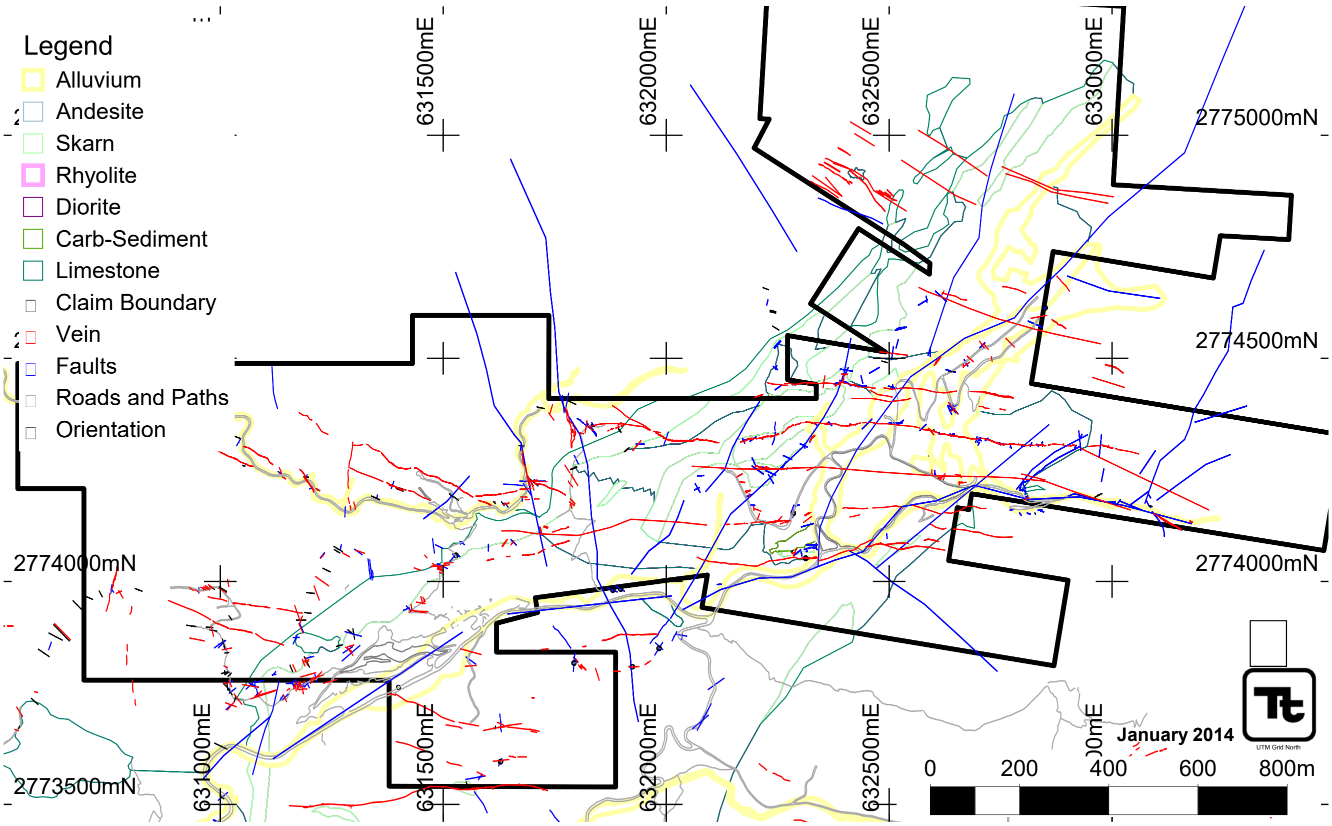


Figure 7-2: Velardeña property geology map

7.2.2 Chicago Property

The geologic setting of the Chicago property is very similar to that at Velardeña (**Figure 7-3**). The oldest rocks outcropping at Chicago are folded limestone of the Aurora Formation which were intruded by Tertiary diorite stocks and dikes. Intrusive rocks occupy the western portion of the property with a northeast orientation. The limestone-diorite contact exhibits widespread recrystallization and marble formation overprinted by a distinctive green calc-silicate alteration dominated by grossular garnet and lesser wollastonite.

As at Velardeña, a system of post-mineralization faults striking northwest-southeast cuts and locally displaces mineralized structures. These faults are normally filled with calcite and can have widths up to 10 m near surface.

In the Chicago mine, rhyolitic volcanic rocks and calcareous conglomerate of the Ahuichila Formation unconformably overlie the mineralized sequence across the eastern half of the area. Mineralization is similar to that encountered at Santa Juana mine in terms of mineralogy, host rocks, geometry of the structures and vein continuity. The difference between the two is orientation - northwest strike, dipping to the northeast for the

Santa Juana system; instead of northeast strike, dipping to the southeast for the Chicago system. **Figure 7-3** shows the geology of the Chicago area with vein traces projected to their assumed surface intersection. Veins are not hosted in alluvial material.

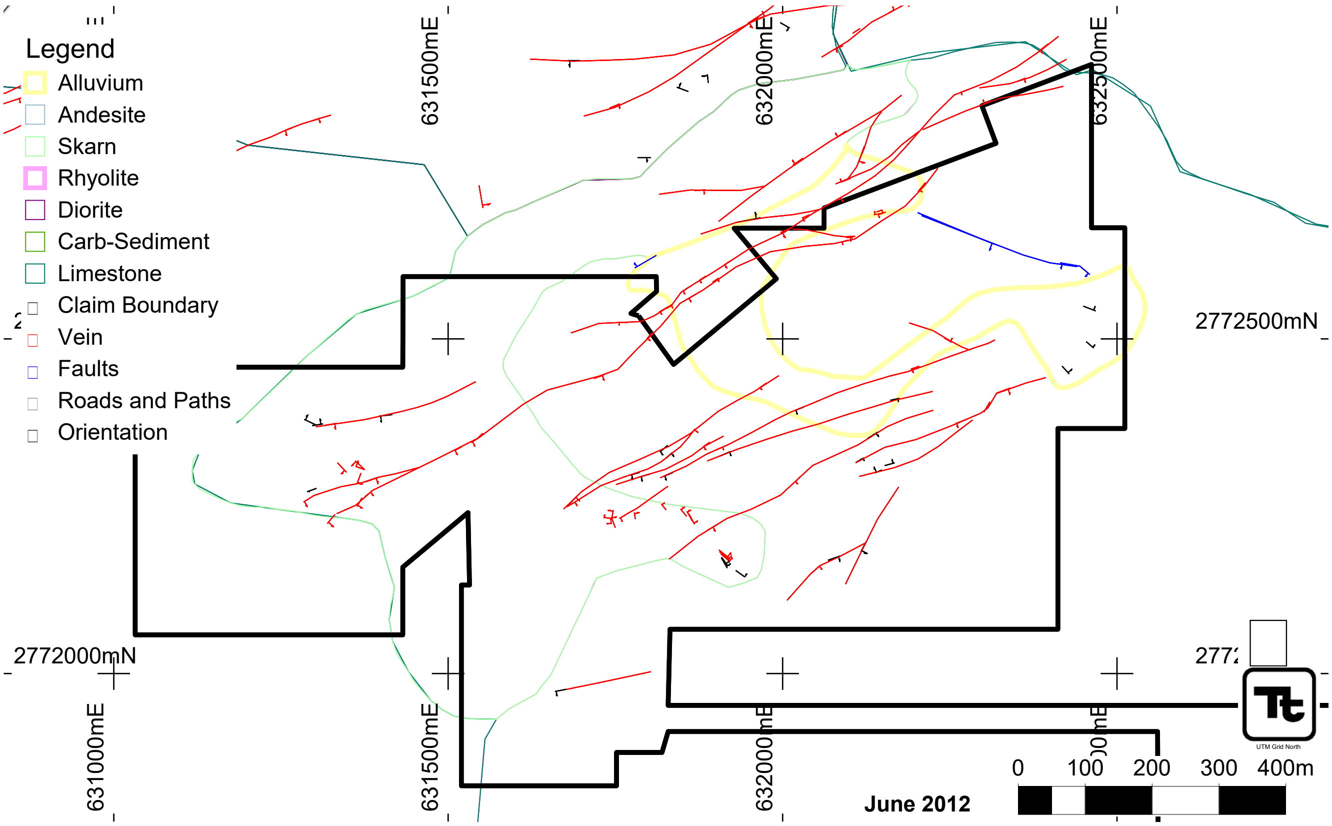


Figure 7-3: Chicago property geology map

7.3 Mineralization

7.3.1 Regional Setting

The Velardeña mineralization system sits near the northern end of the Mexican Silver Belt, a 1,200 km long, northwest trending corridor of Au-Ag and Ag-Pb-Zn vein deposits. Within the belt, the Fresnillo, Guanajuato, Zacatecas, and San Francisco del Oro-Santa Barbara districts have all produced more than 10,000 t of Ag. Currently Mexico's largest Ag production comes from the Santo Niño and San Carlos veins developed by Peñoles in the Fresnillo district, which have been traced for over 4 km along strike and 500 m in depth with widths up to 4 m (Micon, 2009).

In addition to the mines and prospects which are the subject of this report, numerous other historic workings exist within the Velardeña District (**Table 7-1**).

Table 7-1: Geologic characteristics for deposits of the Velardeña District

Mine	Deposit Type / Genesis
Los Azules	Sulfide bodies /felsic intrusive contacts (mesothermal)
San Nicolás	Breccia hosted / felsic intrusive related (mesothermal)
La Industria	Veins / limestone, intrusive hosted (epithermal)
Santa María	Massive sulfide replacement bodies along dike contacts (mesothermal)

Gilmer et al, 1988

Mineralization is variously described as mesothermal or epithermal based on temperature determinations from fluid inclusion analyses (Gilmer et al, 1988). Mesothermal deposits are typically sulfide-rich, lens-like masses dominated variously by pyrite, arsenopyrite, or pyrrhotite. Epithermal deposits in the Industria Mine are located distal to the intrusive core and consist of tabular veins exhibiting banding, crustification, and open-space filling textures. In all cases, there is a persistent association of mineralization with intrusive rocks and with contacts between felsic intrusive rocks and (altered) carbonate host rocks.

7.3.2 Mineralization at Velardeña

Mineralization consists primarily of calcite-quartz veins with minor calc-silicate hosted skarn and massive sulfide replacement bodies. All mineralization is essentially polymetallic, Ag, Au, Pb, Zn, plus or minus Cu. Individual veins are usually thin (0.2 m to 0.5 m) but remarkably consistent along strike and down dip. Coxcomb and rhythmically banded textures are common in some vein exposures. Historical production in the district has been primarily from the oxide portions of the veins that can extend to depths of several hundred meters. Previous workers have suggested a vertical zonation with increasing Au:Ag and Cu:Pb with depth (Pinet, 2009). Physical characteristics of the main vein sets are summarized below as **Table 7-2**.

Table 7-2: Physical characteristics of select veins and vein sets – Velardeña mine

Vein	Orientation	Width	Minimum Dimensions Strike m x Vertical m	Host Rocks
Santa Juana Series				
NW Subset 1 (Santa Juana, A 5-7)	NW curvilinear	0.2 - 1.0	350 x 400	limestone, intrusive, skarn
NW Subset 2 (CO, CC, C1, G1, A 1-4, B's, D1, DD, E)	NW linear	0.2 - 1.0	Variable by vein, up to 600 x 1200 (CC)	limestone, intrusive, skarn
Trans Set	EW/steep S	0.2 - 1.0	100 x 600	limestone, intrusive skarn
Terneras	EW/70-85N	0.3-2	1500 x 650	Intrusive>limestone
San Juanes	EW/85N	0.05-1.9	950 x 600	limestone, intrusive, skarn
San Mateo	EW/75N	0.4-0.5	700 x 500	intrusive, skarn>limestone
Roca Negra	EW/75N	0.15 - 1.15	500 x 600	intrusive, skarn

The mineralization at the Chicago property is similar to that encountered at the Santa Juana mine in terms of mineralogy, host rocks, geometry of the structures and continuity at depth and laterally. The difference between the two is geometric - northwest dipping to the northeast instead of northeast dipping to the southeast.

Characteristics of the mineralization are summarized below based on previous reports and Tetra Tech's observations:

- Veins occur in limestone, marble, calc-silicate, and intrusive host rocks. The geometry of the veins is typically wider but more irregular in the limestone. In addition to being more consistent in width, veins within skarn and intrusive rocks tend to be narrower but higher grade with respect to precious metals. Skarn is the least favorable vein host.

- Although individual veins are typically narrow, zones of vein intersections and certain contacts between intrusions and limestone have focused brecciation and silicification, yielding mineralized chimneys which can reach 7 m in width and extend for tens of meters vertically.
- Within the Santa Juana sector, a zone of sheeted veins has been discovered near the intersection of northwest and east west trending veins. The overall dimensions of this corridor are approximately 500 m along strike and 250 m vertically (level 12 to level 18), with widths up to 100 m.
- Gangue minerals consist of calcite and quartz, which generally represent less than 20% of the volume of individual veins. Higher grade segments of veins generally conform to areas dominated by quartz or quartz-calcite mixtures; calcite rich zones are generally low grade. There is a distinct tendency for the upper portions of many of the veins to be calcite dominant, hence lower grades. Lateral changes in the gangue mineral composition have been observed, suggesting controls other than elevation are at work.
- Depth of oxidation is quite variable and the distribution of oxide and mixed mineral types of complex. Within limestone host rocks, the veins are oxidized down to depths of up to 450 m. Oxides are rare in intrusive and calc-silicate host rocks, reportedly encountered only near the Tres Aguilas and Los Bancos faults, due to increased fracture-controlled permeability and fluid flow.
- The alteration zone along vein margins is generally less than 10 cm and is comprised of argillic alteration and silicification of the intrusive and skarn host rocks, and localized silicification and recrystallization of limestone. While precious and base metal mineralization is generally confined to the veins, sulfide stringers were observed extending outwards along bedding planes within altered limestone.
- Underground drifting and drilling suggest many of the veins are open at depth below the 19th level.

7.3.3 Mineralogy and Paragenesis

Little detailed work has been carried out on the mineralogy of the veins. The sulfide assemblages are quite diverse within the zone of hypogene mineralization and mineralogy is even more so within the zone of partial oxidation. Accurate mapping of this transition has important implications with respect to metallurgical recoveries, vein density and metal grade.

7.3.3.1 Oxide Mineralogy

The oxide portions of the veins are composed of oxides, halides, carbonates, and remnants of sulfide minerals. Concentrations of Cu oxides and carbonates are commonly seen along vein selvages in underground workings.

7.3.3.2 Sulfide Mineralogy

Within the sulfide zone, mineralization consists primarily of galena and sphalerite with lesser amounts of chalcopyrite, tetrahedrite, freibergite, and sulfosalts. Accessory sulfides including arsenopyrite, stibnite, pyrite, and pyrrhotite are locally abundant. Free gold or electrum is rarely seen as microscopic inclusions in pyrite and arsenopyrite.

Disseminated and stringer pyrite is very common in all rock types below 500 m depth and persists to much shallower levels within intrusive and calc-silicate host rocks.

7.3.4 Controls on Mineralization

7.3.4.1 Stratigraphic Controls

As described previously, veins in the district are localized in intrusive rocks and near contacts between intrusions and thermally metamorphosed country rocks but extend up to one kilometer away from these contacts. In detail, however, veins do not conform to these contacts, but in many cases cross at high angles and mineralized limestone, skarn/marble, and intrusive hosts. Observations summarized above suggest that, on average, veins within intrusive are narrower, more regular in form, and higher grade than those in limestone. Skarn is typically a poor vein host with widths and grades less than in diorite or limestone hosts. Observations by mine geological staff suggest that veins may be genetically related to the intrusion of late, felsic porphyries (**Figure 7-4**).

Although data is sparse, it seems likely that at least some of the deeper, massive sulfide mineralization intersected in past drilling will possess more obvious control by stratigraphy, particularly skarn assemblages, than is typical at shallower levels. This would in turn suggest the possible presence of larger mineralized bodies such as have been exploited around the Santa María dome.

7.3.4.2 Structural Controls

Observations underground confirm that at least some veins show an intimate relationship with brittle faulting. In the Santa Juana deposit, two main fracture sets are observed. The most economically significant is a steeply dipping, northwest-trending set that has created dilatant zones that acted as a major control for vein emplacement. A second more spatially extensive fracture swarm trends 110° and, although less obvious, appears to control the orientation of the Trans veins. These veins dip steeply south and, where they intersect the northwest-trending vein set, produce broader stockwork or breccia zones which can be up to seven meters in width. The east-west fracture set also controlled the localization of the parallel Terneras, San Juanes, San Mateo, and Roca Negra veins.

Cross-cutting relationships between the two vein systems are ambiguous, indicating that the two vein sets probably formed contemporaneously as part of a conjugate fault system. A similar structural setting is reported to occur in the Santa María mine.

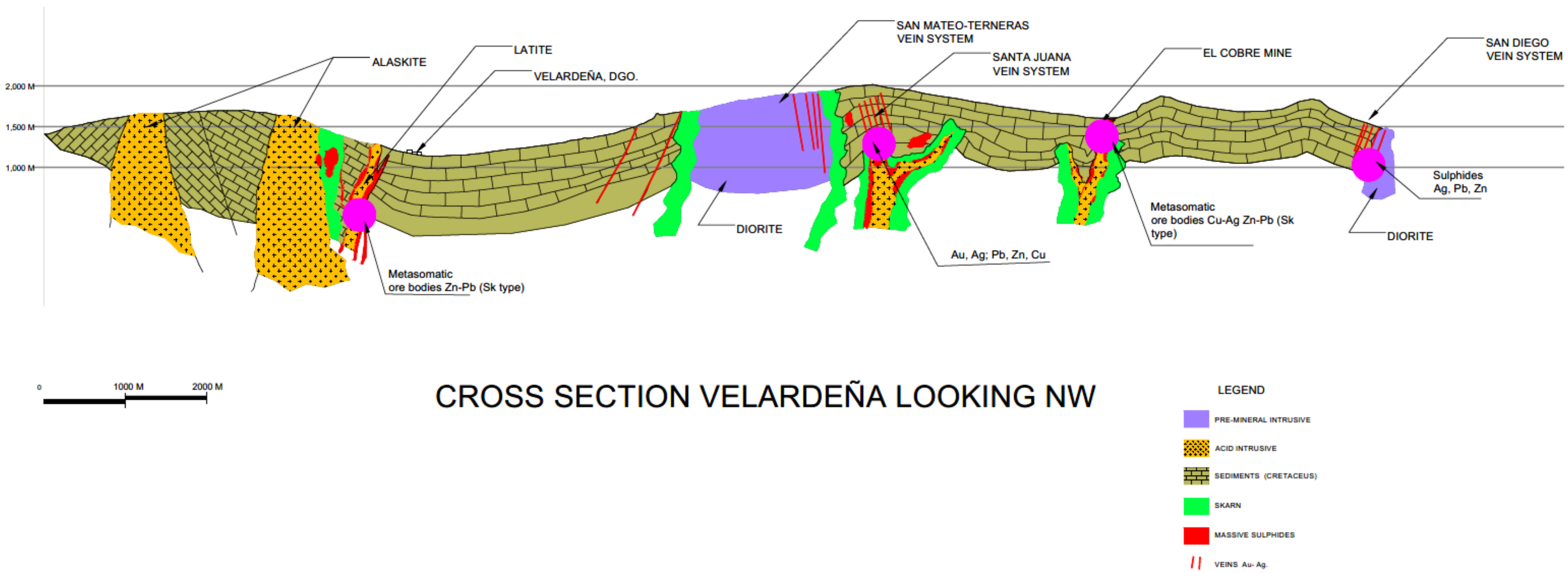


Figure 7-4: Velardeña section looking northwest

8. DEPOSIT TYPES

Although detailed petrologic studies of veins in the Velardeña property have not been completed, individual deposits within the nearby Santa María dome have been studied in some detail and found to correspond to both shallow epithermal and deeper-seated mesothermal styles of mineralization. Epithermal veins, often displaying banded and open-space-filling quartz, occur at La Industria Mine where they are clearly distal to the main intrusive mass (Gilmer et al., 1988). The higher-level veins at Velardeña appear to be of this type. Many veins, especially at deeper levels in the Santa Juana and Terneras mines, are dominated by high modal percentages of coarse- and fine-grained, polymetallic sulfides, have little silicate gangue, and occupy a position within and proximal to intrusions and their thermally metamorphosed aureoles.

True epithermal veins occur at Velardeña, but at depth the majority of veins, breccias, and massive sulfide replacements are mesothermal in character, commonly contain arsenopyrite, and may be related to a deeper intrusive source.

Exploration strategies at the Project are informed by the above model concepts. Current exploration models explore the deposit in the context of vein controls. It has been recently discovered that east-west trending vein sets, in general, tend to have lower concentrations of deleterious elements (As and Sb) and slightly thicker true widths. Drill hole exploration continues to target these veins down dip of current development as the mineralization style transitions away from more typical epithermal Ag-Au veins to deeper-seated mineralization elevated in Au and base metals.

9. EXPLORATION

The Project has been extensively explored from the surface using geologic mapping, vein mapping, and vein sampling. Underground exploration consisted of diamond drilling, geologic level mapping, vein level mapping, vein sampling, drift, and stope development. Tetra Tech is unaware of any geophysical surveys completed on the property.

9.1 Recent Underground Development

In addition to exploration drilling programs, Golden Minerals has driven underground drifts, ramps, and raises to develop the mine as well as explore the extent of the mineralization. **Table 9-1** summarizes the underground drifting, ramping, and raising completed from 2012 to 2014.

Table 9-1: Summary of underground drifting, ramping, and raising (2012 to 2014)

Year	Drifts & Ramps m	Raises m
2012	5,995	1,630
2013	1,991	221
2014	2,136	427

Source: Mine Engineering Department

9.2 Sampling Methods and Approach

Channel samples are taken at drift faces, crosscuts, and stope walls and/or backs according to the following guidelines:

- During level mapping, geologists paint sample locations on the back or development face to guide samplers.
- Samples are collected by chiseling out the painted area, ideally cutting a 5-7 cm wide sample. Often this is not achievable due to rock hardness.
- The sample widths range from 0.2 m to 2.5 m.
- The sample's weight is usually between 2 kg and 5 kg. The sample contains a minimum of ten rock pieces (<20 cm in size) as well as fine material.
- Sampling is carried out as perpendicular to the vein strike as possible and the true width is measured by sighting the vein dip and tilting the measuring tape accordingly.
- Stope and face samples are collected at 3 m intervals across strike. Wall rock and vein material are sampled separately. When dictated by geological features, samples are taken at closer intervals.
- Sampling along crosscuts is carried out continuously.

The locations of the samples are initially determined by means of sighting and taping from established survey markers and annotated on the level plan. The locations are subsequently corrected by the installment of a new survey marker when the drift has been developed completely.

Channel sampling is subject to numerous sources of error, particularly relating to the differential hardness of material being sampled, and the tendency to include a disproportionate volume of softer rock. Diligent and systematic collection of channel samples generates a very large data set, which in most cases is statistically representative, but never completely free of errors or potential bias.

Tetra Tech has not observed the collection of channels at the Project but has spot-checked sample locations throughout the mine and thoroughly discussed procedure with the mine staff. Channel sampling procedures used at the Project result in samples, which are reasonably representative of the mineralization and meet industry best practice guidelines for this type of sampling. The resulting data is sufficient to support the estimation of Resources.

9.2.1 Significant Results

The channel database contains 32,006 sample intervals, of which 14,534 intervals have been interpreted as intersecting a named vein. **Table 9-2** shows grade statistics for channel intervals within the database and those identified as on-vein.

Table 9-2: Channel sample data statistics

Dataset	Selection	Count	Mean Ag g/t	Mean Au g/t	Mean Pb%	Mean Zn%	Mean Apparent Thickness
Channel	All	32,006	281	5.1	1.6	1.6	0.66
Channel	On Vein	14,534	518	9.2	2.8	2.7	0.47

9.3 Exploration Potential

Strike extents for most known veins have been identified by exploration but in many cases mineralized shoots at depth have not yet been defined nor have the down dip extensions been condemned. It is likely that as deeper levels are developed additional mineralized shoots will be identified.

The current exploration strategy is focused on the potential of the deeper sulfide portions of the Terneras, San Mateo, Roca Negra, Santa Juana (A1, A4, C1, CC), and Chicago (Chicago and Escondida) veins.

Exploration potential in the Santa Juana area in the near term is focused on developing the A4 vein in the Tres Águilas southeast fault block where the A4 vein appears to have a greater and more sustained thickness than the other Santa Juana veins. Long term exploration potential in the Santa Juana area is indicated by deep wedge drilling also under the Tres Águilas southeast fault block where encouraging intervals of massive sulfide mineralization hosted within skarn have been observed (**Figure 9-1**).

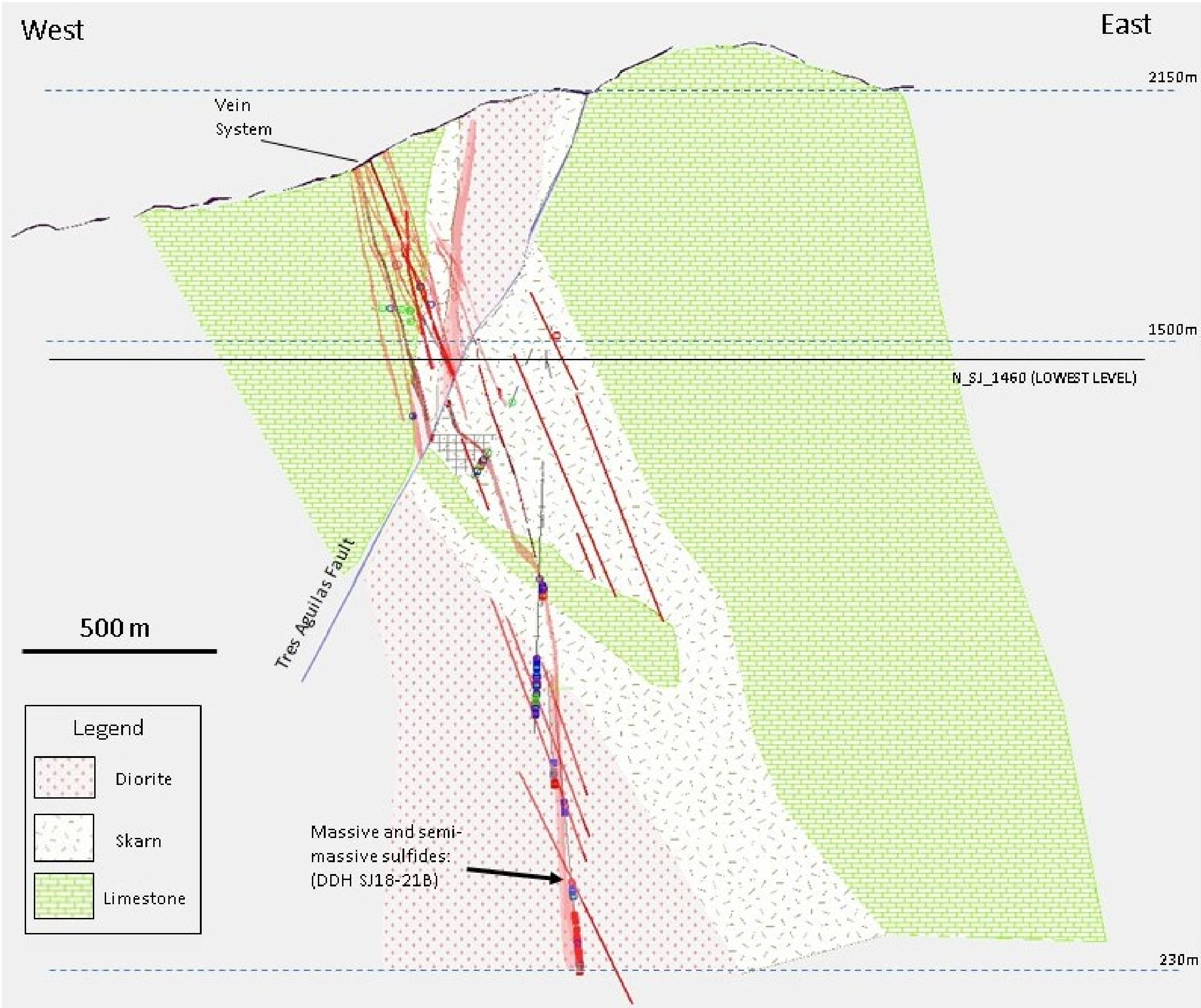


Figure 9-1: Transverse section – Santa Juana geology and vein system

10. DRILLING

Since the 2012 technical report, Golden Minerals completed 47 diamond core holes. The majority were completed in 2014 and drilled from underground targeting the San Mateo, Terneras, and Roca Negra veins. Four holes were drilled from underground in the Santa Juana area targeting primarily the A4 vein. Drill hole locations for this campaign are shown in **Figure 10-1**.

Table 10-1: Drilling 2013-2014

Year	Area	Number of Holes	Length m
2012	Santa Juana	4	186
2014	San Mateo, Terneras, Santa Juana	43	8,875
	Total	**47**	**9,062**

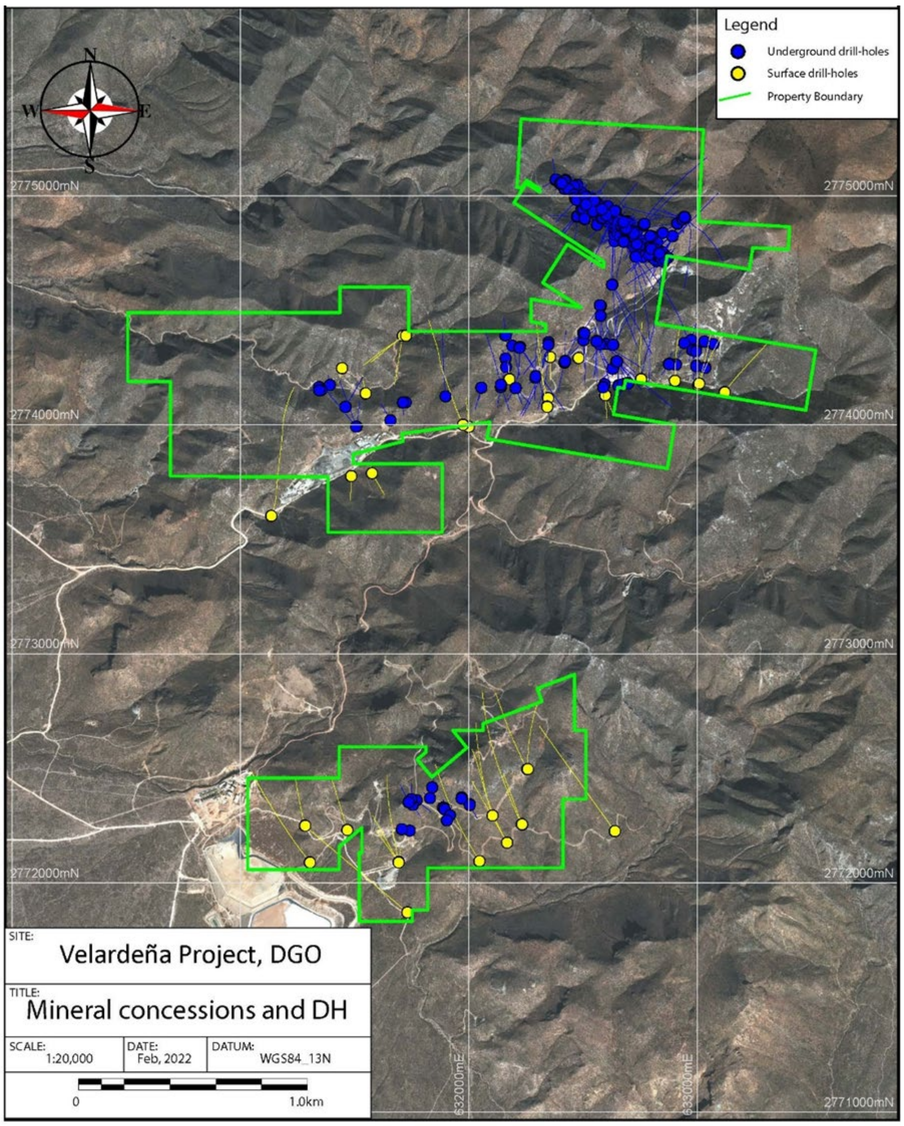


Figure 10-1: Drill hole location map 2013-2014

10.1 Sampling Methods

Diamond drill core samples are taken according to the following criteria:

- Drill core is split using a manual rock splitting device or using a core saw
- Samples are taken from core sections with visible evidence of mineralization and from 1.5 to 2.0 m of surrounding wall rock
- Wall rock between two veins is sampled when the distance is less than 6 m
- The information recorded in the drill logs for each sample includes depth, length, core angle, and rock/ore type

Mineralized sample intervals have a minimum core length of 20 cm and a maximum length of 1 m. For areas sampled outside of the mineralization the maximum sample length for the NQ core is 1.20 m and for BQ core the maximum sample length is 1.50 m. In general, the maximum sample length is 1.50 m except for those areas in which two veins can be joined together in which case the maximum sample length is 2 m.

Sampling was conducted on core not only with visible evidence of mineralization, such as veins and stringers, but also on barren core to preserve the sampling continuity in between mineralized zones and to test for broad zones of lower grade material as well. The sampling of the wall rock next to the zone of mineralization also assists in understanding the grade of the external dilution associated with mining some of the mineralized zones on the Velardeña properties.

Manual splitting of the core can be subject to several sampling biases based usually on the hardness of the material being split. In the case of very hard core, the core may twist in the splitter which may result in uneven core fragments and in a slightly greater split than 50% being sent to the assay laboratory or left in the box as a representative sample. In the case of soft core, the core may crumble when being split or may split along natural fracture lines which again results in uneven core representation. Also, to prevent contamination, the splitter and pans used to collect the samples must be cleaned after each sample. Despite the potential to introduce a bias into the sampling procedure as a result of uneven sample sizes, the splitting of drill core continues to remain a common practice in the exploration and mining industries.

Bazooka drilling is undertaken from the development headings to identify the width of a zone where the hanging wall is not visible or where a secondary mineralized system is suspected as in the case of the sheeted veins. Cores obtained from these programs are not split and are sampled completely.

These drill core sampling procedures are consistent with industry standards and are adequate for use in preparing a Mineral Resource estimate. Along with in-house standards, blanks, and duplicates included in the sample stream, routine check assays are conducted on the samples by a second laboratory.

10.2 Core Recovery

In the case of large diameter core (HQ, NX, BX), recoveries were reported to average around 60% in oxide mineralization and 90% - 97% in the sulfides. For the smaller Bazooka (EX) drill cores, overall recoveries ranged from 30% - 40%. Recovery for Bazooka cores are poor and may result in underestimation of mineralized widths and grades. In the case of Bazooka drilling, drifting is usually conducted afterward to identify the true nature of the mineralization, especially if a secondary zone or vein is suspected. Typically, chip samples from such drifts result in higher grades than initially indicated by the Bazooka drilling.

11. SAMPLE PREPARATION, ANALYSES, AND SECURITY

Sample preparation, analyses, and security procedures followed by Golden Minerals meet industry common practice standards and are adequate to support the estimation of Resources. The quality control (QC) sampling results throughout the campaigns and laboratories are typical of an operation given the amount of throughput and data handling. Current drill hole analyses are completed by ALS Chemex in Vancouver, Canada (ALS Chemex) and mine channel and mill samples are tested at the on-site Labri laboratory facility (Labri), constructed in 2013. A review of QC samples analyzed from 2012-2017 suggested the on-site laboratory could benefit from further improvements and increased real-time review of performance. In 2017 a lab audit and review was conducted by both internal and external resources including and not limited to analytical and mechanical instruments, processes and an enhanced rigorous QA/QC protocol for all Velardeña samples. Based on recent (2017-2021) QC sample review, the analytical results determined by the on-site laboratory are within tolerance to those determined by ALS Chemex. Annual and quarterly ongoing reviews are performed on laboratory instruments and processes.

Previous quality control procedures and results have been reviewed by previous authors and those reviews have resulted in improved protocols and performance, but ultimately previous authors concluded the data is sufficient to support estimation of Resources. The drill hole and channel analytical databases are extensive and include results from several campaigns and laboratories. **Table 11-1** details when each laboratory has been used, and the accompanying umpire laboratory.Table 11-2 details the accreditation and the relationship to Golden Minerals of each laboratory used. Data within both databases, regardless of testing laboratory, is considered current and equivalent.

Table 11-1: Analytical laboratory listing

Time Period	Laboratory Used	Umpire Laboratory Used
Pre-2009	Labri (on-site), Ensayes y Representaciones, S.A. (ERSA)	Servicio Geológico Mexicano (SGM), ALS Chemex
2009 to 2013	Labri (on-site), Ensayes y Representaciones, S.A. (ERSA), SGS	SGS
2013 to Present	Labri (on-site), ALS Chemex	Pulp Duplicate Resubmittal to ALS Chemex

Table 11-2: Laboratory accreditation and independence

Laboratory	Accreditation	Relationship
Labri	Not Accredited	Not independent, operated by Golden Minerals
SGM	Not Accredited	Independent of Golden Minerals
ERSA	Not Accredited	Independent of Golden Minerals
SGS	ISO 17025	Independent of Golden Minerals
ALS Chemex	ISO 17025	Independent of Golden Minerals

Current drill hole analyses are completed by ALS Chemex and channel samples are tested on-site at the Labri laboratory. ALS Chemex is independent of the issuer and is ISO 17025 accredited. The accreditation of ALS Vancouver encompasses preparation processes completed at ALS Chihuahua. The on-site laboratory is not independent of the issuer and is not accredited. Tetra Tech inspected the on-site laboratory in January 2022 and found the facility and the procedures followed to be of adequate standard.

11.1 Sample Preparation

11.1.1 Diamond Drill Core Samples

Drill hole samples are prepared by splitting the core with a manual rock splitting device or core saw using personnel who have been hired by Golden Minerals for this purpose. The Golden Minerals personnel who conduct the core splitting and sampling are supervised by Golden Minerals' geological staff to ensure the integrity of the core splitting and sampling procedures. Half of the core remains in the core box with its identifying ticket while the other half is bagged with a matching ticket. The samples are delivered by mine staff to ALS Chemex's preparation laboratory in Chihuahua or Zacatecas where they are shipped to ALS Chemex in Vancouver for analysis.

11.1.2 Underground Chip Samples

Development chip samples are collected by sampling support staff who are instructed to chip away sample transects painted by the geologist. Sampling is observed by geologic staff. Samples are bagged and transported to the on-site laboratory for preparation and analysis.

11.2 Security, Storage, and Transport

11.2.1 Core, Pulp, and Reject Storage

The core is stored at the Santa Juana mine site in either a closed building, a shed, or on a prepared uncovered area (in which case durable plastic covering is provided) behind a fence. In each case the core remains in a securely locked area. Pulps and rejects are stored in closed areas and are individually packed in plastic bags to avoid contamination. The mine facility is guarded by security personnel 24 hours a day.

11.2.2 Underground Chip, Pulp, and Reject Storage

The chip sampling pulps and rejects are obtained from the assay laboratory and are stored in a secured area at the Santa Juana mine site in either a closed building or a shed. The chip sample rejects and pulps remain in a securely locked area.

11.3 Analyses for Drill Hole Samples

Drill hole samples are analyzed by ALS Chemex initially for Au using fire assay with atomic absorption spectroscopy finish (AA24) with re-run for values exceeding 10 g/t Au using fire assay with gravimetric finish (GRA22).

Samples are initially analyzed for Ag, Pb, Zn, Cu, and 32 additional elements using *aqua regia* inductively coupled plasma – atomic emission spectroscopy (ICP41) with re-run for values exceeding 100 g/t Ag, and 1% Pb, Zn, or Cu using *aqua regia* digestion and inductively coupled plasma - atomic emission spectroscopy (OG46).

11.4 Analyses for Channel Samples

Channel samples are prepared and then analyzed by the on-site facility for Au, Ag, Pb, Zn, Cu, and As. Gravimetric fire assay is used to determine Au and Ag grade. Pb, Zn, Cu, and As are analyzed by atomic absorption spectroscopy with hydrochloric and nitric acid digestion.

11.5 QA/QC Program

As a result of the CAM Quality Assurance and Quality Control (QA/QC) review performed in 2012 QA/QC procedures were refined. Within both the drill hole and channel sampling programs standards, blanks and duplicates are inserted in the sample stream. Quality control samples are inserted in a repeating order depending on the last digit of the sample identification (ID). The effective QC submittal for the drill core and channel campaign is approximately one control sample for ten collected samples. **Table 11-3** details the QC sample submittals for the 2014 drilling and 2013-2014 channel campaigns.

Table 11-3: In-stream quality control samples

QC Sample Type	Drill Hole Stream	Channel Stream
Blank	23	134
Pulp Duplicate	44	197
Standards	51	183
Combined	118	514
QC % of Samples	9%	~10%

11.5.1 Standards

In 2014, 27 low-grade standard samples along with 24 high grade standard samples were analyzed in the drill hole sample stream. The high- and low-grade standards are custom made and tested by SGS. The standard results were reviewed and demonstrate adequate performance. Few errors exist that are most likely attributed to sample ID mislabeling and should be addressed prior to performance analysis. Sampling and QA/QC protocols were updated in 2017 using verified blank material and standards that better reflect the vein grades (low, medium, and high grade) and deposit type. Additional sample analysis verification for blank and standard material is conducted on a routine basis to ensure the results are as expected. This review work led Golden Minerals to identify better performing standards along with having more confidence in the QA/QC program. **Table 11-4** shows the standards insert during the drilling campaign.

Table 11-4: Custom standard reference material for 2014 drill hole stream

Standard Name	Mean Au ppm	Mean Ag ppm	Mean Pb %	Mean Zn %	Standard Deviation Au	Standard Deviation Ag	Standard Deviation Pb	Standard Deviation Zn
M-4 87438	1.239	1.78	0.0083	0.0194	0.032	0.11	0.00812	0.021
M-3 87427	17.38	1503	2.71	1.29	0.330	14.55	0.10	0.06

From the time of 2012 PEA report to the end of 2014, 197 standard samples were analyzed in the channel sample stream at the on-site laboratory. The high- and low-grade standards are custom made and tested by SGS. Two of the standards used in the drill hole stream are used in the channel sample stream as well, which provides a check of both labs. The standard results were reviewed and demonstrate reasonable performance but suggest additional improvements should be made. **Table 11-5** shows the standards inserted during the channel sampling campaign.

Table 11-5: Custom standard reference material for channel stream

Standard Name	Mean Au ppm	Mean Ag ppm	Mean Pb %	Mean Zn %	Standard Deviation Au	Standard Deviation Ag	Standard Deviation Pb	Standard Deviation Zn
M-1 87440	0.961	8.7	0.73	0.16	0.015	0.19	0.037	0.007
M-2 87439	9.06	379	3.18	4.50	0.029	6.50	0.03	0.04
M-3 87427	17.38	1503	2.71	1.29	0.330	14.55	0.10	0.06
M-4 87438	1.239	1.78	0.0083	0.0194	0.032	0.11	0.00812	0.021

Few noticeable errors exist in the testing of the high-grade standards where significantly higher or lower grades are reported for singular metals or Au and Ag together. Review and comparison of Golden Minerals' Labri laboratory performance to ALS show the results from Labri are within acceptable tolerance to the check assays from ALS. This includes duplicates, blanks, and standards.

The results of the analysis of M-4 87438 at both the on-site laboratory and ALS suggest the on-site laboratory provides more variable results at the low-grade end for Au and Ag, often under-reporting the concentration of Au and Ag. This is most likely attributed to issues with the use of Ag inquart technique modifications to the gravimetric procedures for lower grade analysis. **Figure 11-1** compares standards M-3 87427 and M-4 87438 for Au and Ag, which were both tested at the on-site laboratory and ALS Chemex. ALS Chemex testing is shown on the left and the on-site laboratory is shown on the right. Except for the few noticeable issues, the testing of the high-grade standard at ALS Chemex and the on-site facility are similar, the results of the lower grade standard show the on-site laboratory is less precise and less accurate compared to ALS Chemex.

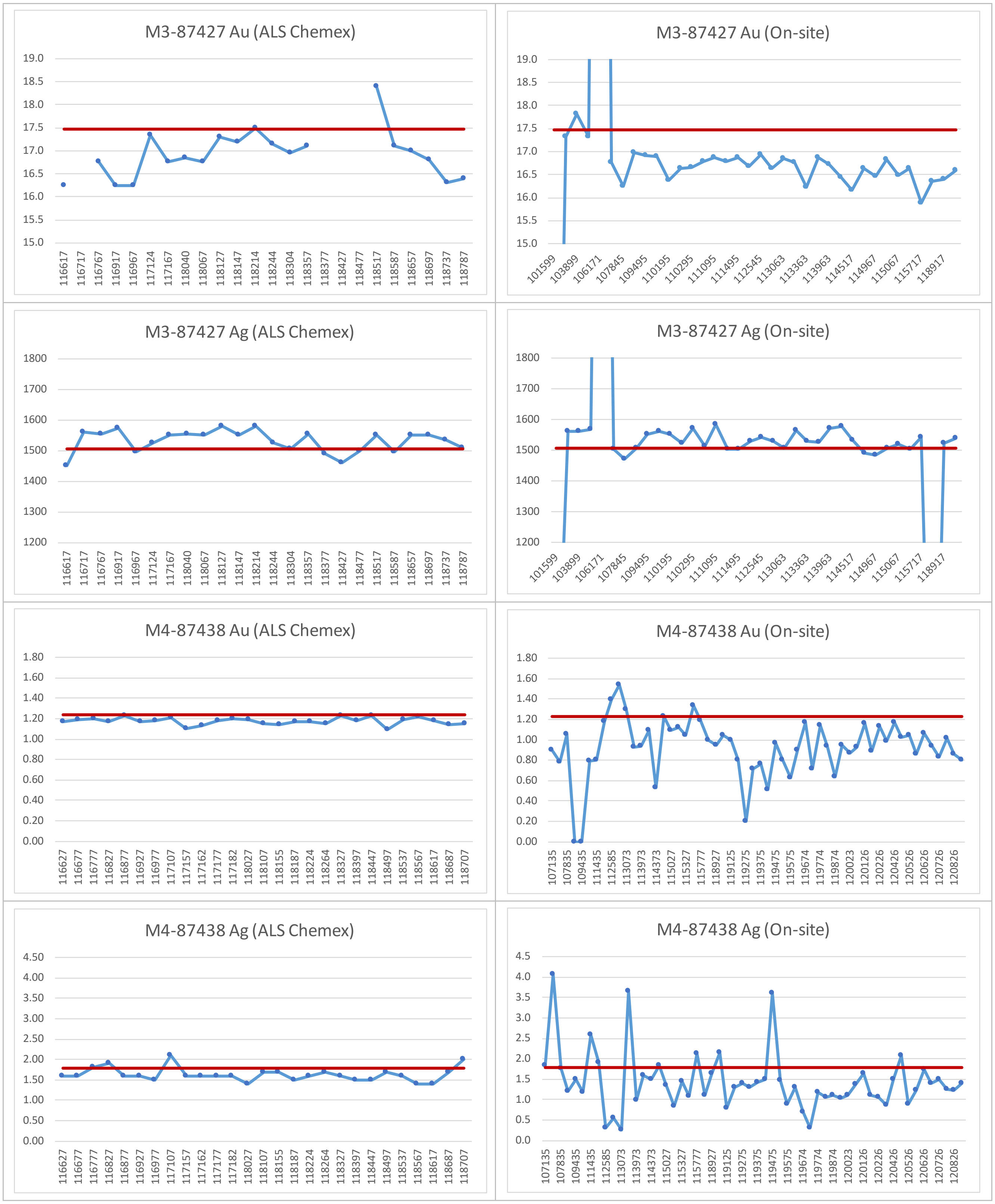


Figure 11-1: Standard performance comparison

More recent analysis of check assays from the on-site lab to ALS show results much closer to the results from ALS compared to earlier reviews, as shown in **Figure 11-2** and **Figure 11-3**.

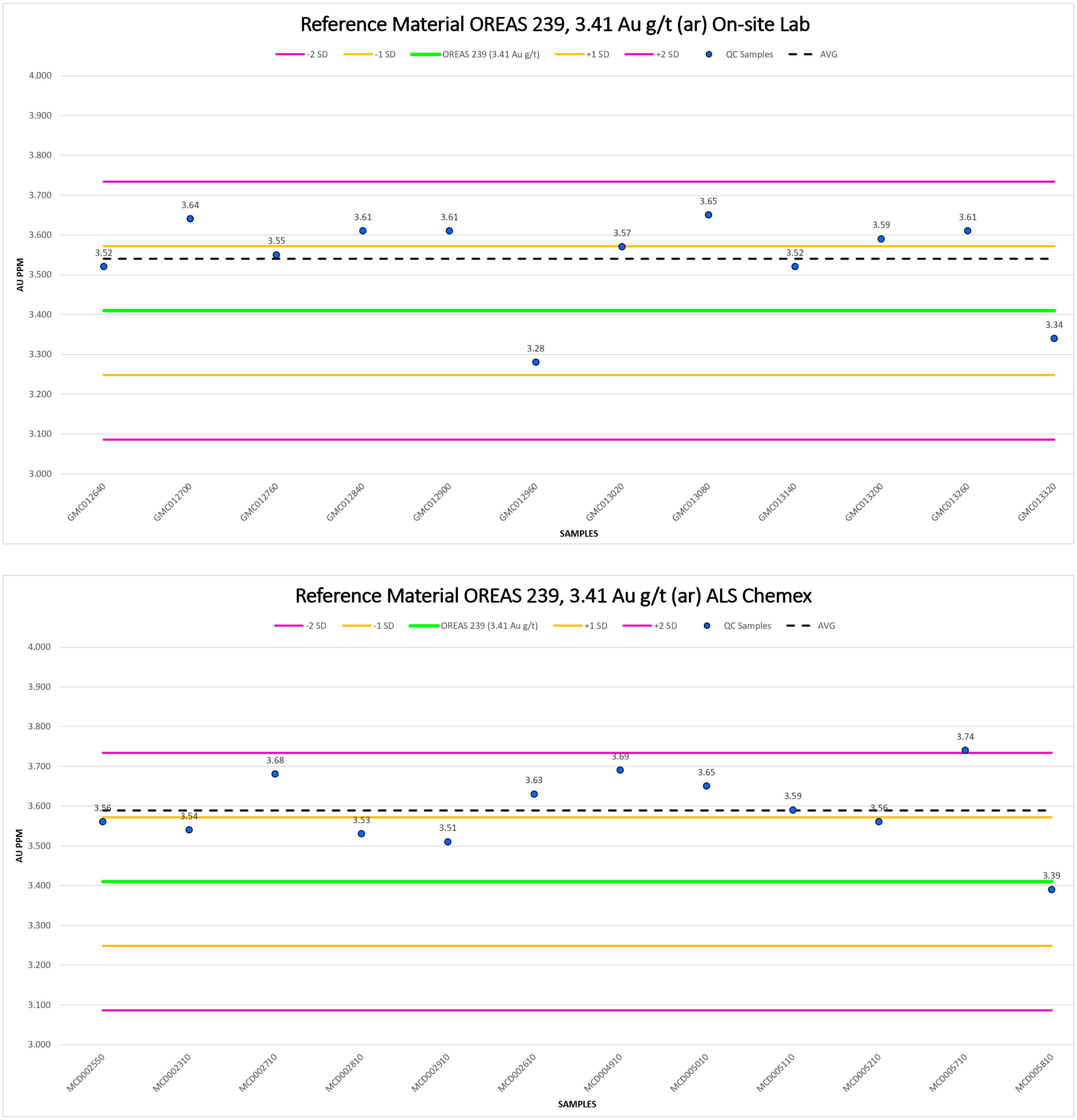
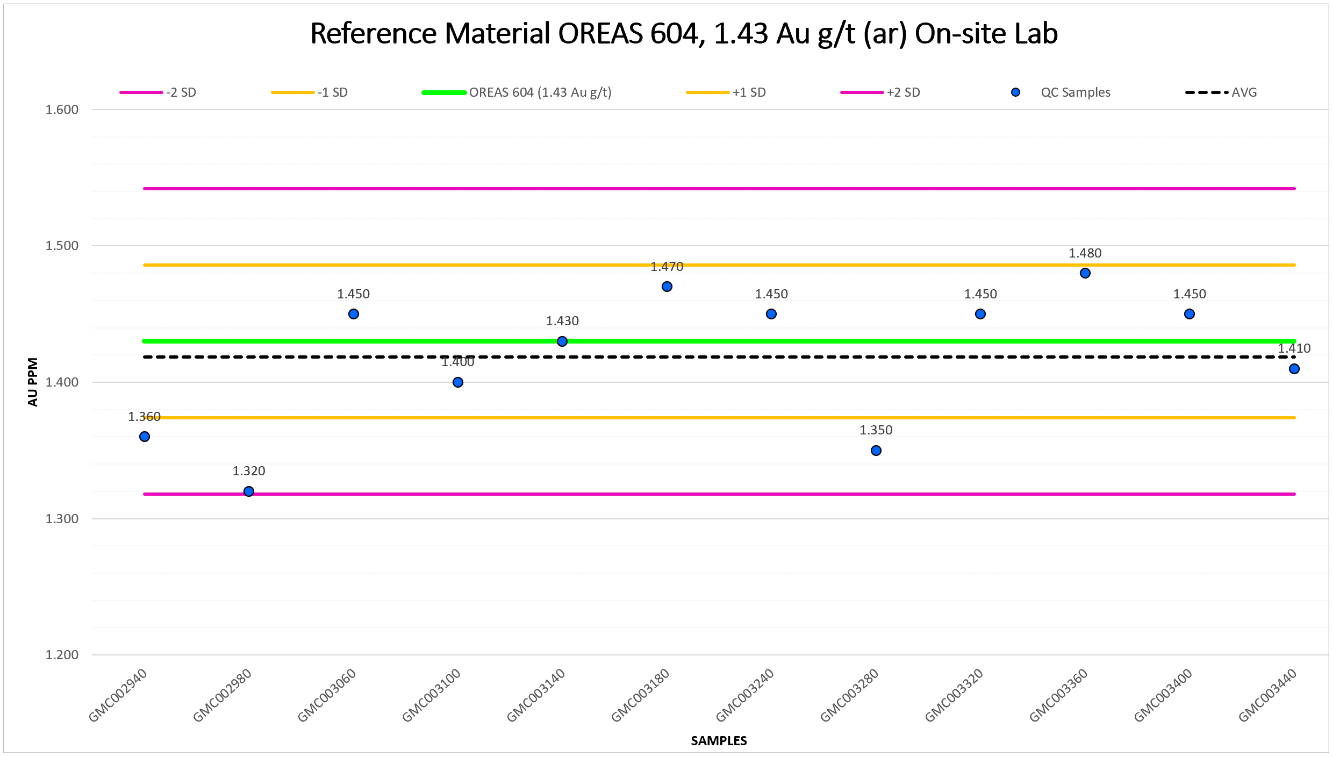


Figure 11-2: Labri vs. ALS Chemex recent results comparison – OREAS 239



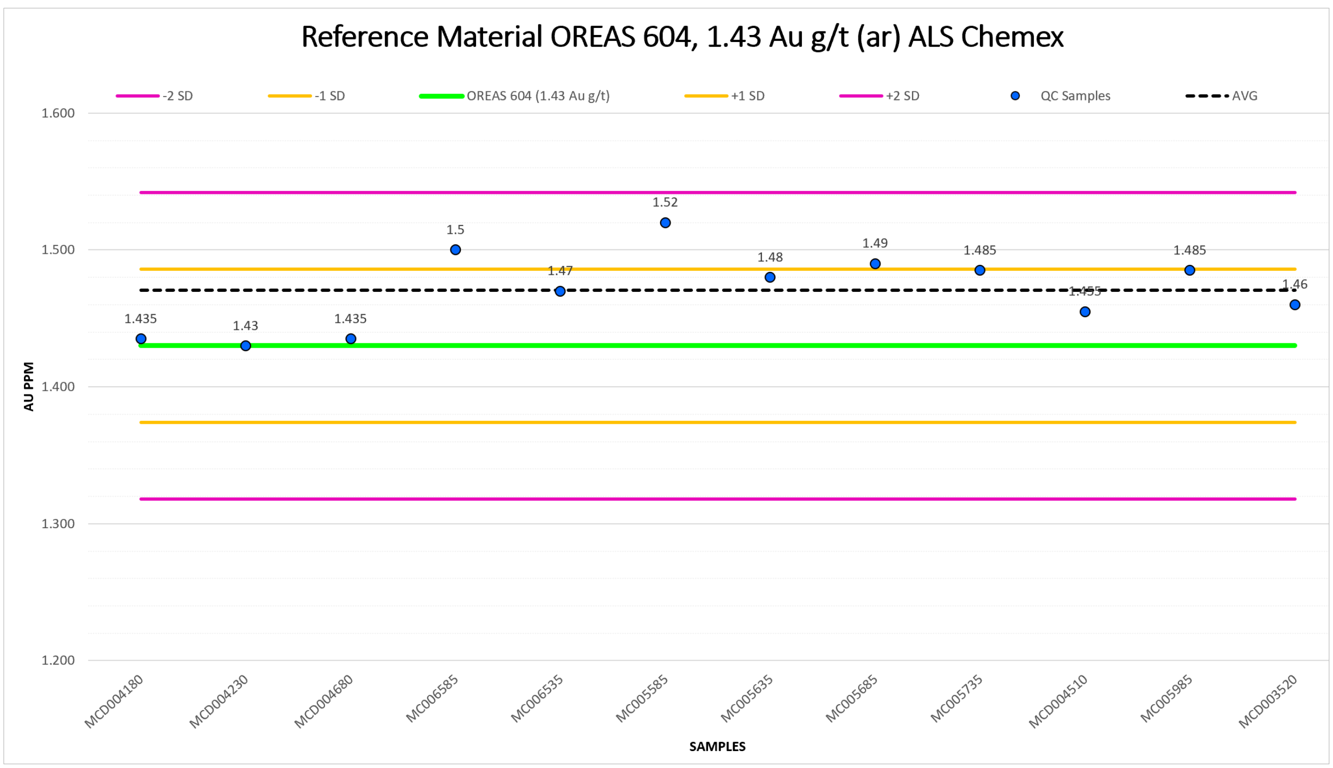


Figure 11-3: Labri vs. ALS Chemex recent results comparison - OREAS 604

11.5.2 Duplicates

In 2014, 44 pulp duplicates were analyzed within the drill hole sample stream. Review of the duplicates indicates good reproducibility. **Figure 11-4** shows Au, Ag, Pb, and Zn in a single log ten transformed scatter plot.

Figure 11-5 shows in-stream pulp duplicates tested at the on-site laboratory also in a single log ten transformed scatter plot with Au, Ag, Pb, and Zn. In general, the sample pair fit for each element is good with few examples for high-grade Ag duplication issues, suggesting, as mentioned above in the review of the standard analysis, that gravimetric process protocols could be improved (for earlier samples). The duplicate analyses also indicate that error bias could be positive. Based on visual inspection of the scatter plot, noted duplication errors do not appear to be balanced on either side of the 1:1 fit line. The previously noted issues in the standards and duplicates suggest improvements but are infrequent and do not suggest invalidation of the results obtained from the onsite facility. Additionally, the more recent sample analysis supports this conclusion.

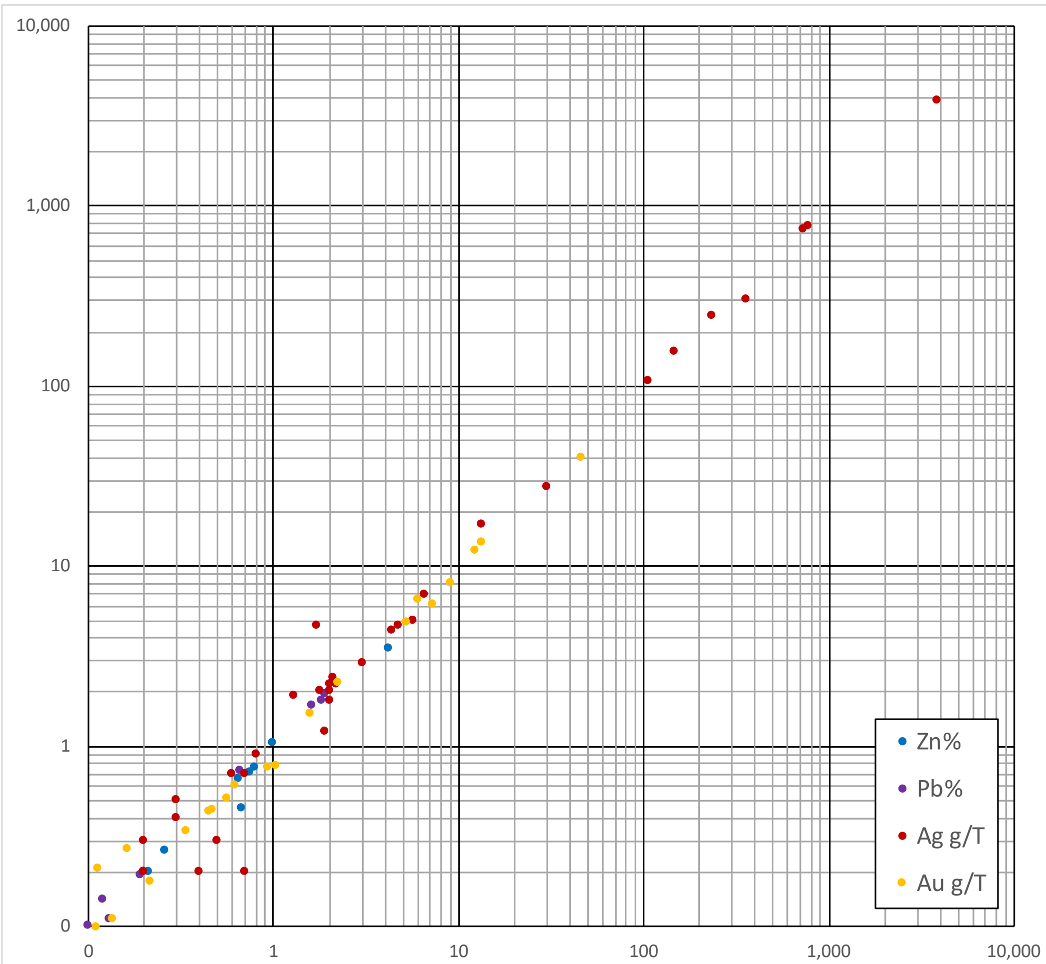


Figure 11-4: 2014 Drill hole ALS Chemex pulp duplicates

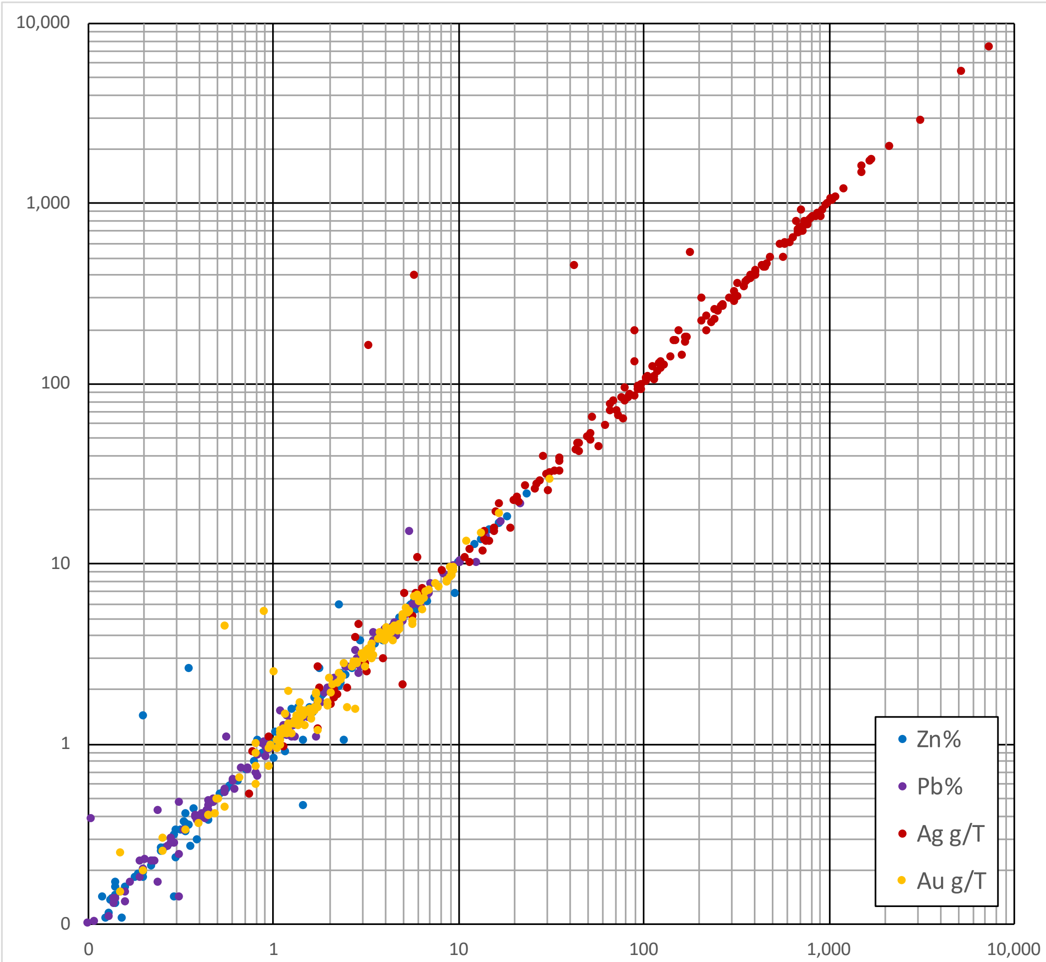


Figure 11-5: On-site channel sample pulp duplicates

In 2021, 97 pulps and coarse rejects from the Rodeo mine were sent to ALS Chemex for umpire check analysis for Au and Ag. The results of the duplicates seen indicate good reproducibility leading to greater confidence in the on-site Labri laboratory.

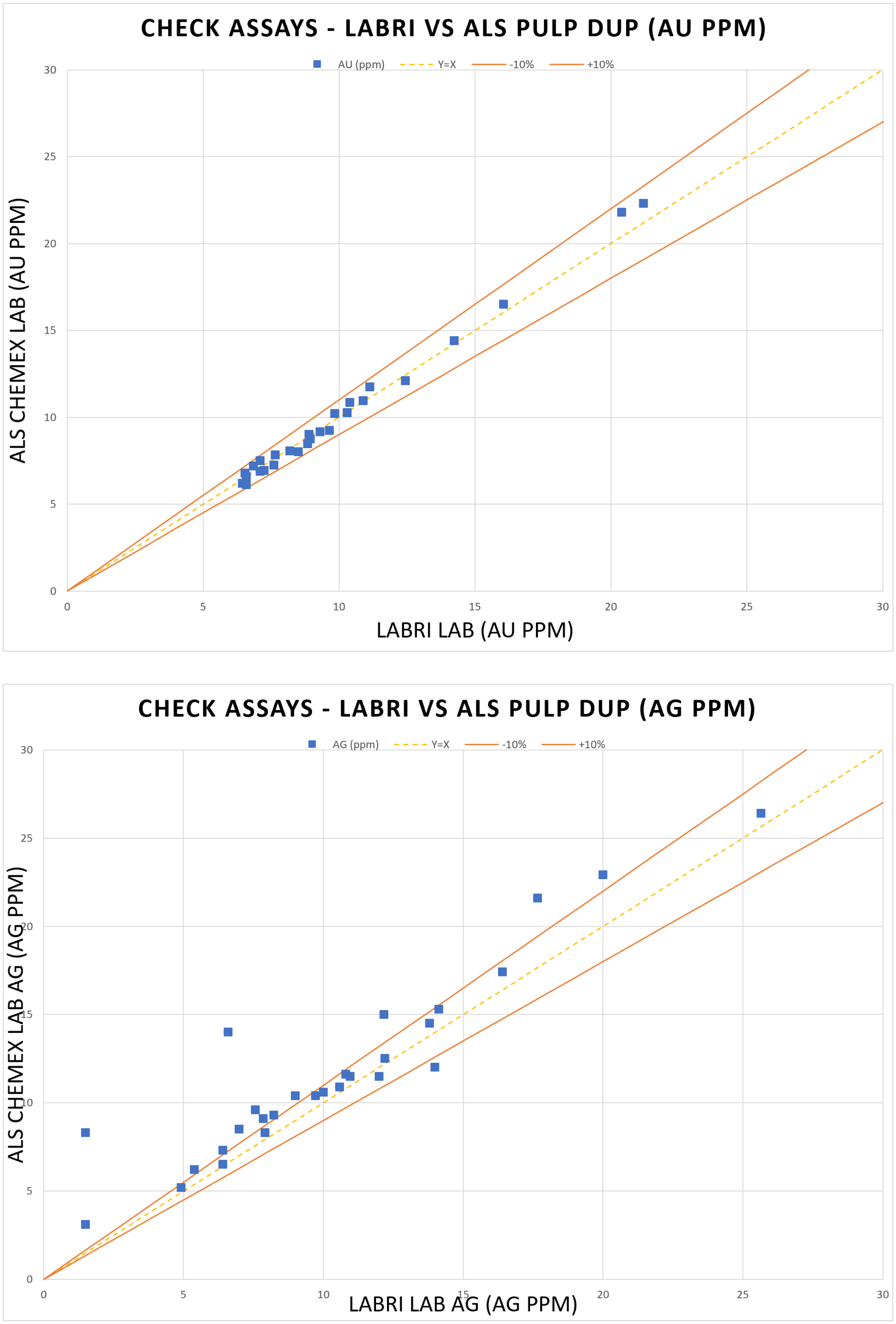
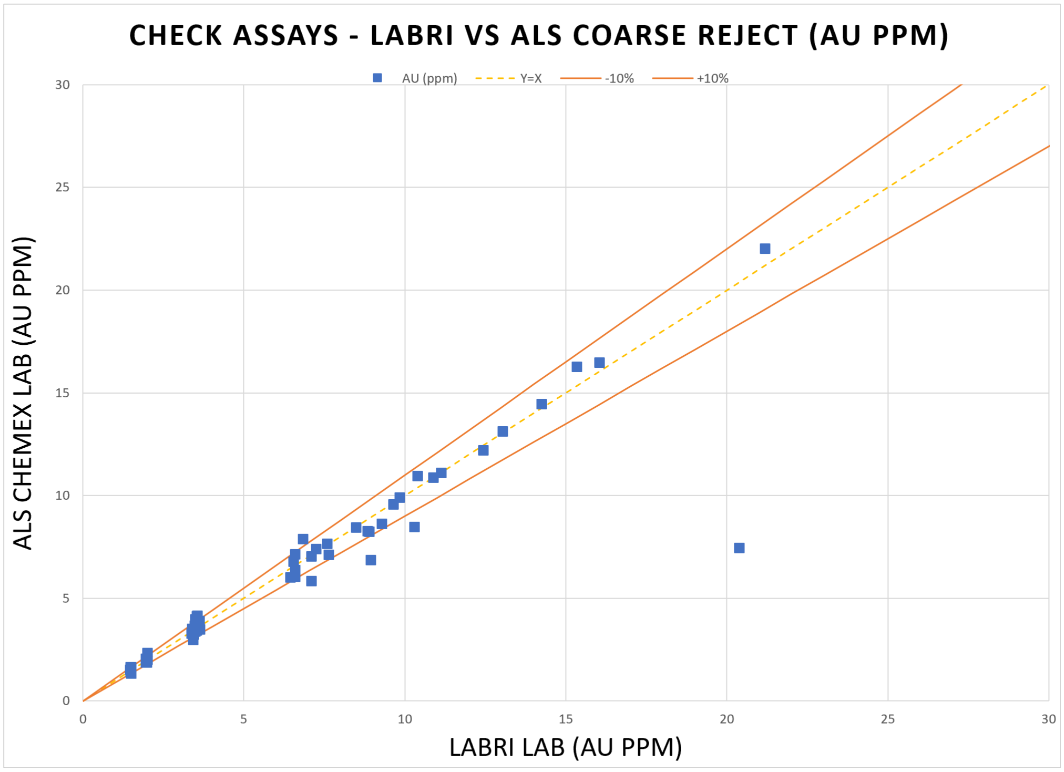


Figure 11-6: Check assays - Labri vs. ALS pulps



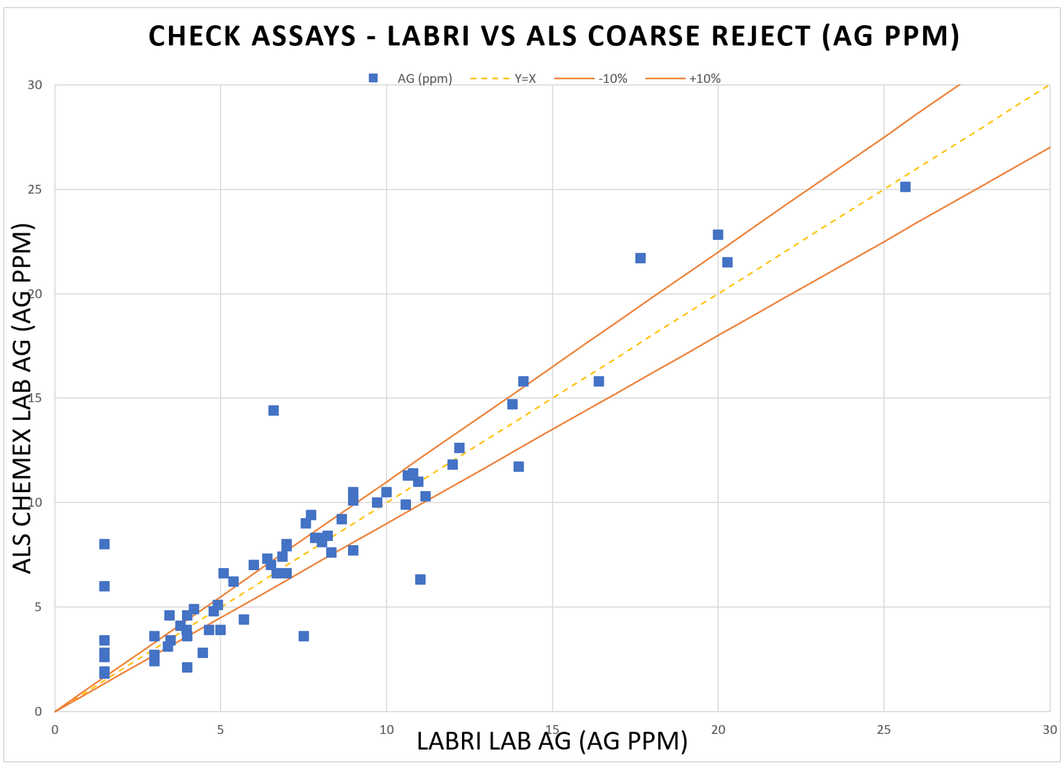


Figure 11-7: Check assays - Labri vs. ALS coarse rejects

11.5.3 Blanks

In 2017, the company conducted a comprehensive review of the Velardeña Lab (including a previous external lab audit) in preparation to receive samples from the company's Rodeo Mine. Results of the review work included buying silica sand to replace the locally sourced blank material (used historically as the blank material) to be used as the coarse blank at the Velardeña Lab as well as a thorough review of all analytical lab equipment.

The new blank material was sourced from Abrasivos de Laguna S.A. de C.V. Golden Minerals submitted five samples of the new blank material to both the Velardeña Lab and to ALS Chemex for analysis for Au and Ag to make sure that the material contained minimal Au and Ag. The results were in tolerance for blank material and both labs had similar results, as shown in **Figure 11-8** and **Figure 11-9**.

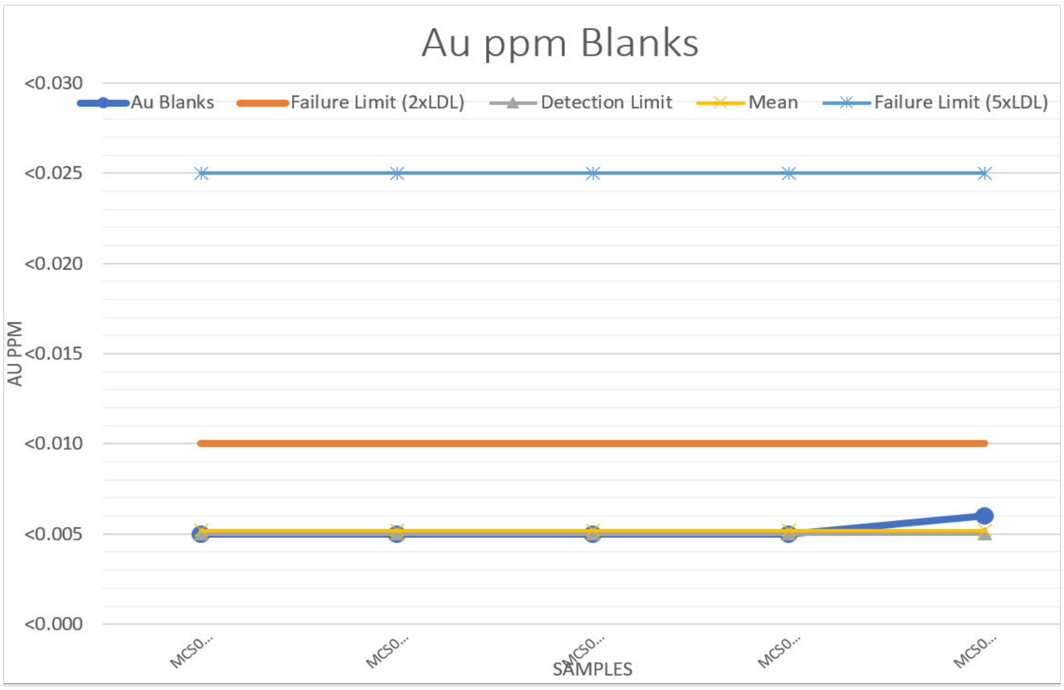


Figure 11-8: Au assay results from new coarse blank material samples

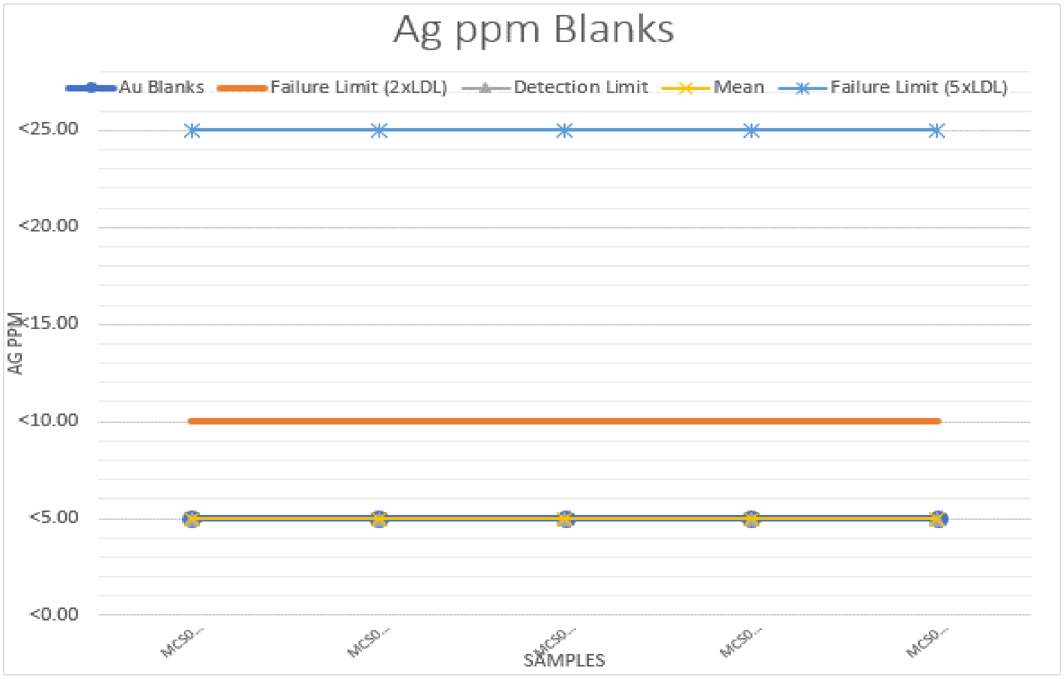


Figure 11-9: Ag assay results from new coarse blank material samples

As part of the updated QA/QC procedures, the QA/QC data is reviewed continually to check for problems with the analytical data including reviewing the standard, blank, and duplicate samples. Scheduled analytical maintenance occurs regularly with additional lab checks reviewed by lab management over short and long-term schedules.

To check potential contamination during sample preparation, a batch of high-grade samples from the Rodeo mine were submitted with a blank sample being inserted into the sample stream after each high-grade sample.

11.6 QA/QC Recommendations

Improvements since the 2017 Labri lab review have demonstrated greater consistency between the sample results at the on-site lab and ALS Chemex, leading to greater confidence for the samples at the on-site lab along with improved accuracy. This was accomplished through an initial lab audit, continued regular lab and analytical instrument review, as well as a more rigorous QA/QC procedure and protocols, and real-time sample batch review. This also includes using standards that are more representative to the actual mine and exploration grades, as well as deposit type and setting. Additionally, Golden Minerals is using certified blank material that is tested regularly by both the in-house lab and ALS for improved confidence in the QA/QC program and sample results.

11.7 Analysis Pre-2009 Methodology (Micon)

11.7.1 Laboratories, Methods, and Procedures

ECU used the Ensayes y Representaciones, S.A. (ERSA) laboratory in Torreón, Coahuila as its primary laboratory. The ERSA laboratory is an independent laboratory in Mexico, which is certified according to the International Standard ISO/IEC 17025:2005.

Analyses performed at the laboratory are based on international and certified standards for Au, Ag, Cu, and Zn in high concentrations as well as for atomic absorption and plasma. The laboratory is also in charge of the assay interchange with the smelters where they perform assays as part of round robin exercises every six months. In this respect, the ERSA laboratory is no different from any number of small independent commercial laboratories, which are operated in Canada, and which participate in round robins but do not have ISO certification. While the assay laboratory in Torreón is currently not certified, Micon concluded that the laboratory has sufficient experience and QA/QC procedures in place for it to serve as ECU's primary assay laboratory in Mexico.

At the ERSA laboratory, a sample is first reduced to quarter-inch fragments using a jaw crusher. It is further reduced to ten mesh size using a small cone crusher. The material is then split in a Jones-type splitter until 300 g of the sample is collected. The split sample is then pulverized to minus 150 mesh, homogenized for about three minutes, and placed in a tagged plastic bag. When the sample contains moisture, it is dried at 110°C for approximately four hours prior to the process.

11.8 Quality Control Pre-2009 (Micon Assessment)

Quality control procedures conducted include the routine incorporation of certified geochemical standards, blanks, and sample duplicates, according to the following protocol:

- Diamond Drilling: alternate insertion of a laboratory certified laboratory standard or blank for every 10^{th} sample
- RC Drilling: For every alternate 10^{th} sample, a duplicate sample of the preceding interval was taken as a field duplicate, or a certified laboratory check standard or blank sample was submitted respectively
- Trenching: For every alternate 10^{th} sample, a duplicate sample of the preceding interval was taken as a field duplicate, or a certified laboratory check standard or blank sample was submitted respectively

11.8.1 In-house Reference Material

ECU's on-site reference material consisted of finely ground material from the Santa Juana mine. The material was collected, crushed, and mixed at one time. Several samples were assayed at various laboratories to assure constant values prior to their use as an on-site reference. One on-site reference sample for every twenty samples was sent to the laboratory. The statistics regarding the on-site reference sample are summarized in **Table 11-6**.

Table 11-6: Summary of the in-house reference material for the Velardeña and Chicago properties

Element	Units	Average Value	Minimum Value	Maximum Value	Standard Deviation
Au	g/t	9.6	0.7	13.1	2.2
Ag	g/t	1,094	215	2,241	258
Pb	%	8.01	0.82	14.52	2.37
Zn	%	13.15	1.34	19.46	4.49
Cu	%	1.24	0.01	2.04	0.35
As	%	4.16	1.13	5.44	0.72
Fe	%	14.74	1.45	22.35	4.66

The on-site standard was derived from a total of 51 samples which were collected, crushed and mixed. Table provided by ECU Silver Mining Inc.

ECU created its on-site reference samples as there were no low- or high-grade Ag standard reference standards available on the market at the time. While this is not always the recommended course of action in a QA/QC program, it is preferable to not including a reference sample.

11.8.2 Blanks

The material ECU used for blank samples is barren limestone collected from a nearby location for which reasonably constant values have been previously tested in several laboratories. One blank for every 20 samples is sent to the laboratory. The statistics regarding ECU's blanks are summarized in **Table 11-7**.

Table 11-7: Summary of the blank material for the Velardeña and Chicago properties

Element	Average Value	Minimum Value	Maximum Value	Standard Deviation	Units
Au	0.16	0.00	2.60	0.40	g/t
Ag	12.00	0.00	110.00	19.04	g/t
Pb	0.20	0.00	2.85	0.48	%
Zn	0.51	0.00	19.15	2.75	%
Cu	0.01	0.00	0.16	0.02	%
As	0.14	0.00	0.87	0.18	%
Fe	0.92	0.09	4.60	0.85	%

Total samples =51. Table provided by ECU Silver Mining Inc.

11.8.3 Duplicate Samples

Field duplicates from the stopes and mill were assayed occasionally to test ECU's mill laboratory (Labri), comparing it against the results from the regular ERSA laboratory. The on-site laboratory was used to verify stope sampling and mill assays. The on-site mill laboratory has not been used to assay the samples contained in the ECU database.

Underground samples collected by ECU between 1997 and 2001 were assayed at the previous mill laboratory which was sold to Hecla Mining Company in 2001. The use of an on-site laboratory to assay the development sampling at a mine is a common practice in the mining industry and in most cases this database is also used in the Resource estimate. This sampling is considered historical and the development sampling dating to this period is contained for the most part in mined out areas. Thus, these assays were not used in the current Resource estimate.

Duplicate sampling using the rejects is not conducted on the core or development chip samples. Micon recommended that ECU conduct some duplicate assaying on the core and development chip rejects to assist in checking the variance in the mineralization and the sample preparation procedures and the assay laboratories.

11.8.4 Re-assays

Re-assaying was systematically carried out on batches of pulp samples. In the case of pulp samples these were conducted on a random grouping of samples approximately every three months.

Each pulp sample selected for re-assaying was re-assayed at the ALS Chemex or Servicio Geológico Mexicano (SGM).

Some sample pulps are sent to the ALS Chemex certified laboratory facilities in Guadalajara (Mexico) and Vancouver (Canada). The ALS Chemex Guadalajara laboratory conducted the sample preparation and sent the pulps by plane to the Vancouver laboratory for assaying. The assaying procedures used by ALS Chemex for these samples were described earlier in this section.

Additional sample pulps were sent to the SGM laboratory in Chihuahua, Mexico. This laboratory is a Mexican government facility which services the mining industry and University of Chihuahua. This government facility is an ISO 9001:2000 and BS EN ISO 9001:2000 certified laboratory and conducts assaying and mineralogical test work.

ECU conducted several comparisons using the assay results from these laboratories against the original assays conducted at ERSA. An example of these comparisons made on the average grades for 113 samples from the three assay laboratories is summarized in **Table 11-8**.

Table 11-8: Summary of the assay laboratory comparisons for the average grades based on 113 samples

Assay Laboratories	Averages					
	Au g/t	Ag g/t	Pb %	Zn %	Cu %	As %
ERSA	2.82	178.9	0.68	0.58	0.22	1.08
Chemex	2.91	153.7	0.67	0.57	0.21	1.14
SGM	2.14	168.0	0.80	0.71	0.20	1.15
	Differences (%)					
	Au	Ag	Pb	Zn	Cu	As
ERSA/ALS Chemex	-3.2	14.0	2.4	1.2	4.8	-5.4
ERSA/SGM	24.0	6.0	-17.0	-22.0	6.0	-6.0
ALS Chemex/SGM	24.0	-9.0	-20.0	-24.0	2.0	-1.0
	Correlation					
	Au	Ag	Pb	Zn	Cu	As
ERSA/ALS Chemex	0.98	0.95	1.00	0.99	1.00	0.95
ERSA/SGM	0.63	0.17	1.00	0.84	1.00	0.93
ALS Chemex/SGM	0.62	0.18	1.00	0.84	1.00	0.98

Table provided by ECU Silver Mining Inc.

As indicated by **Table 11-8** the correlation between ERSA and ALS Chemex for the pulp samples is good. For the assay correlations between ERSA and SGM as well as ALS Chemex and SGM, the correlation for the base metals range from fair, in the case of Zn, to good for Pb, Cu, and As. For the precious metals, it is poor for Au and nonexistent for Ag.

Since one of the samples (No. 43293) included in the batch of 113 samples sent to the other two laboratories was high in Ag, this sample was removed and a comparison of the average grades for the remaining 112 samples was conducted. The comparison conducted on the 112 samples is summarized in **Table 11-9**.

Table 11-9: Summary of the assay laboratory comparisons for the average grades based on 112 samples

Assay Laboratories	Averages					
	Au (g/t)	**Ag (g/t)**	**Pb (%)**	**Zn (%)**	**Cu (%)**	**As (%)**
ERSA	2.75	128.2	0.68	0.58	0.16	1.05
Chemex	2.83	123.9	0.67	0.57	0.15	1.11
SGM	2.13	155.1	0.80	0.71	0.15	1.12
	Differences (%)					
	Au	Ag	Pb	Zn	Cu	As
ERSA/ALS Chemex	-2.8	3.0	2.5	1.2	2.3	-5.4
ERSA/SGM	23.0	-21.0	-17.0	-22.0	2.0	-7.0
ALS Chemex/SGM	25.0	-25.0	-20.0	-24.0	0.0	-2.0
	Correlation					
	Au	Ag	Pb	Zn	Cu	As
ERSA/ALS Chemex	0.99	0.99	1.00	0.99	1.00	0.95
ERSA/SGM	0.63	0.04	1.00	0.84	1.00	0.93
ALS Chemex/SGM	0.63	0.09	1.00	0.84	1.00	0.98

Table provided by ECU Silver Mining Inc.

As indicated by **Table 11-9,** the correlation between ERSA and ALS Chemex for pulp samples is good. For the assay correlations between ERSA and SGM as well as ALS Chemex and SGM, the correlation for the base metals range from fair, in the case of Zn, to good for Pb, Cu, and As. For the precious metals it is again poor for Au and nonexistent for Ag.

11.9 2009 to 2012 Sample Preparation, and Assaying (CAM Assessment)

A significant proportion of samples from the 2012 exploration program were analyzed at the ERSA laboratory which is not certified. Additionally, the pulps and coarse rejects from this work were lost. Analysis of the available QA/QC data for these assays indicated the quality of the ERSA assays was not satisfactory. For these reasons CAM recommended, and Golden Minerals agreed, that these samples be re-tested at a certified laboratory. Because the pulps and coarse rejects were lost this required a re-sampling, prep, and assay according to the following steps:

1) A re-split of the remaining samples at the Velardeña site
2) Insertion of QA/QC samples into the sample stream and an approximate rate of one in 15
3) Transport of the samples to the SGS laboratory in Durango
4) Dry, crush to 75% passing through a two-millimeter (mm) screen, subsample 250 g, and pulverize to 85% passing through a 75 micrometer (µm) screen

5) Assay using standard SGS procedures; because of detection limits multiple assays were sometimes run on the same sample pulps

11.9.1 General QA/QC

There are several types of QA/QC samples which are regularly inserted into the sample stream to assure the results obtained are representative of the samples and are correct in terms of contained metal.

Types of QA/QC samples include:

- **Standards.** Standards are samples, usually pulps that have a known value. Standards may be purchased commercially and have an accepted value provided by the commercial entity preparing the standard for at least some elements. Internal standards are prepared by the company (often using contractors because of the larger volumes desirable for standards) with the accepted value being estimated as a result of a series of round-robin assays at various labs. Commercial standards have the advantage that at least some assay values are known "a priori". Commercial standards may have the disadvantage that not all elements of interest for a given operation are provided by the commercial vendor. For example, in a polymetallic deposit like Velardeña, several different standards are required from a commercial lab to cover all the elements of interest. Internal standards are less independent than commercial standards but have the advantage that they tend to be more representative of the mineralogy of the specific deposit and are more likely to cover the elements of interest in more reasonable grade ranges.
- **Blanks.** Blanks may be considered a special type of standard with elemental values of zero. However, blanks, particularly prep blanks, are extremely useful in detecting cross-contamination between samples. Generally, blanks are prepared by the company.
- **Replicates.** Replicates are repeats of prior assay values and for most operations are duplicates. However, the term replicate is used because in some cases multiple analyses for the same element by the same method are run on the same pulp. There are several types of replicate samples including a prep replicate, which is a re-preparation of the course rejects after the first size reduction step. Prep replicates are also called coarse replicates, if multiple pulp envelopes are available the pulp replicates may be submissions of the same envelope or another envelope. For any reputable laboratory there are also replicates out of the same pulp envelope. These are typically used by the laboratory for internal QA/QC.

11.9.2 QA/QC SGS Re-assays

A total of 10,755 assay records in 197 batches from SGS were provided to CAM in tab delimited spreadsheets by Golden Minerals. In addition to these assay records, 561 internal lab duplicates by SGS were provided.

Relative to non-QA/QC samples this represents a QA/QC sample rate of nearly 15% which is consistent with best industry practice. This 15% does not include the internal SGS duplicates.

SGS provided assays on 35 different elements by 47 different assay methods (multiple assay methods are required for some elements because of the detection capabilities of the analytical equipment). CAM only reviewed QA/QC on the elements impacting NSR which were Au, Ag, Cu, Pb, Zn, As, and antimony (Sb). QA/QC review of all these elements were reported to Golden Minerals; however, for this report only QA/QC data for Au and Ag are discussed. These results are representative of assay results for the other elements.

A detailed table of QA/QC samples is given in **Table 11-10**.

Table 11-10: Count of Velardeña QA/QC samples by type

Type	Count
Blank	252
Pulp Duplicate	222
Coarse Duplicate	343
Standards	
STD 1-87440	54
STD 3-87427	60
STD Au 0.0849 ppm	40
STD Au 4.086 ppm	35
STD CDN-ME-18	173
STD CDN-ME-4	169
STD OREAS 134a	26
Total Standards	557

Graphical review of QA/QC data is the easiest way to determine if there are issues in QA/QC. Figures of QA/QC results are shown in **Figure 11-10** through **Figure 11-19**. Brief comments are presented following the figures.

Figure 11-10 shows two anomalous values of over one g/t but is still less than a 1% anomaly rate. **Figure 11-11** shows only one anomalous value.

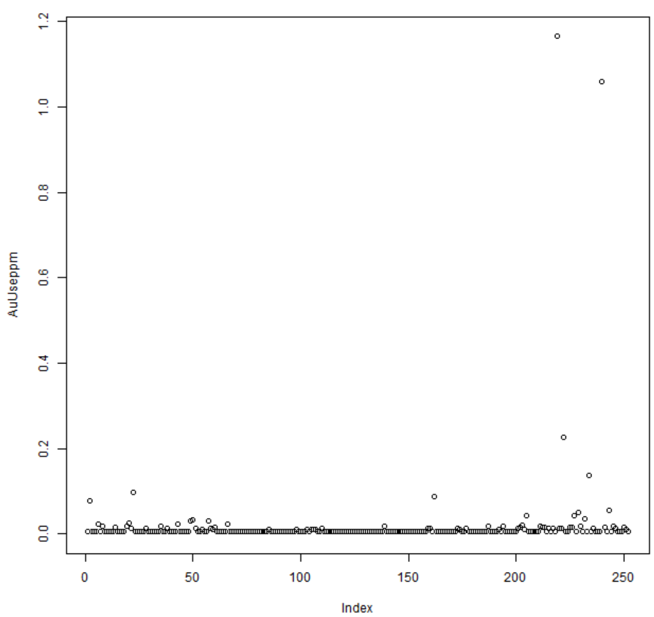


Figure 11-10: Au blanks

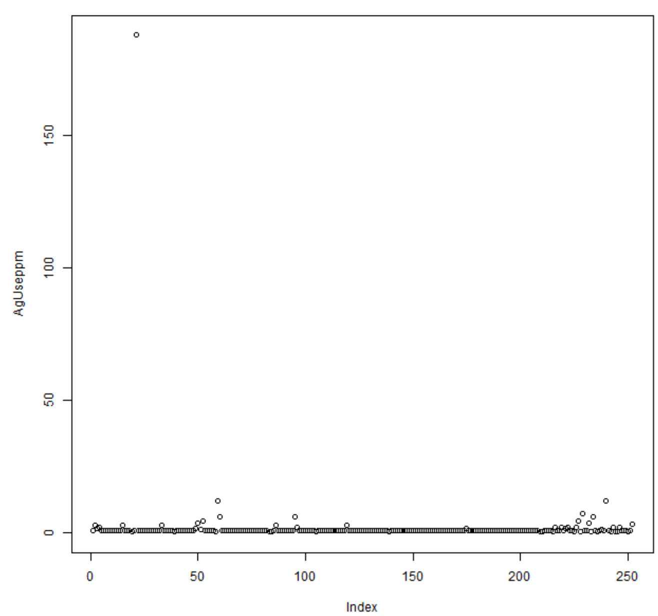


Figure 11-11: Ag blanks

No anomalous values are shown in **Figure 11-12**. Two anomalous values are shown in **Figure 11-13**, with an anomaly rate of just over 1%.

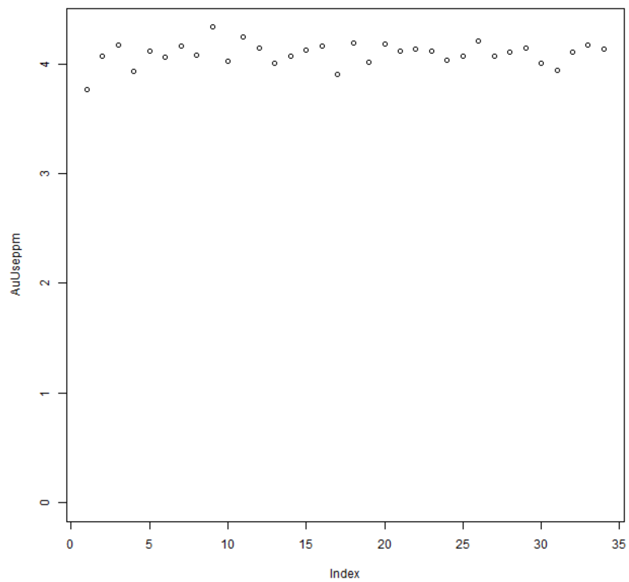


Figure 11-12: Typical Au standard

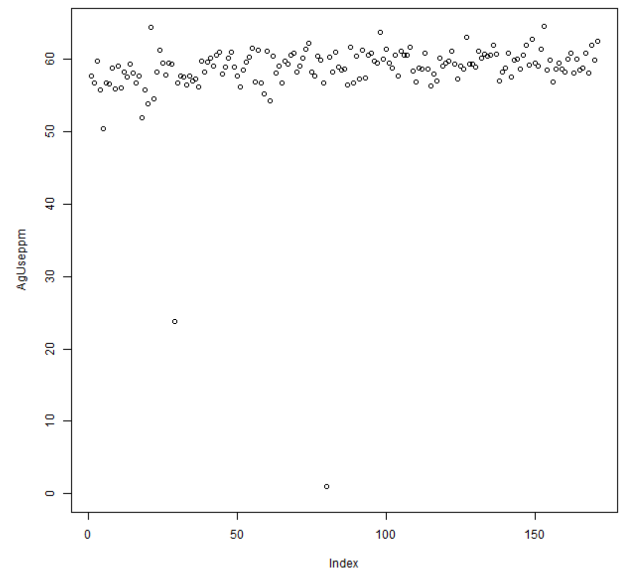


Figure 11-13: Typical Ag standard

Figure 11-14 shows four or five anomalous points; a higher anomaly rate is typical for duplicates than for blanks and standards. **Figure 11-15** shows two or three anomalous points; a higher anomaly rate is typical for coarse duplicates than for fine duplicates.

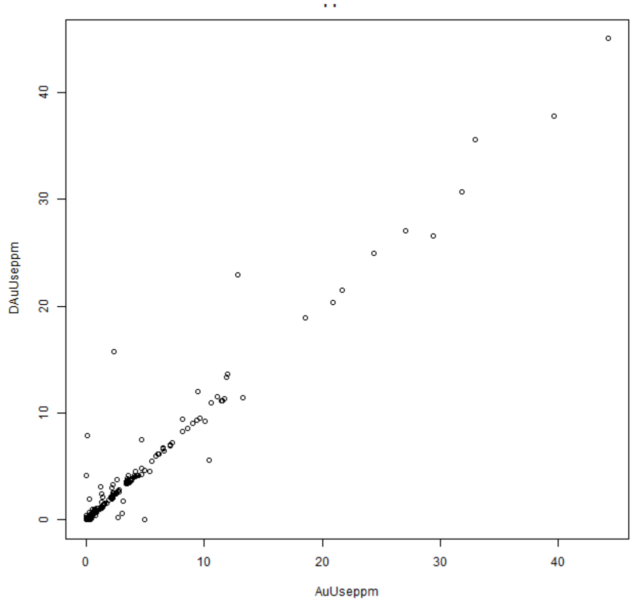


Figure 11-14: Au coarse duplicates

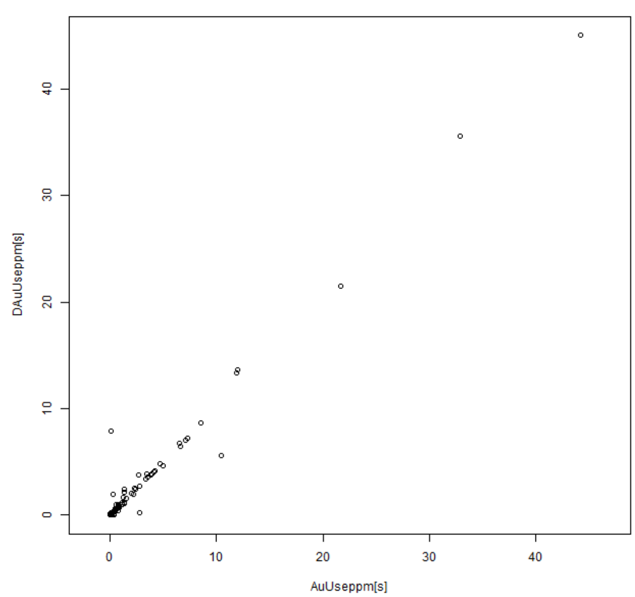


Figure 11-15: Au fine duplicates

Figure 11-16 shows three or four anomalous points as with Au the anomaly rate for duplicates is higher than for blanks and standards. **Figure 11-17** shows one or two anomalous points as with Au the anomaly rate for fine duplicates is lower than for coarse duplicates.

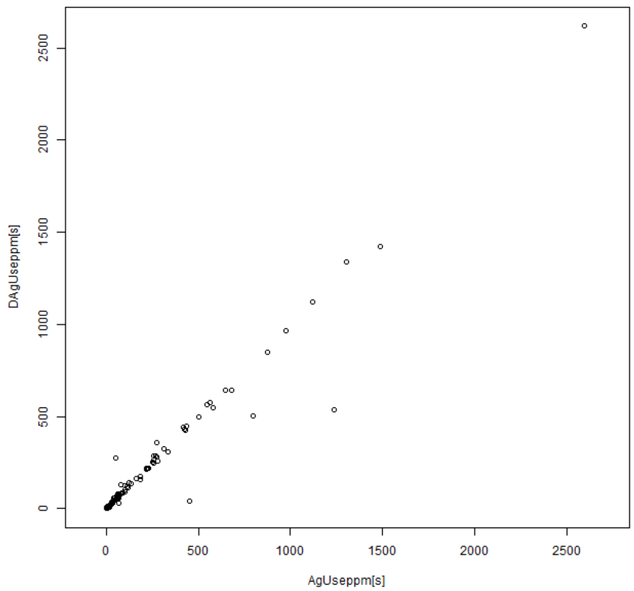


Figure 11-16: Ag coarse duplicates

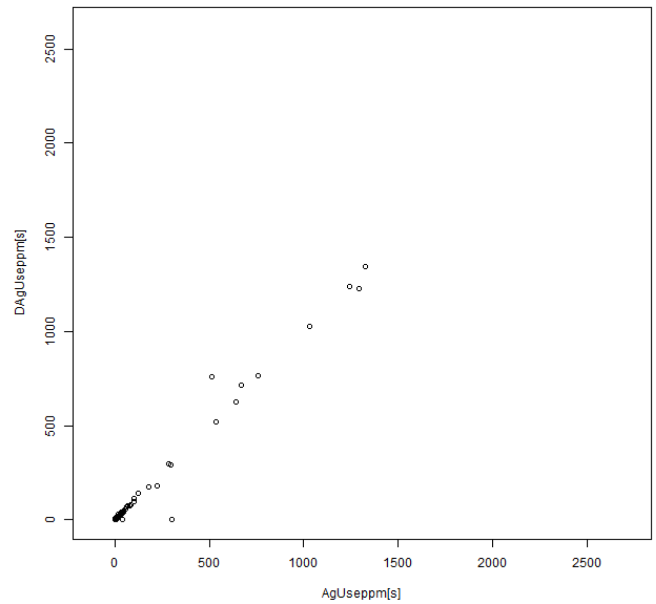


Figure 11-17: Ag pulp duplicates

Figure 11-18 shows one anomalous data point, which is unusual for internal duplicates because normally batches containing these are re-run and never reported to the client. CAM recommended Golden Minerals review SGS reporting standards to determine why this anomaly occurred. In this same context, internal standards for SGS reruns should be disclosed to the client.

There are no immediately obvious anomalous points in **Figure 11-19**. However, it appears the scatter on the low end is somewhat higher than for the Au duplicates in terms of percentage. Since Ag is a significant revenue element, routinely including log-log plots of replicates is suggested.

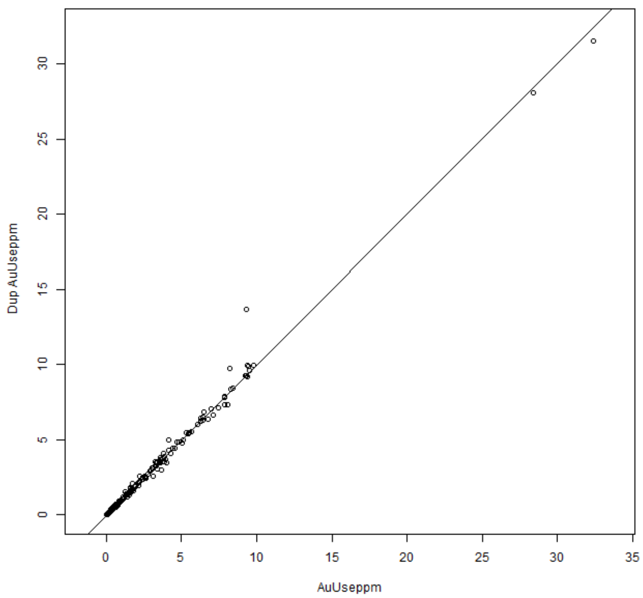


Figure 11-18: SGS Au internal duplicates

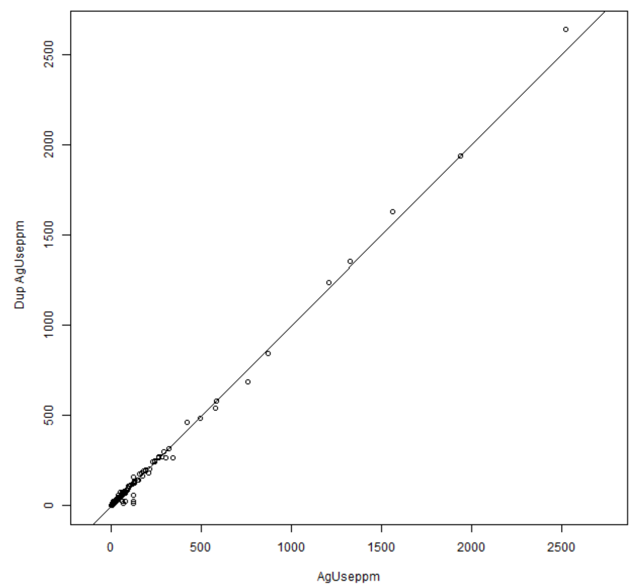


Figure 11-19: SGS internal Ag duplicates

1.1.1.1 Conclusions on the SGS Re-assay Dataset

Minera William has followed best practices in terms of the number of QA/QC samples and the number of statistically anomalous values observed in the QA/QC charts occur at a rate of less than 2%. Hence, CAM concluded the SGS re-assay dataset is suitable for use in calculation of Resources.

11.10 Specific Gravity Determinations

Specific gravity measurements have been made on chip and core samples for varying lithological units and mineral types (oxide, mixed, and sulfide) present at each area of the Project (Santa Juana, Terneras, and Chicago). Samples were selected to represent the major lithology, alteration, and mineralization types.

Several thousand density samples were available from water-immersion measurements on core samples and some hand specimens. The data are of sufficient accuracy for use in Resources estimation, but new samples should be routinely collected and used for Resource estimation.

Specific gravity is calculated by the following formula:

$$\text{Specific Gravity} = \text{weight dry} / (\text{weight dry} - \text{weight submerged})$$

Table 11-11 lists the averages by process type and **Table 11-12** lists the averages by vein by process type.

Table 11-11: Velardeña average densities by mineral type (g/cm^3)

Mixed	Oxide	Sulfide
3.34	2.82	3.57

Table 11-12: Velardeña average density by vein and process type (g/cm^3)

Vein	Ore Type	Average Density
A1	Oxide	2.39
	Mixed	3.38
A2	Sulfide	3.65
A4	Oxide	2.97
	Mixed	3.76
	Sulfide	3.55
Bs	Oxide	2.88
	Mixed	3.57
CO	Oxide	3.00
SJ	Sulfide	3.81
C1	Oxide	2.90
CC	Oxide	2.98
	Sulfide	4.03
E	Sulfide	3.50
E1	Mixed	2.86
G1	Oxide	2.77
Nueva	Oxide	2.89
	Mixed	3.59
	Sulfide	3.59
San Juanes	Sulfide	3.81
San Mateo	Oxide	2.67
	Sulfide	3.41
Oriente	Sulfide	3.21
Terneras	Oxide	2.81
Flechas	Oxide	2.55
Roca Negra	Sulfide	3.18
Trans	Oxide	2.85
Gambusino	Oxide	2.94
	Mixed	3.05
Escondida	Mixed	3.19

11.10.1 Comparing Specific Gravity Datasets

There is a very high level of variability in sulfide densities due to highly variable sulfide assemblages and modal proportions. Conclusions regarding densities include:

- Oxides are generally consistent.
- Mixed does not appear in the 2005 dataset and only in the Santa Juana set for 2011. Within the latter, densities are consistent.
- Densities for diorite, limestone, and skarn are generally consistent. Locally high densities on limestone presumably represent a calc-silicate component.

The variation in total sulfide and sulfide mineral assemblages within sulfide mineral types are the main source of density variations and overshadow relatively subtle differences in host rock. It is important to accurately estimate volumes of vein versus host rock mined as this will have significant impacts on density/tonnage factors, as well as grade dilution.

12. DATA VERIFICATION

The data collected by the mine staff is in support of operations planning and many of the data inputs provided by Golden Minerals are supported by historic and current production actuals and through this activity have been verified. Additional verification procedures are described below.

12.1 Geologic Data Inputs

To verify geologic data inputs, the qualified person reviewed the provided digital data in context of other data provided along with physical observations while on-site. For example, the level mapping was reviewed alongside selected vein samples; geologic mapping was reviewed in conjunction with drill hole geologic interval logging; on-vein development was compared to sample locations; and mine stopes were compared to development and channel sampling.

Traditional drill hole database validation checks were run on the drill hole and channel database and errors were provided to Golden Minerals staff for correction. Each provided on-vein interval for every modeled vein was reviewed in three-dimensional (3D) view, level plan, and in section during model construction and was checked for consistency of location and grade in context of nearby samples.

The quantity of data provided is immense and is not free of errors and omissions. Data provided often required additional organization and, in some instances, alterations, to be internally consistent with respect to location. Location inconsistencies are often related to levels not being perfectly flat and often partially following ramps.

Golden Minerals has undertaken an effort to examine database intervals that intercept the vein. Each interval was examined alongside the mine level maps, as well as existing wireframes. If it was deemed that the vein code was not correct, the database was corrected. Special attention was also given to intervals and whether they contain dilution or not in the sampling.

The geologic data provided is adequate for the purposes used in this PEA.

12.2 Mine Planning Data Inputs

Tetra Tech conducted a site visit to the Velardeña mine to verify parameters used in mine planning are adequate for use in the PEA. This included visiting underground workings, as well as test mining areas. This site visit allowed for verification of mining parameters used in the PEA, confirming that the parameters are adequate for a study of this level.

12.3 Mineral Processing Data Inputs

Technical and cost data were obtained during the Project site visit and in subsequent communications with Golden Minerals personnel at the Velardeña site and in Golden Minerals' Golden, Colorado office. The data provided by Golden Minerals conforms to industry standards and is within the required accuracy for a study of this level.

At no time was there any limitation to, or failure to provide the requested technical and cost data for the processing plants or infrastructure to Tetra Tech's metallurgical or infrastructure personnel.

12.4 Economic Data Inputs

A technical economic model template and cost data were obtained in subsequent communications with Golden Minerals. The data provided by Golden Minerals conforms to industry standards and is within the required accuracy for a study of this level.

At no time was there any limitation to, or failure to provide the requested technical and cost data for the economic model to Tetra Tech.

12.5 Environmental Information

A list of current permits was obtained from Golden Minerals. The information provided by Golden Minerals conforms to the requirements of Mexican environmental regulations; however, no information regarding an environmental monitoring program or adherence thereto was reviewed and the waste rock area permits will need to be updated before mining recommences.

13. MINERAL PROCESSING AND METALLURGICAL TESTING

There are two processing plants at the Project. Plant 1 is designed to treat sulfide material by conventional crush, grind, and differential flotation to produce Pb, Zn, and pyrite concentrates. Process Plant 2 has two production circuits for separately processing oxide and sulfide Au-Ag material to produce Au-Ag doré by cyanide leach/Merrill-Crowe and a bulk Au-Ag rich sulfide concentrate by flotation, respectively.

Operation of Plant 1 was discontinued in late 2015 due to a combination of low metal prices, dilution, and metallurgical challenges. Plant 2 was leased to Hecla Mining Company from July 2015 through December 2020 after which the lease expired. Ore from the Golden Minerals Rodeo mine has been processed through Plant 2 since January 2021.

Because of the historical production for Plant 1, the liberation characteristics of the material and subsequent response to differential flotation are within typical design criteria and known by the operations personnel. There are no geological, lithological, or mineralogical changes in the process plant feed anticipated for the envisaged future production as compared to previous operations. Historical operational results support the existing process flowsheet for potential future production at Plant 1. Further, the use of existing and refurbished equipment within the pre-existing facilities is Golden Minerals' preferred method of future treatment.

In 2007 the potential to increase Au recovery from Plant 1 and improve project economics by installing a bio-oxidation circuit to treat pyrite concentrates on-site and recover Au and Ag to doré was explored by sending samples to SGS in South Africa for test work. Treatment on-site would allow operating the flotation circuit to pull more mass to the pyrite circuit containing Au and Ag previously lost to tailings. The test work indicated Velardeña pyrite concentrate could be successfully oxidized with the BIOX® process prior to cyanidation. Golden Minerals sent additional samples for testing at Outotec facilities in 2019 that confirmed the initial findings. Further test work is planned.

An abbreviated Outotec description of the process follows:

- The BIOX® process was developed for the pre-treatment of sulfide refractory ores and concentrates ahead of a conventional cyanide leach for Au recovery. The gold in these ores is encapsulated in sulfide minerals such as pyrite, and arsenopyrite, thus preventing the gold from being leached by cyanide. The BIOX® process destroys the sulfide minerals and exposes the gold for subsequent cyanidation, thereby increasing the overall gold recovery that can be achieved.
- The heart of the BIOX® process is a mixed culture of naturally occurring microbes which, under controlled conditions, are able to oxidize Au-bearing sulfide ores or concentrates due to a chemo lithotrophic mode of metabolism. This means that they require inorganic compounds for the acquisition of both energy and carbon.
- The carbon requirements of the microbes for biosynthesis of cellular biomass are met by CO_2 in the atmosphere or from the dissolution of carbonate minerals in the ore.
- The microbial culture in the BIOX® reactors is not controlled but rather allowed to adapt to the concentrate and operating conditions.
- The species, viz. *Acidithiobacillus ferrooxidans*, *Leptospirillum ferrooxidans*, *Leptospirillum ferriphilum*, *Ferroplasma cupricumulans* as well as many archaea species make up the dominant species of the BIOX® microbial consortia. Detailed laboratory and pilot plant studies have indicated that the microbes require a very acidic environment (pH 1.1 to 1.7), a temperature of between 35°C and 45°C and a steady supply of oxygen and carbon dioxide for optimum growth and activity. The unusual operating conditions, which are optimal for the BIOX® microbes, are not favorable for the growth of most other microbes, thus eliminating the need for sterility during the BIOX® process. The

BIOX® microbes are non-pathogenic and incapable of causing disease. The microbes employed in the BIOX® process do not, therefore, pose a health risk to humans, animals, or plant life.

- The oxidation reactions are also highly exothermic. In addition to the direct oxidation of sulfide minerals, several indirect chemical and microbial assisted reactions occur.

An additional benefit of oxidizing Fe concentrates on site would be the ability to precipitate arsenic solubilized as arsenic acid in the BIOX liquor into a stable ferric arsenate compound suitable for disposal in a tailings dam.

Two series of Batch Amenability Tests (BAT) were performed on different samples of Fe concentrate; in 2007 at SGS Lakefield Research Africa and in 2019 at Outotec BIOMIN (Pty) Ltd RSA. Based on results of the test work, both reports concluded the refractory Velardeña pyrite concentrate is amenable to bio-oxidation treatment. The oxidized sulfides yielded improved Au and Ag dissolutions in a cyanide leach from single digits before treatment to greater than 90% for Au, and from less than 40% before to 50 - 95% for Ag.

Operating conditions, reagent consumptions, and results for a BIOX® BAT treatment period of 24 days was chosen for evaluation in this assessment. **Figure 13-1** shows the increase in oxidation with time for the two series of BATs. Au dissolution approaching 90% was achieved in both test reports after sulfide oxidation to near 60%, corresponding to plateauing of the Gold Dissolution vs. Sulfide Oxidation curve, **Figure 13-2.**

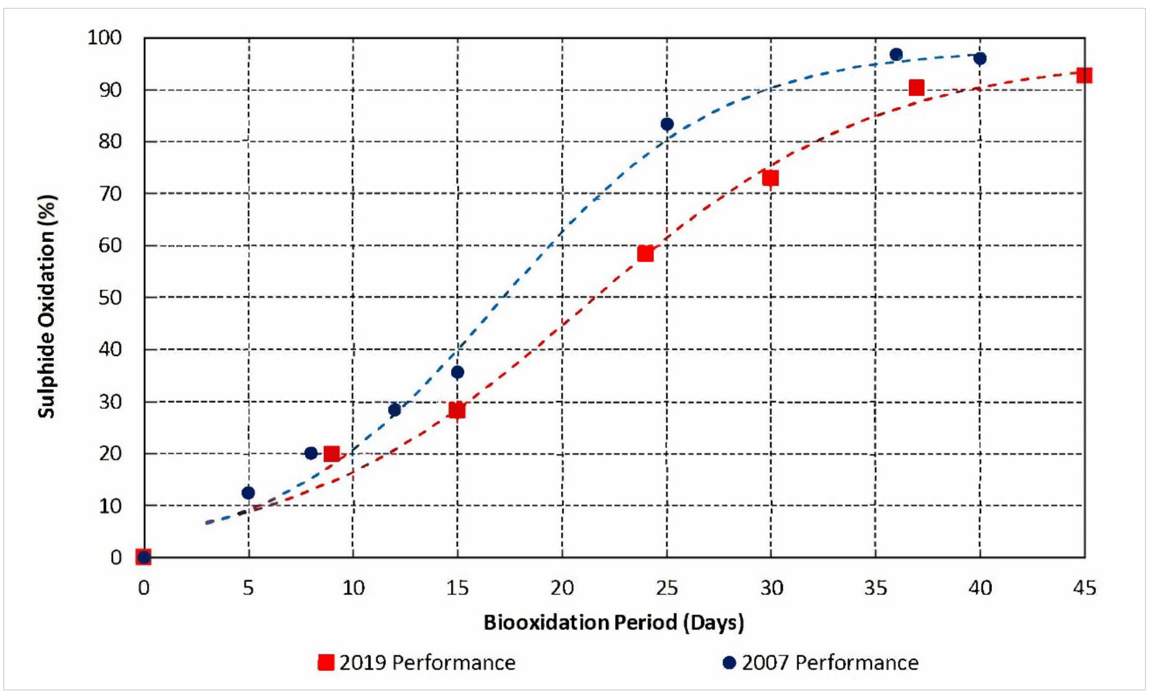


Figure 13-1: BIOX® sulfide oxidation profiles of the Velardeña samples described by the logistic model

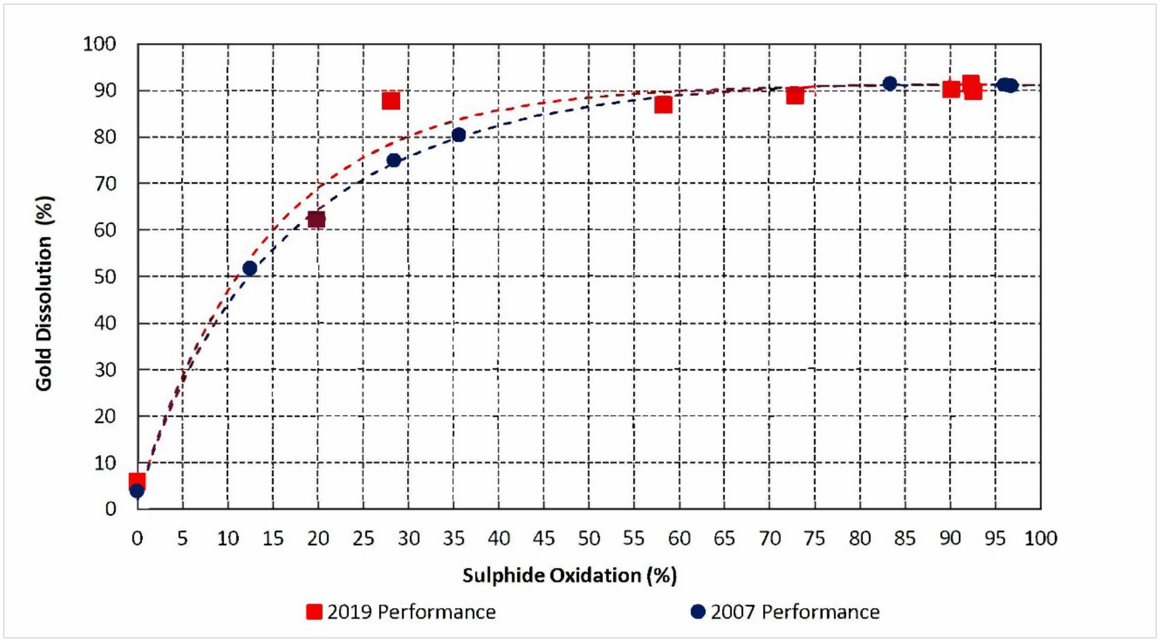


Figure 13-2: Au dissolution vs. sulfide oxidation for the Velardeña concentrates

Neutralization of the acidic ferric arsenate BIOX® solution with a two-stage treatment with limestone and lime produced environmentally stable arsenic compound residues fully compliant with the United States of America's Environmental Protection Agency guidelines for tailings disposal. These guidelines call for arsenic re-solubilization of tailings residues to be < 5 mg/L. For the Velardeña neutralization tests, arsenic values of 0.06 and 0.07 mg/L were obtained.

With the success of the testing programs, this updated PEA includes a BIOX® circuit to oxidize the pyrite concentrate for recovery of the contained Au and Ag to doré on site.

14. MINERAL RESOURCE ESTIMATES

Resources have been estimated independently for 39 known veins. Estimation was completed using vein wireframes for the principal veins, and centerline guiding surfaces for the secondary veins. A combination of variable thickness block models and block factor models were used for the veins. Block attributes have been estimated in three passes, using inverse distance to a power of 2.5.

Estimated Mineral Resources for the Velardeña Project are shown in **Table 14-1** below, as well as the mineral type portions for each Resource class.

Table 14-1: Velardeña Project Resources

Classification	Mineral Type	NSR Cutoff	Tonnes	Grade Ag g/t	Grade Au g/t	Grade Pb%	Grade Zn%	Ag oz	Au oz	Pb lb.	Zn lb.
Measured	Oxide	175	128,800	268	5.69	1.74	1.53	1,108,000	23,500	4,936,000	4,333,400
Indicated	Oxide	175	280,300	262	5.06	1.73	1.45	2,361,200	45,600	10,681,500	8,936,600
Measured + Indicated	Oxide	175	409,100	264	5.26	1.73	1.47	3,469,200	69,100	15,617,500	13,270,000
Inferred	Oxide	175	351,400	417	4.95	2.55	1.45	4,714,600	56,000	19,729,500	11,248,200
Measured	Sulfide	175	256,200	357	5.52	1.56	1.91	2,942,800	45,500	8,819,300	10,769,700
Indicated	Sulfide	175	603,500	341	4.79	1.46	1.91	6,619,400	92,900	19,475,600	25,408,900
Measured + Indicated	Sulfide	175	859,700	346	5.01	1.49	1.91	9,562,200	138,400	28,294,900	36,178,600
Inferred	Sulfide	175	1,357,700	348	4.76	1.52	1.97	15,179,000	207,800	45,534,200	58,952,900
Measured	All	175	385,000	327	5.58	1.62	1.78	4,050,800	69,000	13,755,300	15,103,100
Indicated	All	175	883,800	316	4.88	1.55	1.76	8,980,600	138,500	30,157,100	34,345,500
Measured + Indicated	All	175	1,268,800	319	5.09	1.57	1.77	13,031,400	207,500	43,912,400	49,448,600
Inferred	All	175	1,709,200	362	4.80	1.73	1.86	19,893,600	263,800	65,263,700	70,201,100

Notes:

(1) Resources are reported as diluted tonnes and grade to 0.7 m fixed width

(2) Metal prices for NSR cutoff are: $23.70/oz-Ag, $1,744/oz-Au, $0.97/lb.-Pb, and $1.15/lb.-Zn

(3) Columns may not total due to rounding

14.1 Input Data

The Project database contains 10,649 assayed drill holes and 35,273 channel sample intervals. Of those, 1,814 drill hole intervals and 22,568 channel intervals have been interpreted as intersecting a named vein and subsequently used for Resource modeling. **Table 14-2** shows grade statistics for intervals within the overall project database and those selected for Resource modeling.

Table 14-2: Input data statistics

Dataset	Selection	Count	Mean Ag g/t	Mean Au g/t	Mean Pb%	Mean Zn%
Channel	All	35,273	292	5.22	1.66	1.73
Drill hole	All	10,649	47	0.99	0.18	0.30
All	**All**	**45,922**	**235**	**4.24**	**1.32**	**1.40**
Channel	On Vein	22,568	423	7.66	2.42	2.46
Drill hole	On Vein	1,814	175	3.51	0.65	1.09
All	**On Vein**	**24,382**	**405**	**7.35**	**2.28**	**2.36**

14.2 Compositing

Each drill hole and channel that intersected the vein was composited into one variable length composite and a generated centroid coordinate. Each composite represents an accumulation of the intervals from the hanging wall to footwall of the vein. A channel sample set or drill hole was permitted to have only one composite per vein. There was no predetermined interval length for the composites.

14.3 Grade Capping

Assay intervals from the combined drill hole and channel sample database that were identified as being on-vein were analyzed as a natural log transformed population to determine upper grade limits. Upper limits were applied to composited vein intervals. The upper limit chosen for Ag was 4,000 g/t and 55 g/t for Au, and 20% for both Pb and Zn. **Table 14-3** shows capping statistics and the effects on the population mean **Figure 14-1** shows probability plots for Ag, Au, Pb, and Zn. A traditional interpretation of the probability plots, shown in **Figure 14-1** could conclude higher capping limits are justified; however, limits higher than selected would not be supported by observed vein variability.

Table 14-3: Capping statistics

Element	Uncapped Mean g/T	Upper Limit g/T	Number Capped	Capped Mean g/T
Ag	513	4000	149	491
Au	9.30	55	163	9.00
Pb	2.70	20	181	2.64
Zn	2.67	20	204	2.60

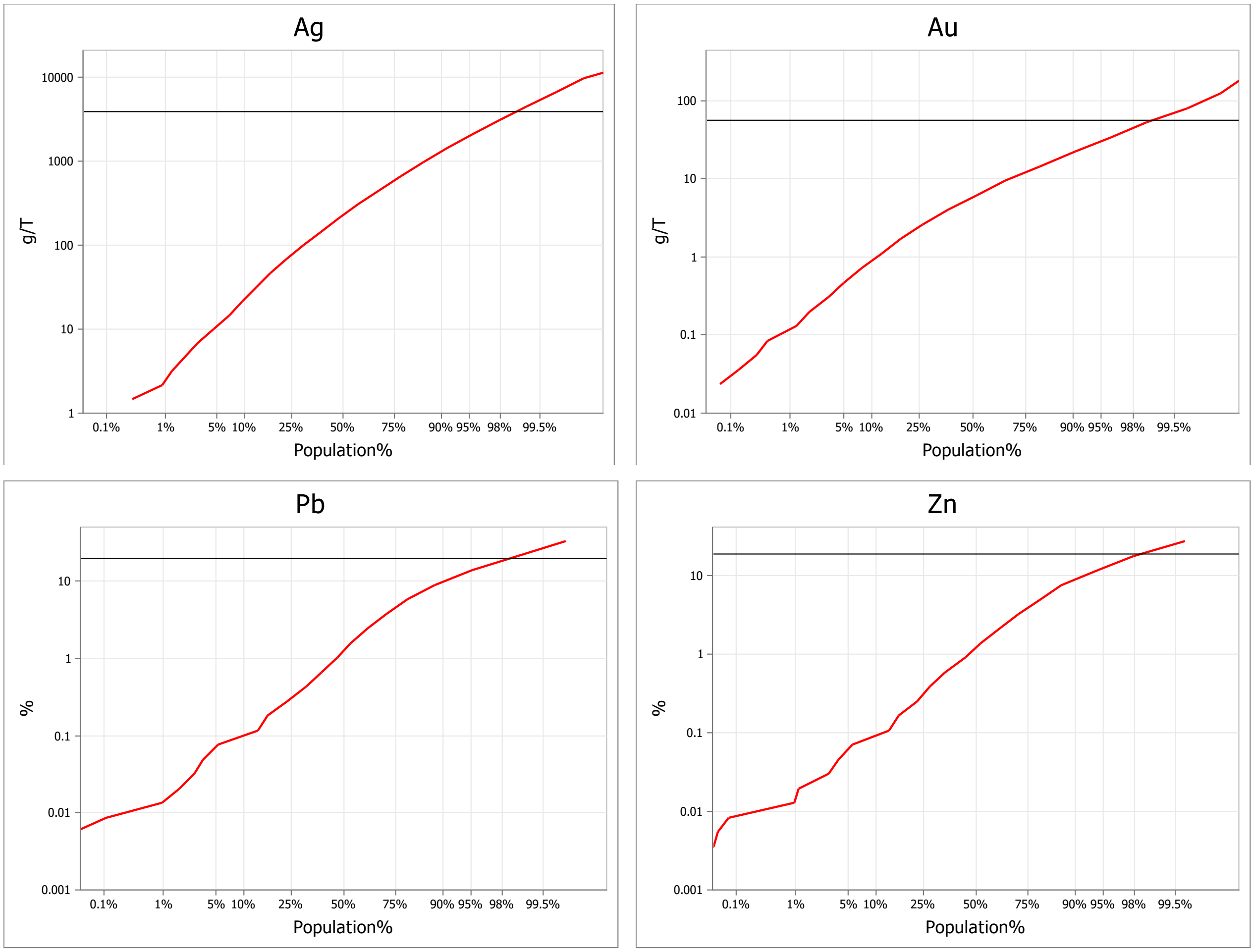


Figure 14-1: Upper limit analysis probability plots

14.4 Vein Modeling

The veins at the Project are interpreted to be epithermal type formed by fluids that have flooded relatively narrow pre-existing structurally prepared zones. Initial vein intervals were provided by Golden Minerals as an attribute in the project database along with indicative vein surface models. These initial picks were reviewed in 3D in context of the vein mapping and underground development mapping provided by the company.

14.4.1 Principal Veins

Each interval was examined with level mapping and vein mapping to define whether it was assigned the appropriate vein coding. There was also investigation into the diluted vs. undiluted samples in the database. The diluted and undiluted samples were originally mixed, and both used for estimation purposes, adding additional dilution to the estimate. The undiluted samples were used for the database modification exercise and was completed for the principal veins at the site, which include CC, C1, A4, F1, G1, San Mateo, Roca Negra, Hiletas, Terneras, Chicago, and Escondida. The new database information was utilized by Golden Minerals to create updated models for these veins. The updated interval data was fed into Leapfrog software and new wireframes were created that honored the intervals in the database, using only on vein, undiluted intervals. The new wireframes were brought into Micromine and used to create and estimate Resource models. The wireframe models are shown below with the existing development in **Figure 14-2**, **Figure 14-3**, and **Figure 14-4.**

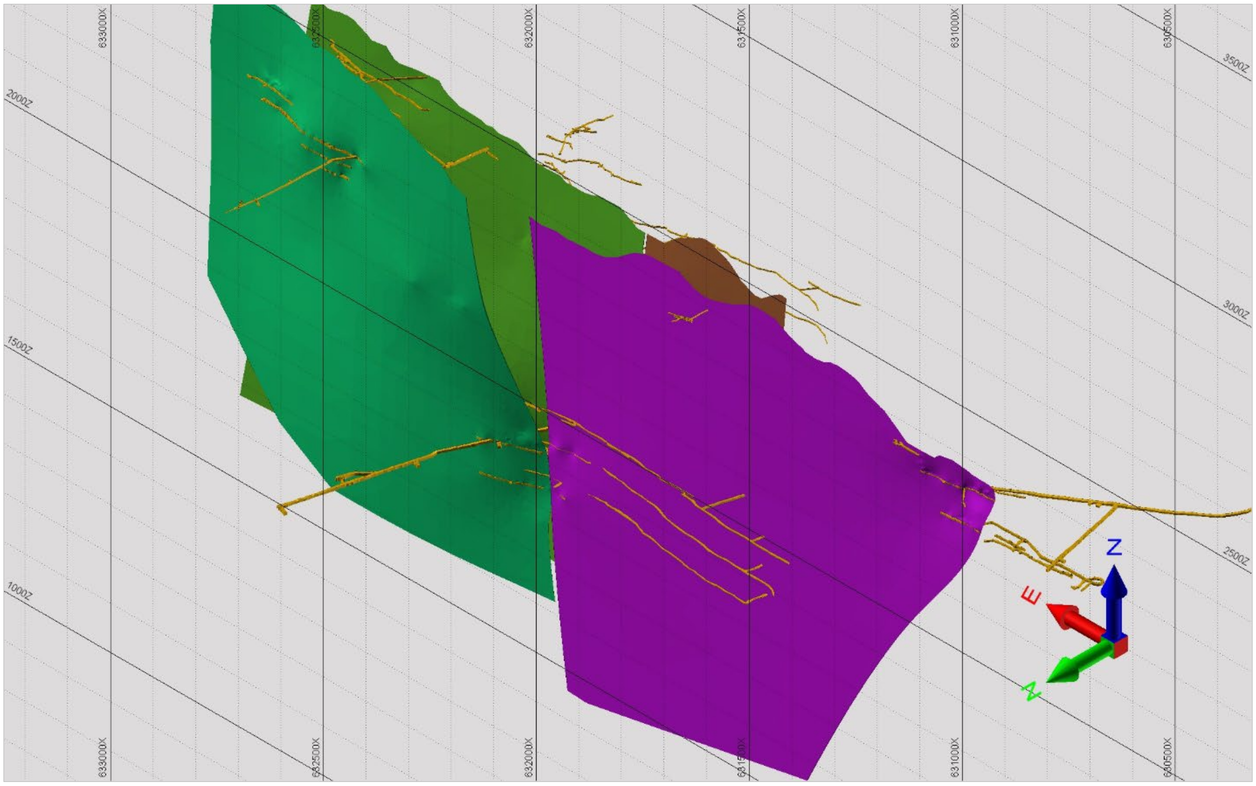


Figure 14-2: 3D view of the wireframes from the Terneras area

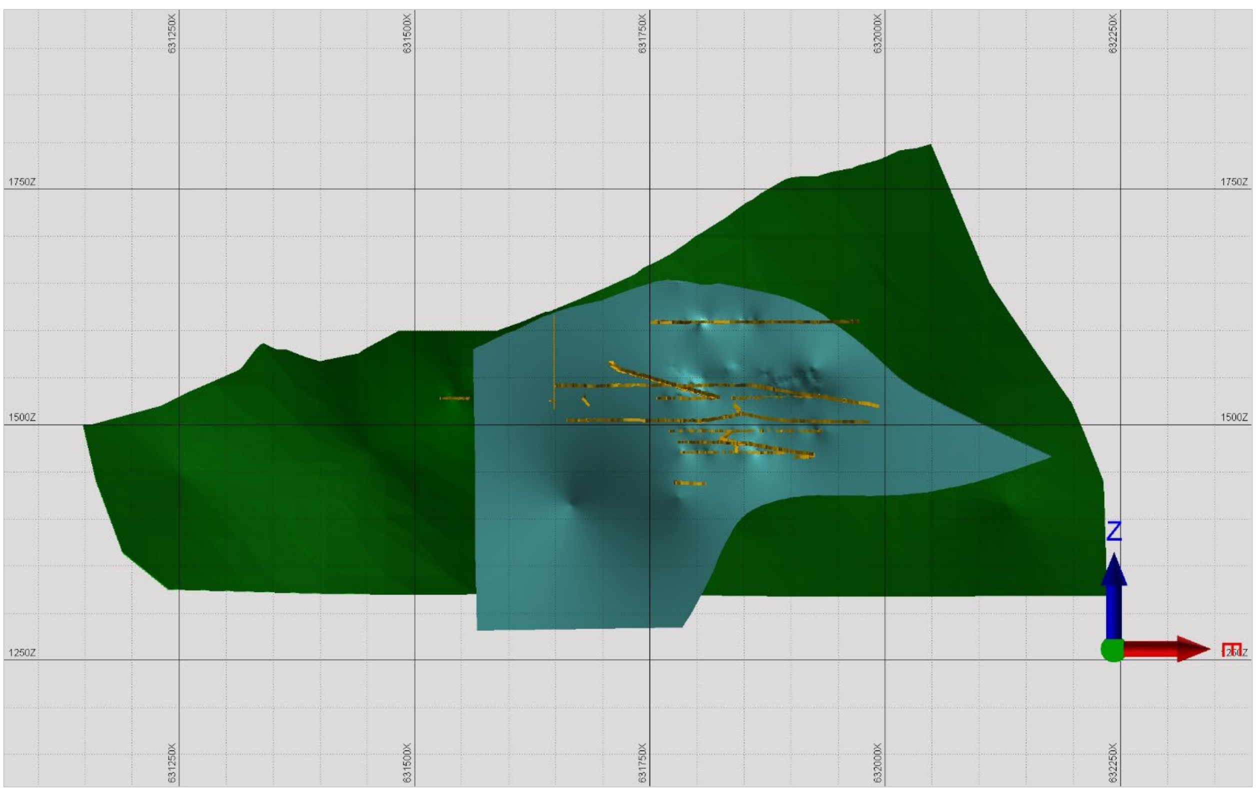


Figure 14-3: 3D view of the Chicago area wireframes, looking north

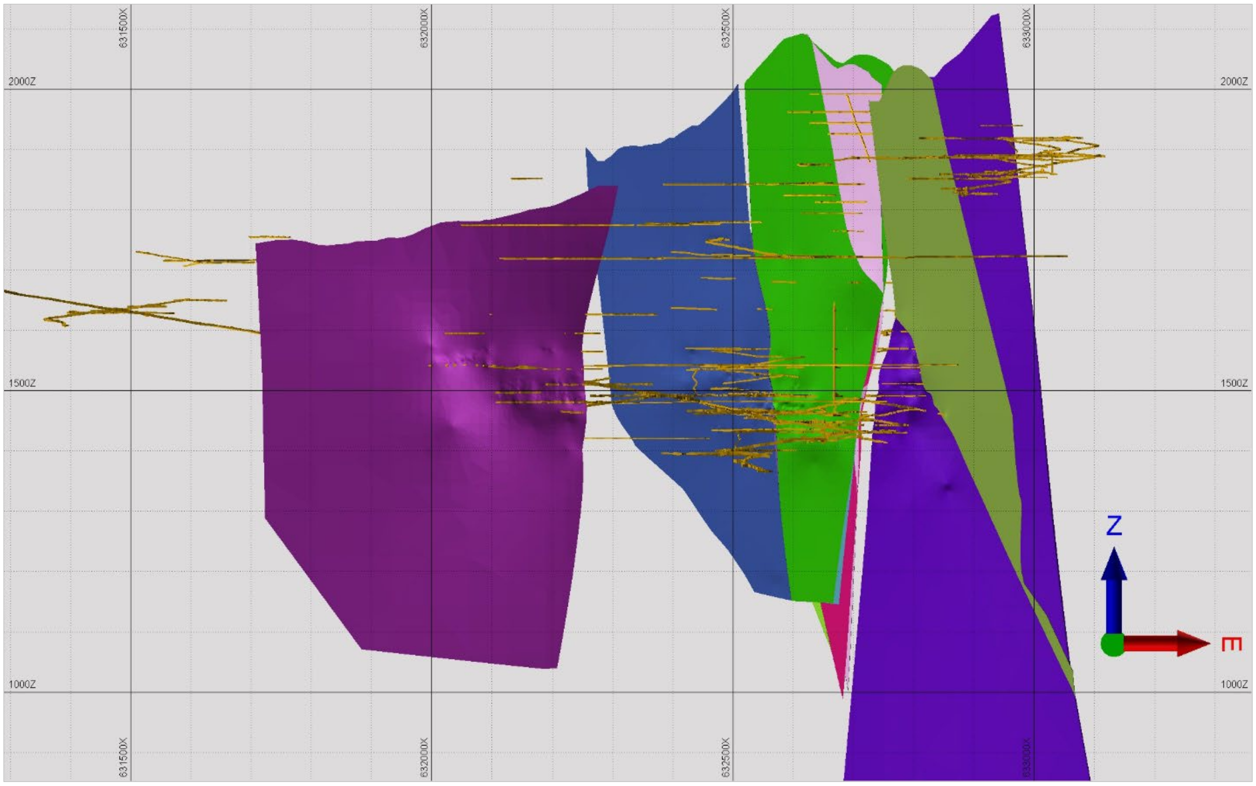


Figure 14-4: 3D view looking north of the wireframes from the Santa Juana Area (north) and San Mateo Area (south)

14.4.2 Secondary Veins

For the secondary veins, initial vein intervals were used to generate a vein centerline surface. Intervals were adjusted to construct the most spatially probable vein surface. The highest-grade vein interval was not necessarily chosen when fitting the vein centerline surface. Gentle curvature in surfaces were common as veins extended away from ideal host lithologies and became distal to the features that prepared the host structures. The vein model proposed assumes a continuous traceable vein structure as suggested in the level mapping. Vein splays were captured and assigned subordinate identifiers where they could be traced along dip and strike. Each interval interpreted to be on-vein was given a numeric vein code, position code (center, hanging wall, or footwall), and a fault side indicator where offsets existed. Following vein assignment centerline surfaces were generated for each unique combination of identifiers. Combinations without extensive sample support or spatial continuity were not generated into centerline surfaces.

The centerline surface was interpolated using implicit modeling on a fixed 4 m by 4 m grid. The surfaces are not "snapped" to the vein intervals due to resistance in the implicit modeling algorithm and insignificant localized positioning error. Where initial vein extrapolations deviated greatly additional spatial control points were added to guide the model. The extrapolation of the vein surfaces was limited by spherical buffers, the topography, and known termination points. Each vein surface was pierced by each drill hole in the database. If a vein was pierced by a drill hole and a composite was not previously identified for that drill hole, a composite was inserted with a given thickness of 0.001 m and half detection limit grade attributes. Very low values were used instead of "0" because of the issue caused with "0" when estimating grade multiplied by thickness and converting back to grade. The effect of the inserted composites was block model attributes that pinched in grade and thickness at pierce points that were not flagged as on-vein. **Figure 14-5** and **Figure 14-6** show 3D views of modeled vein centerline surfaces for the Chicago and Santa Juana areas.

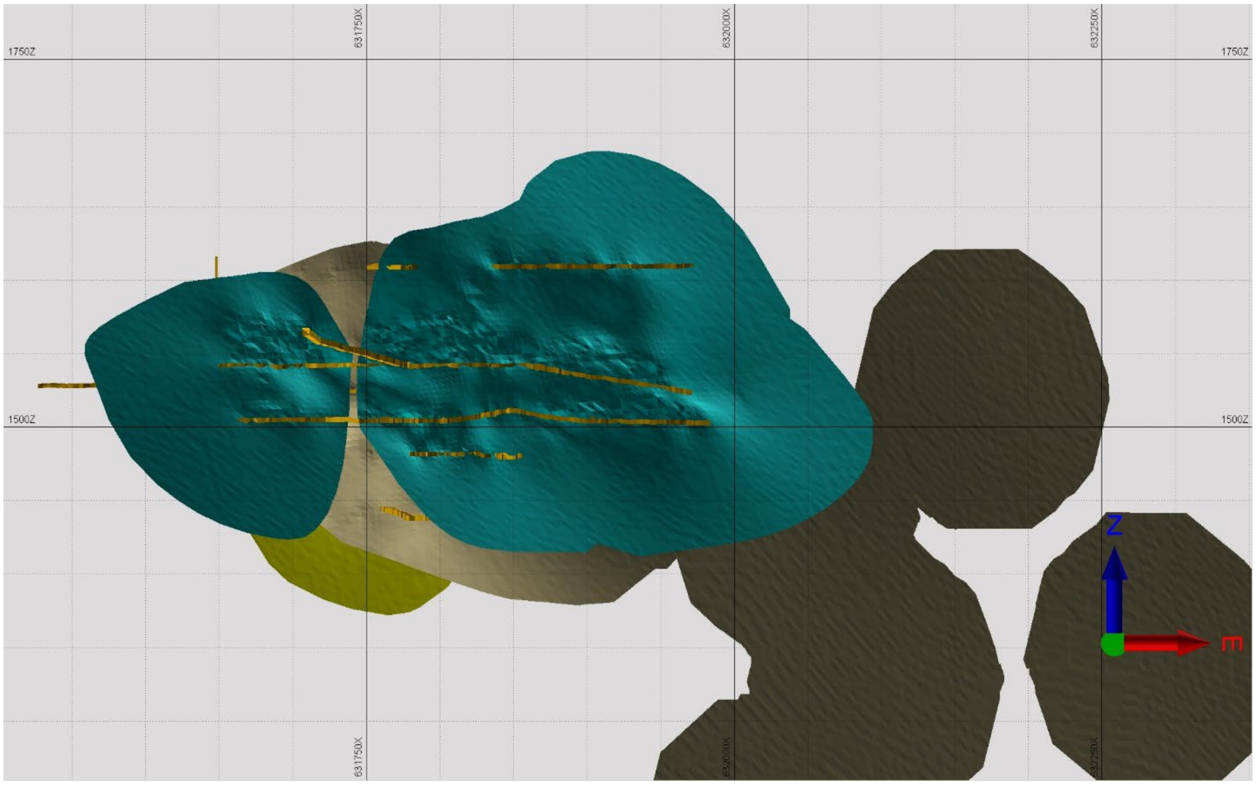


Figure 14-5: Surfaces of secondary veins in the Chicago area, looking north

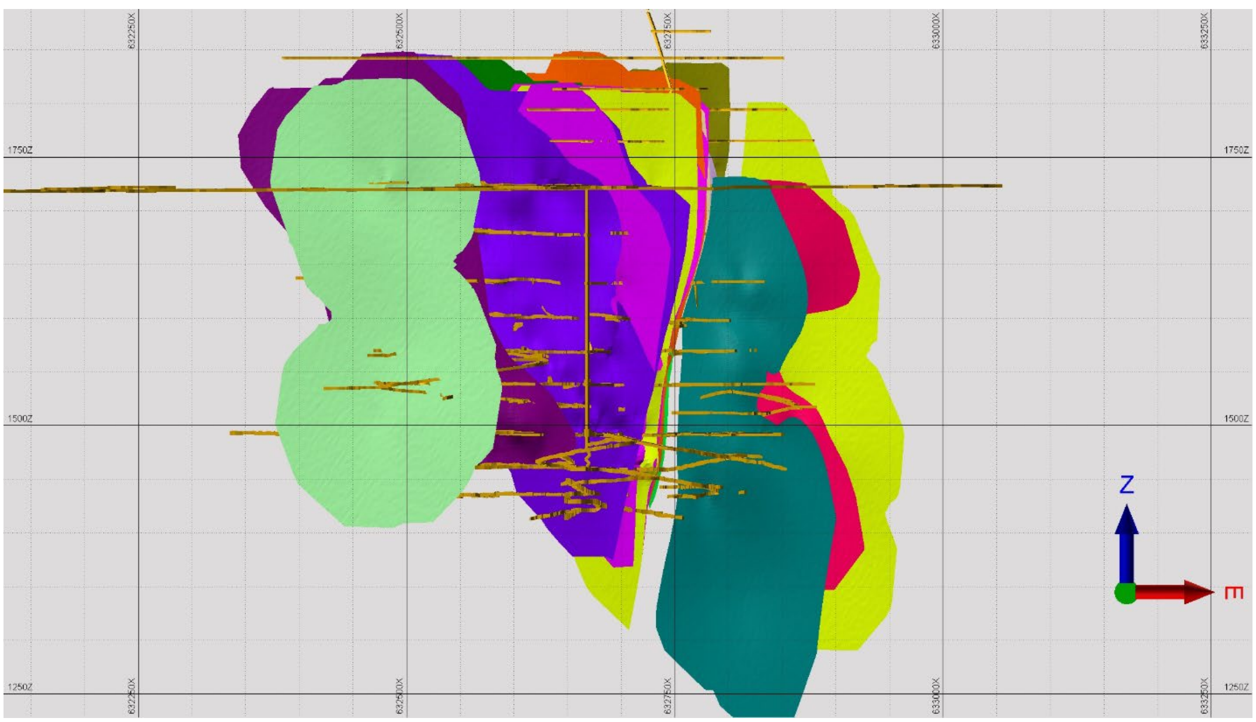


Figure 14-6: Surfaces of secondary veins in the Santa Juana area, looking north

14.4.3 Mineral Type Boundaries

Mineral types have been flagged as attributes in the block model along with grade attributes. Polygons were created to model the oxide, sulfide, and mixed (transition) boundaries.

14.4.4 Boundary Exclusions

Each block has been flagged by historic and recent mine cavity (stope) polygons and assigned a mined-out code. In addition, Resource reporting has been limited to within the claim boundary by adding an on-claim designation to the block model.

Mined out shapes have been provided by the mine site staff. Due to the three dimensionality of the current block model and the mine working primarily in 2D, and often in false coordinate space, the depletion boundaries are not exact when reviewed in context of the channel positions. The current model and the composite positions are relative to each other in as close to true 3D as possible.

14.4.5 Density Determination

Golden Minerals' geologists have made several thousand measurements on core and hand samples collected from underground workings using the water immersion method. Samples were collected where accessible and were not collected on all veins. Where measurements were not made, values associated with nearby veins or the default values based on mineral types were used.

Vein density values for oxide, mixed and sulfide mineral types were assigned to blocks of the same vein and mineral type. For purposes of dilution, waste was assigned a density of 2.6 g/cm^3. **Table 14-4** details the density values used for each vein.

Table 14-4: Vein density used in model (g/cm^3)

Vein Name	Oxide	Mixed	Sulfide	Vein Name	Oxide	Mixed	Sulfide
A4	2.97	3.76	3.55	C2_NW	2.82	3.34	3.57
CC	2.98	3.34	4.03	D0_NW	2.82	3.34	3.57
C1	2.9	3.34	3.57	D1_NW	2.82	3.34	3.57
G1	2.77	3.34	3.57	DD_NW	2.82	3.34	3.57
F1	2.82	3.34	3.57	Ds_NW	2.82	3.34	3.57
Escondida	2.82	3.19	3.57	E_NW	2.82	3.34	3.5
Chicago	2.82	3.34	3.57	E1_NW	2.82	2.86	3.57
Hiletas	2.82	3.34	3.57	EE_NW	2.82	3.34	3.57
Roca Negra	2.82	3.34	3.18	Trans_NW	2.85	3.34	3.57
San Mateo	2.67	3.34	3.41	VetaOriente_NW	2.82	3.34	3.21
Terneras	2.81	3.34	3.57	A1_SE	2.39	3.38	3.57
D2_NW	2.82	3.34	3.57	A2_SE	2.82	3.34	3.65
SantaJuana_NW	2.82	3.34	3.81	AA4SE_A4Alto	2.82	3.34	3.57
SantaJuana_SE	2.82	3.34	3.81	D1_SE	2.82	3.34	3.57
SantaJuanaFW1_SE	2.82	3.34	3.81	Chicago NE	2.82	3.34	3.57
Trans_Alto_NW	2.85	3.34	3.57	Gambusino_NE	2.94	3.05	3.57
A1_NWHW1	2.39	3.38	3.57	Gambusino_SW	2.94	3.05	3.57
A2_NW	2.82	3.34	3.65	Nueva	2.89	3.59	3.59
A3_NW	2.82	3.34	3.57	Brenda	2.82	3.34	3.57
Bs_NW	2.88	3.57	3.57	LosMuertos	2.82	3.34	3.57
Bs_NWhw	2.88	3.57	3.57	San Juanes	2.82	3.34	3.81

Vein Name	Oxide	Mixed	Sulfide	Vein Name	Oxide	Mixed	Sulfide
G2_NW	2.82	3.34	3.57	San Juanes_fw1	2.82	3.34	3.81
C0_NW	3.00	3.34	3.57	Estrato_Chicago	2.81	3.34	3.57

14.5 Estimation Methods and Parameters

Resources have been estimated for each named vein using a variable thickness block model oriented in the best fit plane of the vein for the secondary veins. Principal veins have been updated in a 4x4x4 m, block factored block model. Block attributes have been estimated using inverse distance weighting to a power of 2.5.

14.5.1 Variography and Search

The grade distance relationship was investigated for Ag, Au, Pb, and Zn using natural log transformed omni-directional variography on composited vein intervals. The entire composite dataset contributed to the variogram model without cross-vein influence. Composites from each vein were shifted to false space by a separation distance of the maximum range of the analysis. This enabled the mineralized system to be analyzed all at once.

Experimental and modeled variograms are shown in **Figure 14-7**, and **Table 14-5** details the modeled components. Nugget and sill portions have not been made relative to a total sill of one or 100% to correspond with the graphical output presented in **Figure 14-7**. Each variogram was well formed with Ag and Au having better-formed experimental variograms than Pb and Zn.

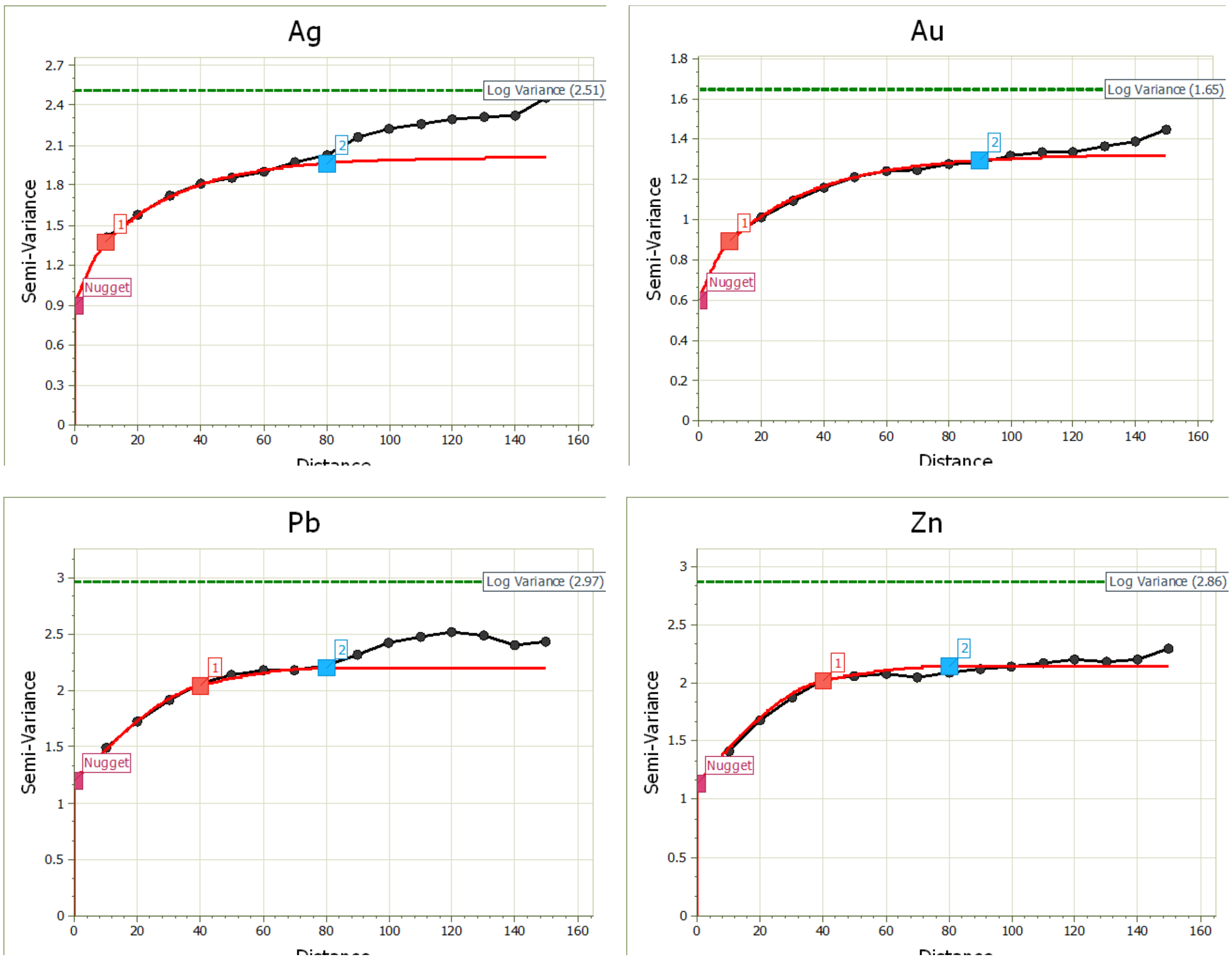


Figure 14-7: Natural log transformed omni-directional variography

Table 14-5: Modeled variograms

Element	Nugget	C1 Partial	C1 Range m	C2 Partial Sill	C2 Range m	Total Sill
Ag	0.9	0.18	10	1	85	2.1
Au	0.6	0.125	10	0.6	90	1.3
Pb	1.2	0.5	40	0.5	80	2.2
Zn	1.14	0.6	40	0.4	80	2.1

Although grade-distance relationships were investigated, the ultimate search distances, classifications, orientations, and anisotropies implemented were guided by a combination of the results of the Ag and Au variography, visual review of the vein and professional judgment.

14.5.1.1 Principal Vein Estimation

A 3D block model was created for each of the principal veins, with block sizes of 4x4x4 m. Block percent on vein was assigned to an attribute within the block using the vein wireframe models. Principal vein block models utilized dynamic anisotropy for each block in the model. A direction was assigned to each block by Micromine using the wireframe vein models. The search ellipse was then oriented based on this information in each block, providing a dynamic search that follows the curves of the vein as modeled.

14.5.1.2 Secondary Vein Estimation

A tilted and rotated point model was generated from the nodes of the modeled vein centerline surface for the secondary veins. This was possible because each surface was triangulated on a grid with 4 m by 4 m cells. The point models generated are not typical fixed array block models. The location of each node is dependent on the interpolated surface and not centered at typical block model centroids. Each point node has been assigned the vein ID and estimated grade and thickness attributes for the secondary veins, search orientation, anisotropies, and maximum ranges are shown in **Table 14-6**.

Table 14-6: Vein estimation parameters for secondary veins

Vein Name Character	Dip+	Dip Direction+	Radius Pass1	Axis1 Azi	Axis1 Plunge	Axis2 Plunge	Vein Name Character	Dip+	Dip Direction+	Radius Pass1	Axis1 Azi	Axis1 Plunge	Axis2 Plunge
D2_NW	76	57	75	57	76	0	E1_NW	72	46	75	46	72	0
SantaJuana_NW	75	58	75	58	75	0	EE_NW	72	66	75	66	72	0
SantaJuana_SE	75	49	75	97	70	-14	Trans_NW	70	182	75	130	53	30
SantaJuanaFW1_SE	77	51	75	97	70	-14	VetaOriente_NW	54	15	75	338	51	19
Trans_Alto_NW	70	182	75	130	53	30	A1_SE	75	49	75	140	58	32
A1_NWHW1	76	57	75	65	79	0	A2_SE	72	35	75	55	80	0
A2_NW	76	57	75	68	79	0	AA4SE_A4Alto	77	50	75	54	77	0
A3_NW	76	57	75	68	79	0	D1_SE	77	47	75	47	77	0
Bs_NW	74	58	75	65	79	-5	ChicagoNE	72	140	75	140	72	0
Bs_NWhw	73	40	75	65	79	-5	Gambusino_NE	65	140	75	140	65	0
G2_NW	77	35	75	35	77	0	Gambusino_SW	60	150	75	150	60	0
C0_NW	84	40	75	112	73	-16	Nueva	74	160	75	160	74	0
C2_NW	78	34	75	40	73	1	Brenda	79	148	75	148	79	0
D0_NW	76	57	75	57	76	0	LosMuertos	86	150	75	258	83	7
D1_NW	76	57	75	57	76	0	San Juanes	60	3	75	25	60	-7
DD_NW	76	57	75	57	76	0	San Juanes_fw1	60	325	25	25	60	-7
Ds_NW	75	48	75	48	75	0	Estrato_Chicago	82	168	75	168	82	0
E_NW	60	51	75	51	60	0							

14.5.2 Resource Classification

Block attributes were estimated in three passes from small to large. **Table 14-7** details the search ellipse sizes and orientations along with sample selection criteria and classification. Resource classification was assessed by pass (maximum search), number of samples, and the nearest composite and average distance. Maximum extrapolation and therefore total potential was limited by the extent of the modeled vein surface as well as the clipping limitations where veins were known to be limited. Measured or Indicated classification was only permitted in pass one, 75 m maximum search, and was primarily, but not exclusively, defined within blocks haloing the existing drifts and stopes.

Table 14-7: Pass parameters and classification

Pass	Method	Max Search	Ratio 1st:2nd:3rd	Sectors	Max Per Sector	Comp Min	Comp Max	Classification
First	IDW 2.5	75	See vein parameter table	4	2	1	8	Inferred, Indicated if; comps >=3 and nearest comp <= 50m, Measured if; comps >=4 and nearest comp <= 16m and average comp distance <= 25
Second	IDW 2.5	150	1:0.25:0.5	1	2	1	2	Not classified, Inferred if; nearest comp <= 125m
Third	IDW 2.5	200	1:0.5:0.5	1	2	1	2	Not Classified

14.5.3 Dilution

Grade and thickness estimations were completed as undiluted. Diluted thickness and grades were calculated after estimation. The dilution assumes a minimum mining width of 0.70 m, and has accounted for hanging wall and footwall waste where true thickness was less than 0.70 m. If a block is estimated to have a true thickness less than 0.70 m, the diluted thickness is 0.70 m. If a block is estimated to have a true thickness greater than or equal to 0.70 m, the diluted thickness is equal to true thickness. Grades and tonnes were diluted by the ratio of true thickness to diluted thickness. Variable vein density was used for the true thickness vein portion and the waste portion was assigned a density of 2.6 g/cm^3.

14.5.4 Cutoff Grade and NSR Calculation

Resources have been tabulated using a $175/t NSR cutoff grade for each 4 m by 4 m block with the price assumptions shown in **Table 14-8**. The Resource tabulation is based on the long-term average consensus prices from 40 banks. The prices used are $23.70/oz-Ag, $1,744/oz-Au, $0.97/lb.-Pb, and $1.15/lb.-Zn.

Table 14-8: Cutoff price assumptions

Assumption	Value
Ag Price $/oz	23.70
Au Price $/oz	1,744
Pb Price $/lb.	0.97
Zn Price $/lb.	1.15

NSR has been calculated with concentrate characteristics and marketing terms supplied by Golden Minerals. Metal contributions are dependent on the concentrate and mineral type, and the overall recoveries are shown in **Table 14-9**.

Table 14-9: NSR metallurgical recovery assumptions

Metal	Sulfide Metallurgical Recovery %
Au	67
Ag	90
Pb	72
Zn	77

For the oxide and mixed NSR equations the payable terms were combined as single factors with the recoveries and were provided by Golden Minerals. Oxide and mixed mineral types are not the subject of the subsequent sections of this report that assess preliminary economics. Independent NSR cutoff calculations have been applied to oxide and mixed mineral types, but the tabulated Resources have been grouped in the oxide category. The sulfide NSR equation has been updated for proposed mining areas that are the subject of this PEA and is based on metallurgical testing from that area.

14.6 Deleterious Elements

Deleterious elements that are relevant to the potential extraction of Resources are As and Sb. The Project database has inconsistent coverage for these elements. Recently collected channel and drill hole samples have the most complete information for As, but Sb is limited to recent drilling. Concentrate characteristics for As and Sb, determined through testing and mill actuals, have been used for purposes of Resource NSR cutoff calculations, instead of the incomplete project drill hole and channel database. This approach is the best alternative because the presence of As and Sb is most relevant in achieved concentrates; however, it does not account for spatial variability.

14.7 Statement of Resources

Resources at a $175 NSR cutoff are shown in **Table 14-8. Figure 14-8** to **Figure 14-15** show the grade and tonnage relationship at a range of NSR cutoffs using the base case price inputs.

Table 14-10: Velardeña Project Mineral Resources

Classification	Mineral Type	NSR Cutoff	Tonnes	Grade Ag g/t	Grade Au g/t	Grade Pb%	Grade Zn%	Ag oz	Au oz	Pb lb.	Zn lb.
Measured	Oxide	175	128,800	268	5.69	1.74	1.53	1,108,000	23,500	4,936,000	4,333,400
Indicated	Oxide	175	280,300	262	5.06	1.73	1.45	2,361,200	45,600	10,681,500	8,936,600
Measured + Indicated	Oxide	175	409,100	264	5.26	1.73	1.47	3,469,200	69,100	15,617,500	13,270,000
Inferred	Oxide	175	351,400	417	4.95	2.55	1.45	4,714,600	56,000	19,729,500	11,248,200
Measured	Sulfide	175	256,200	357	5.52	1.56	1.91	2,942,800	45,500	8,819,300	10,769,700
Indicated	Sulfide	175	603,500	341	4.79	1.46	1.91	6,619,400	92,900	19,475,600	25,408,900
Measured + Indicated	Sulfide	175	859,700	346	5.01	1.49	1.91	9,562,200	138,400	28,294,900	36,178,600
Inferred	Sulfide	175	1,357,700	348	4.76	1.52	1.97	15,179,000	207,800	45,534,200	58,952,900
Measured	All	175	385,000	327	5.58	1.62	1.78	4,050,800	69,000	13,755,300	15,103,100
Indicated	All	175	883,800	316	4.88	1.55	1.76	8,980,600	138,500	30,157,100	34,345,500
Measured + Indicated	All	175	1,268,800	319	5.09	1.57	1.77	13,031,400	207,500	43,912,400	49,448,600
Inferred	All	175	1,709,200	362	4.80	1.73	1.86	19,893,600	263,800	65,263,700	70,201,100

Notes:

(1) Resources are reported as diluted tonnes and grade to 0.7 m fixed width

(2) Metal prices for NSR cutoff are: $23.70/oz-Ag, $1,744/oz-Au, $0.97/lb.-Pb, and $1.15/lb.-Zn

(3) Columns may not total due to rounding

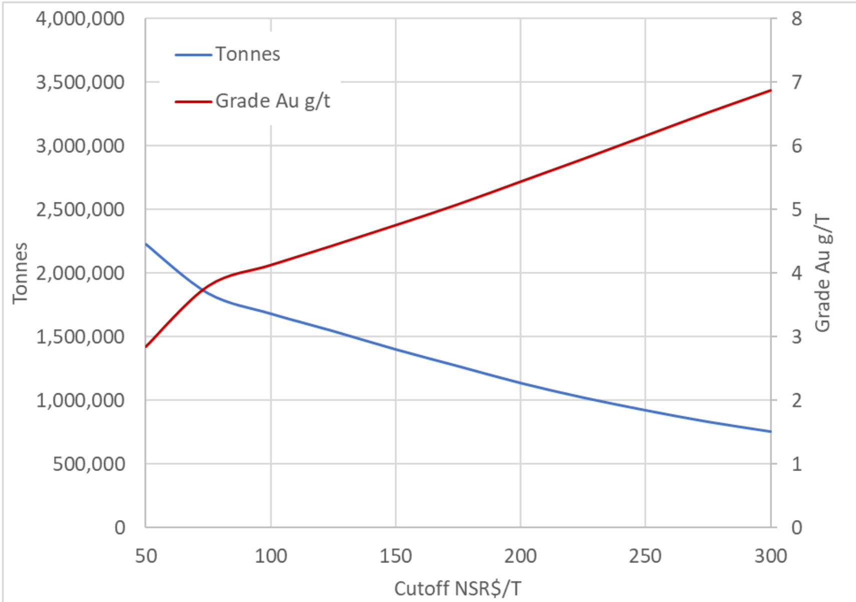


Figure 14-8: Grade tonnage curve, Measured and Indicated, oxide and sulfide, Au

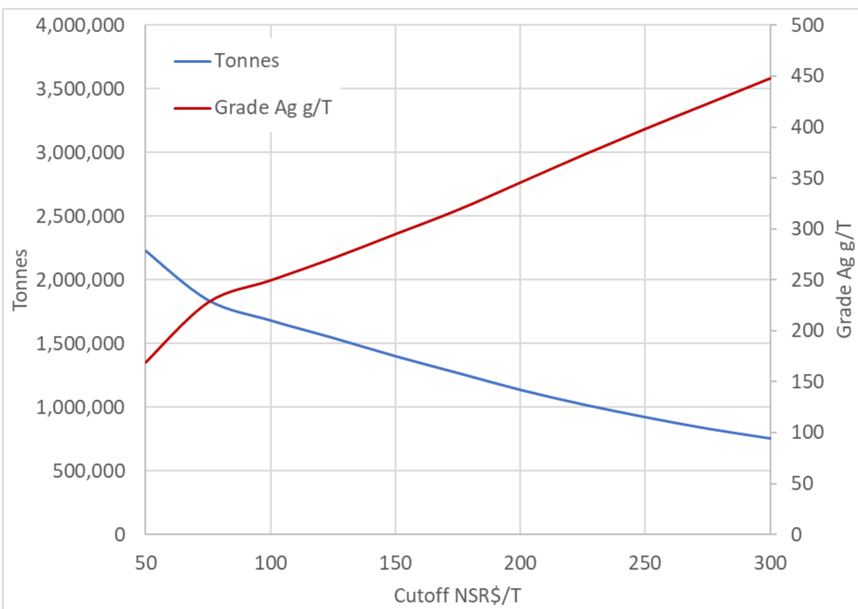


Figure 14-9: Grade tonnage curve, Measured and Indicated, oxide and sulfide, Ag

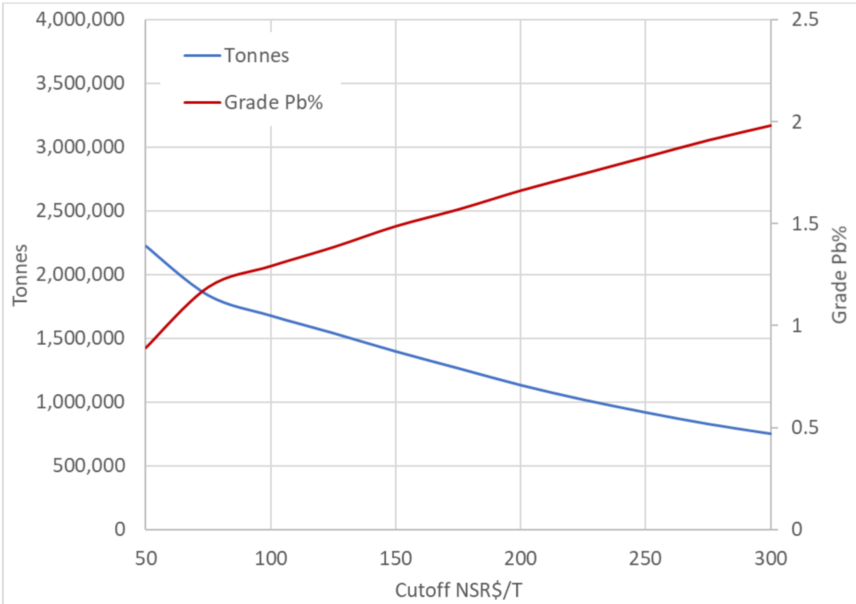


Figure 14-10: Grade tonnage curve, Measured and Indicated, oxide and sulfide, Pb

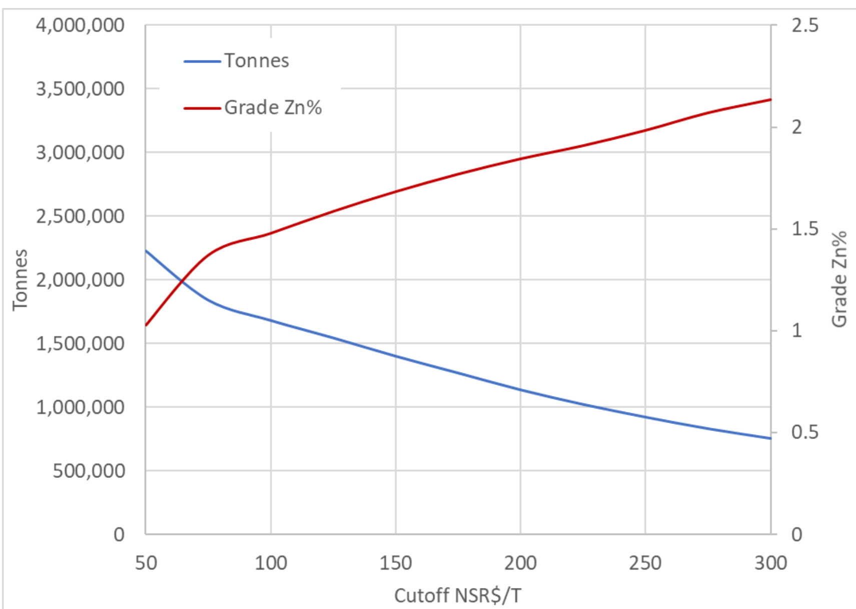


Figure 14-11: Grade tonnage curve, Measured and Indicated, oxide and sulfide, Zn

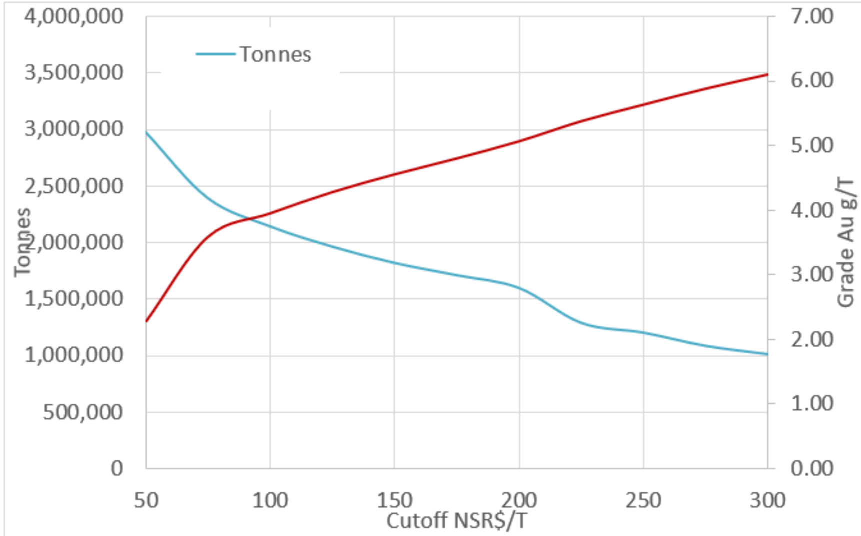


Figure 14-12: Grade tonnage curve, Inferred, oxide and sulfide, Au

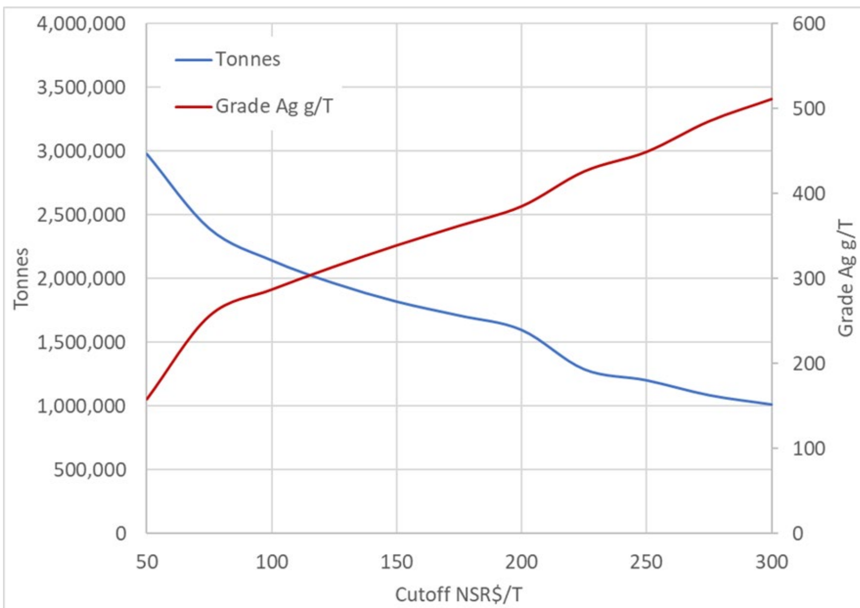


Figure 14-13: Grade tonnage curve, Inferred, oxide and sulfide, Ag

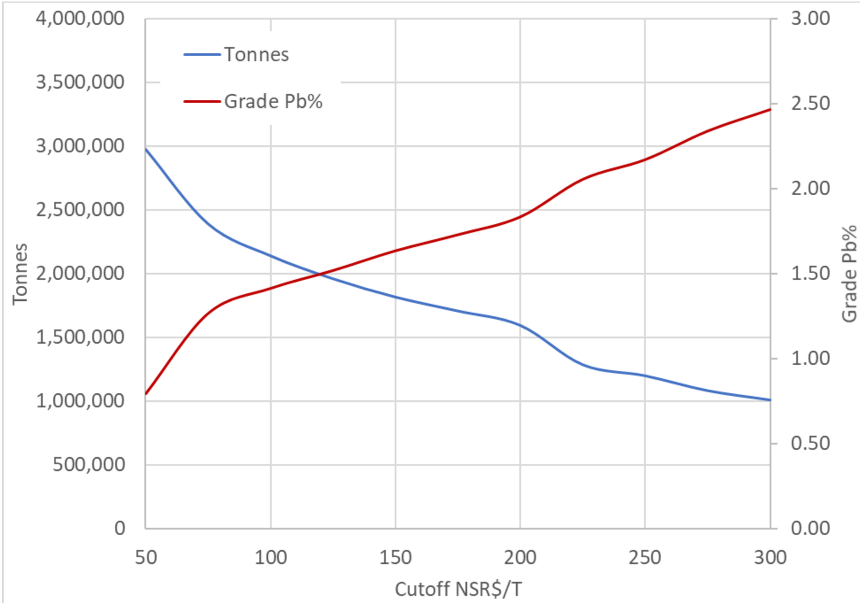


Figure 14-14: Grade tonnage curve, Inferred, oxide and sulfide, Pb

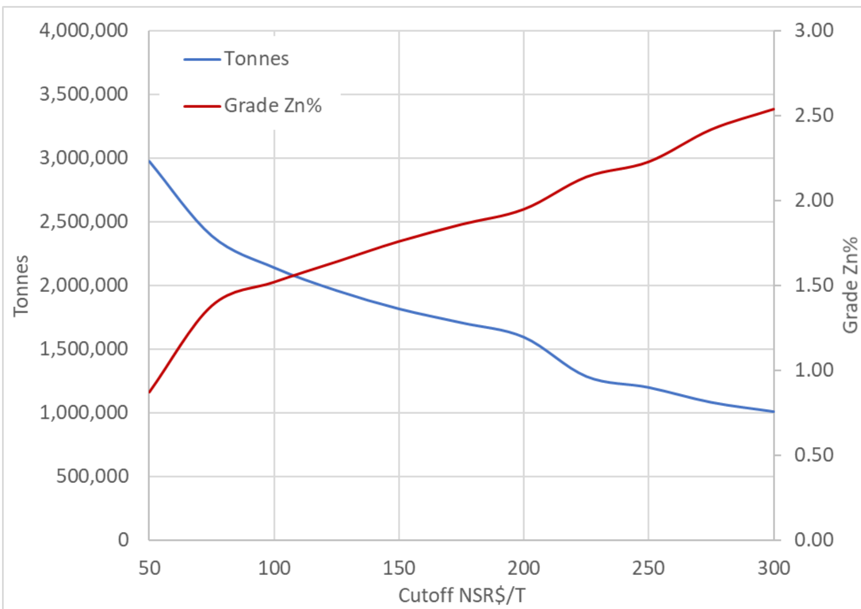


Figure 14-15: Grade tonnage curve, Inferred, oxide and sulfide, Zn

14.8 Model Verification

Resource estimations have been verified by visual review and population analysis.

The grade population was tracked for Ag from input assays (drill hole and channel), to composites, and to block grades. The grade progression histograms were compared as population relative as well as log-normal transformed. The population comparison shows the means throughout the progression are sufficiently similar and that the high-grade component of the raw assays and composites have been satisfactorily moderated in the block population.

Long-section review of composite samples and block grades verify that the estimation respects the input data well. **Figure 14-16** to **Figure 14-19** is a series of long-sections looking north for the San Mateo vein as an example, showing composite values and resulting block grades for Ag, Au, Pb, and Zn. **Figure 14-20** shows the location of channel samples and the location of drill hole intercepts in relation to blocks classified as Measured, Indicated, and Inferred.

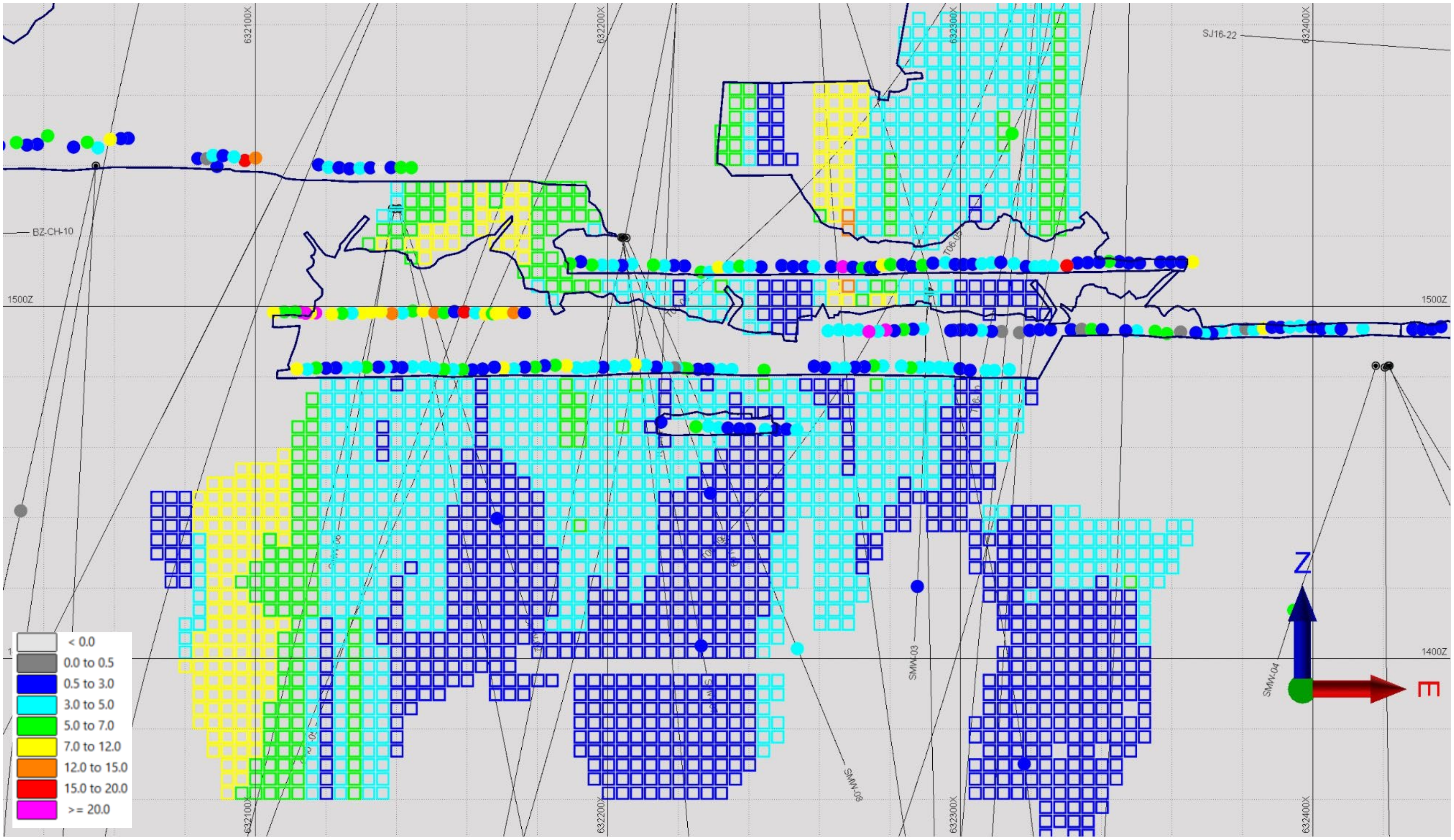


Figure 14-16: Long section San Mateo vein Au, composites, and blocks in g/t.

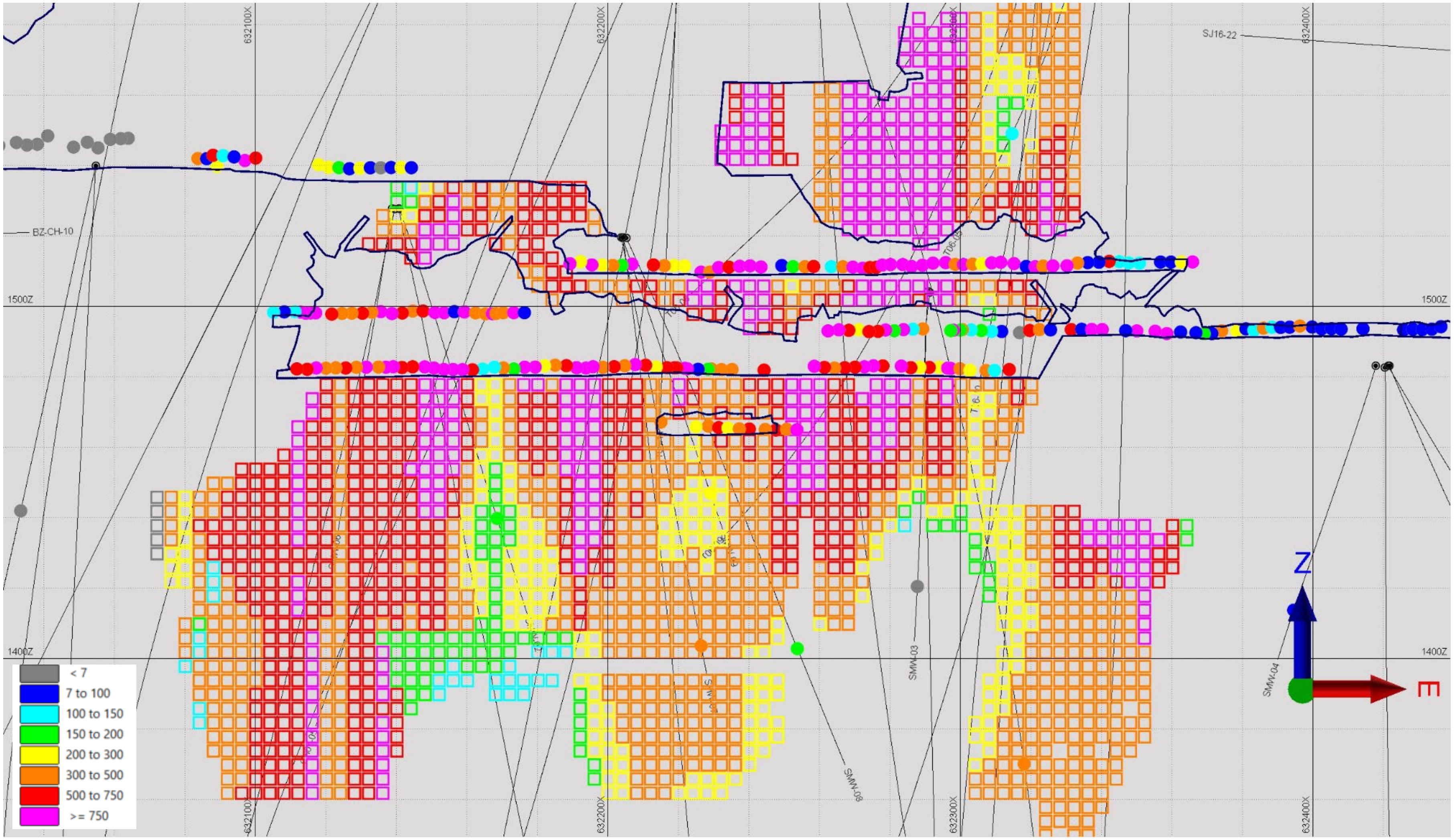


Figure 14-17: Long section San Mateo vein Ag, composites, and blocks in g/t.

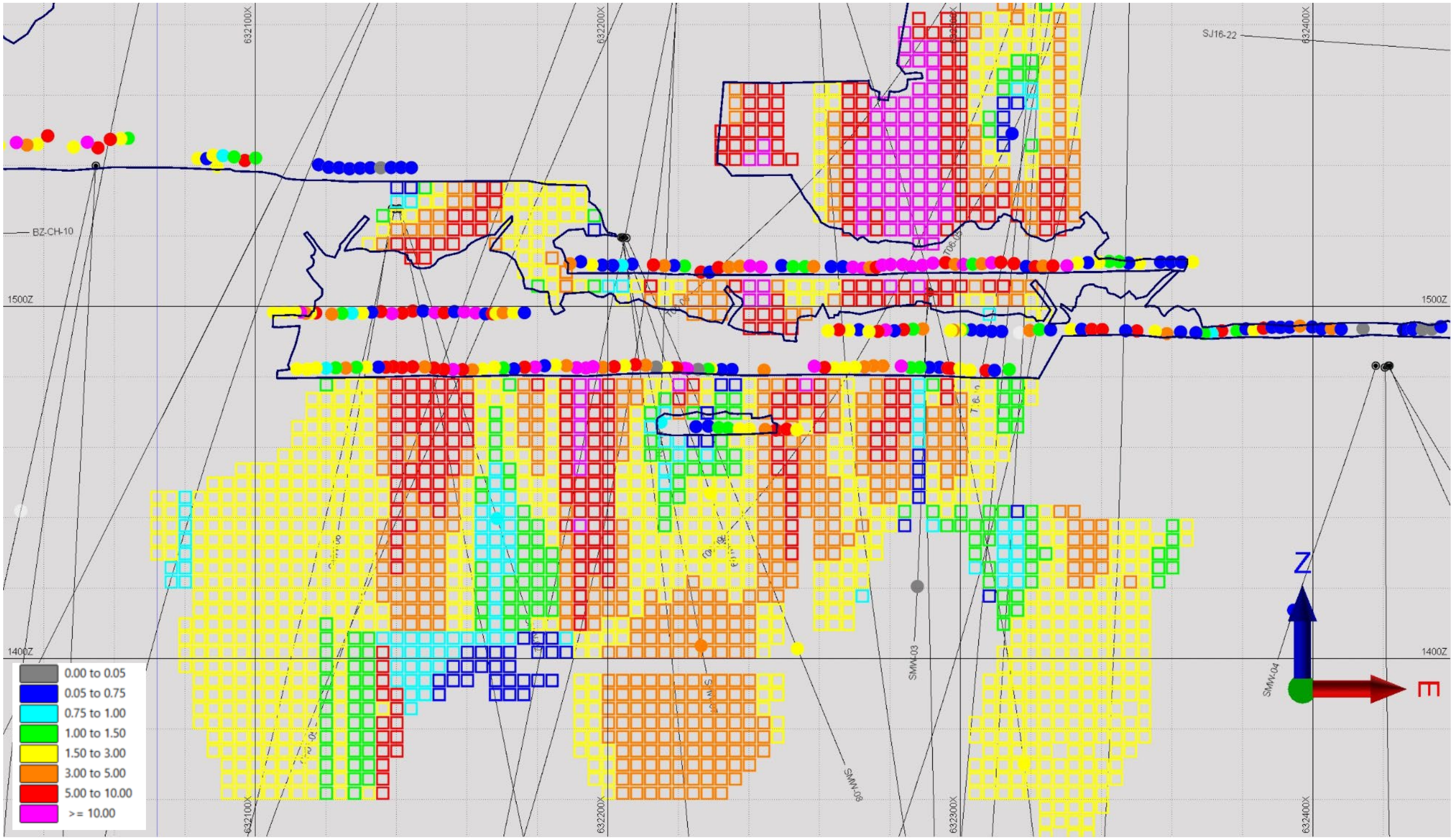


Figure 14-18: Long section San Mateo vein Pb%, composites, and blocks

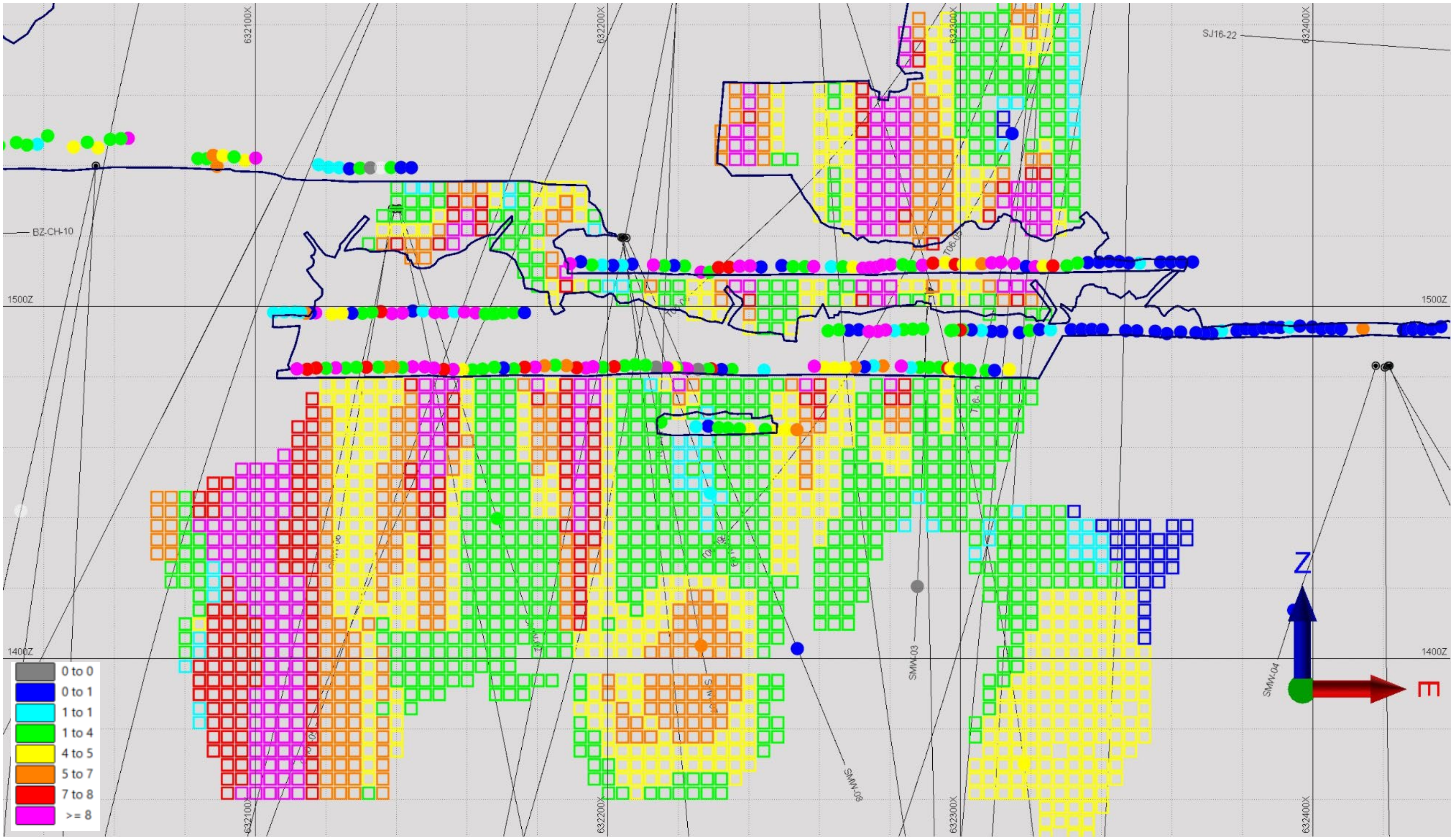


Figure 14-19: Long section San Mateo vein Zn%, composites, and blocks

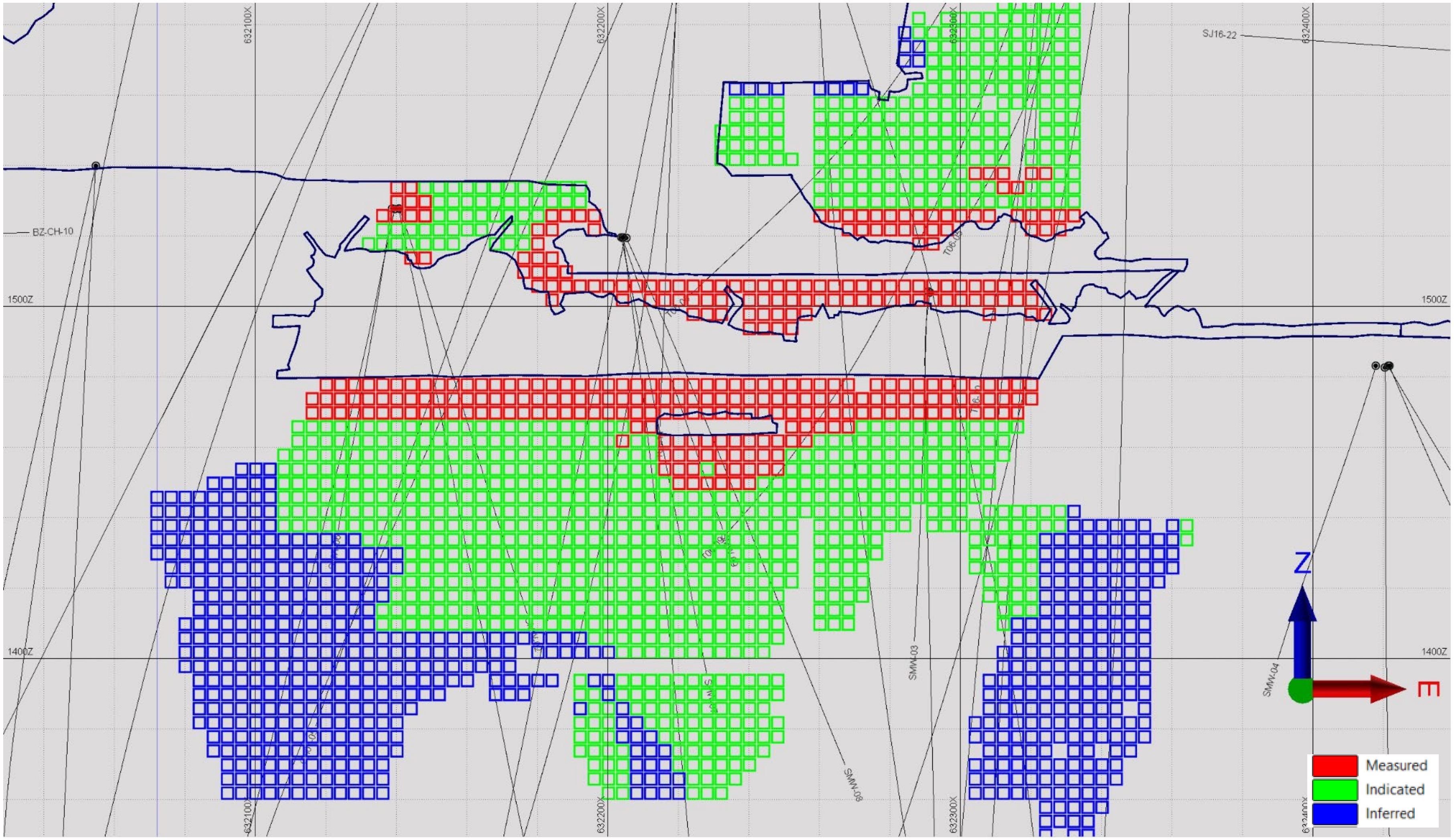


Figure 14-20: Long section San Mateo vein classification

14.9 Resource Expansion Targets

The following discussion of Resource expansion targets is conceptual in both tonnage and grade. There has been insufficient exploration to define these areas as a Mineral Resource and it is uncertain if further exploration will result in the target being delineated as a Mineral Resource. Quantification of Resource expansion potential is presented in **Table 14-11** and has been limited to the extent of the vein surface buffers and the potential classification estimated within passes two and three. Maximum extrapolation is 150 m and maximum search is 200 m. True Resource expansion potential is most likely much greater but additional quantifications cannot currently be justified. Previous estimates for potential were extrapolated 300 m from data points excluding the tonnage where Resources were classified; whereas this estimate for potential only represents the distance between the currently defined Resources and the maximum vein buffer, 105 m to 150 m, with the classified Resource excluded. In comparison to the previous, this estimate for potential is substantially more conservative.

Table 14-11: Quantifiable Resource expansion targets

Mineral Type	Cutoff NSR	Tonnes	Grade Ag g/t	Grade Au g/t	Grade Pb%	Grade Zn%
All	50	1,000,000 to 1,500,000	175 to 225	3 to 4	1 to 1.5	0.5 to 1

Notes:

(1) Resource expansion potential is not Resource and is not a recognized Resource category under SEC Industry Guide 7 or NI 43-101

(2) Resource expansion potential is reported as diluted tonnes and grade

(3) There is no guarantee or expectation that the above tonnage can be demonstrated or upgraded to a recognized Resource classification

Most of the known veins' strike extents have been identified by exploration but in many cases mineralized shoots at depth have not yet been defined nor have the down dip extensions been condemned. It is likely that as deeper levels are developed additional mineralized shoots will be identified and enrich the Resource base. Demonstrating Measured and Indicated Resources below existing development levels is particularly difficult in a mine of this mineralization style. Resource expansion is unlikely to outpace level development due to the cost of drilling versus the achieved sample spacing.

Deep wedge drilling under the Tres Aguilas southeast fault block in the Santa Juana Mine area shows encouraging intercepts well below the deepest quantified potential. These intercepts have not been included in resource estimation because sufficient information regarding mineralizing style and orientation is not known. They do however suggest the system is mineralized well below the current Resource area.

14.10 Relevant Factors

If subsequently converted to Reserves and mined, the inability to precisely predict the true shape and orientation of mineralized shoots could materially affect the Mineral Resources. The geologic controls dictating the extents of the mineralized shoots are not currently known in much of the Inferred Resource areas. Interpolation and extrapolation of channel and drill hole samples represents an unbiased approximation of mineralized shoot shape but will fall short of predicting the shape exactly.

NSR calculations are based on reasonable price and contract assumptions. The inability to market concentrates or changes in prices or contract terms could materially affect the quantified Resources in relation to the NSR cutoff. The estimation of *in-situ* tonnage and grade attributes estimated would not be affected.

There are no additional environmental, permitting, legal, title, taxation, socio-economic, marketing, political, or other relevant factors that Tetra Tech is aware of that could materially affect the Mineral Resource estimate. The property has been in operation and many of the above factors have been studied in detail and addressed in the initial permitting process and have not affected the Resource estimates to date. It is possible complications with any or all the above-mentioned factors could arise in the future, but currently no material complications are known.

Once the mine starts operations, it is recommended to closely check the productivity of the new bio-oxidation plant to verify if the expected results are obtained.

15. MINERAL RESERVE ESTIMATES

Mineral Reserves were not calculated for the Velardeña Project.

16. MINING METHODS

The Project is planned to be operated as an exclusively underground operation. The current mine plan includes only the sulfide material from the principal veins, which include veins CC, C1, A4, F1, G1, San Mateo, Roca Negra, Hiletas, Terneras, Chicago, and Escondida. The plan targets an annual maximum of 112,775 tonnes.

The past extraction methods used at the Velardeña mines are mechanized cut and fill stoping and mechanized resuing cut and fill stoping. These two techniques are considered for the PEA and are discussed below. These methods are suitable for the steeply dipping veins found at the Project.

16.1 Resue Cut and Fill Stoping

Mechanized resue cut and fill stoping is used when a vein system contains high grade material in a narrow width, less than one meter in width for the Velardeña vein packages. The following sequence outlines the stope life:

- Resue stoping begins by accessing the vein from a development drift with an attack ramp that enters the vein at a near perpendicular angle. The slope of the attack ramps ranges from -27% (initial) to +27% (final) to keep the attack development length to a minimum.
- The excavation of the stope's sublevel is driven away from the attack ramp intersection on vein. The sublevel is excavated using a horizontal resue technique; the footwall side of the face is excavated to one meter width for a single drill-round, followed by a slab waste round on the hanging wall side that brings the sublevel's final width for the single drill round to +/-2.0 m. The single round horizontal resue technique is continued until the longitudinal boundaries of the process grade material is reached. Internal waste chutes encountered in the sublevel are excavated to the final sublevel width, +/-2.0 m, with a single drill round. The sublevel is also taken in a single drill round when the mineralized material is greater than the resue cutoff width.
- The first cut will start once the sublevel is complete; the process grade material in the back will be drilled with vertical holes outlining the width of the process grade material; the minimum width is 0.7 m. The drilled process grade material will be blasted and mucked from the stope before the widening of the excavation is started. The waste material will be blasted to bring the excavation to a final width of +/-2.0 m, the blasted waste material will not be removed from the stope.
- The attack ramp will be slabbed, to enable smooth access to the stope excavation, with each resue cut.
- Waste from mine development areas or the surface will be hauled into the stope as fill to bring the sill level up to approximately 2.2 open vertical meters (the fill is the floor for working on the next cut).
- Tailings from Plant 1 will be spread in the stope on top of the course fill to reduce dilution and losses.
- The excavation of cuts continue until the top of the stope block is reached, 30 meters for the Velardeña mine plan.

The top of the stope block usually has a three-meter crown pillar that will be left to support the fill in the stope above. An engineered crown pillar can be constructed in the sill above the block so that the entire 30 vertical meters can be extracted; however, this normally occurs in areas of very high grade. The typical daily production for resue stoping at Velardeña is planned to be 20 to 30 tonnes per day of process grade material; the stope unit rate production is highly dependent of stope length. **Figure 16-1** displays a typical resue cut and fill stope.

Ventilation of the stope is gained by installing an Axivane fan in the development where the attack ramp begins. Brattice vent line, usually 24 to 30 inches, extends from the fan to the working faces in the stope. The development also contains main piping for compressed air, drill water, and drainage. Typically, HDPE lines are extended from the main lines located in the development to the working faces. The brattice vent line and HDPE service lines are removed and re-installed each time the attack ramp is slabbed.

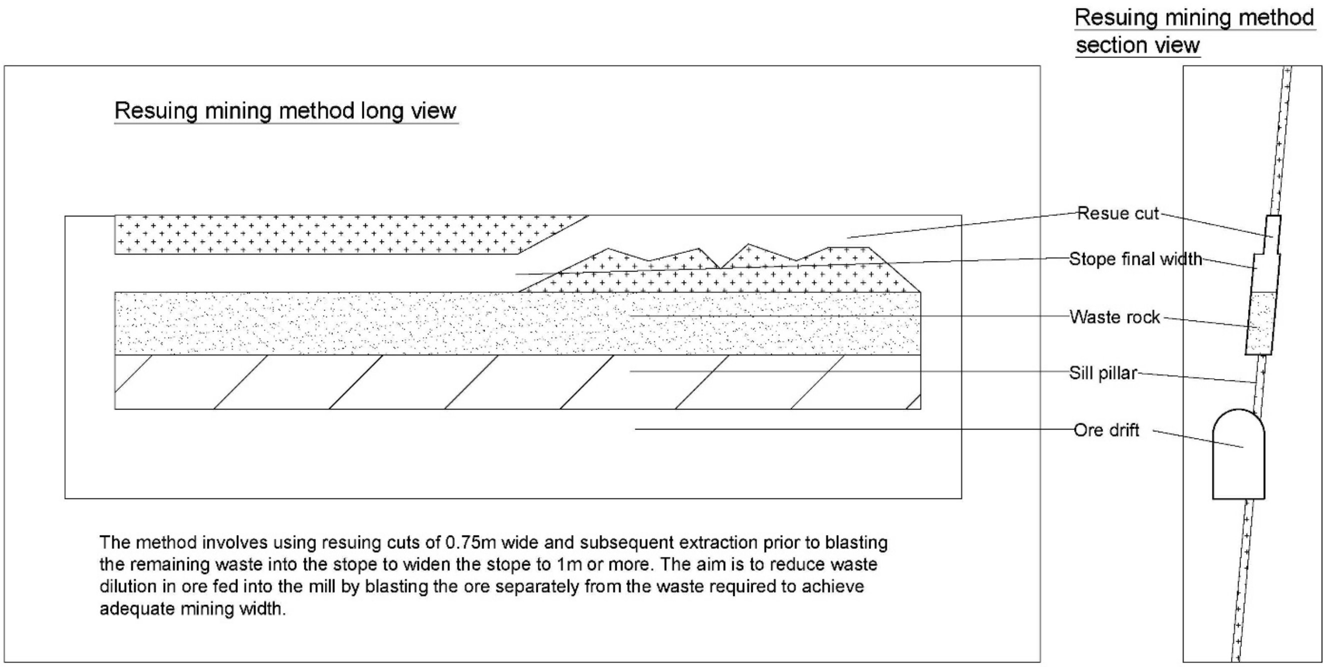


Figure 16-1: Illustration of resuing mining method as applied at Velardeña

16.2 Mechanized Cut and Fill Mining

Mechanized cut and fill stoping is planned to be used when a vein system contains process grade material in a width greater than 1.8 meters; or when an area can be mined without the resue technique because the material with dilution is above the cutoff grade. The following sequence outlines the stope lifecycle:

- Cut and fill stoping begins by accessing the vein from a development drift with an attack ramp that enters the vein at a near perpendicular angle. The slope of the attack ramps ranges from -27% (initial) to +27% (final) to keep the attack development length to a minimum.
- The excavation of the stope's sublevel is driven away from the attack ramp intersection on vein developing the sublevel at the width of the process grade material or the minimum width.
- The first cut will start once the sublevel is complete; the back will be drilled with vertical holes at the width of the process grade material or the minimum width. The drilled material will be blasted and mucked from the stope.
- The attack ramp will be slabbed, to enable smooth access to the stope excavation, with each resue cut.
- Waste from mine development areas or the surface will be hauled into the stope as fill to bring the sill level up to approximately 2.2 open vertical meters (the fill is the floor for working on the next cut).
- Tailings from Plant 1 will be spread in the stope on top of the course fill to reduce dilution and losses.
- The excavation of cuts continue until the top of the stope block is reached, 30 meters for the Velardeña mine plan.

- The top of the stope block usually has a three-meter crown pillar that will be left to support the fill in the stope above. An engineered crown pillar can be constructed in the sill above the block so that the entire 30 vertical meters can be extracted; however, this normally occurs in areas of very high grade. The typical daily production for stoping at Velardeña is planned to be 40 to 50 tonnes per day of process grade material; the stope unit rate production is highly dependent of stope length.

16.3 Geotechnical Analysis

A geotechnical analysis for the Project has not been conducted or reviewed by Tetra Tech. The mine has historically operated without significant underground support. Several areas of the underground workings were inspected during the site visit, and it was observed that the rock mass is competent and self-supporting. No areas of concern were noted. It is recommended that, for mining at depth greater than the current, the services of rock engineering firms are engaged to provide expertise on stope layout and future potential rock mass stability concerns that may arise due to increased stress and/or depth.

16.4 Dilution

Due to the narrow vein widths, waste dilution is greater than typical for underground mining operations. **Table 16-1** outlines the estimated dilution methods for the PEA. In addition, a minimum drift width of 2.5 m has been estimated for stope development.

Stopes have been planned to use a weighted average vein width of 0.67 m, with a weighted average stoping width of 0.98 m, resulting in an average dilution of 42% for stoping and 171% for development.

Table 16-1: Mining dilution estimation parameters

Mining Method	Minimum Mining Widths	Dilution Applied
Resue	0.7 m	Vein width less than 0.5 - mining width is estimated at 0.7 Vein widths above 0.5 - mining width is estimated as vein width plus 0.2 m
Cut and fill	3.0 m	Vein width less than 2.6 m - mining width is estimated at 3 m Vein widths above 2.6 m - mining width is estimated as vein width plus 0.4 m

16.5 Mining Extraction and Recovery

Overall extraction of planned stopes has been estimated at 93%.

For this PEA, the loss of Resources available to mining through mining extraction losses has been considered. The considerations include stoping with both shrinkage and resue mining which require the leaving of rib, sill, and crown pillars. For the PEA, rib, sill, and crown pillars have been included as 3 m in width.

A mining loss of 5% has been included, which accounts for blasted material left *in-situ* in stopes, above pillars and in stope drifts after stope completion.

16.6 Mining Equipment

Table 16-2 shows the list of equipment available at the Project as provided by Golden Minerals. The key pieces of equipment required for mining are scoop-trams, underground trucks, and drilling jumbos. The current equipment fleet is expected to be adequate to achieve the 373 tpd of mill feed for processing and, as such, no additional equipment is expected to be purchased. Not listed here, but owned by Golden Minerals, are jacklegs required for stoping and underground development (narrow drifts), and ventilation equipment for use underground.

Table 16-2: Velardeña equipment list

List of Available Equipment					
#	Tag #	Model	Manufacturer	Series	Motor
Scoop Trams					
1	ST-1	MTI-270	MTI	3215	Deutz F5L912W
2	ST-04	EJC 100A	Emco Jarvis Clark	9171808	Deutz F6L413FW
3	ST-8	LT-125	MTI	509	Deutz F4L912W
4	ST-13	LT-270	MTI	9171808	Deutz F5L912W
5	ST-10	EJC-100	Sandvik	O8861795	Deutz F6L914
6	ST-11	ST-2D	Wagner	RBO42009	1RBO42009
7	ST-17	ST 1030	Atlas Copco	AVO 11X265/8997 3178 00	Cummins QSL
8	ST-18	LT-250	JCI	67695	Deutz F6L914
9	ST-19	LH-203	Sandvik	L203D767	Deutz BF6L914
10	ST-20	LH-203	Sandvik	L103D778	Deutz BF6L914
11	ST-23	LT-210	MTI	4314	Deutz F4L912W
12	ST-24	LT-210	MTI	4313	Deutz F4L912W
13	ST-25	ST 1030	Atlas Copco	AVO 07X430/8997 149900	Cummins QSL
14	ST-26	LH-203	Sandvik	L003D685	Deutz BF6L914
15	ST-27	LH-203	Sandvik	L103D787	Deutz BF6L914
16	ST-28	LH-203	Sandvik	L007D303	Deutz BF6L914
17	ST-29	LH 307	Sandvik	L007D303	MB OM906LA
18	ST-30	LH-203	Sandvik	L203D790	Deutz BF6L914
19	ST-31	50M	JCI	87388	
Drilling Jumbos					
1	JB-01	Boomer S1D	Atlas Copco	AVO 11A239/8991894700	
2	JB-03	Boomer S1D	Atlas Copco	AVO 08A640/8991 7 74400	Deutz D914L04
3	JB-02	Boomer T1D	Atlas Copco	AVO11A362/8991895700	
Motor Grader					
1	MOTO-01	CAT 140M	Caterpillar	CAT0140MLB9D02937	
Personnel Transport (Underground)					
1	KU-01	RTV 900	Kubota	A5KB1FDACBG0C4080	
2	KU-02	RTV 900	Kubota	A5KB1FDACBG0C4078	
3	KU-03	RTV 900	Kubota	A5KB1FDAHBG0C6068	

List of Available Equipment					
#	**Tag #**	**Model**	**Manufacturer**	**Series**	**Motor**
4	KU-04	RTV 900	Kubota	A5KB1FDAKBG0C7535	
5	KU-06	RTV 900	Kubota	A5KB1FDAPCG0D4307	
6	KU-07	RTV 900	Kubota	A5KB1FDAACG0D1107	Kubota D902-ET03
7	KU-08	RTV 900	Kubota	A5KB1FDACG0D3167	
8	KU-08	RTV 900	Kubota	A5KB1FDACG0D3167	
9	KU-10	RTV 1140	Kubota	A5KB1FDAHCG0D6374	
Underground Trucks					
1	CBP-01	JCI 704	MTI		Deutz F6L914
2	CBP-02	JCI 704	MTI		Deutz F6L914
3	CBP-05	JCI 704	MTI	RB-148-0812	Deutz F6L914
4	CBP-06	JCI 704	MTI	RB-149-0812	Deutz F6L914
5	CBP-07	MT 431B (264)	Atlas Copco	AVO 12X463/8997 4225 00	Detroit S-60
6	CBP-08	MT 431B (265)	Atlas Copco	AVO12X513	Detroit S-60
7	CBP-09	TH-320	Sandvik	4565	Mercedes-Benz
8	CBP-10	TH-320	Sandvik	4649	Mercedes-Benz
Front End Loader					
1		916	Caterpillar	2XB01887	
2		930G	Caterpillar	CAT0930GETWR02020	
3		930G	Caterpillar	CAT0930GHTWR01237	
Telehandler					
1	TH-01	TH 580 B	Caterpillar	CATTH580JSLH01098	
TLB (Tractor, Loader, Backhoe)					
1		420E	Caterpillar	CAT0420ELKMW01116	
2		416E	Caterpillar	CAT0420ELKMW1116	
3		416D	Caterpillar	CAT0416DAB2D00688	
Bobcat					
1		236B	Caterpillar		
Compressors and Generators					
1	COM	TS-20-250-60	Sullair	9963	
2	COM	SSR-EPE300	Ingersoll Rand	E1241U94053	
3	COM	EAU99P	Gardner Denver	S290593	

List of Available Equipment					
#	**Tag #**	**Model**	**Manufacturer**	**Series**	**Motor**
4	COM	SSR-XF100	Ingersoll Rand	F8769U94104	
5	COM	267913U66327	Ingersoll Rand	185WJD-196-D	
6	COM	P375WCU	Ingersoll Rand	309961UCK413	
7	COM	9185WJD	Ingersoll Rand	347689UG0221	
8	COM	P185WJD	Ingersoll Rand	267913UGG327	
9	COM	ZR-4	Atlas Copco		
10	GEN	432R5L2014A-L00W		UH3509556	
Tractors					
1	TR-01	2635	Massey Ferguson	FX729539	TSJ436E 05190 / MF 2635 4WD STD2
2	TR-02	2635	Massey Ferguson	FX729535	MF 2635 4WD STD2
3	TR-03	2635	Massey Ferguson	FX752999	MF2635 /MF 2635 4WD STD2
4	TR-04	2635	Massey Ferguson	FX777239	MF2635 /MF 2635 4WD STD2
Vehicles for Transporting Personnel and Cargo					
14	EX65140	International	Chasis Cabina Tandem 740		
15	EX01679	International	Chasis C 7400-300 Camión		
18	EX01622	International	Chasis C 4400-250 Camión		
33	EX05301	International	Chasis Coraza 3300 210 CE		
34	EX01616	International	Chasis Cabina 7400 310		
35	EX01625	International	Chasis Cabina 7400 310		
4	EX05302	International	Autobus 4700 22 FE		

16.7 Waste Rock

Waste rock from the underground mine consists of tonnage from the ramp and lateral development. Since the mining methods include cut and fill, the waste from the stopes would either be stored underground in mined out stopes or transported to the mill with the diluted mined material. Limited cut and fill mining is planned and, as such, most of the waste rock is planned for surface storage.

The waste rock that would not be stored underground would be contained along the valley between the San Mateo adit and the Santa Juana adit.

16.8 Tailings

The dry tailings placed near Plant 1 are suitable for spreading on the fill of each cut to eliminate the dilution and losses associated with blasting process grade material on course placed fill. Tailings will be hauled from Plant 1 to the active mine and dumped at a centralized area. Trucks will then haul the tailings underground to a stope area where an LHD will spread the material on top of the recently placed course fill, a cover of approximately 15 cm. The planning and calculated production rates used in this estimate contain time for placing the tailings cover.

16.9 Dewatering

Neither a water balance nor dewatering investigations were performed for this PEA. The water handing system currently in place relies on a chain of submersible dirty water pumps to evacuate the inflow from the mine. No significant water infiltration was noted at the underground mine site during the site visit. Seepage and dewatering are not expected to be of concern; it is not anticipated that excessive dewatering costs will be incurred during the life of mine, but further studies are recommended to confirm this.

16.10 Ventilation

The current underground workings at the Project are naturally ventilated, with the main ramp used as an intake airway and the old Santa Juana mining areas and shafts for exhausting air. However, Golden Minerals is planning to install a booster fan which will force air from the San Mateo and Terneras areas down the main adit and ultimately out of the old Santa Juana mining areas, as shown in **Figure 16-2**.

Access to the old shafts within the Santa Juana Mine is still possible and provides access for inspections to ensure that the old excavations remain open to provide exhaust.

Ventilation circuits are created in stoping areas through forced ventilation via fans and ducting of various sizes. Stopes are set up to have a minimum of two entrances, which when connected provide for thorough ventilation.

No further evaluation on the ventilation has been performed but it is expected that the main booster fan, once installed, will be adequate for mine ventilation.

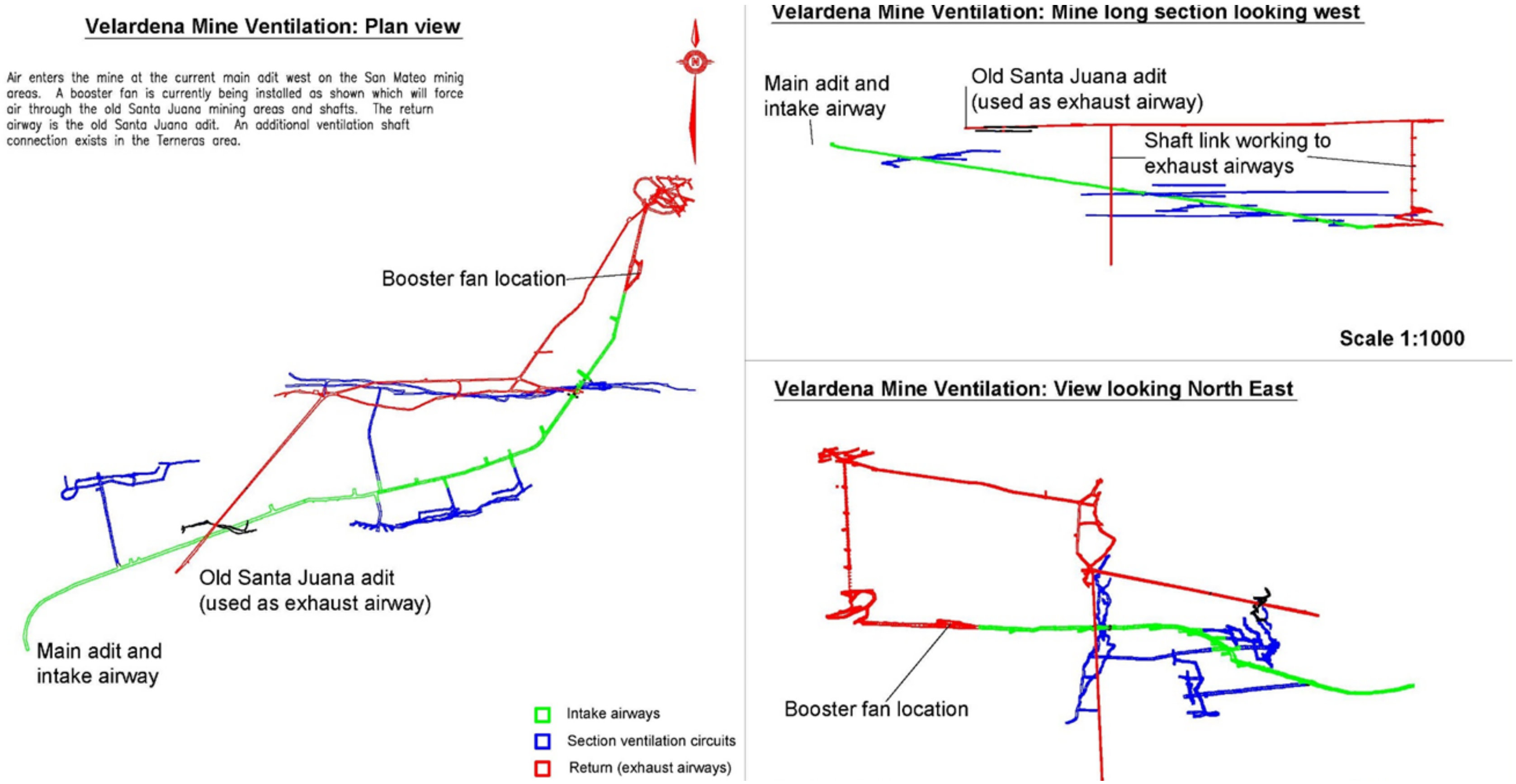


Figure 16-2: Ventilation layout of the Velardeña mine

16.11 Power

The underground power is available from a primary substation located at the portal. The power taken into the mine is stepped down at the substation to 4,160 volts. The 4,160 is stepped down to a typical working voltage of 440 volts using mobile mine load centers or pad mount transformers set on concrete. The power is stepped down to 120/240 single phase in many locations at the load centers. The mine power system was modernized in 2011.

16.12 Mine Plan

To plan stopes for the PEA, areas were selected where the estimated diluted NSR for a minimum of a 0.7 m mining width exceeds $175 within the principal veins. **Table 16-3** summarizes the tonnes and metal contents included in the conceptual mine plan.

Table 16-3: Summary of tonnes and grade included in the conceptual mine plan

Category	Total/Avg
Tonnes (kt)	1,237
NSR ($M)	506
Ag (g/t)	344
Ag (koz)	13,678
Au (g/t)	5.30
Au (koz)	210
Pb (%)	1.34
Pb (klb.)	36,586
Zn (%)	1.64
Zn(klb.)	44,731

16.12.1 Stope Layout

Resources were selected with a diluted NSR above $175 and conceptual 2D stope shapes created for these areas. Existing development was considered for the mine plan. **Figure 16-3** to **Figure 16-6** shows the 2D stope plans with the existing development. The stope shapes were then used to flag the Resource blocks within the stope and calculate attributes of each stope. Mining, dilution, extraction, and stope development parameters were applied to each individual stope to estimate grades and tonnages of potential mill feed from each stope.

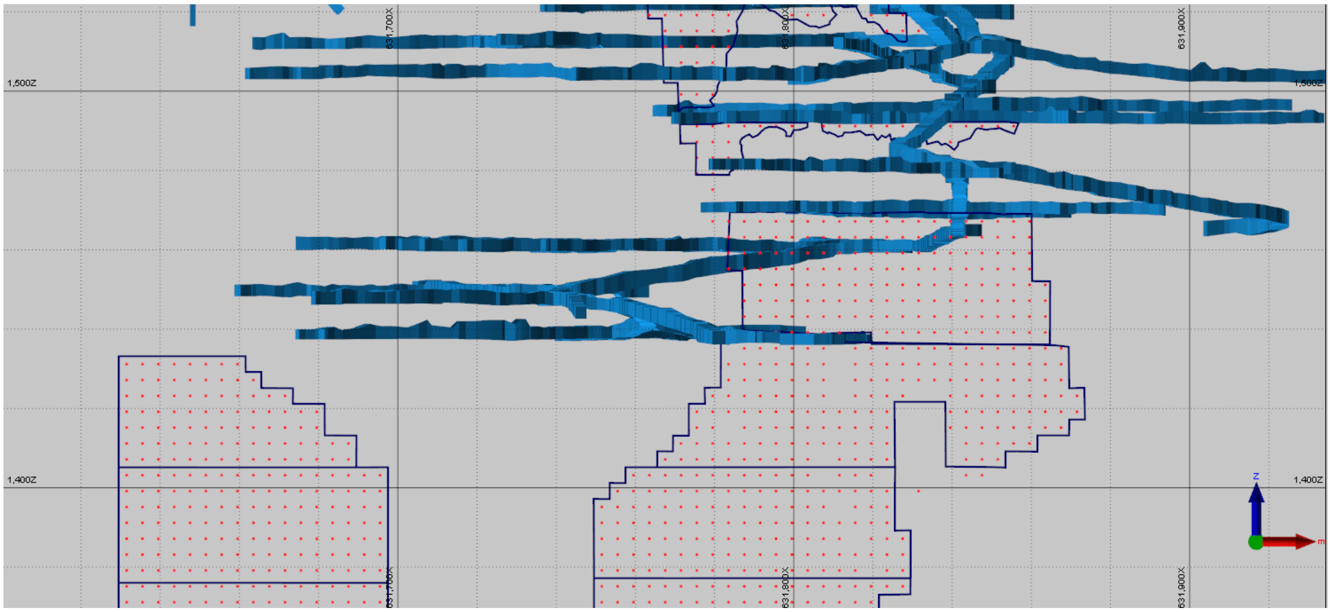


Figure 16-3: Example of detailed view of Chicago area, Escondida vein, stopes, existing development, and blocks above NSR $175

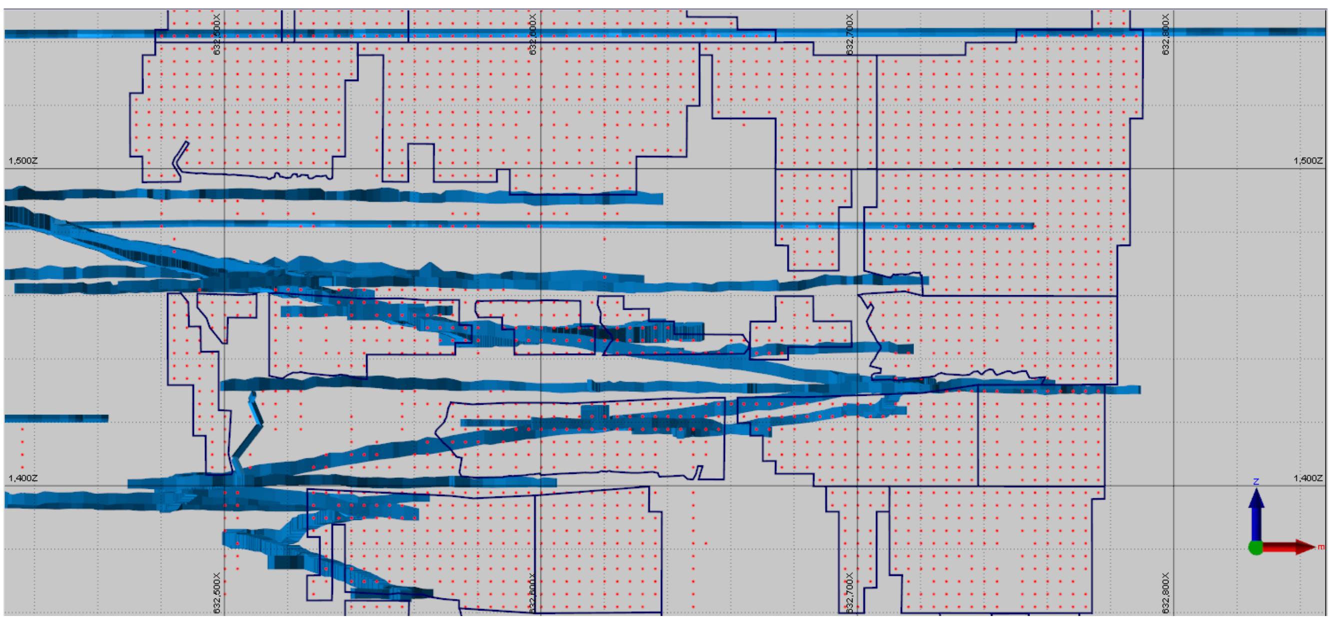


Figure 16-4: Example of detailed view of San Mateo area, stopes, existing development, and blocks above NSR $175

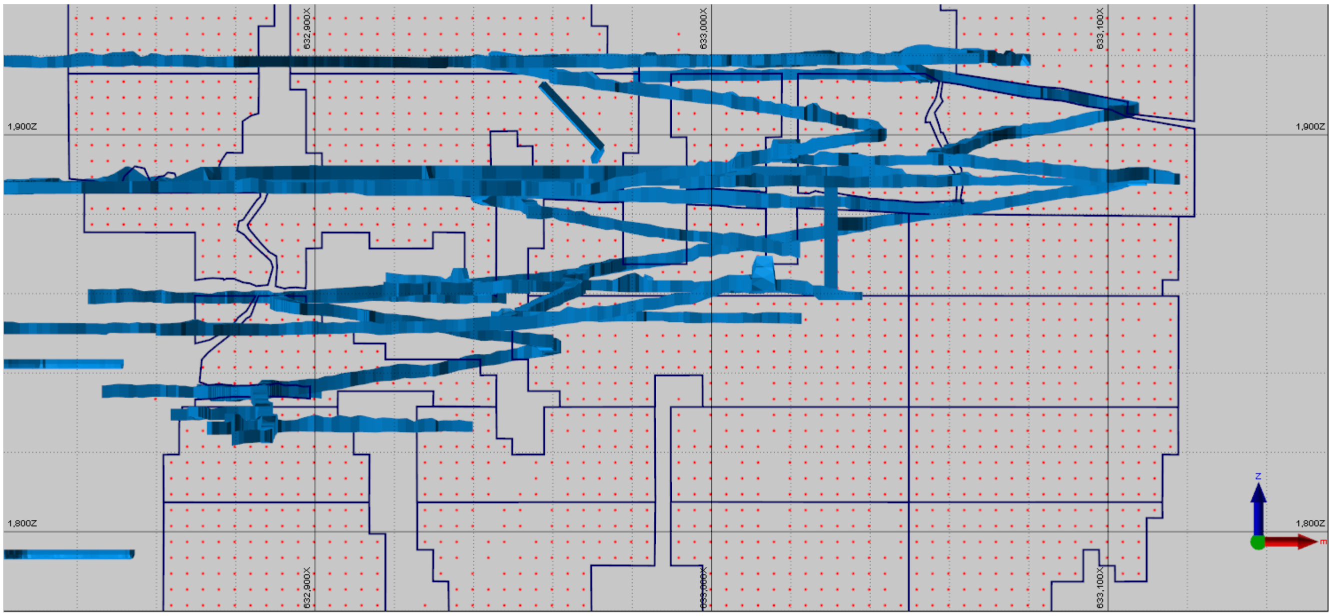


Figure 16-5: Example of detailed view of Terneras area, Roca Negra vein, stopes, existing development, and blocks above NSR $175

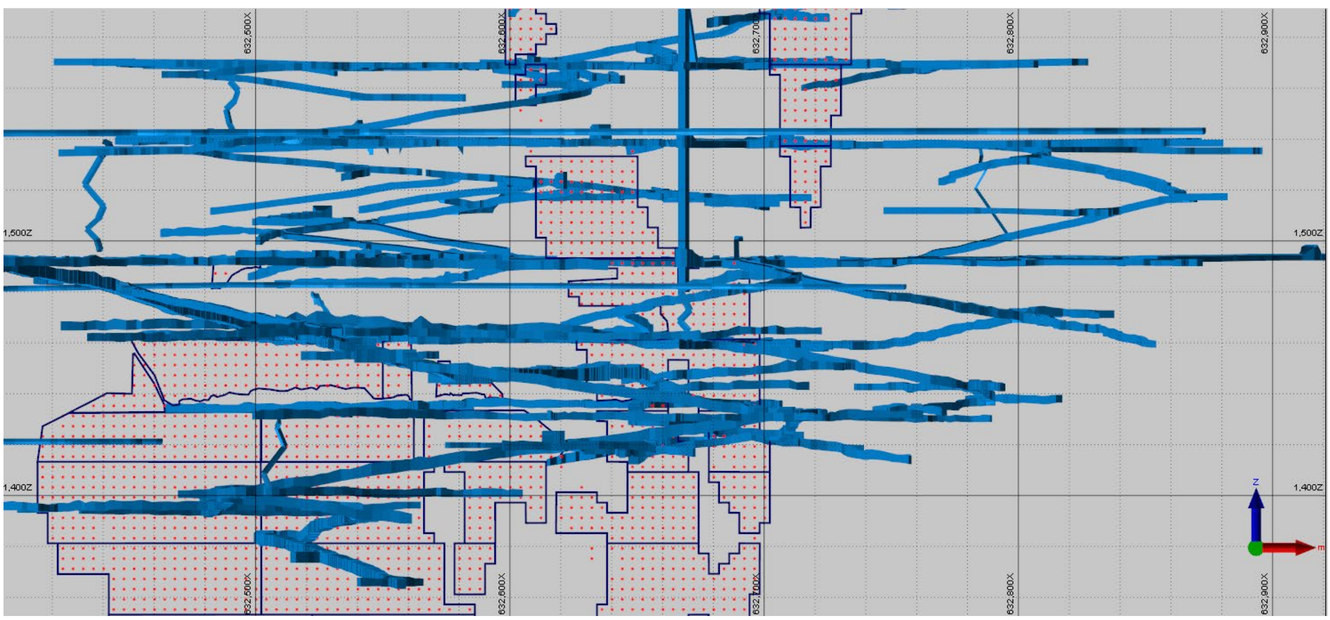


Figure 16-6: Example of detailed view of Santa Juana area, CC vein, stopes, existing development, and blocks above NSR $175

16.12.2 Main Access Ramps

The main access ramps are 4 m high by 4 m wide. The ramps are planned with grades no greater than 15%. The ramps are designed to be equipped with HDPE lines carrying compressed air, drill water, and mine water drainage. The Velardeña advance rate for ramps is planned at 4.4 m per day. Single boom hydraulic jumbos are planned for drilling, with mucking to be conducted using 6 LCY LHD units. An AWG0 600-volt rated three phase conductor is to be included in the ramps to provide power for the jumbos, pumps, and other equipment.

16.12.3 Crosscuts and Footwall Development

Crosscuts and footwall development required to access each stope for mining were examined. On-vein development was utilized where possible. This mine plan includes some stopes that were previously in production, and as such, additional development was not required for access.

16.12.4 Production Schedule

A mining schedule was developed based on the stopes described above. The schedule is based on an annual production target of 112,775 tonnes. Mining will be conducted using a six-day week and two 10-hour shifts per working day. The plants will operate seven days a week with three 8-hour shifts per working day.

Table 16-4 shows the annualized mining schedule.

Table 16-4: Annual mining schedule

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Total
Tonnes	112,775	112,775	112,775	112,775	112,775	112,775	112,775	112,775	112,775	112,775	109,507	1,237,257
Ag (g/t)	343	403	399	413	408	386	336	241	330	223	300	384
Ag (oz)	1,242,356	1,461,014	1,447,869	1,496,693	1,477,654	1,399,105	1,219,111	872,783	1,196,990	808,281	1,055,986	13,677,843
Au (g/t)	4.12	4.39	4.47	7.30	4.85	5.01	5.19	5.64	5.93	5.62	5.58	5.28
Au (oz)	14,956	15,924	16,206	26,453	17,585	18,173	18,814	20,458	21,490	20,361	19,642	210,062
Pb (%)	2.29	1.12	1.97	1.34	1.42	1.42	1.09	1.16	0.97	1.24	0.73	1.34
Pb (lb.)	5,698,027	2,787,400	4,901,903	3,319,673	3,526,152	3,519,795	2,711,158	2,887,174	2,400,559	3,070,740	1,763,299	36,585,881
Zn (%)	2.54	1.80	2.91	1.97	1.87	1.57	1.46	1.20	0.69	0.96	1.04	1.64
Zn(lb.)	6,315,386	4,485,318	7,225,477	4,907,583	4,644,543	3,913,417	3,637,794	2,977,939	1,706,372	2,398,946	2,518,472	44,731,246

**Note: Columns may not total due to rounding*

17. RECOVERY METHODS

There are two existing process plants, Plant 1 and Plant 2, at the Project. Plant 1 is designed to treat sulfide material to produce Pb, Zn, and pyrite concentrates and is located near the village of Velardeña, approximately eight kilometers from the mining operations. Plant 1 has an operating capacity of 340 tpd with net capacity of 325 tpd, equal to 112,775 tpy on a 347-day schedule. Plant 2 is an agitated leach plant for treating oxide Au-Ag mineralized material to produce Au-Ag doré. Plant 2 was purchased by William Resources in 1996. Operations were suspended at both plants in June 2013. In July 2014, Golden Minerals restarted mining operations to feed Plant 1, which started production on November 3, 2014. During the shutdown, Golden Minerals completed several capital projects at Plant 1 prior to restart including overhauling the electrical system, installing new concentrate filters, and refurbishing the flotation cells. Operation of Plant 1 was discontinued in late 2015 due to a combination of low metal prices, dilution, and metallurgical challenges. Plant 2 was leased to Hecla Mining Company from July 2015 through November 2020. Mineralized material from the Golden Minerals Rodeo Project has been processed through Plant 2 since January 2021.

17.1 Plant 1

Plant 1 is designed to process sulfide material in a conventional flow sheet of crushing, grinding, and differential flotation to produce three separate concentrates: Pb-Ag, Zn, and pyrite. **Figure 17-1** shows the processing flow sheet for Plant 1, and **Figure 17-2** shows a layout of Plant 1 and the tailings dams. **Table 17-1** and **Table 17-2** list the major equipment and process materials required for operations at Plant 1. Reagents include lime, collectors, depressants, and frothers.

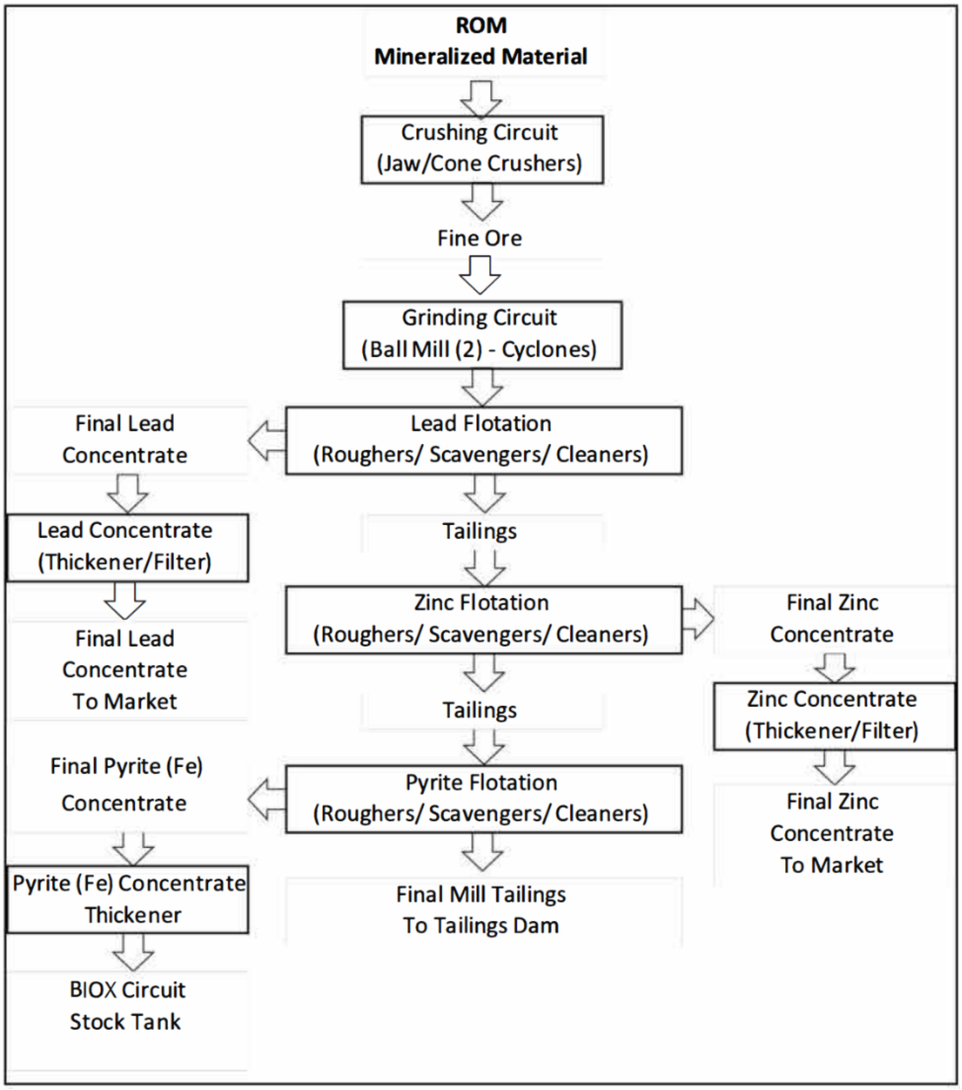


Figure 17-1: Process flow sheet for Plant 1

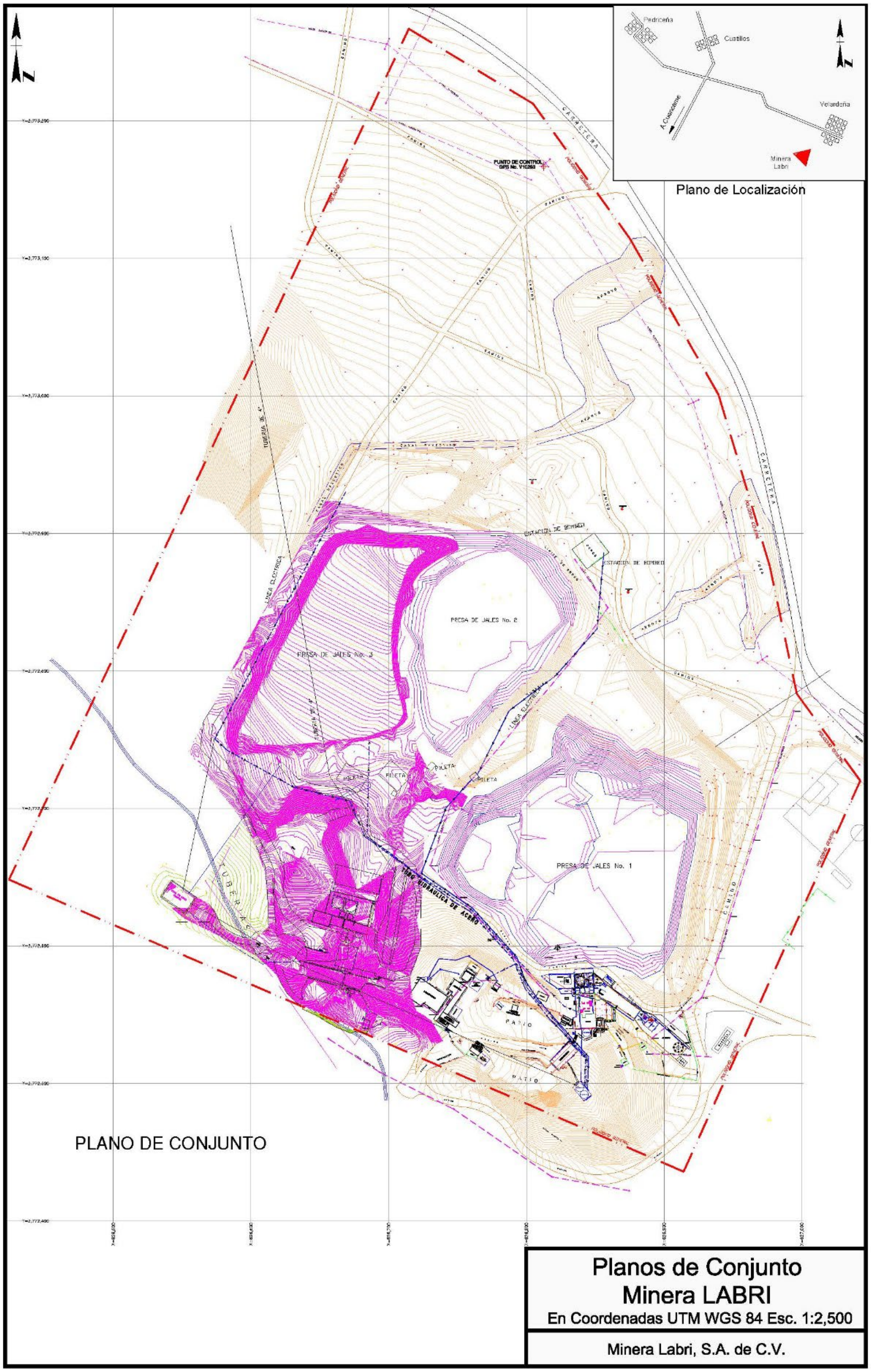


Figure 17-2: Site layout for Plant 1

Table 17-1: Major process plant equipment for Plant 1

Description	Quantity	Function
Coarse Ore Bin; 120 t Capacity	1	ROM Feed Ore Bin
Jaw Crusher; 10 in. by 30 in.; 100 HP	1	Primary Crusher
Cone Crusher; Sandvik Model H3800; 200 HP	1	Secondary Crusher
Vibrating Screen; FIMSA 4 ft by 6 ft; 10 HP	1	Size Classification
Fine Ore Bin; 350 t Capacity	1	Surge Capacity
Ball Mill #1; FIMSA; 7 ft by 10 ft; 200 HP	1	Ore Grinding
Ball Mill #2: MERCY; 5 ft by 8 ft; 125 HP	1	Ore Grinding
Cyclones; D6	3	Size Classification
Lead Conditioning Tank; 6 ft by 6 ft; 10 HP	1	Conditioning
Lead Rougher Flotation Cells; FIMSA; 100 cu ft; 60 HP	4	Lead Rougher Flotation
Lead Scavenger Flotation Cells; FIMSA; 100 cu ft; 20/30 HP	4	Lead Scavenger Flotation
Lead Cleaner Flotation Cells; FIMSA; 3 stages; 24 cu ft; 7.5/10 HP	6	Lead Cleaner Flotation
Lead Concentrate Thickener; 25 ft diameter; 2 HP	1	Thicken Final Lead Concentrate
Lead Concentrate Filter; SEW; 6 ft diameter; 3 Discs; 2 HP	1	Filter Lead Concentrate
Zinc Conditioning Tank; 6 ft by 6 ft; 10 HP	1	Conditioning
Zinc Rougher Flotation Cells; Denver; 100 cu ft; 15 HP	6	Zinc Rougher Flotation
Zinc Primary Scavenger Flotation Cells; Denver; 50 cu ft; 15 HP	6	Zinc Scavenger Flotation
Zinc Secondary Scavenger Flotation Cells; Denver; 50 cu ft; 15 HP	4	Zinc Scavenger Flotation
Zinc Cleaner Flotation Cells; Denver; 3 stages; 24 cu ft; 7.5 HP	6	Zinc Cleaner Flotation
Zinc Concentrate Thickener; 25 ft diameter; 2 HP	1	Thicken Final Zinc Concentrate
Zinc Concentrate Filter; Filter Press; 0.25 HP	1	Filter Zinc Concentrate
Pyrite Conditioning Tank; 6 ft by 6 ft; 10 HP	1	Conditioning
Pyrite Rougher Flotation Cells; MINPRO; 100 cu ft; 30 HP	4	Pyrite Rougher Flotation
Pyrite Scavenger Flotation Cells; Denver; 50 cu ft; 25/30 HP	5	Pyrite Scavenger Flotation
Pyrite Cleaner Flotation Cells; Denver; 2 stages; 25 cu ft; 7.5 HP	8	Pyrite Cleaner Flotation
Pyrite Concentrate Thickener; 25 ft diameter; 2 HP	1	Thicken Final Pyrite Concentrate
Pyrite Concentrate Filter; 0.25 HP	1	Filter Pyrite Concentrate

Table 17-2: Process materials for Plant 1

Process Materials	Consumption Rate (kg/t processed)
Grinding Balls - 2.5 in. diameter	0.83
Grinding Balls - 2 in. diameter	0.72
Grinding Balls - 1.5 in. diameter	0.17
Lime	1.16
Sodium Cyanide	0.07
Sulfate	0.88
Xanthate 350	0.8505
Aeropromoter 211	0.02
Aeropromoter 3416	0.0675
Aerofloat 31	0.054
Frother 1065	0.0945
Aerofloat 70	0.01
P404	0.03
P242	0.04
Copper Sulfate	0.92

Run of Mine (ROM) material is received from the underground mines by truck and unloaded onto a small area near the Plant 1 crushing circuit. The ROM material is reclaimed by a front-end loader and fed to a jaw crusher for primary crushing. The primary crushed material is sized by a vibrating screen operating in closed-circuit with a secondary cone crusher. The crushed fine material is conveyed to a 350-t fine ore bin ahead of the grinding circuit. The fine material is ground in two ball mills operating in parallel. The ball mill discharge is classified by cyclones, with the cyclone underflow (oversize material) returned to the ball mills and the cyclone overflow (product), at 80% minus 200 mesh, advances to a conditioning tank ahead of Pb flotation. After conditioning, the slurry is fed to the Pb flotation circuit comprised of rougher, scavenger, and three stages of cleaner cells. The Pb concentrate from the cleaner cells represents the final Pb concentrate, which is then thickened and filtered to a moisture content of 10-12%, by weight, for shipment. The final Pb concentrate has a low projected grade of 35-40% Pb, which is rich in Au and Ag byproducts. The Pb and Ag recoveries to the Pb concentrate are projected to be over 65% and about 70% respectively.

The tailings from the Pb flotation circuit are fed to a conditioning tank ahead of the Zn flotation circuit. The conditioned slurry is fed to the Zn flotation circuit comprised of rougher, scavenger, and three stages of cleaner cells. The Zn concentrate from the cleaner cells represents the final Zn concentrate, which is then thickened and filtered to a moisture of 10-12%, by weight, for shipment. The final Zn concentrate is projected to contain over 40% Zn. The Zn recovery to the Zn concentrate is projected to be over 70%. Both the Pb and Zn concentrates contain levels of As and Sb impurities.

The tailings from the Zn flotation circuit are fed to a conditioning tank ahead of the pyrite flotation circuit. The conditioned slurry advances to the pyrite flotation circuit comprised of roughers, scavengers, and two stages of cleaner cells. The concentrate from the cleaners represents the final pyrite concentrate, which contains high Au and Ag values, would then be thickened for transport as a slurry to the BIOX® plant for oxidization, leaching and recovery of the precious metals into doré.

The tailings from pyrite flotation represent the final flotation plant tailings that are pumped to Tailings Dam 3 located adjacent to Plant 2. Tailings Dam 3 has sufficient capacity to hold 3.9 years of tailings from Plant 1. Any additional capacity in Tailings Dam 3 would need to be permitted.

Plant 1 obtains power from the national grid. The nominal electrical consumption for Plant 1 is approximately 33 kWh/t of material processed. Fresh water for Plant 1 is obtained from existing water wells located near Plant 1 and Plant 2 at an average consumption rate of 184 cubic meters per day. Historically, some fresh water has been trucked from Plant 2 to Plant 1 during periods of insufficient water flow. Golden Minerals plans to re-install a 4-in. diameter water line from Plant 2 to Plant 1, about five kilometers.

17.2 Plant 2

Plant 2 is a conventional 550-tpd agitated cyanide leach facility that includes crushing and grinding circuits to process ROM mineralized material that would not be utilized for the treatment of pyrite concentrates from Plant 1. **Figure 17-3** shows a processing flow sheet and **Figure 17-4** illustrates the site layout for Plant 2. **Table 17-3** and **Table 17-4** list the major equipment and reagents at Plant 2. Plant 2 is located approximately four kilometers from Plant 1. Oxidized pyrite concentrate from a BIOX® plant constructed nearby would be transported to the eight-tank agitation unit. Slurry from the agitation tanks passes to a four-unit counter-current decantation circuit where the pregnant solution is recovered and passed to storage tanks before filtering and processing in the Merrill-Crowe circuit. The pregnant solution is filtered in horizontal pressurized disk filters using diatomaceous earth as the filtering medium. Zn dust is used to precipitate precious metals in the Merrill-Crowe circuit. Underflow of the counter-current decantation circuit is pumped to the plant's Tailings Storage Facility (TSF), which is a lined constructed impoundment. Solution is recovered from the TSF and pumped back to the plant for re-use. The precipitate from the Merrill-Crowe circuit is refined to bars of Au-Ag doré in an on-site refinery with a single 100-kg charge induction furnace. Reagents used in the Plant 2 leach and Merrill-Crowe circuits are cyanide, Zn dust, diatomaceous earth, flocculants, and lime.

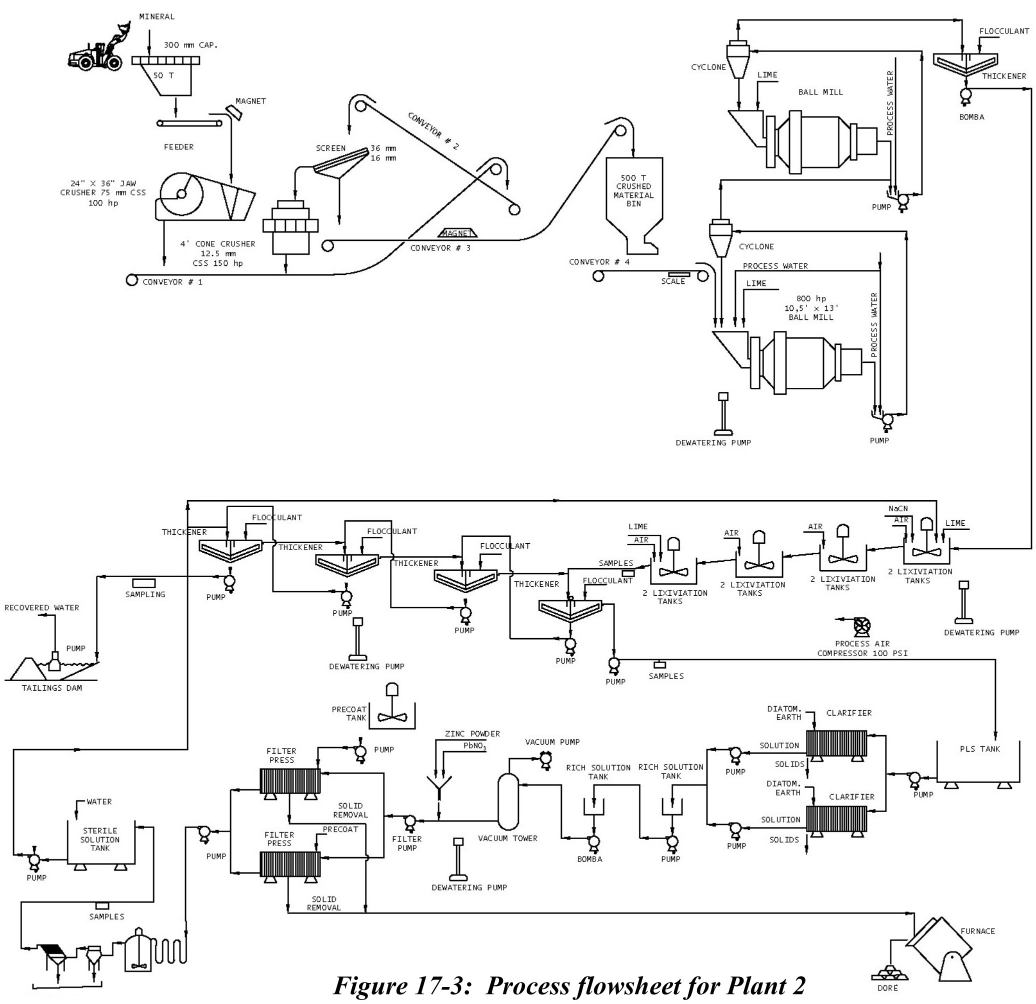


Figure 17-3: Process flowsheet for Plant 2

The plant is currently processing material from Golden Minerals' Rodeo mine. Water consumption at Plant 2 averaged 0.80 m3/t from January through December 2021. Average power consumption at the plant was 831,000 kWh for the same period. The plant employs 98 workers.

Table 17-3: Major equipment list for Plant 2

Description	Number	Function
Coarse Ore Bin; 7 ft by 11 ft by 14 ft; 50 t Capacity	1	ROM Feed Ore Bin
Coarse Ore Apron Feeder; 4 ft by 17 ft; 3 HP	1	Feed Jaw Crusher
Jaw Crusher; 24 in. by 36 in.; Allis-Chalmers; 100 HP	1	Primary Crusher
Cone Crusher; 4 ft diameter Standard; Symons; 100 HP	1	Secondary Crusher
Vibrating Screen; Double-Deck; TYLER, 6 ft by 10 ft; 20 HP	1	Size Classification
Fine Ore Bin; 8 m by 9 m; 500 t Capacity	1	Surge Capacity
Ball Mill; Allis-Chalmers; 10.5 ft by 13 ft; 800 HP	1	Ore Grinding
Cyclones; Krebs D6	10	Size Classification
Ball Mill; 8 ft by 22 ft	1	Secondary Ore Grinding
Cyclones		Size Classification
Primary Thickener; 16 m diameter by 3 m high; 3 HP	1	Thicken Cyclone Overflow
Leach Tanks; Agitated; 8 m by 8.5 m; 25 HP	8	Cyanide leach Au and Ag
CCD Thickeners; 60 ft diameter; 5 HP	4	Solid-liquid separation; PLS
PLS Tank; 8 m diameter by 4 m high	1	PLS Surge Tank
Clarifiers; 52 sq. m; Diatomaceous Earth; 1.5 HP	2	Clarify PLS
Clarified PLS Tank; 5 m diameter by 6 m high	1	Clarified PLS Surge Tank
Zinc Filter Presses; 1.84 m diameter by 1.84 m high; 4.89 cu m	2	Filter Zinc Precipitate
Primary Flotation Cells; WEMCO; 75 cu m; 15 HP	3	Au-Ag rougher flotation
Cleaner Flotation Cells; First Stage; DENVER; 25 cu ft; 5 HP	2	First stage cleaners
Cleaner Flotation Cells; Second Stage; DENVER; 45 cu ft; 10 HP	4	Second stage cleaners
Conditioner; 1.7 m diameter by 2 m high; 25 HP	1	Conditioning
Concentrate Thickener; 6.84 m diameter by 2.45 m high; 3 HP	1	Thicken Final Concentrate
Concentrate Filter; Vacuum; Komline-Sanderson	1	Concentrate Filter
Smelting Furnace; INDUCTOTHERM, 650 kg charge; 150 KW	1	Precipitate Smelting
Filter Presses; DURCO/PERRIN/HYSTAR	3	Filter

Table 17-4: Process reagents for the Plant 2 leach circuit

Process Materials	Consumption Rate (kg/t processed)
Lime	4.4
Sodium Cyanide	7.5
Flocculant	0.05

When processing oxide material, the cyclone overflow is sent to a thickener with the thickener underflow fed to the cyanide leach tanks. Discharge from the cyanide leach tanks advances to a four-stage counter current decantation (CCD) thickener circuit. The solution from the first stage is Au-Ag rich solution, termed pregnant liquor solution (PLS). The PLS is clarified of any fine particles and pumped to a Merrill-Crowe circuit where Zn dust is added to precipitate the contained Au and Ag from the PLS. The resulting Zn precipitate is smelted in an induction furnace to produce doré that is shipped to refineries. The underflow from the last CCD thickener represents the final tailings from the oxide circuit that are pumped to the nearby tailings dam.

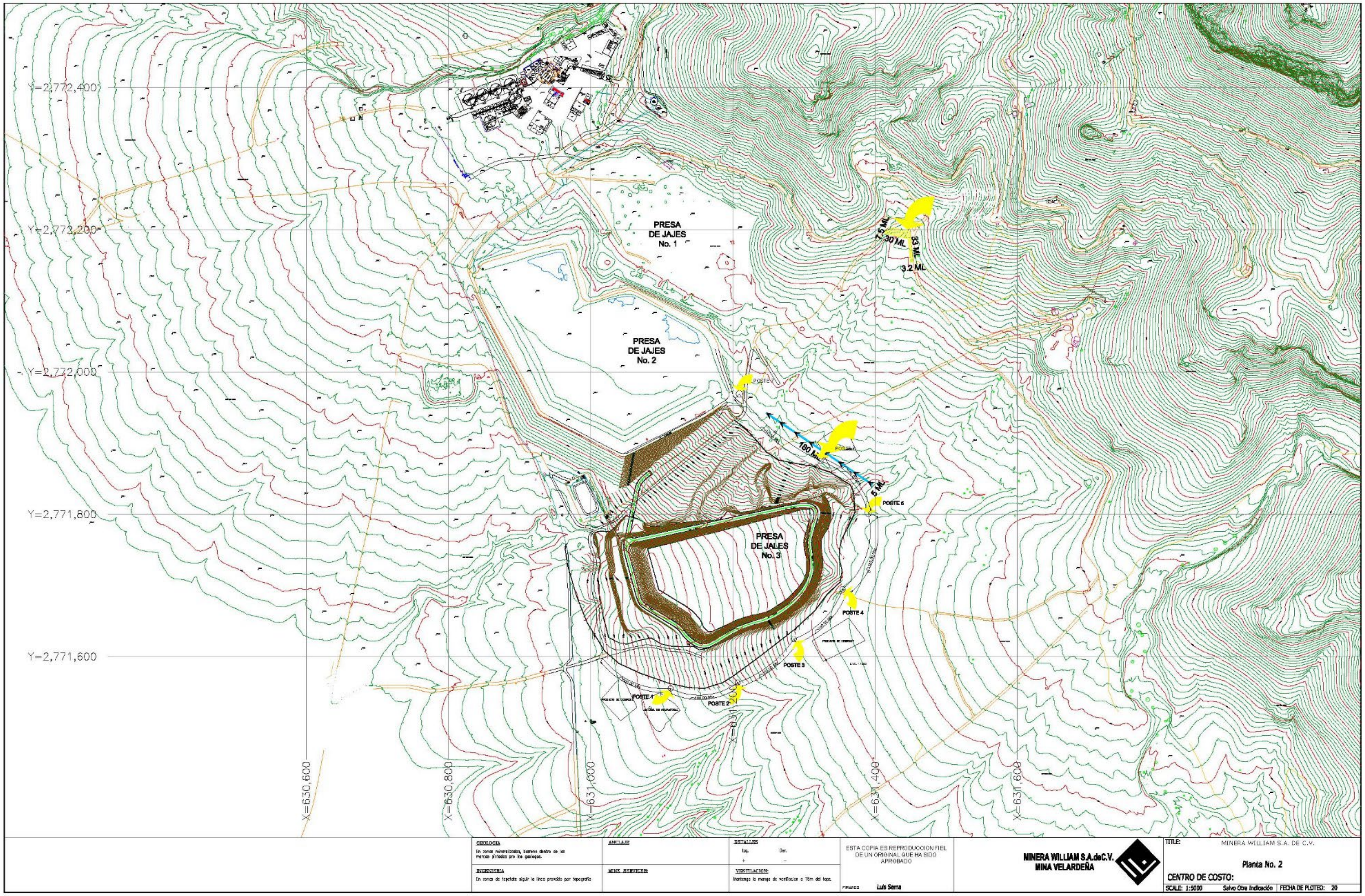


Figure 17-4: Site layout for Plant 2

17.3 Proposed BIOX® Plant at Plant 2

Oxidized pyrite concentrate from a BIOX® plant constructed at Plant 2 would be transported to the eight-tank agitation unit. Slurry from the agitation tanks passes to a four-unit counter-current decantation circuit where the pregnant solution is recovered and passed to storage tanks before filtering and processing in the Merrill-Crowe circuit. The pregnant solution is filtered in horizontal pressurized disk filters using diatomaceous earth as the filtering medium. Zn dust is used to precipitate precious metals in the Merrill-Crowe circuit. Underflow of the counter-current decantation circuit is pumped to the plant's Tailings Storage Facility (TSF), which is a lined constructed impoundment. Solution is recovered from the TSF and pumped back to the plant for re-use. The precipitate from the Merrill-Crowe circuit is refined to bars of Au-Ag doré in an on-site refinery with a single 100-kg charge induction furnace. Reagents used in the Plant 2 leach and Merrill-Crowe circuits are cyanide, Zn dust, diatomaceous earth, flocculants, and lime.

Table 17-5 is a list of the major equipment that will be required in the construction of the BIOX® plant.

Table 17-5: Major equipment for BIOX® plant

Description	Number	Function
500 kW Prime Diesel Generators; 440/277 volt, 3-phase	3	Backup Power
CCD Thickeners; 20 ft diameter; 5 HP	1	Solid-liquid separation; Fe Con
BIOX® Tanks; 9 m diameter x 9 m high Standard; Agitator; 25 HP	3	Bio-oxidation
CCD Thickeners; 20 ft diameter; 5 HP	3	Solid-liquid separation; Slurry
CCD Thickener; 30 ft diameter; 5 HP	1	Solid-liquid separation; WRT
pH Adjustment tanks; 3 m Dia. X 3 m high; Agitator; 10 HP	2	Slurry pH Conditioning
Water Conditioning Tanks; 4 m Dia. X 5 m high; Agitator; 25 HP	6	Water Recovery Circuit (WRT)
High Volume Blowers;	3	Bio-oxidation Air
Evaporative Cooling Towers;	4	Bio-oxidation/Blower Cooling
BIOX® Transfer Tank; 6 m diameter x 6 m high Standard; Agitator; 15 HP	1	Temp. Storage Fe Con
BIOX® Transfer Tank; 2 m diameter x 2 m high Standard; Agitator; 5 HP	2	Temp. Storage Nutrients
BIOX® Transfer Tank; 1.5 m diameter x 1.5 m high Standard; Agitator; 5 HP	2	Temp. Storage Reagents
100-DMT Limestone/Lime Silos	3	Lime Slurry Circuit
Process Pumps; Various sizes	30	Slurry and Solution handling

The proposed location for the BIOX® plant at Plant 2 is shown in **Figure 17-5**. **Figure 17-6** shows the BIOX® plant infrastructure.

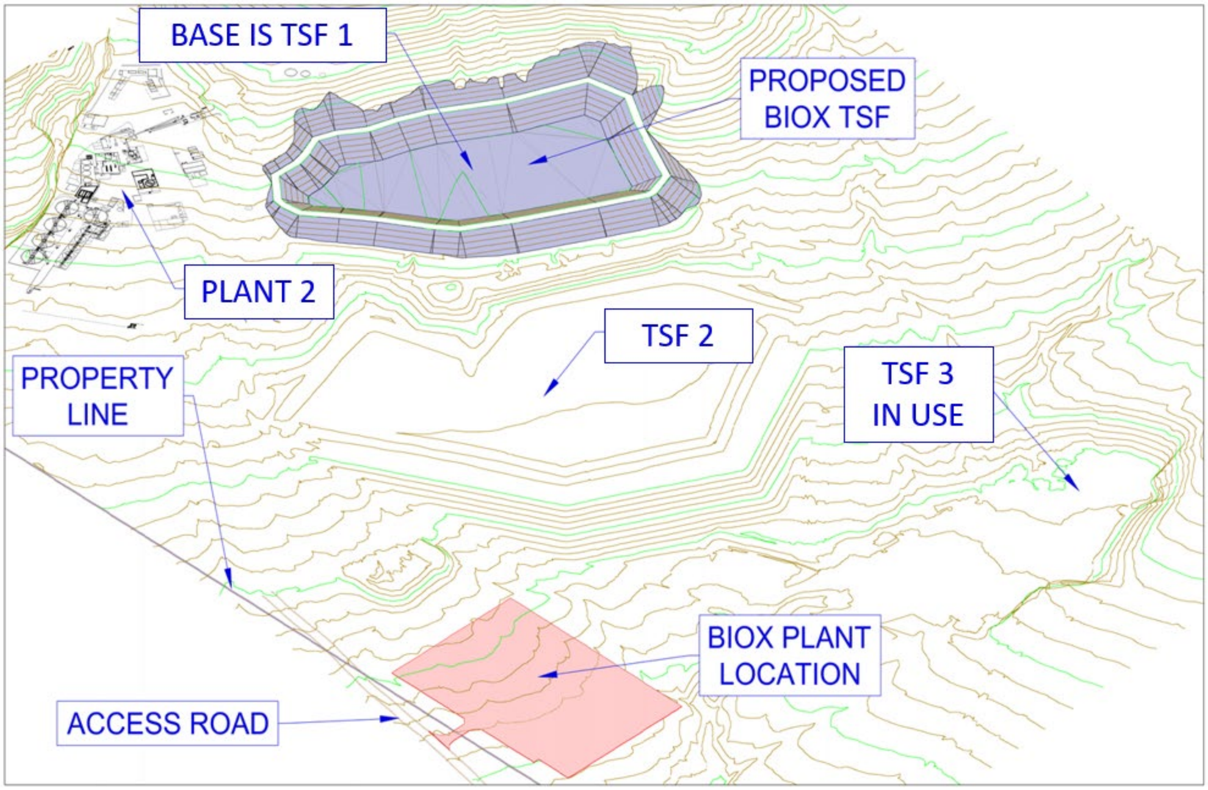


Figure 17-5: Proposed BIOX® plant location, relative to Plant 2 and the required TSF

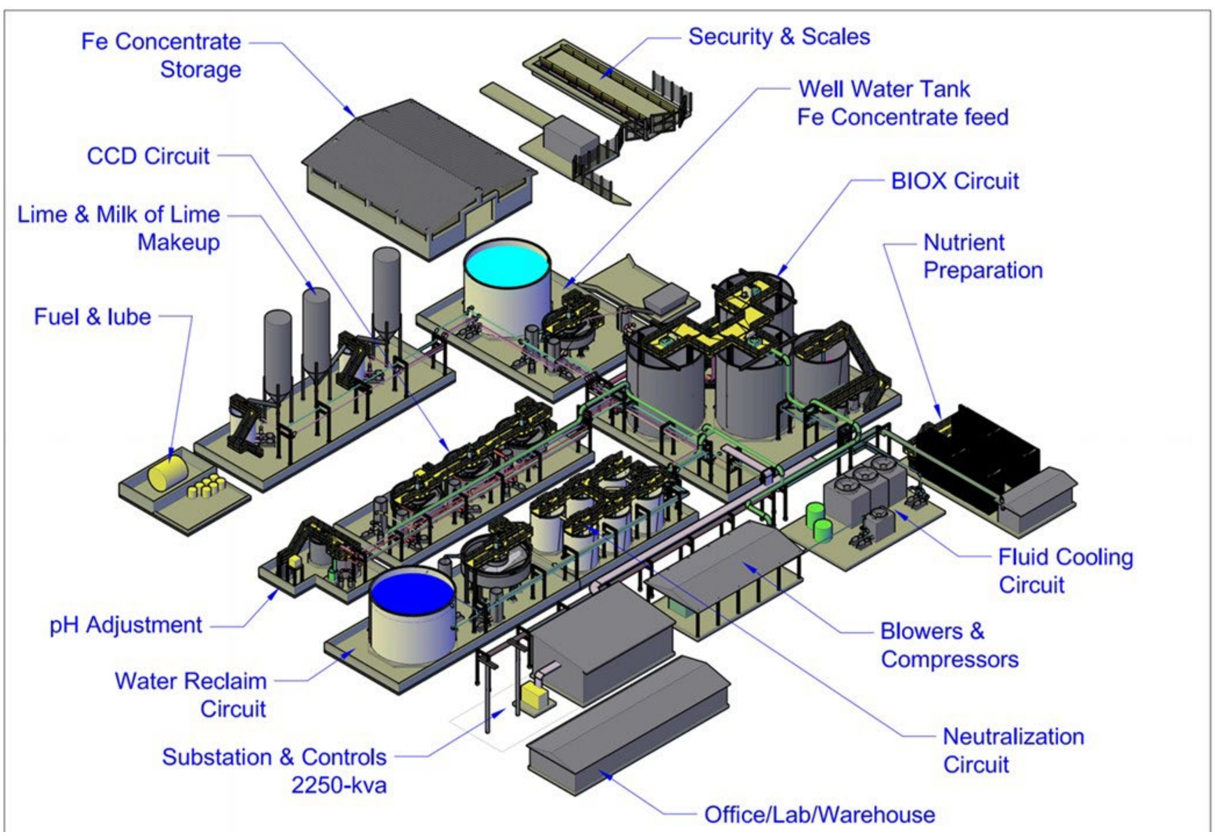


Figure 17-6: Conceptual BIOX® plant proposed for Velardeña

18. PROJECT INFRASTRUCTURE

Infrastructure facilities at the Project include the following:

- Access roads
- Power line
- Ancillary buildings
- Water wells

Figure 18-1 provides an overview of the infrastructure at the Project.

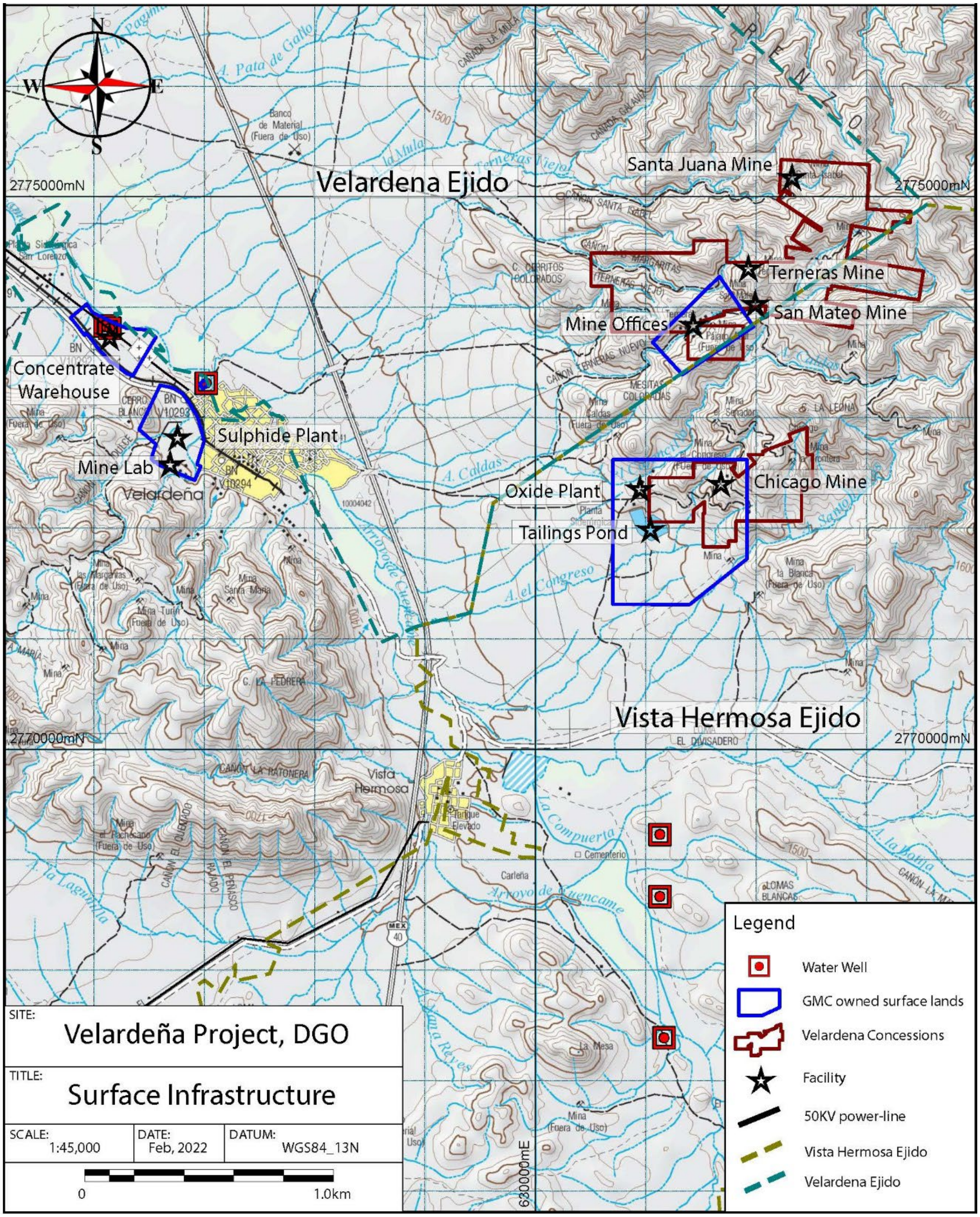


Figure 18-1: Velardeña Project site infrastructure

18.1 Access Roads

The Project is in the Mexican state of Durango, approximately 65 km southwest of the city of Torreón and 150 km northeast of the city of Durango. A major 4-lane highway, Highway 40, connects these cities. Plant 1 is located adjacent to the village of Velardeña, which is approximately 500 m west of the highway. The Velardeña mines are located about 8 km from Plant 1 via a gravel road. Plant 2 is located approximately 3.5 km from the Velardeña mine, also via gravel roads.

18.2 Waste Rock

Waste rock from the underground mine consists of tonnage from the ramp, lateral development, and stopes. Since the mining methods include cut and fill, the waste from the stopes would either be stored underground in mined out stopes, hauled to the surface, or transported to the mill with the diluted mined material. Limited cut and fill mining is planned and, as such, most of the waste rock is planned for surface storage.

The waste rock not stored underground will be deposited along the valley between the San Mateo adit and the Santa Juana adit.

18.3 Tailings

The dry tailings from Plant 1 are suitable for spreading on the fill of each cut to eliminate or reduce the dilution and losses associated with blasting and mucking process grade material on coarse placed fill. Tailings will be hauled from Plant 1 to the active mine and dumped at a central area. Trucks will then haul the tailings underground to a stope area where an LHD will spread the material on top of the recently placed coarse fill, a cover of approximately 15 cm. The planning and calculated production rates used in this estimate contain time for placing the tailings cover.

18.4 Power

The underground power is available from a primary substation located at the portal. The power taken into the mine is stepped down at the substation to 4,160 volts. The 4,160 is stepped down to a typical working voltage of 440 volts using mobile mine load centers or pad mount transformers set on concrete. The power is stepped down to 120/240 single phase in many locations at the load centers. The mine power system was modernized in 2011.

18.5 Ancillary Buildings

Ancillary buildings for the Project include administration buildings, warehouses, maintenance shops, offices, a metallurgical laboratory, and an analytical laboratory for the preparation and assaying of mine and plant samples. Security gates are located at the entrances of the mines and both Plant 1 and 2.

18.6 Water Wells

There are six existing water wells (three at Plant 1 and three at Plant 2) for extracting water from local aquifers. These wells are authorized, regulated, and permitted by CONAGUA. **Table 18-1** and **Table 18-2** summarize the data for these wells.

Table 18-1: Data for water production wells - Plant 1

Pump	Well Depth (m)	Well Pump Submersible	Authorized Volume	
			m3/d	m3/yr
Discordia	25	2-inch	67.53	24,655
Noria	25	2-inch	67.53	24,655
Rancho	200	2-inch	49.165	17,946

Table 18-2: Data for water production wells - Plant 2

Pump No.	Well Depth (m)	Well Pump Submersible	Flow Rate (L/s)	Authorized Volume	
				m^3/d	m^3/yr
1	220	4-inch	8	460.65	168,192
2	400	4-inch	5	201.5	73,584
3	431	6-inch	11	431.8	157,680

Prior to start-up, Golden Minerals will re-install a 5 km, 4-inch diameter water line from Plant 2 to Plant 1 to provide an adequate water supply.

19. MARKET STUDIES AND CONTRACTS

Detailed market studies have not been performed for the Velardeña project. Markets for the Pb and Zn concentrates include metal brokers and direct sales to smelters. Doré produced at Plant 2 can be sold to downstream metal refiners. The concentrates and doré produced are typical within the Mexican mining industry and the concentrate and doré markets within Mexico and worldwide are liquid. For purposes of this study, it is assumed that Golden Minerals will be successful in securing buyers for its concentrates and doré.

19.1 Doré

The Velardeña operations has a small furnace capable of smelting the precipitates produced in the Merrill-Crowe circuit into a Ag/Au doré bar. The bars produced are expected to contain approximately 85-90% Ag and 4-6% Au. For purposes of the PEA, it is assumed the Velardeña operations will be paid for 97% of the contained Au and Ag in the doré, with a treatment charge of $5.00/kg of doré and a refining charge of $6.00/oz-Au and $0.60/oz-Ag. Marketing studies with potential buyers of doré have not been completed and therefore have not been reviewed by the author of this section.

19.2 Concentrates

The sulfide plant at the Velardeña operations contains a typical flotation circuit that produces lead, zinc and pyrite concentrate products for sale to customers. Pb and Zn concentrates each comprise approximately 10% of total concentrate production from the sulfide plant. Pyrite concentrates comprise approximately 80% of total concentrate production from the sulfide plant. The pyrite concentrates produced will be used as feed for the bio-oxidation circuit and then processed through an agitation leach circuit utilizing Merrill-Crowe to produce a Au-Ag rich doré. The Pb and Zn concentrates will be sold to various customers under annual contracts, which are generally re-negotiated each calendar year. The concentrate products are generally shipped in covered trucks. The company generally incurs the cost of freight to the customer. Marketing studies with potential buyers for concentrates have not been completed and therefore have not been reviewed by the author of this section.

19.2.1 Pb Concentrates

The Pb concentrates have typical assays as follows: 35-40% Pb, 8,000-10,000 g/t Ag, and 40-50 g/t Au. After metal deductions, the company is generally paid for 90-95% of the contained Pb, Ag, and Au. Concentrate treatment charges are negotiated annually and generally reflect market terms for the industry for similar products. The following treatment charges have been assumed for purposes of the PEA:

- Pb concentrate treatment charge: $200 per dry metric tonne of Pb concentrate
- Au refining charge of $15.00 per payable ounce
- Ag refining charge of $0.95 per payable ounce
- Penalties:
  - Arsenic: For As contents less than 0.3% As, there is no penalty. If the As content is greater than 0.3% and less than 0.7%, there is a penalty of US$2.00/t of Pb concentrate for every 0.1% As greater than 0.3%. If the As content is greater than 0.7% but less than 1.0%, there is a penalty of US$3.00/t of Pb concentrate for every 0.1% As greater than 0.7%. For As above 1.0% there is a penalty of US$5.00/t of Pb concentrate for every 0.1% As greater than 1.0%.
  - Antimony: For Sb contents less than 0.3% Sb, there is no penalty. If the Sb content is greater than 0.3% there is a penalty of US$1.50/t of Pb concentrate for every 0.1% Sb greater than 0.3%.

- Bismuth: For Bi contents less than 500 ppm Bi, there is no penalty. If the Bi content is greater than 500 ppm there is a penalty of US$2.00/t of Pb concentrate for every 100 ppm Bi greater than 500 ppm.

19.2.2 Zn Concentrates

The Zn concentrates have typical assays as follows: 40-45% Zn, 90-100 g/t Ag, and 5-6 g/t Au. After metal deductions, the Company is generally paid for approximately 85% of contained Zn and 60--70% of Ag with lesser amounts payable for the contained Au. Concentrate treatment charges are negotiated annually and generally reflect market terms for the industry for similar products. The following treatment charges have been assumed for purposes of the PEA:

- Zn concentrate treatment charge: $300 per dry metric tonne of Pb concentrate
- Penalties:
  - Arsenic and antimony: For As+Sb contents less than 0.5% As+Sb, there is no penalty. If the As+Sb content is greater than 0.5% and less than 1.0%, there is a penalty of US$2.50/t of Zn concentrate for every 0.1% As+Sb greater than 0.5%. If the As+Sb content is greater than 1.0% As+Sb there is a penalty of US$6.00/t of Zn concentrate for every 0.1% As+Sb greater than 1.0%.

20. ENVIRONMENTAL STUDIES, PERMITTING AND SOCIAL OR COMMUNITY IMPACT

The Project consists of the existing Velardeña and Chicago mines, the Labri Mill sulfide processing facility (Plant 1), an oxide processing facility (Plant 2), and related ancillary facilities including tailings impoundments, access roads, storage buildings and water pumping stations. The Project is located within the Municipality of Cuencamé, State of Durango, México.

Environmental studies were prepared by Consultores en Ecología con Visión Integral S.A. de C.V.

20.1 Current Property Status and Environmental Liabilities

In early 2012, Golden Minerals applied for, and was accepted into, the Mexican National Environmental Auditing Program (NEAP). Under NEAP, Golden Minerals participated in an audit program to verify compliance with existing regulations and identify non-regulated potential issues that could result in environmental contingencies. Golden Minerals holds various permits required for conducting their current operations at the Velardeña operations, and their participation in NEAP allows them to continue their current operations during the remediation of any potential non-compliance matters. Prior to the suspension of operations at Plant 1 in 2014, Golden Minerals had achieved 85% compliance at the plant.

Golden Minerals is required to update their environmental licenses and environmental impact assessments for any expansion of or modification to any of the existing two plants. The construction of new infrastructure beyond the current plant facilities may require additional permitting, possibly including environmental impact assessments and land use permits. Golden Minerals does not expect to have difficulty obtaining additional permits or environmental impact assessments, if required.

Tetra Tech is unaware of any outstanding environmental liabilities attached to the Velardeña properties and is unable to comment on any remediation, which may have been undertaken by previous companies.

20.2 Mexican Permitting Framework

Environmental permitting of the mining industry in Mexico is mainly administered by the federal government body SEMARNAT, the regulatory agency that establishes the minimum standards for environmental compliance. Guidance for the federal environmental requirements is largely held within the General Law of Ecological Equilibrium and Environmental Protection (Ley General del Equilibrio Ecológico y la Protección al Ambiente, [LGEEPA]). Article 28 of the LGEEPA specifies that SEMARNAT must issue prior approval to parties intending to develop a mine and mineral processing plant. An environmental impact assessment (Manifestación de Impacto Ambiental, [MIA]) must be filed with SEMARNAT for its evaluation and, if applicable, further approval by SEMARNAT through the issuance of an Environmental Impact Authorization. The document specifies approval conditions where work or activities have the potential to cause ecological imbalance or have adverse effects on the environment. Further requirements for compliance with Mexican environmental laws and regulations are included in Article 27 Section IV of the Ley Minera, and Articles 23 and 57 of the Reglamento de la Ley Minera. Article 5 Section X of the LGEEPA authorizes SEMARNAT to provide the approvals for the work specified in Article 28. The LGEEPA also contains articles for soil protection, water quality, flora and fauna, noise emissions, air quality, and hazardous waste management.

The National Water Commission (Comisión Nacional del Agua, [CONAGUA]), an agency within SEMARNAT, to issue water extraction concessions, and specifies certain requirements to be met by applicants.

Another important piece of environmental legislation is the General Law for Sustainable Forest Development (Ley General de Desarrollo Forestal Sustentable, [LGDFS]). Article 117 of the LGDFS indicates that authorizations must be granted by SEMARNAT for land use changes to industrial purposes. An application for change in forestry land use (CUSF), must be accompanied by a technical study that supports the Technical Justification Study (Estudio Técnico-Justificativo, [ETJ]). In cases requiring a CUSF, a MIA for the change of forestry land use is also required.

Mining projects also must include a Risk Analysis (AR) and an Accident Prevention Plan (PPA) from SEMARNAT.

The General Law for the Prevention and Integral Management of Waste (Ley General para la Prevención y Gestión Integral de los Residuos, [LGPGIR]) regulates the generation and handling of hazardous waste coming from the mining industry. Guidance for the environmental legislation is provided in a series of Norms, (NOMs). These regulations provide specific procedures, limits and guidelines and carry the force of law.

20.3 Project Permitting Requirements and Status

There were several environmental permits required to put the project into operation. Most of the mining regulations are at a federal level through SEMARNAT, but there are also a number regulated and approved at state and local level. There are three SEMARNAT permits that were required prior to construction; MIA, CUSF and AR, which are described below. A construction permit was also required from the local municipality and an archaeological release letter from the National Institute of Anthropology and History (INAH); and an explosives permit was required from the Ministry of Defense (SEDENA) before construction as well. The key permits and the stage at which they are required are summarized in **Table 20-1**.

- **Environmental Impact Manifest** – Regulations within Mexico require that an MIA be prepared by a third-party contractor for submittal to SEMARNAT. The MIA must include a detailed analysis of climate, air quality, water, soil, vegetation, wildlife, cultural resources, and socio-economic impacts.
- **Analysis of Risk** – A second required permit is an AR. A study is developed to obtain this permit. This study identifies potential environmental release of hazardous substances and evaluates the risks to establish methods to prevent, respond to, and control environmental emergencies. In the Project, since no hazardous substances will be used or processed, SEMARNAT will not need an AR to be done for current project conditions.
- **Forest Land Use Change** – The third permit is CUSF. In Mexico, all land has a designated use. The various areas comprising the project site are designated as forest land, cattle grazing, and agriculture. The CUS is a formal instrument for changing the designation to allow mining in these areas. The CUSF study is based on the forestry law and its regulations. It requires that an evaluation be made of the existing conditions of the land, including a plant and wildlife study, an evaluation of the current and proposed use of the land and impacts on natural resources and an evaluation of the reclamation and revegetation plans. The establishment of agreements with all affected surface landowners is also required.

A construction permit is required from the local municipality and an archaeological release letter is required from the National Institute for Anthropology and History (Instituto Nacional de Antropología e Historia, [INAH]). An explosives permit is required from the Secretary of Defense before construction begins. Water discharge and usage must be granted by CONAGUA. A project-specific unique environmental license (Licencia Ambiental Única, [LAU]), which states the operational conditions to be met, is issued by SEMARNAT when the agency has approved the project operations. The key permits and the stages at which they are required are summarized in **Table 20-1**.

Table 20-1: Permitting requirements

Permit Type	Mining Stage	Agency
Environmental Impact Assessment	Construction/Operation/Post-Operation	SEMARNAT
Forest Land Use Change	Construction/Operation	SEMARNAT
Risk Analysis	Construction/Operation	SEMARNAT
Construction Permit	Construction	Local Municipality
Explosive & Storage Permits	Construction/Operation	SEDENA
Archaeological Release	Construction	INAH
Water Use Concession	Construction/Operation	CONAGUA
Water Discharge Permit	Operation	CONAGUA
Unique Environmental License	Operation	SEMARNAT
Accident Prevention Plan	Operation	SEMARNAT

The Project has acquired permits for mineral exploration, construction, and operation activities. The permitted activities and the corresponding permit numbers are listed in **Table 20-2**.

Table 20-2: Permitting status

Authorization, Procedure, or Project	Number	Authorization Date	Comment
Plant 1 Permitting			
Environmental Risk Study	NA	Aug. 27, 2008	Valid
Accident Prevention Program	DGGIMAR.710/004071	May 21, 2021	Valid
Single Environmental License (LAU)	SG/130.2.1/001312	Jul 4, 2008	Valid
Special Conditions for Ducts and Chimneys	DGGCARETC/0418/2011	Aug 19, 2011	Valid as long as the conditions of the equipment do not change
La Discordia Well	B00-L-0459-21-09-15	Dec 4, 2015	Valid through December 5, 2025
El Rancho Well	B00.909.01.02/1508	Jul 7, 2018	Valid through July 8, 2028
La Noria Well	BOO.E.231.1/0478 002927	Sep 29, 2014	Valid
Plant 2 and Velardeña Mine Sites Permitting			
Environmental Impact Study for the Production and Operation of the Velardeña Mines	SG/130.2.1.1/002387/13	Aug 29, 2013	Valid
Environmental Impact Study for Plant 2 and Tailings Dam IV	SG/130.2.1.1/001783/12	Jul 16, 2012	Valid for operations through June 2025 and for closure to June 2028
Environmental Risk Assessment – Plant 2	NA	Oct 30, 2015	Valid but must be modified if the hazardous substances or quantities to be used at the plant change
Accident Prevention Program	DGGIMAR.710/006062	Jul 27, 2016	Valid but must be modified if the hazardous substances or quantities to be used at the plant change
Single Environmental License	SG/130.2.1/002086	Nov 3, 2009	Valid
Single Environmental License Update	SG/130.2.1/001398/17	May 24, 2017	Valid
Special Conditions for Ducts and Chimneys	DGGCARETC/774/2017	Dec 19, 2017	Valid
Mine Waste Management Plan	DGGIMAR.710/0006148	Jul 31, 2018	Valid through July 31, 2048
Hazardous Waste Management Plan	DGGIMAR.710/0004490	Jun 13, 2018	Valid
Water Well #1	B00.E.23.1.1/0481002930	Sep 17, 2014	Valid
Water Well #2	B00.E.23.1.1/0479002928	Sep 17, 2014	Valid
Water Well #2	B00.3.23.1.1/0480002929	Sep 17, 2014	Valid
Environmental Impact Statement for Tailings Dam III	SG/130.2.1.1/002292/11	Dec 7, 2011	Valid for operations through July 2031 and for closure to July 2033
Preventive Report of the Tailings Dam Expansion Phase 2A and 3A	SG/130.2.1.1/2126/16	Nov 28, 2016	Valid through September 2024, including closure stage
Technical Justification Study for Change of Land Use for Tailings Dam III Phase 2A and 3A	SG/130.2.2/000098/16	Jan 12, 2017	Currently valid; a request was submitted to SEMARNAT for a 2-year extension at time of authorization
Extension Authorization	SG/130.2.2/0053/2020	Jan 13, 2020	Valid
Explosives Permit	4596-Dgo	Oct 15, 2021	Valid; renewable each year

Golden Minerals personnel report that the Project holds and has retained the necessary permits to operate the mines and plants at Velardeña, and further there are no unresolved issues with the environmental regulatory agencies. They do not anticipate any limitations on the operations due to future inspections or evaluations by the environmental authorities

20.3.1 Environmental Monitoring Program

As part of the MIA for the Project and in compliance with environmental regulations, Golden Minerals has established an Environmental Monitoring Program that identifies potential impacts during each of the phases of the project along with actions to prevent and/or mitigate the effects. The program requires internal control and periodic reporting to verify compliance with the program. Golden Minerals has retained an independent consultant to evaluate compliance with current environmental reporting and requirements.

20.4 Environmental Baseline Data

The following subsections have been sourced from the Environmental Impact Statement for the Velardeña Mine Project Exploration and Mining Operation (April 2013).

20.4.1 Flora and Fauna

20.4.1.1 Flora

According to the classification of INEGI-INE (1996), the type of vegetation where the project is located corresponds to a vegetation type known as desert shrubland *rosetophilous* (rosette-forming vegetation) and sub montane scrub.

The project area is in a transition zone between two types of ecosystems: the desert scrub *rosetophilous* and the submontane scrub. However, there is no demarcation that determines the separation between the ecosystems, so it is possible to find species from the two ecosystems. In the lower parts of the Project area, the type of vegetation presented in the middle and lower mountains was the xeric scrub, which includes desert shrubland *rosetophilous* and sub montane scrub. This vegetation is sparse in places, while less extensive areas may have higher densities with the presence of shrubs and trees (*Prosopis laevigata* (smooth mesquite), *Acacia constricta* (whitethorn acacia), *Dasylirion palmeri*, *Yucca carnerosana* (giant Spanish dagger), *Fouqueira splendens* (ocotillo), and *Flourensia cernua* (tarbush).

Based on the results obtained in the field and bibliographic records, on-site and surrounding areas and six sampling sites, a total of 24 plant species were registered. The best represented family was the *Cactaceae* (cactus) family, represented with a total of eight species, followed by the *Fabaceae* (legume, pea, or bean) family with four species.

Of the 24 species of flora recorded for the Project study area, only one species is reported within a risk category: *Mammillaria candida* (snowball cactus), falls under the category of endangered.

The densest vegetation is located in the northern study area, where the following species can be found: *Acacia farneciana* (needlebush), *Agave lechuguilla* (lechuguilla), *Jatropha dioica* (leatherstem and Sangre de Drago), *Fouquieria splendes* (ocotillo), *Opuntia microdasy* (bunny ears cactus, bunny cactus, or polka-dot cactus), and *Larrea tridentata* (creosote bush).

In the south of the mineral processing plant area the density of the vegetation of desert shrubland *rosetophilous* is low and species like *Agave lechuguilla, Jatropha dioica, Fouquieria splendes, Opuntia microdasy, Lippia graveolens* (Mexican oregano), and *Larrea tridentata* are present.

The vegetation in the Project study area is diverse, abundant and has been deteriorated in areas with significant traffic of locals and paths. The arid ecosystem provides for a predominately shrub vegetation cover, mainly by species from gobernadora (creosote), ocotillo, and lechuguilla which contribute to soil stability. An indication of the stability maintained in this environment is shown by the abundance of various cacti species.

Among the species that should be monitored due to their intrinsic biological and ecological characteristics, include the species: *Conglomeratus echinocereus* cactus (hedgehog cactus), *Mammillaria heyderi* (ball cactus, cream cactus, cream pincushion, flat cream pincushion), *Mammillaria candida* (snowball cactus), *Opuntia* *imbricata* (giant tree or cane cholla), *Opuntia microdasy* (bunny ears cactus), *Opuntia violácea* (violet prickly pear), *Opuntia leptocaulis* (desert Christmas cactus), *Opuntia humifusa* (creeping prickly pear), and *Fouquieria Splende* (ocotillo).

The area where the mineral processing plant is located does not currently have any type of vegetation. Because no roads will be built and existing dirt roads will be used, the disturbance will generally be low in terms relative to the size of the project. Where soil degradation and erosion processes are likely, the affected area will be covered with rock or other material to hold the soil in place.

20.4.1.2 Fauna

There are 106 recorded animal species in the State of Durango: 35 mammals; 13 species of reptiles; and 58 species of birds.

The fauna present in the State of Durango represent 19% of the total Mexican fauna, the aviary species represent 32% and the reptilian fauna represent 19% of the total species registered for the country.

The Project area is located within the mammalian fauna area known as Zacatecana. The 35 mammal species identified in the zone are distributed in 26 subgroups and 17 families. Two of the mammal species are considered threatened: *Vulpes macortis*, commonly known as the kit fox, and *Peromyscus boylii*; commonly known as the brush mouse. One species is considered endangered: *Erethizon dorsatum,* commonly known as the North American porcupine.

Within the State of Durango there are 13 areas of importance for the conservation of birds, although; none of the areas is located close to the Velardeña Project. Of the 58 species of birds that were identified in the study area: four of the species are under special protection: Red-tailed hawk, Peregrine falcon, pine siskin, and Townsend’s solitaire; one is an endangered species: *Falco mexicanus*, commonly known as the prairie falcon; and another is considered threatened: *Vireo atricapillus*, known as the black-capped vireo.

Finally, in the general area of the Chihuahuan desert that extends to the north in the country, there are 13 species of amphibians and reptiles that have been identified. Two of the species are considered threatened; *Coluber constrictor* (black racer) and *Masticophis flagellum* (coachwhip snake); and another two are identified under special protection; *Cnemidophorus neomexicanus* (New Mexico whiptail), and *Crotalus lepidus* (rock rattlesnake).

20.4.2 Climate, Topography, and Vegetation

The following has been sourced from CAM (2012).

The area in which the Velardeña properties are situated is semi-arid with a climate predominantly warm and dry, with a mean annual temperature of 21.1°C and rainfall averaging 243.7 millimeters per year. Temperatures can drop below freezing in the winter and commonly reach the high thirties from July through to September. The predominant winds are northeast-southwest, with speeds of 2.1 to 6.0 meters per second.

The Velardeña district is located on the northwestern edge of the Meseta Central physiographical province, within the Sierras Transversales sub-province, on the eastern flank of the Sierra Madre Occidental Mountain range. The village of Velardeña is in the valley floor set between two northwest trending ranges. To the west is the Sierra Santa Maria which rises approximately 300 m above the valley floor and, to the east, is the Sierra San Lorenzo rising approximately to 750 m. The Sierra San Lorenzo hosts the Velardeña, Chicago, and San Diego properties, the latter being located farthest to the east into the Cerros El Trovador.

In physiographic terms, the zone is mature with a mixed topography. Streams within the area drain either to internal drainage systems or tributaries of the Nazas and Aguanaval rivers, which are connected to the Laguna de Mayrán. All the streams are intermittent and flow only during the rainy season. A series of water dams were built over the years to control water flow from the two rivers for irrigation and water management purposes. The Francisco Zarco dam, located 25 km to the west, is the closest to the Velardeña properties.

The geomorphology shows characteristics typical of a cycle of arid to semi-arid areas. There is an abundance of valleys and flat alluvial plains variably filled with erosional debris derived from adjacent highlands. The drainage systems are generally dendritic and poorly defined; many channels disappear when they reach the valley floor due to infiltration into poorly consolidated alluvial sediments.

20.4.3 Hydrology

The Velardeña project property is in the Hydrologic Region RH 6 Nazas-Aguanaval on the center-west part of the State of Durango. The Hydrologic Region consists of five basins: R. Aguanaval, R. Nazas-Rodeo, P. Lazaro Cardenas, L. de Mayran y Viesca, and R. Nazas-Torreón.

The Project property is in the Rio Nazas-Torreón basin, next to the Rio Aguanaval basin. The two water bodies are connected by both surface and groundwater.

20.4.3.1 Surface Water Hydrology

The Cuencamé River is the dominant stream course in the region with the headwaters located in the Sierrilla Atotonilco. There are several small springs that are tributary to this river. In the watershed there are 17 washes or stream courses; however, all but two of these are ephemeral and flow only for a brief time after a rainfall event. The two permanent waters are the Aguanaval River located roughly 29 Km, and the Nazas River located 35 km, respectively, from the site.

Two dams were identified, the Francisco Zarco and Las Mercedes located 27.8 km and 29.9 km from the site, respectively. These were constructed in the 1950s to divert flood water and for irrigation water storage and are located north of the Cuencamé community within the Nazas River basin.

20.4.3.2 Geohydrology

The Project is in the area containing Pedriceña-Velardeña aquifer (identified with key 1021 according to the Geographic Information of Underground Water). The surface area extent of the aquifer is approximately 3,000 square kilometers (km^2) and is in middle of the state of Durango.

The majority of the aquifer is located under the municipality of Cuencamé and a small portion lies underneath Peñon Blanco. The aquifer is mainly used for irrigation of crops and a small proportion of the water is used for the urban community. There is no district or irrigation unit, and neither is there a Technical Committee of Underground Water. According to the federal water law, in force since 2008, the municipality of Cuencamé and Peñon Blanco are classified as areas of beneficial use.

20.5 Community Relations and Social Responsibilities

Ejido Velardeña holds surface rights at the Project's Velardeña property. Golden Minerals reports that it has an agreement with the ejido for surface access and to perform work related to exploration and mining on the property. As part of this agreement, Golden Minerals makes quarterly payments of $2,000 to the ejido. The agreement was formalized before a notary as required by law and, although the formal agreement expired in December 2021, Golden Minerals remains in good standing with the community and has finalized a renegotiation of the agreement.

Ejido Vista Hermosa holds surface rights for the Project's Chicago property. Golden Minerals reports that it has an agreement with the ejido allowing access to the property to perform work related to mineral exploration and mining. The agreement was formalized before a notary and is valid until 2038. As part of the agreement, Golden Minerals makes a payment of $400,000 MXN plus applicable taxes by the 24th of March each year.

The agreements with the ejidos also state that the mine will preferentially hire residents from the Ejidos. When it is not possible to hire from either of the Ejidos, Golden Minerals seeks candidates from the local communities of Cuencamé, Cuatillos, or Pedriceña.

The Ministry of Health and Welfare runs a health center, which provides outpatient services and first aid. More serious problems are channeled to the Regional General Hospital of Cuencamé or the city of Gomez Palacio or Guadalupe Victoria. The Regional Hospital serves the inhabitants of the towns of: Cuencamé, Nazas, Simón Bolívar, Santa Clara, White Rock, Guadalupe Victoria, San Juan de Guadalupe, Juan Aldama, and Miguel Auza in the state of Zacatecas.

20.6 Closure and Reclamation

The closure plan addresses the closure, reclamation, and monitoring of the disturbed areas related to the Velardeña mines as well as the two processing plants.

20.6.1 Reclamation Statement of Responsibility

Golden Minerals has assumed the responsibility for the reclamation of surface disturbances that are attributable to the Velardeña mineral properties. All areas that have been disturbed at the Velardeña mineral properties by Golden Minerals will be reclaimed to a safe and stable condition upon cessation of mining operations.

20.6.2 Velardeña Project – Plant 1

The Plant 1 area includes a total of 71.4060 ha of land of which 13.0218 ha are considered affected areas requiring closure and reclamation. The affected area is further broken down into three property zones – the Industrial zone, La Palapa, and Las Liebres, as shown in **Figure 20-1**.

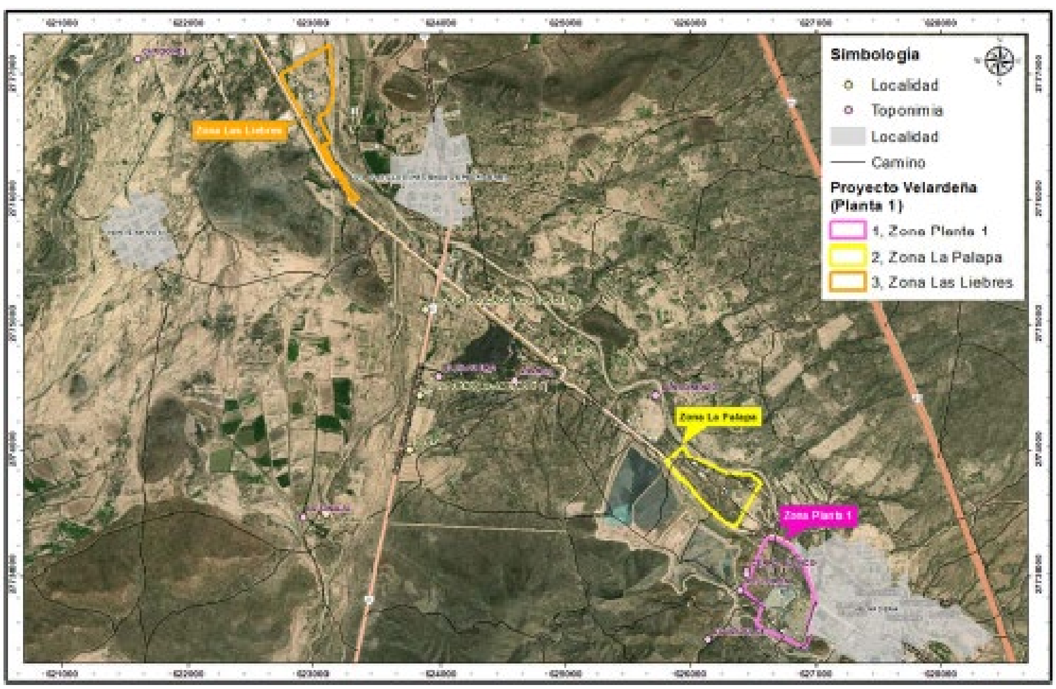


Figure 20-1: Plant 1 reclamation zones

The affected areas are summarized in **Table 20-3** below.

Table 20-3: Plant 1 impacted surface area

Reclamation Zone	Total Area (ha)	Affected Area (ha)
Industrial Zone	31.0843	11.7534
Las Liebres Zone	19.3426	0.3327
La Palapa Zone	20.9791	0.9357
Total	**71.4060**	**13.0218**

The cost estimate for the Plant 1 impacted areas is summarized in **Table 20-4**. Total estimated cost, including maintenance, monitoring, and contingency, is $1.5M.

Table 20-4: Plant 1 reclamation cost estimate

Domain/Activity	Cost ($000s)
Plant 1	$134
Tailings	$241
La Palapa	$23
Las Liebres	$11
Studies and Investigations	$259
Maintenance and Monitoring	$351
Subtotal	**$1,019**
Contingencies	$237
Integration of Associated Costs	$250
Total Estimated Cost	**$1,506**

20.6.3 Velardeña Project – Plant 2

The Plant 2 area includes 179.9654 ha of surface area of which 46.1693 ha are considered impacted and requiring closure and reclamation. The impacted area is further broken down into three zones – the Industrial Zone, the Mine Zone, and the San Juanes Zone, as shown in **Figure 20-2**.

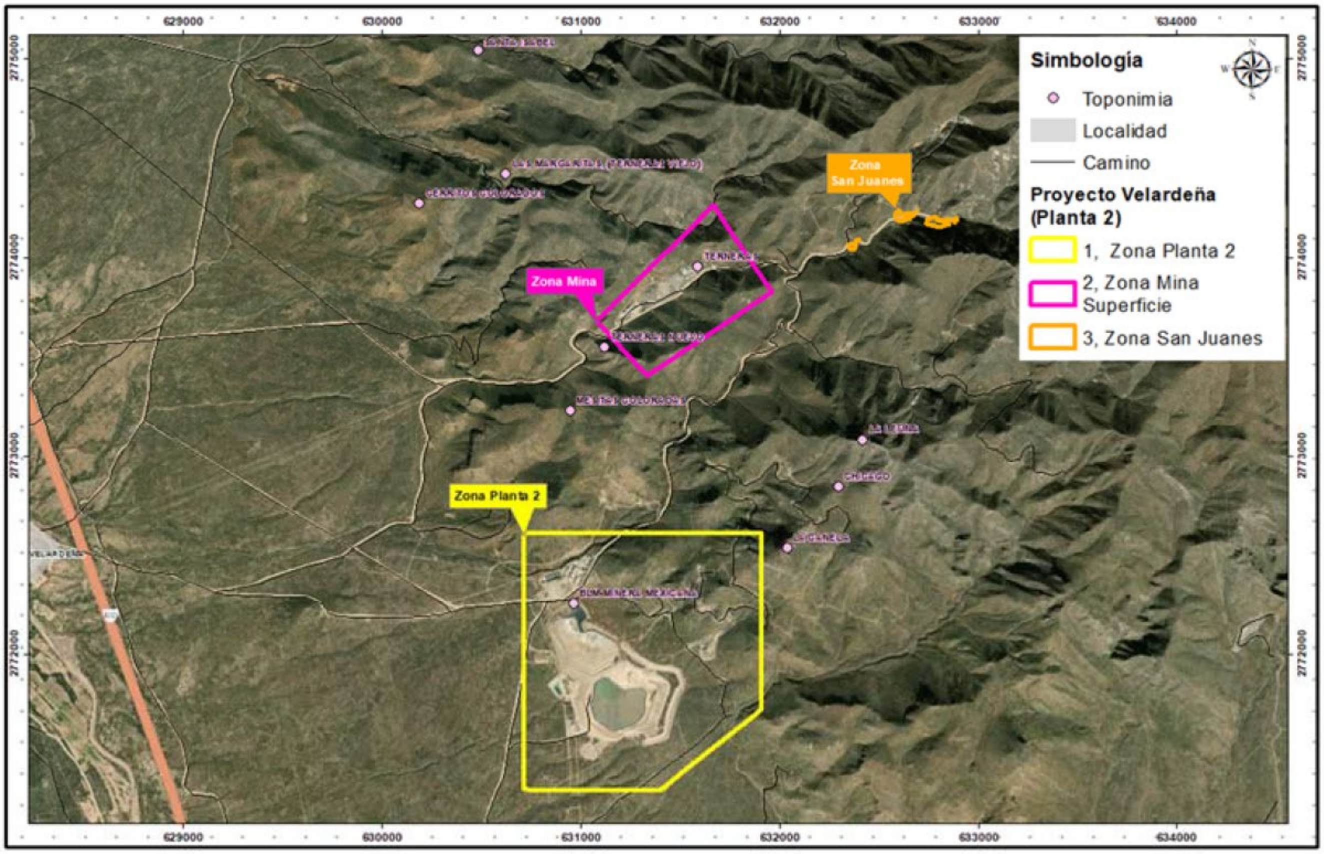


Figure 20-2: Plant 2 impacted zones

The respective areas of the mining facilities and the current mining disturbances at the Plant 2 area are described in **Table 20-5**.

Table 20-5: Reclamation and Disturbance Areas (ha)

Area Description	Total Area	Impacted Area
Industrial Zone (Plant 2)	144.0096	103.1300
Mine Zone	35.3471	4.6810
San Juanes Zone	0.6087	0.6087
Total	**179.9654**	**46.1693**

The cost estimate for the Plant 2 impacted areas is summarized in **Table 20-6**. Total estimated cost, including maintenance, monitoring, and contingency, is $2.4M.

Table 20-6: Plant 2 area estimated costs

Domain/Activity	Cost ($000s)
Plant 2	$288
Tailings	$502
Mine Surface	$81
San Juanes	$33
Studies and Investigations	$289
Maintenance and Monitoring	$425
Subtotal	**$1,618**
Contingencies	$378
Integration of Associated Costs	$365
Total Estimated Cost	**$2,361**

20.6.4 Post-Mining Land Use

Golden Minerals will remove the mining equipment and structures at the facilities that are not required for the post-mining land use and will regrade all the applicable disturbed areas of the property to a safe and stable condition suitable for the post-mining activities upon completion of the closure and reclamation work.

20.7 Reclamation Approach

The following reclamation activities are adapted from the closure plan and are assumed to meet the requirements necessary for the post-mining land use discussed in **Section 20.7.5**.

20.7.1 Equipment and Building Removal

All equipment (mobile equipment, feeders, crushers, conveyor belts, screens, stackers, etc.) and structures (offices, shops, tanks, process buildings, fuel, and oil tanks, etc.) will be removed from the property upon completion of operations. Structures may remain if requested for future land use. Any contaminated soil resulting from vehicle traffic and maintenance, or from other processing activities, may be subject to remediation prior to closure according to applicable environmental rules.

20.7.2 Roads, Power Lines, Water Lines, and Fences

Any roads constructed or used specifically for mining and processing operations at this facility and not required for the post-mining use will be reclaimed. The roads will be regraded and ripped to inhibit erosion and to promote revegetation seed growth as appropriate. Roads required for use during reclamation and closure will be reclaimed upon completion of reclamation and closure activities. Primary power lines and water lines installed on the property for mining and processing operations will generally remain in place as designated for post-mining use.

20.7.3 Area Regrade and Closure

Upon cessation of mining activities, all disturbed areas of the property will be assessed for any hazardous conditions including unstable soils or slopes, hazardous depressions, potential erosion conditions, and drainage requirements. Potentially unstable slopes or hazardous depressions will be regraded to a stable condition. Mine shafts or portals will be plugged, bulkheaded, sealed, or capped. All areas will be regraded to blend with natural topography and ripped, as appropriate, prior to the application of a hydro-mulched seed mix as appropriate.

20.7.4 Slope Stabilization

Slopes deemed unstable at their operational slopes will be regraded to minimize erosion and provide geotechnical stability.

20.7.5 Soil Conservation

Stockpiles of salvaged soil (plant growth material) that may be developed during mining operations may be located on the property as soil stockpiles and maintained for use during reclamation activities. All soil stockpiles will be stabilized as necessary during operations to prevent excessive losses from erosion or fugitive dust emissions. During reclamation activities, areas will be regraded and ripped as necessary to incorporate plant growth materials, to prevent excess compaction, and to achieve a suitable soil zone to enhance voluntary plant growth.

20.7.6 Revegetation

Where surface disturbances result in compaction of the soil, ripping, disking, or other measures will be employed to reduce compaction and establish a suitable root zone to promote the hydro-mulched revegetation growth.

20.7.7 Mining and Processing Areas

Reclamation of the mine disturbances, processing plants, tailing piles, and the associated mining areas as described in this report and in the Clifton closure estimate will be initiated within one year after cessation of mining activity and will be completed within three years.

20.7.8 Personnel

Golden Minerals personnel will inspect and maintain this facility as appropriate during the post-closure period until such time as closure and reclamation is complete. Golden Minerals will not have any full-time personnel assigned to this facility following completion of the reclamation project.

20.7.9 Monitoring

The closure of operations at this site will be monitored by Golden Minerals personnel to ensure environmental compliance of the reclamation work.

21. CAPITAL AND OPERATING COSTS

Capital and operating costs used in this study have been provided to Tetra Tech by Golden Minerals based on past production data and internal forecasts, which Tetra Tech has reviewed and found consistent with a mine of this type. The capital and operating cost estimates are considered to be accurate to within ±50%.

21.1 Capital Costs

Capital cost expenditures over the LOM are estimated to be $21.2 million as shown in **Table 21-1**. For the restart of operations, Golden Minerals will spend $17.0 million in the pre-production year.

Table 21-1: Capital costs ($000s)

Capital Costs	Pre-Production	LOM	Full LOM
Mine Development	$788	$0	$788
Process Plant	$14,498	$2,750	$17,248
Contingency and Other	$1,755	$1,375	$3,130
Total(1)	**$17,041**	**$4,124**	**$21,166**

[1]Columns may not total due to rounding

The pre-production costs include

- $788k for rehabilitation of the LHD fleet, installation of air compressors, installation of underground air doors, installation of the mine de-watering system, and equipment purchases
- $14.5M for the construction of the BIOX® plant at Plant 2
- $1.8M for other capital requirements and contingency

Planned expenditures over the mine life include $100k per year as sustaining capital for the Project, tailings sustaining capital of $230k per year, and an allocation of $275k for a tailings dam expansion at Plant 1.

21.2 Operating Costs

Operating Costs will average $242/t milled over the remaining LOM as shown in **Table 21-2**. For the purposes of this PEA, costs for estimated underground development are included as operating costs.

Table 21-2: Operating cost estimates

Item	Total ($000s)	Unit Cost ($/t)
Mining Costs - Stoping	$131,261	$106.09
Mining Costs - Development	$33,653	$27.20
Milling costs	$105,234	$85.05
Mine & Process	$270,148	$218.34
Contingency and Other	$27,015	$21.83
Federal Precious Metal Royalty	$2,532	$2.05
Total[1]	**$299,695**	**$242.23**

[1]Columns may not total due to rounding

22. ECONOMIC ANALYSIS

An economic model was prepared for the Project using Measured, Indicated, and Inferred Mineral Resources. Mineral Resources are not Mineral Reserves and do not have demonstrated economic viability. This PEA also considers Inferred Mineral Resources that are too speculative for use in defining Reserves. Results of the economic analysis are:

- Mine Life: 11 years
- Pre-tax $NPV_{8\%}$: $119M, IRR: 114%
- Payback: One year
- Federal Precious Metal Royalty: $2.53M

22.1 Inputs and Assumptions

Technical assumptions used in the economic analysis are presented in **Table 22-1**. Metal prices are based on long-term average consensus prices from 40 banks. Reclamation costs are assumed to be canceled by salvage value and are therefore not considered in the analysis. Results are reported pre-tax.

Table 22-1: Economic model input parameters

Description	Value	Units
Market Prices		
Gold (Au)	$1,774.00	/oz
Silver (Ag)	$23.70	/oz
Lead (Pb)	$0.97	/lb.
Zinc (Zn)	$1.15	/lb.
Royalties		
Federal Precious Metal Royalty	0.50	%
Financial		
Discount Rate	8	%

Mine and process plant production summaries over the LOM are summarized in **Table 22-2** and **Table 22-3**, respectively.

Table 22-2: ROM production summary

Description	Value	Units
ROM Milled	1,237	kt
ROM Grades		
Au	5.3	g/t
Ag	344	g/t
Pb	1.34	%
Zn	1.64	%
Metal Contained in ROM		
Au	210	koz
Ag	13,678	koz
Pb	36,586	klb.
Zn	44,731	klb.

Pb values in the Zn concentrate as well as Zn values in the Pb concentrate are not paid-for by the smelters and are therefore not reported in the table. Au and Ag payables are different for each concentrate produced and are appropriately accounted for in the economic model.

Table 22-3: Process summary

Description	Unit	Total Conc. (kt)	Pb Conc. (kt)	Zn Conc. (kt)	Doré (kg)
Products		66,338	31,120	35,218	44,959
Metal Recoveries					
Au	%	67%	20%	3%	44%
Ag	%	90%	71%	10%	9%
Pb	%	72%	72%	0%	0%
Zn	%	76%	0%	76%	0%
Contained Metals					
Au	koz	140	42	6	93
Ag	koz	12,291	9,732	1,322	1,237
Pb	klb.	11,868	11,868	0	0
Zn	klb.	15,519	0	15,519	0

Payable metals for each concentrate type are derived using the smelter terms as described in **Section 19** and shown in aggregate in **Table 22-4**. These metals account for the gross value of the concentrates.

Table 22-4: Payable metals

Description	Value	Units
Au	133	koz
Ag	11,328	koz
Pb	10,934	klb.
Zn	13,191	klb.

22.2 Technical-Economic Results

Technical-economic results are presented in **Table 22-5**. Over the LOM, the Project is projected to return a pre-tax $NPV_{8\%}$ of $119M with an IRR of 114%.

Table 22-5: Economic model results ($000s)

Item	Total ($000s)	Pb Concentrate	Zn Concentrate	Doré
Gross Payable	**$556,905**	**$311,680**	**$59,772**	**$185,453**
TCs, RCs and Penalties	**($35,939)**	**($19,791)**	**($14,663)**	**($1,485)**
Freight & Insurance	**($14,512)**	**($5,885)**	**($5,195)**	**($3,432)**
NSR	**$506,454**	**$286,004**	**$39,914**	**$180,536**
Operating Costs				
Mining costs - Stoping	($131,261)			
Mining Costs – Development	($33,653)			
Milling Costs	($105,234)			
Contingency and Other	($27,015)			
Federal Mining Royalty	($2,532)			
Total Operating	**($299,695)**			
Operating Margin	**$206,759**			
$/t-milled	**($242.23)**			
Capital Costs	**Full LOM**	**Pre-Production**	**LOM**	
Process Plant	($788)	($788)	$0	
Infrastructure	($17,248)	($14,498)	($2,750)	
Contingency and Other	($3,130)	($1,755)	($1,375)	
Cash Flow	**$185,594**			
$NPV_{8\%}$	**$118,933**			
IRR	**114%**			
Payback (years)	**1**			

The LOM cash flow results are presented in **Table 22-6** on an annual basis.

Table 22-6: LOM cash flow

Item	Total	Year -1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11
NSR													
Gross Payable	$556,905		$50,312	$52,463	$55,817	$62,526	$52,967	$52,776	$48,695	$43,629	$49,314	$42,240	$46,166
TCs, RCs, Freight	($50,451)		($6,831)	($4,464)	($6,776)	($5,338)	($4,933)	($4,674)	($4,167)	($3,456)	($3,213)	($3,375)	($3,225)
NSR	**$506,454**		**$43,481**	**$47,998**	**$49,041**	**$57,188**	**$48,035**	**$48,102**	**$44,528**	**$40,173**	**$46,101**	**$38,865**	**$42,941**
Operating Costs													
Mining Costs - Stoping	($131,261)		($11,965)	($11,965)	($11,965)	($11,965)	($11,965)	($11,965)	($11,965)	($11,965)	($11,965)	($11,965)	($11,615)
Mining Costs - Development	($33,653)		($3,067)	($3,067)	($3,067)	($3,067)	($3,067)	($3,067)	($3,067)	($3,067)	($3,067)	($3,067)	($2,979)
Milling Costs	($105,234)		($8,140)	($9,388)	($8,711)	($11,021)	($9,067)	($9,471)	($9,329)	($10,080)	($10,275)	($10,059)	($9,693)
Contingency and Other	($27,015)		($2,317)	($2,442)	($2,374)	($2,605)	($2,410)	($2,450)	($2,436)	($2,511)	($2,531)	($2,509)	($2,429)
Precious Metal Royalty	($2,532)		($217)	($240)	($245)	($286)	($240)	($241)	($223)	($201)	($231)	($194)	($215)
Total Operating Costs	**($299,695)**		**($25,706)**	**($27,102)**	**($26,363)**	**($28,944)**	**($26,749)**	**($27,194)**	**($27,020)**	**($27,825)**	**($28,068)**	**($27,795)**	**($26,930)**
Operating Margin	**$206,759**		**$17,775**	**$20,897**	**$22,679**	**$28,244**	**$21,286**	**$20,908**	**$17,508**	**$12,349**	**$18,033**	**$11,070**	**$16,011**
Capital Costs													
Pre-production Development	($788)	($788)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Process Plant	($17,248)	($14,498)	($226)	($226)	($226)	($501)	($226)	($226)	($226)	($226)	($226)	($226)	($219)
Contingency and Other	($3,130)	($1,755)	($133)	($133)	($133)	($160)	($133)	($133)	($133)	($133)	($133)	($133)	($22)
Pre-tax Cash Flow	**$185,594**	**($17,041)**	**$17,417**	**$20,539**	**$22,321**	**$27,583**	**$20,928**	**$20,550**	**$17,150**	**$11,991**	**$17,675**	**$10,712**	**$15,770**
Pre-tax $NPV_{8\%}$	**$118,933**												
IRR	**114%**												
Payback (years)	**1**												

22.3 Sensitivities

Project sensitivity to Au price, capital and operating costs are shown in **Figure 22-1.** Results of the sensitivity analyses show the project is most sensitive to operating costs and Au price. A 10% increase in operating costs results in a 16% reduction in project NPV. Due to the sensitivity to operating costs, efforts to control or reduce the operating costs are material to the economic success of the Project.

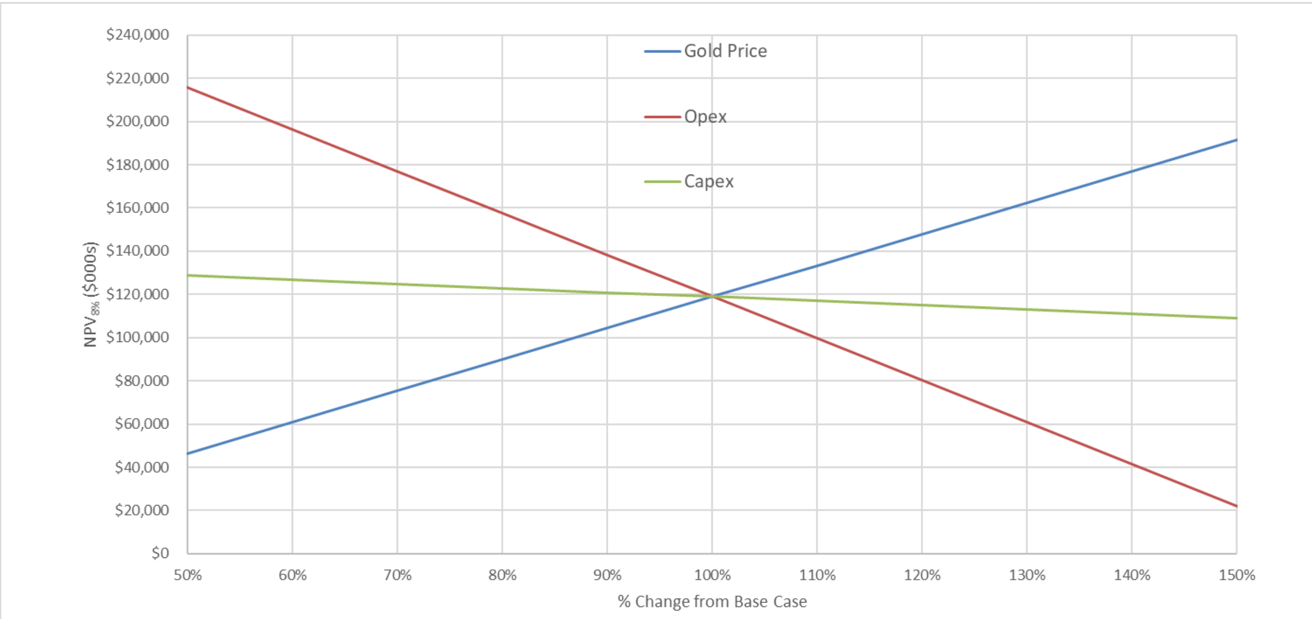


Figure 22-1: Sensitivities

23. ADJACENT PROPERTIES

The Project is surrounded by claims held by various entities, with the most significant holdings controlled by Industrias Peñoles, S.A.B. de C.V. (Peñoles), and Grupo México S.A.B. de C.V. (Grupo Mexico). Publicly available data regarding exploration results, Mineral Resources, and Mineral Reserves for adjacent properties were not located.

As described in **Section 6**, the Velardeña property is located within a broader district of the same name, which is host to several significant, past-producing Ag-Au-Pb-Zn mines. The most important of these cluster within the Sierra Santa Maria Dome, west of the pueblo of Velardeña, and include the Santa Maria, La Industria, San Nicolás, and Los Azules mines.

24. OTHER RELEVANT DATA AND INFORMATION

Tetra Tech is not aware of any additional information for which the exclusion thereof would render this report misleading.

25. INTERPRETATIONS AND CONCLUSIONS

With the inclusion of Measured, Indicated, and Inferred Mineral Resources the findings of this PEA suggest the Project is conceptually economically viable. The PEA has been based on Mineral Resources, which are not Mineral Reserves and do not have demonstrated economic viability; therefore, without the definition of Reserves and subsequent feasibility or pre-feasibility studies, the project cannot be determined to be economically viable.

25.1 Geology and Resources

Drill hole and channel samples have been collected and analyzed using industry standard methods and practices and are sufficient to support the characterization of grade and thickness and further support the estimation of Measured, Indicated and Inferred Resources.

25.2 Mining

Results of the PEA indicate mining is potentially economically viable. However, due to the thin-veined nature of the mineralization and the scale of the operations, extensive Resource drilling of the deposit is not planned at this time. Conceptual stope outlines have been used for the purposes of this PEA.

The Project is sensitive to mining dilution, which could increase the costs of saleable products, but also provides opportunity as any potential reductions in dilution from the mining would greatly benefit the Project. Recent test mining at the site has confirmed a minimum selective mining width of 0.7 m is achievable, which can contribute to reducing dilution.

25.3 Metallurgy and Process

There are no geological, lithological, or mineralogical changes in the process plant feed anticipated for the envisaged potential future production as compared to previous operations. Existing legacy operational data supports the existing process flow sheet for future production at Plant 1.

The use of existing and refurbished equipment within the pre-existing facilities, and the production of marketable concentrates, is Golden Minerals' preferred method of treating potential future production. A new BIOX® plant would be constructed to treat the pyrite concentrates if further testing confirms the potential for increased gold recovery.

25.4 Significant Risk Factors

Factors that could affect the potential economic viability of the project could include underestimations of operating capital and declines in any or all the metal prices. Estimation of Resources could be affected by changes in metal prices and the actual mineralized shoot shapes and orientations. Successful implementation of the proposed mine plan is subject to the successful conversion of Inferred Resources to Indicated or Measured classification as well as conversion of Measured and Indicated Mineral Resources to Mineral Reserves, the prediction of stope layout and shape which is controlled by the actual shape of mineralized shoots and their orientations, and the ability of the mining operations to control waste dilution.

The performance of the BIOX® plant is key to the economics estimated in this PEA. If the expected results are not achieved, the BIOX® process would compromise an important part of the entire process.

Many of the above stated risks are balanced with the opportunity to add potential value in excess of what has been described in this PEA.

26. RECOMMENDATIONS

The following recommendations are made to further develop the Project but are not integral to the implementation of the plan proposed in this PEA. **Table 26-1** outline estimated costs if the following recommendations were completed.

Table 26-1: Estimated costs associated with recommendations

Description	$USD
Exploration Drilling ($100/m)1	500,000
Mining Trade-off Studies	35,000
Metallurgical Test work	100,000
Total	**635,000**

[1]*Assuming 9,000 m drill program.*

26.1 Geology and Resources

- Continue to collect specific gravity measurements and refine current estimations of specific gravity; additional measurement should ideally be made with a paraffin wax or epoxy coating
- Implement procedures of duplicate channel sampling by secondary sampling teams of drifts prior to stope development to ensure grade and thickness characteristics and to serve as field duplication of channel samples
- Setup of strict control sample review procedures and tolerances involving review of control sample failure on receipt of each batch's results, and automatic triggering of batch re-analysis immediately after being alerted to failures
- Improve sample data transcription methods to reduce control sample labeling errors and immediately resolve errors when encountered
- Perform a detailed model reconciliation on a completed stope early in the proposed mine life and alter the estimation methods if the result of the reconciliation suggest refinements should be made
- Continue to advance exploration drilling down dip of current Inferred Resources as new levels are established; preferentially target the Terneras, San Mateo, Roca Negra, and A4 veins

26.2 Mining

It is recommended that Golden Minerals implements cut and fill mining where waste and vein material are blasted separately to reduce ore dilution. This practice would consider more total tonnes blasted in each section. Vein tonnes would be reduced, but the resulting grade would be higher. Recent tests on selective mining widths of 0.7 meters has proven to be achievable. Because this practice requires efficient operations control, Tetra Tech recommends having detailed control in drilling and blasting.

The mine plan developed for the PEA should be optimized and undertaken at a more detailed level, which will enable a greater understanding of mining constraints, costs, and resulting mill feed. Additionally, the oxide Resource should be evaluated for inclusion into future mine plans.

26.3 Metallurgy and Process

Antimony and arsenic are penalty elements in the Pb and Zn concentrates and could be added to the database and spatially modeled. Additional metallurgical test work is recommended to investigate the depression of antimony and arsenic from the final Pb and Zn concentrates, and Zn from the pyrite concentrate.

The potential of a new bio-oxidation plant to improve gold recovery warrants further test work to confirm previous encouraging results.

26.4 Economic Analysis

Currently, it is anticipated that the salvage sale of equipment will cover the reclamation costs. However, the salvage value of the mine equipment at the end of the LOM has not been estimated. It is recommended that an estimate of the salvage value of the Project's assets be determined and incorporated into the economic analysis alongside the closure cost estimates to increase the resolution of the Project's economics.

27. REFERENCES

Chlumsky, Armbrust & Meyer, LLC, (2012), NI 43-101 Technical Report, Velardeña Project, Durango State, Mexico, prepared by Craig Bow, Ph.D. and Robert L. Sandefur, P.E. for Golden Minerals, filed on SEDAR on June 29, 2012, 106 p.

Gilmer, A.L., Clark, K.F., Conce, C.J., Hernandez, C.I., Figueroa, J.I., and Porter, E.W., 1988, Sierra de Santa Maria, Velardeña mining district, Durango, Mexico. Econ Geology, v. 83, p. 1802-1829.

Mexican Mining Journal, (1909). Ore deposits at Velardeña, Dgo. The Mexican Mining Journal http://www.researchgate.net/journal/0008-4077_Canadian_Journal_of_Earth_Sciences , Volume 8, #1, pp. 35.

Micon International Inc., (2008), NI 43-101 Technical Report, Review of the Mineral Resource Estimate for the Velardeña District Properties, Velardeña Mining District, Durango State, Mexico, prepared by W Lewis for ECU Silver Mining Inc., filed on SEDAR on March 10, 2008 and amended on September 30, 2008, 137 p.

Micon International Inc., (2009), NI 43-101 Technical Report, Updated Mineral Resource Estimate for the Velardeña District Properties, Velardeña Mining District, Durango State, Mexico, prepared by William J. Lewis for ECU Silver Mining Inc., filed on SEDAR on January 20, 2009, 180 p.

Pinet, N., Tremblay, A. (2009). Structural analysis of the Velardeña mining district, Mexico: a faulted Au-Ag-rich hydrothermal system. Canadian Journal of Earth Sciences, *46*(2), pp. 123-138.

Tetra Tech, Inc., 2020: Preliminary Economic Assessment NI 43-101 - Technical Report of the Velardeña Project; technical report

Tinoco, Mauricio Chavez M. and Aguilar, Cesar Calleros, (April 2013), Environmental Impact Statement for the Velardeña Mine Project Exploration and Mining Operation, Located in the Town of Cuencamé of Ceniceros, State of Durango, 202 p.

28. DATE AND SIGNATURE PAGE

CERTIFICATE OF AUTHOR

Guillermo Dante Ramírez-Rodríguez, PhD, MMSAQP
Principal Mining Engineer of Tetra Tech
350 Indiana Street, Suite 500
Golden, Colorado 80401
Telephone: (303) 217-5700

I, **Guillermo Dante Ramírez-Rodríguez, PhD, MMSAQP**, of Golden, Colorado do hereby certify:

a) I am a Principal Mining Engineer with Tetra Tech, Inc. with a business address of 350 Indiana St., Suite 500, Golden, CO 80401.

b) This certificate applies to the Technical Report titled "Preliminary Economic Assessment NI 43-101 Technical Report of the Velardeña Project, Durango State, Mexico" with an effective date of March 1, 2022.

c) I have a Bachelor's degree in Mining and Metallurgical Engineering from the University of Zacatecas School of Mines in Mexico, and a Master and Doctorate degrees in Mining and Earth Systems Engineering from the Colorado School of Mines, in the United States of America. I am a QP member for the Mining and Metallurgical Society of America (Member No. 01372QP). I have over 35 years of professional experience since my graduation in 1987. I am a "Qualified Person" for purposes of National Instrument 43-101 (the "Instrument").

d) I visited the property December 10,2019.

e) I am responsible for Sections 15, 16, 18-22, as well as portions of Sections 1, 2, and 24-27.

f) I satisfy all the requirements of independence according to NI 43-101.

g) I have read NI 43-101, Form 43-101 F1, and the Companion Policy to NI 43-101 (43-101 CP) and this Technical Report has been prepared in compliance with NI 43-101, Form 43-101 F1, and 43-101 CP.

h) As of the effective date of the Technical Report, to the best of my knowledge, information and belief, the Technical Report contains all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

i) I consent to the filing of the Technical Report with any stock exchanges or other regulatory authority and any publication by them, including electronic publication in the public company files on the websites accessible by the public, of the Technical Report.

Dated: May 6, 2022

"Guillermo Dante Ramírez-Rodríguez PhD, MMSAQP"
SIGNATURE OF QUALIFIED PERSON

Guillermo Dante Ramírez-Rodríguez PhD, MMSAQP
PRINT NAME OF QUALIFIED PERSON

CERTIFICATE OF AUTHOR

Randolph P. Schneider, QP
Associate Metallurgical Engineer of Tetra Tech
350 Indiana Street, Suite 500
Golden, Colorado 80401
Telephone: (303)-217-5700

I, **Randolph P. Schneider, QP**, of Wellington, Colorado do hereby certify:

a) I am currently employed as subcontractor of Tetra Tech located at 350 Indiana Street, Suite 500, Golden, Colorado 80401.
b) This certificate applies to the Technical Report titled "Preliminary Economic Assessment NI 43-101 Technical Report of the Velardeña Project, Durango State, Mexico" with an effective date of March 1, 2022.
c) I am a Professional Metallurgist and a Registered Member of The Society for Mining, Metallurgy & Exploration, a member of the Canadian Institute of Mining, Metallurgy and Petroleum, a fellow of the Australasian Institute of Mining and Metallurgy, a QP member of Mining & Metallurgical Society of America (Member No. 01330), a member of the Extractive Metallurgy Chapter of Denver, and a member of the Colorado Mining Association.
d) I graduated from the Colorado School of Mines with BSc in Metallurgical Engineering. I have practiced my profession continuously since graduating and have more than 40 years' experience.
e) I have read the definition of "Qualified Person" set out in National Instrument 43-101 (NI 43-101) and certify that by reason of my education, affiliation with a professional association and relevant work experience, I fulfill the requirements for the purposes of NI 43-101.
f) I visited and inspected the subject property on December 10, 2019.
g) I participated and am responsible for Sections 13 and 17, and portions of Sections 1, 2, and 24-27 of this Technical Report.
h) I satisfy all the requirements of independence according to NI 43-101.
i) I have read NI 43-101, Form 43-101 F1, and the Companion Policy to NI 43-101 (43-101 CP) and this Technical Report has been prepared in compliance with NI 43-101, Form 43-101 F1, and 43-101 CP.
j) As of the effective date of the Technical Report, to the best of my knowledge, information and belief, the Technical Report contains all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.
k) I consent to the filing of the Technical Report with any stock exchanges or other regulatory authority and any publication by them, including electronic publication in the public company files on the websites accessible by the public, of the Technical Report.

Dated May 6, 2022

"Randolph P Schneider, MMSAQP"- Signed

Signature of Qualified Person

Randolph P Schneider, MMSAQP

Print name of Qualified Person

CERTIFICATE OF AUTHOR

Kira Lyn Johnson, MMSAQP
Senior Geological Engineer of Tetra Tech
350 Indiana Street, Suite 500
Golden, Colorado 80401
Telephone: (303) 217-5700

I, **Kira Lyn Johnson, MMSAQP**, of Golden, Colorado do hereby certify:

a) I am a Senior Geological Engineer with Tetra Tech, Inc. with a business address of 350 Indiana St., Suite 500, Golden, CO 80401.

b) This certificate applies to the Technical Report titled "Preliminary Economic Assessment NI 43-101 Technical Report of the Velardeña Project, Durango State, Mexico" with an effective date of March 1, 2022.

c) I have a Bachelor's degree in Geological Engineering from South Dakota School of Mines and Technology. I am a QP member for the Mining and Metallurgical Society of America (Member No. 01539). I have 15 years of professional experience. I am a "Qualified Person" for purposes of National Instrument 43-101 (the "Instrument").

d) I inspected the property on December 10, 2019.

e) I am responsible for section 7-12, 14, and 23 of the report, as well as portions of Sections 1-6 and 24-27.

f) I satisfy all the requirements of independence according to NI 43-101.

g) I have read NI 43-101, Form 43-101 F1, and the Companion Policy to NI 43-101 (43-101 CP) and this Technical Report has been prepared in compliance with NI 43-101, Form 43-101 F1, and 43-101 CP.

h) As of the effective date of the Technical Report, to the best of my knowledge, information and belief, the Technical Report contains all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

i) I consent to the filing of the Technical Report with any stock exchanges or other regulatory authority and any publication by them, including electronic publication in the public company files on the websites accessible by the public, of the Technical Report.

Dated May 6, 2022.

"Kira Lyn Johnson, MMSAQP" - Signed
Signature of Qualified Person

Kira Lyn Johnson, MMSAQP
Print name of Qualified Person