GOLDER

REPORT

Geotechnical Exploration Plan

Allison Mine, New Mexico

Submitted to:

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Submitted by:

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Table of Contents

1.0 INTRODUCTION

Golder Associates Inc. (Golder) prepared this geotechnical exploration plan for the Abandoned Mine Land Program (AML Program) to support the undermining hazard assessment for the Allison Project Extent (APE) in the community of Allison, McKinley County, New Mexico. Allison is the location of a former underground coal mine, and much of the community and project area has been undermined. Under SHARE No. 19-521-0620-0195, the AML Program tasked (Task Order 1) Golder to conduct a preliminary geotechnical assessment of the Allison Project Area. Golder presented a preliminary hazard assessment in our Draft Preliminary Hazard Report issued to the AML Program on January 17, 2020. This exploration plan is intended to advance Golder's preliminary hazard assessment with physical data.

1.1 Objectives

The intent of this exploration plan is to efficiently collect data to support and refine the undermining hazard assessment of the APE. In addition to the condition of the mine workings, the characteristics and thickness of the rock above the mine workings is a primary factor in assessing the undermining hazard. Thus, the data collected from the exploration program is intended to improve the understanding of:

- Lithology, including
  - Elevation of top of rock
  - Elevation of the mined coal seams
  - Coal seam thickness
  - Overburden characteristics
- Condition of unmitigated, mapped workings (both primary and secondary mining)
- Previous AML Program Mitigation work (confirmation drilling and backfill grouting from 1985-1986)
- Areas where no workings are mapped

1.2 Previous Field Investigation

Golder reviewed the results of previous field geophysical and geotechnical investigation efforts with regards to successes and weaknesses, and we applied the lessons learned from those efforts in the development of this plan. Previous investigation work was focused as follows:

- 1985-1987 Investigation and Backfill – The AML Program advanced rotary borings throughout the community with the intent to: mitigate mapped workings under structures and confirm that no unmapped workings were present under structures. Phase 1 drilling was completed by Stewart Brothers in 1985 and 1986 included 709 borings totaling approximately 160,000 linear feet of drilling and Phase 2 drilling was completed by Badger Western in 1987 and consisted of 19 borings totaling 2,119 linear feet. The borings were generally located adjacent to houses where mine plans indicated undermining, and on a very tight spacing (approximately 20-foot centers) along the roads through the populated area of the community where no workings were mapped. The investigation and mitigation program also included casing borings that encountered workings to allow for subsequent placement of backfill material into the void spaces and it is evident that some borings (possibly cased) were not properly abandoned. Investigation and mitigation records and data available from the program is limited. From Phase 1, the records consist of *some* (approximately 140) of the driller's daily logs and a sketch showing approximate boring locations with notes regarding where workings were possibly encountered. The daily logs (where available) include rough boring logs compiled by the drillers (i.e., not by a geological or geotechnical professional). No records regarding the drilling locations are available for Phase 2; total concrete and grout backfill volumes were recorded, but with no record of where materials were placed.

- 2015 to 2017 Sinkhole Mitigation – After a sinkhole developed along the western extent of the townsite the AML program completed drilling and geophysical investigations; sinkhole and undermining backfill; and ground improvement in the sinkhole area. All work was limited to the immediate vicinity of the sinkhole.
  - Geophysical investigations included: electromagnetic survey (EM-31 survey), ground penetrating radar (GPR), seismic refraction, and electrical resistivity imaging (ERI). The EM-31 and GPR are both limited to near surface; EM-31 survey has a maximum depth of approximately 20 Feet Below ground Surface (ft-bgs), and GPR was limited to a maximum depth of less than 5 ft-bgs. These investigation methods have limited use to detect shallow voids (i.e., sinkholes that are near surface, but have not yet daylighted). Seismic refraction was completed with different focal depths and found useful for estimating the depth to top of rock. Micro-seismic survey may have some potential for locating shallow workings, and pending further investigation, may have potential for investigation of previous mitigation (backfill) efforts.
  - Drilling investigation was completed with both air rotary and rock coring methods with boring logs logged by a geological/geotechnical professional.

Previous drilling investigations using standard rotary methods seem to have mixed cuttings from throughout the borings such that the lithologic logs, as well as the logged depth to the mine workings, is suspect. Core drilling provided more clarity of the depth at which materials were encountered; however, core drilling is slower, making it more expensive and much of the overburden rock is weak making it subject to drilling induced (mechanical) fracture and poor recovery.

2.0 PROPOSED INVESTIGATION PLAN

2.1 Phased Approach

We propose a phased approach to the investigation as follows:

Phase 1 – Seismic Refraction Survey – Seismic refraction can rapidly collect data over a large area. Based on previous results, we expect seismic refraction to allow for mapping the depth to bedrock.

Phase 2 – Test Pitting and Initial Drilling – Initial drilling locations are identified to support our investigation objectives (Section 1.1) and:

a. Support the interpretation of the seismic refraction results

b. Characterize the geological and geotechnical conditions across the APE

c. Investigate some of the near surface workings and workings that present a critical hazard

d. Support hydrologic design

Phase 3 – Mitigation Investigation Geophysics – If initial drilling results indicate that micro-seismic geophysics methods were able to identify areas of previous mitigation (backfilling), additional geophysics may be useful for rapid assessment of those areas and reduce the second phase of drilling.

Phase 4 – Detailed Drilling Investigation – Depending on the results of the other phases of investigation, a second phase of drilling would be used to:

a. Address data gaps identified after the initial drilling

b. Further assess high hazard areas and other areas of interest/concern

c. Provide additional information to support mitigation design

This additional investigation may be completed as part of and in conjunction with mitigation efforts.

This geotechnical exploration plan details the first two proposed phases; the detailed investigation drilling would be planned after evaluating the results from the initial drilling. Results from the seismic survey and initial drilling will allow Golder to refine the preliminary hazard assessment significantly. After the hazard assessment is updated with results of the initial investigation, it will be a much more useful tool for identifying the areas of critical risk.

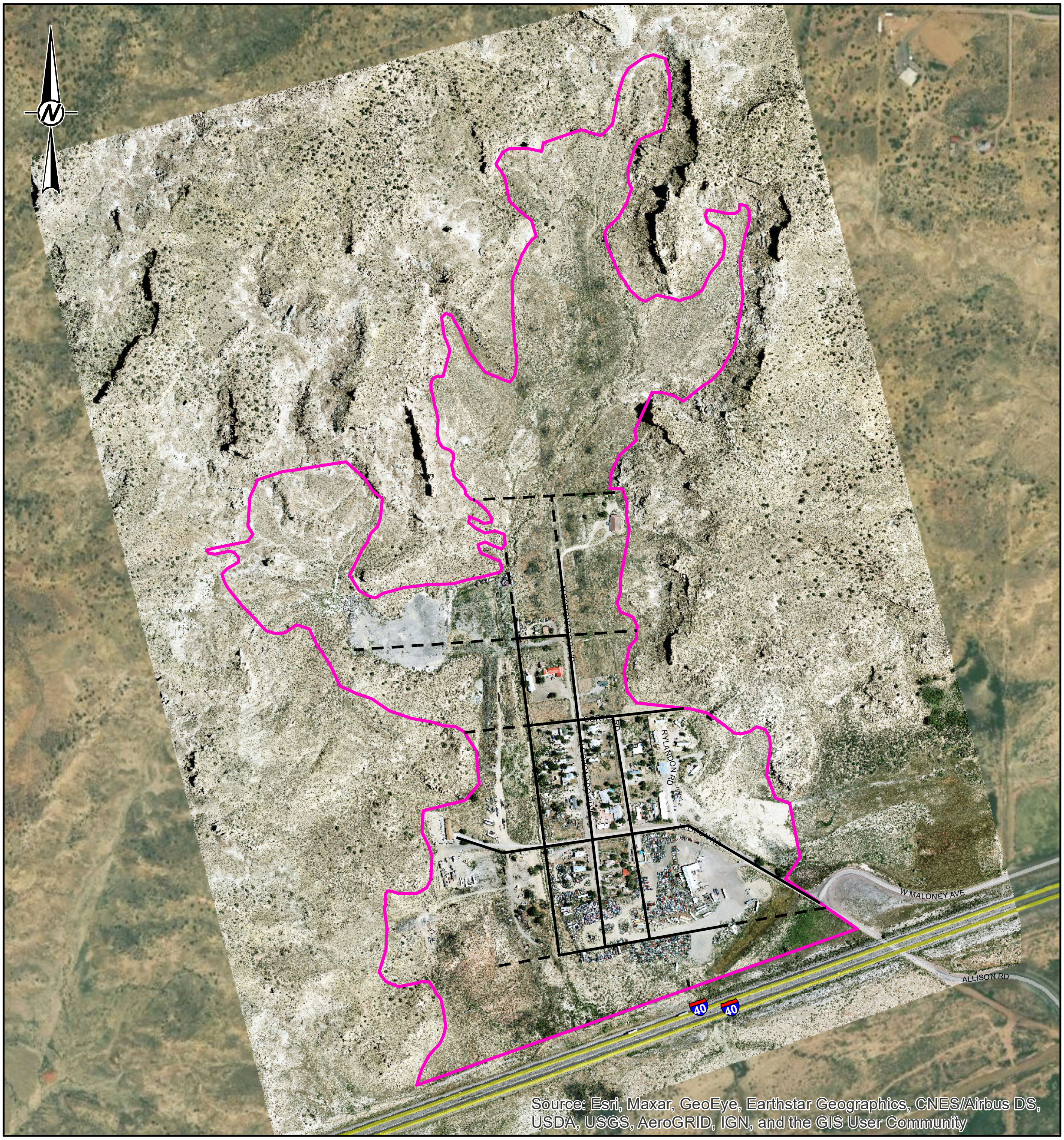
2.2 Phase 1 – Seismic Refraction

Based on previous results, seismic refraction appears to be useful for rapidly mapping the depth to top of rock. A series of both north-south and east-west oriented seismic refraction arrays should provide sufficient spatial coverage of the area to generate a top of rock contour map.

The proposed arrays are shown on Figure 1. In general, the arrays are located along existing access roads to minimize the ground disturbance; dashed lines indicate where the arrays extend beyond existing roads.

Seismic refraction consists of placing a long string of geophones in direct contact with the ground, and a seismic energy source (typically a hammer strike onto a hard surface in contact with the ground). Where the array is accessible by a vehicle (pickup truck or all terrain utility vehicle ([UTV]), the hammer can be mounted on a standard receiver hitch. Where vehicle access is not possible or ground disturbance is not allowed, the work can be completed on foot. Ground disturbance may consist of a maximum 12-foot wide access road/path.

We anticipate that the proposed arrays could be completed in approximately one week of field effort with a two-person crew (assuming a vehicle mounted hammer is used for most of the arrays).



LEGEND

Allison Project Extents (APE)

Proposed Seismic Refraction Arrays (Max width 10ft)

- - Land Disturbance

— No Land Disturbance

0 400 800 1,600

FEET

REFERENCE(S)

1. ALLISON APE, NEW MEXICO EMNRD AML, 2019.

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEW MEXICO WEST FIPS 3003 FEET
PROJECTION: TRANSVERSE MERCATOR
DATUM: NORTH AMERICAN 1983

CLIENT
NEW MEXICO ENERGY MINERALS AND NATURAL RESOURCES DEPARTMENT ABANDONED MINE LAND PROGRAM

PROJECT
ALLISON MINE
GEOTECHINCAL EXPLORATION PLAN

TITLE
PROPOSED SEISMIC REFRACTION ARRAYS

CONSULTANT

GOLDER

YYYY-MM-DD	2020-06-22
DESIGNED	NRL
PREPARED	NRL
REVIEWED	JP
APPROVED	JC

PROJECT NO.	CONTROL	REV.	FIGURE
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2.3 Phase 2 – Initial Drilling, Test Pitting and Trenching

2.3.1 Drilling Methods and Equipment

In general, much of the information from drilling is gained by careful observation of the drilling conditions (e.g., chattering drill rods, lost circulation) and experienced drillers should be used. In addition, drillers should be encouraged to advance the boring with consideration to the investigation purpose. To encourage this, drilling contracts should use time and materials payment terms (versus footage rates) to avoid a contract incentive for footage production that would otherwise encourage drillers to advance borings as rapidly as possible. Drilling should be overseen, and borings logged by a qualified geological/geotechnical professional.

Drilling should be conducted using either reverse circulation or coring methods. Coring will generally provide the most material for observation; however, as Golder observed during the sinkhole investigation, it can be difficult to differentiate broken rock core resulting from disturbed (failed) ground and the core drilling induced fracturing, reducing the usefulness of the core sample. In addition, the rock is generally weak shale, which is prone to drilling induced fracture and poor recovery. When broken rock is encountered, circulation loss is likely. Reverse circulation provides middle ground between rock coring and standard rotary drilling; reverse circulation should have a similar production advantage over coring as standard rotary drilling but improves confidence in the logging over standard rotary methods. Selection of the drilling method should consider availability, cost, production rates, and effectiveness (e.g., data collection, sample recovery, downtime, etc.). If the drilling method is found to be ineffective with regards to data collection and/or production (i.e., the understanding the subsurface conditions does not improve, or the equipment is frequently breaking down or encountering production delays), the contractor should be engaged on how the effectiveness could be improved, and if it is necessary to change the drilling tools, operator, or methods.

Where underground voids are indicated, temporary casing (PVC or steel) should be used through the zone of alluvium and broken rock before using downhole tools for further investigation. Key downhole tools include borehole camera, sonar and LIDAR to assess the size and shape of the void. When voids are encountered, they should be investigated before advancing the borehole deeper. Dependent on the conditions observed, casing left in the hole could be used for subsequent mitigation efforts.

We anticipate that borings that intersect void space may be completed by setting for use in subsequent mitigation efforts, and that borings that do not intersect voids will be abandoned at completion in accordance with applicable regulations (NMAC 19.27.4) by backfilling with cuttings to approximately 10 foot below surface with a topping plug of bentonite or cement (for boreholes that do not encounter water), or by tremie backfill using bentonite or cement (for boreholes that encounter groundwater). Borings that intersect voids should be completed for subsequent mitigation use by properly setting casing inside a locking surface completion (or by abandonment).

We anticipate that the work would be completed by a two to three-person drill crew with oversight by an AML representative with the following equipment:

- Truck mounted drill rig
- Water truck or trailer
- Air compressor
- Drill pipe trailer
- Support vehicles (pickup truck)

The physical disturbance and impacts to landowners of the drilling investigation will be dependent on the size and types of equipment used. Drill pads typically range in size from approximately 20 to 40 feet square; a maximum drill pad dimension of 100 by 100 feet should be considered. A drill pad of this size will allow for multiple borings should offset locations be required. Access to the drill pad should consider a maximum 20-foot wide road.

2.3.2 Test Pitting and Trenching Methods and Equipment

Test pit or trench excavation and sampling is conducted to provide information from the shallow subsurface (i.e. depths less than 12 to 15 feet, or the limitation of the backhoe or excavator reach. Test pitting and trenching results in significant disturbance of the underlying soils and of the surface material (e.g., asphalt), and should therefore not be employed at sites where such disturbance is of concern.

For practical purposes, a borehole provides only a one-dimensional, generally discontinuous view of subsurface conditions. In contrast, a test pit enables one to “see” more of the subsurface and provides for a relatively inexpensive continuous view of soil stratigraphy and heterogeneity, extent of staining, odors, and debris.

Test trenches are simply pits that extend a significant distance (up to several yards) in one direction. Soil and material samples can be collected from distinct horizons from the pit or trench.

For this investigation test pitting and trenching would be used to find evidence of the shafts including foundation material, shaft timber or backfill. The size of the investigation areas would typically range 20 to 40 feet square. Excavations would immediately be backfilled; no open excavations would be allowed to remain overnight.

Test pits and trenches may be excavated using a backhoe, or excavator; an equipment operator and spotter would be required along with oversight by an AML representative and possibly require archaeological clearance. Test pitting and trenching operations would require identifying and marking of the locations prior to excavation and would follow utility clearance regulations (NM One Call Notification).

2.3.3 Boring and Test Pit Locations

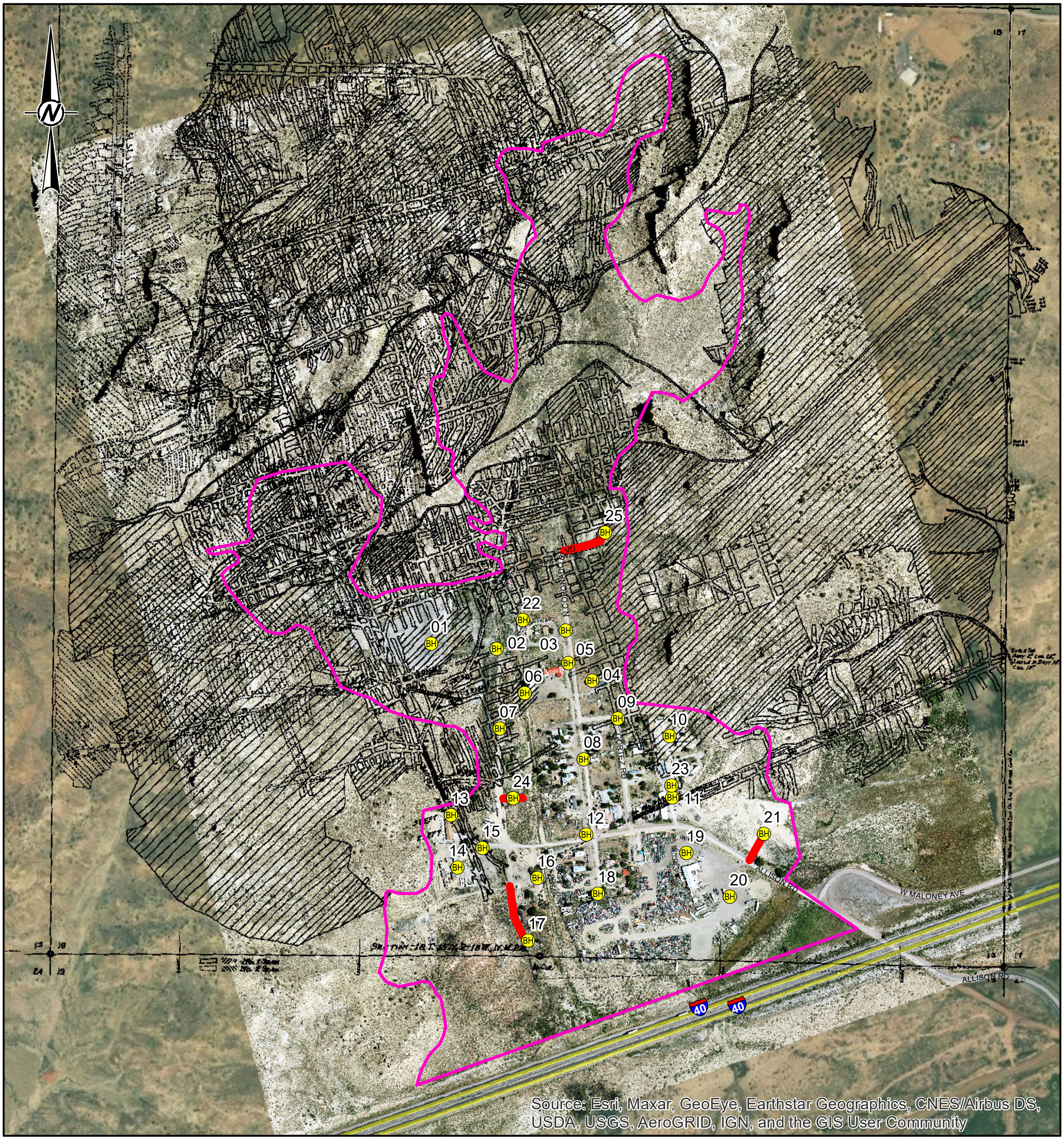
Proposed borings and test pits are located to provide spatial coverage of the APE, address data gaps, and investigate areas of concern. Boring and test pit locations are shown on Figure 2 and Figure 3 and provided in Table 1 and Table 2 below. Due to the uncertain accuracy of the mine plan, ground conditions, and utilities, we expect that the boring locations will requires some adjustment; the actual borings will be within a 50-foot radius (approximate) of each point.

Table 1: Proposed Initial Drilling Locations

Borehole	Notes	Ground Surface
BH-1	Mapped as 2nd Mining. Fill pad, possible future development.	Fill Pad
BH-2	No mapped workings. Culvert investigation	Road
BH-3	No mapped workings. Near far NW house. Reported surface holes that make water.	Road
BH-4*	Primary workings, occupied lot, no prior mitigation.	Vacant lot, vegetated.
BH-5*	Primary workings near Red Roof house. Possibly mitigated.	Road

Borehole	Notes	Ground Surface
BH-6	Mapped as 2nd Mining. Near house.	Berm
BH-7	Primary workings. Possible unmapped No2 Seam workings.	Road
BH-8	No mapped workings. Possible paleo-channel wash out zone.	Road
BH-9	Primary workings, possible mitigation.	Road
BH-10	Mapped as 2nd Mining. Possible mitigation.	Drive/road/parking
BH-11*	Investigate Slope 3.	Drive/road/parking
BH-12	No mapped workings. Possible paleo-channel wash out zone.	Road
BH-13*	Mains at Stedman's house. Possibly Mitigated.	Lightly vegetated
BH-14	No mapped workings near mine buildings. Possible Casna.	Road/driveway
BH-15*	Main Slope (decline).	Road/driveway
BH-16	No mapped workings. Possible Casna. Potential future development.	Graded, disturbed
BH-17	No mapped workings. Possible Casna.	Road
BH-18	No mapped workings. Possible paleo-channel wash out zone.	Road
BH-19	No mapped workings. Possible paleo-channel wash out zone.	Driveway
BH-20	No mapped workings.	Driveway
BH-21	No mapped workings.	Disturbed
BH-22	No mapped workings. Near far NW house.	Berm
BH-23*	Primary workings, the area was drilled in 1985 and 1986; voids were encountered and some holes were cased. Possibly mitigated. Anomaly from 2019 Geophysics.	Drive/road/parking
BH-24	No mapped workings. Possible1st seam, paleo-channel wash out zone.	Lightly vegetated
BH-25*	Mapped workings near far NE house. The lot was heavily drilled in 1985 and 1986; voids were encountered, and several holes were cased. Possibly mitigated.	Driveway

Note – Borehole locations with an asterisk indicate the boring is intended to target mapped workings; multiple borings may be needed at the location.



LEGEND

- BH Proposed Boring Locations (100 x 100ft Max)
- Allison Project Extents (APE)
- Access Disturbance (20ft Wide Max)

0 400 800 1,600
FEET

REFERENCE(S)
1. ALLISON APE, NEW MEXICO EMNRD AML, 2019.
2. ALLISON MINE WORKINGS, MM-CO-00124 G; 4323; M2-2G3; H9; ALLISON; 1932U; G3; D5 MAP NO. 1533, NEW MEXICO BGMR & NEW MEXICO EMNRD AML

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEW MEXICO WEST FIPS 3003 FEET
PROJECTION: TRANSVERSE MERCATOR
DATUM: NORTH AMERICAN 1983

CLIENT
NEW MEXICO ENERGY MINERALS AND NATURAL RESOURCES DEPARTMENT ABANDONED MINE LAND PROGRAM

PROJECT
ALLISON MINE
GEOTECHINCAL EXPLORATION PLAN

TITLE
PROPOSED BORING LOCATIONS

CONSULTANT

GOLDER

YYYY-MM-DD	2020-06-22
DESIGNED	NRL
PREPARED	NRL
REVIEWED	JP
APPROVED	JC

PROJECT NO.	CONTROL	REV.	FIGURE
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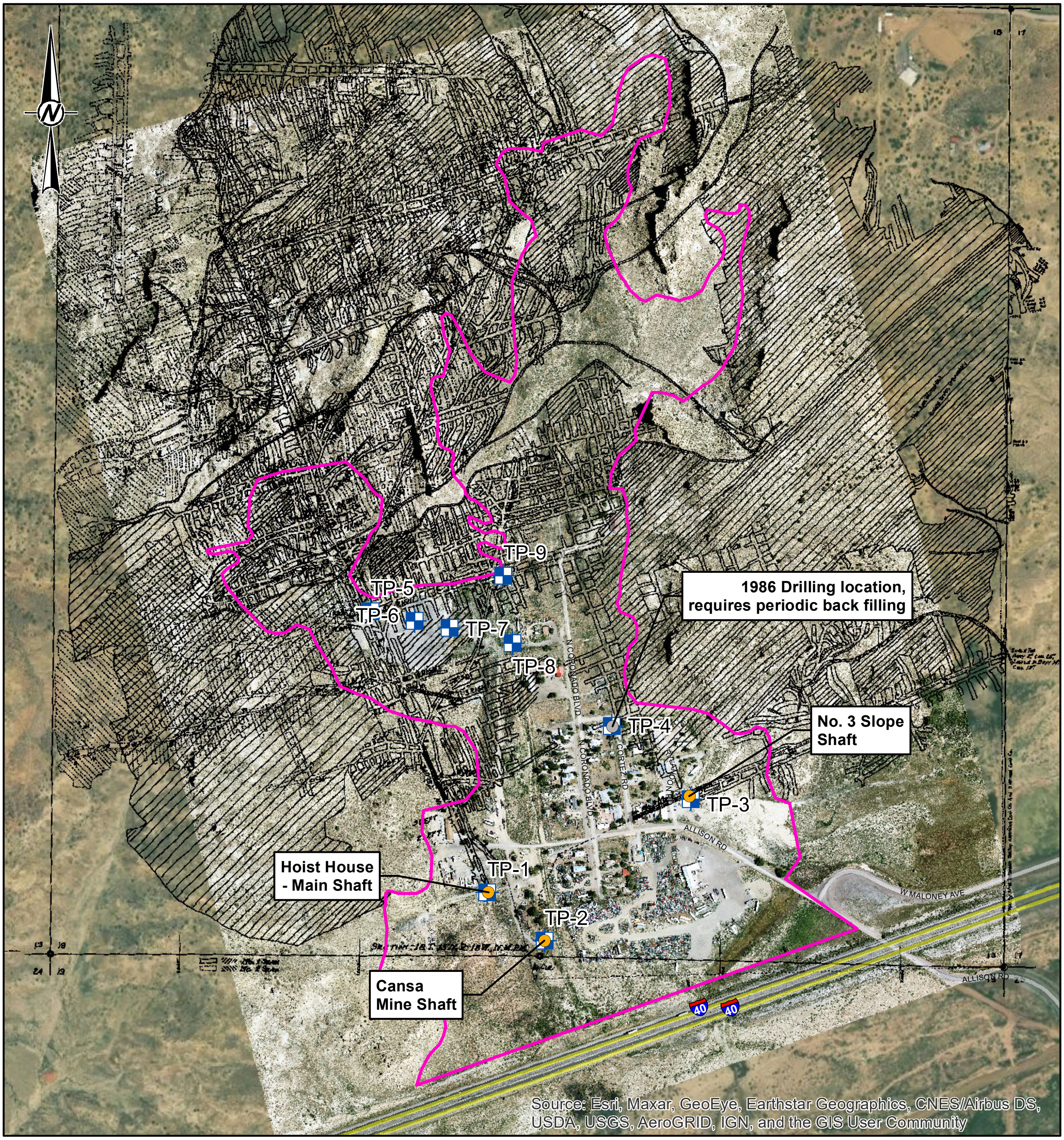
Table 2: Proposed Initial Test Pit Locations

Test Pit	Notes	Ground Surface
TP-1	Main Shaft	Disturbed
TP-2	Possible Casna Shaft (south of mule barn)	Lightly vegetated
TP-3	No. 3 Slope Shaft	Disturbed
TP-4	Drill hole location that has needed repeated backfilling	Roadway shoulder
TP-5	Fill Pad	Fill surface
TP-6	Fill Pad	Fill surface
TP-7	Fill Pad	Fill surface
TP-8	Culvert	Road
TP-9	Upper drainage channel	



LEGEND

- Test Pit Locations
- Allison Mine Workings Map
- Allison Project Extents (APE)

Field Findings

- Drill Hole
- Possible Shaft

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REFERENCE(S)

1. ALLISON APE, NEW MEXICO EMNRD AML, 2019.
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NEW MEXICO ENERGY MINERALS AND NATURAL RESOURCES DEPARTMENT ABANDONED MINE LAND PROGRAM

PROJECT

ALLISON MINE
GEOTECHINCAL EXPLORATION PLAN

TITLE

PROPOSED TEST PIT LOCATIONS

CONSULTANT

GOLDER

YYYY-MM-DD	2020-06-22
DESIGNED	NRL
PREPARED	NRL
REVIEWED	JP
APPROVED	JC

PROJECT NO.	CONTROL	REV.	FIGURE
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Borings, test pits and trenches are located on or immediately adjacent to existing roads, driveways, and otherwise disturbed ground. Where work locations are away from a road, the most direct, or least impactful route will be used to access the location. We anticipate that access would be approximately 12 feet wide and will require agreement with property owners and may require some clearing/grubbing.

Borings are located to provide spatial coverage of the community to characterize the subsurface conditions. All borings should be advanced to below the anticipated depth of the No. 2 Coal Seam; in general borings are anticipated to range from approximately 100 to 150 feet below ground surface.

Borings located where no workings are mapped are intended to provide some information on the potential for unmapped workings. While a boring that encounters the coal seam(s) in areas of no mapped mining does not necessarily eliminate the potential for nearby workings (because the boring may be located in a pillar), they will provide information critical to assessing the hazard of unmapped workings, if present (i.e., thickness of the coal seam and rock cover).

Where borings or test pits are located to investigate a specific feature (e.g., a decline or mapped primary workings), it is likely that the initial boring or test pit will not hit the intended target and additional offset work will be needed. Offset borings and test pits would generally be located within a 50-foot radius (approximate) of the initial work location. For this reason, few borings are located to specifically target a feature. Features targeted include possibly mitigated areas near dwellings, and potentially unmitigated primary workings near dwellings, and near surface workings.

3.0 CLOSING

We appreciate the opportunity to work with the AML Program on this important public safety project. Please contact the undersigned with any questions

Golder Associates Inc.

John Purcell
Sr. Project Engineer

Jeffrey Clark, PE
Associate, Sr. Consultant

JP/JC/js/mb

https://golderassociates.sharepoint.com/sites/29193g/deliverables/011 - geotech investigation/rev0/18104080-r-rev0-011-20200623-geotechnicalexplorationplan.docx

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