PRE-DESIGN TECHNICAL MEMORANDUM

MADRID STORMWATER AND EROSION SAFETY PROJECT

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Weston Solutions, Inc. (Weston) was tasked by the New Mexico Mining and Minerals Division, Abandon Mine Land (AML) Program, to prepare this technical memorandum. The technical memorandum provides a narrative analysis of existing project documentation provided by the AML Program including reports and conceptual plans. It identifies data gaps in the documentation and proposes alternative design concepts.

1. PROJECT DESIGN GUIDELINES AND GOALS

The Madrid Stormwater and Erosion Safety Project addresses three primary project areas of the community including Ice House Road, Firehouse Lane, and the Water Storage Area. The following design guidelines and goals were established by the AML Program to guide the work described herein.

1.1 DESIGN GUIDELINES

In order to implement the project goals, the AML Program has established the following guidelines for the conceptual designs proposed herein:

- New stormwater and sediment management systems that are installed on private property in Madrid will be maintained by the Madrid Landowners Association (MLA). Infrastructure should be designed to limit regular and long-term maintenance of these facilities.
- Potable and fire suppression water service in Madrid is provided by the Madrid Water Cooperative. New improvements should not limit easy access to existing water distribution facilities.
- Legacy coal waste piles on the east slope of Madrid are historic features and symbols of Madrid's history as a company town. Proposed improvements will minimize visual and physical impacts to these features. In many cases, direct reclamation of exposed coal waste may not be feasible. Any targeted direct reclamation of coal waste must provide clear and crucial benefits toward achieving project goals.
- Madrid is considered to be a complex project venue and early stages of conceptual design should emphasize creative and innovative ideas that provide project partners with several options to carry forward in project development.

1.2 PROJECT GOALS

Ice House Road / Madrid Arroyo Area Goals:

- Reduces flooding and coal waste sedimentation in homes, businesses, and roads
- Increase water retention and infiltration on east slope near concentrated coal waste areas
- Reduces long-term maintenance costs of stormwater systems
- Addresses emergency vehicle access in east Madrid during large storm events

- Addresses flooding at the low point on Highway 14 and assist conveyance of stormwater past private properties to the Madrid Arroyo
- Ensures safe and sustainable conveyance of stormwater into the Madrid Arroyo

Firehouse Lane Area Goals:

- Reduces coal waste movement downhill toward Firehouse Lane
- Increase water retention and infiltration on east slope near concentrated coal waste areas
- Reduces stormwater flows from Firehouse Lane toward commercial properties to the north

Water Storage Tank Area Goal:

- Improve security and reliability of stored water that supplies Madrid's fire hydrants

2. REVIEW OF EXISTING PROJECT DOCUMENTATION

The following reports and plans describe previous design work that has been proposed. Figure 1 depicts a summary of the previous design concepts that are described in these documents.

- Stormwater Study, Madrid, (URS 2011)
- Madrid Stormwater L.I.D. Project Preliminary Design Notes (Riverbend 2013)
- Madrid Stormwater Improvement Project, Preliminary Designs (AML et. al. 2013)
- Preliminary Design for Drainage Improvements, Madrid Gulch Open Space (Riverbend 2019).
- Preliminary Engineering Report for the Community of Madrid Santa Fe County Fire Suppression System (Occam, 2016).

The following paragraphs summarize the strengths and weaknesses of the proposed design concepts in terms of the AML Program's design guidelines and project goals discussed above. More detailed reviews of the Stormwater Study (URS 2011) and the Madrid Stormwater LID Project Preliminary Design (Riverbend 2013) are included in Appendix A.

2.1 STORM WATER STUDY (URS, 2011)

This report summarizes a comprehensive hydrology, hydraulic and sedimentation study in support of the Madrid Mining Landscape Project. It provides much of the baseline storm water hydrology and hydraulic data used to plan conceptual storm water improvements for the town. The report recommends four conceptual design solutions for the drainage basins that impact the central residents of Madrid. The conceptual designs are combinations of drainage channels/ditches, detention ponds and plunge pools.

The report specifically addresses thirteen locations affected by storm water related problems. Most of these areas are located on the west-facing slope and east of New Mexico Highway 14 within a large area of flooding impacts. A few areas located on flatter terrain west of Madrid Arroyo and were identified to be within areas of isolated flooding impacts.

The drainage areas were subdivided into six sub-basins to specifically evaluate flows on the west-facing slope east of Highway 14. Four sub-basins, identified as Sub-basin 1, 2, 3 and 6, specifically address the project area (see basin map in Appendix A).

Strength: The overall concepts are viable approaches and some were later developed in subsequent work. These concepts address the following project goals and design guidelines:

- The proposed conveyances will reduce flooding and coal waste sedimentation in homes, businesses, commercial properties and roads and may reduce coal waste movement downhill toward Firehouse Lane.
- The proposed channelized road on Ice House Road will addresses emergency vehicle access in east Madrid during large storm events
- The proposed detention pond will address flooding at the low point on Highway 14 and assist conveyance of stormwater past private properties to the Madrid Arroyo
- The channel modifications consider safe and sustainable conveyance of stormwater into the Madrid Arroyo however needs to be reevaluated as discussed below.

Weakness: None of the concepts described in the report addressing water retention and infiltration on east slope near concentrated coal waste areas. Also, further reliance on this report should consider the following:

- Refine the flow computations for Sub-Basins 1, 2, 3, and 6 including assessment of curve numbers (NRCS's land runoff prediction value), times of concentration and determination of the specific contributing stormwater flow to each proposed drainage structure.
- Revise the Ice House Road conceptual drainage channel designs. The proposed trapezoidal shaped cross section would be more effective as an inverted crown road cross section.
- Reconsider detention pond options that were presented but eliminated from consideration. Detention ponds are considered a viable option when considering stormwater control and infiltration.
- Incorporate plunge pools as energy dissipation structures to control erosion. The stated storm water flow reduction benefit is considered negligible.
- Re-evaluate the 1,125 foot stream meander with a downstream sediment basin that was proposed for the Madrid Arroyo. The proposed meander is not justified by the geomorphology of this stream. The preliminary design prepared by Riverbend Engineering for Santa Fe County meets this condition (Riverbend 2019).

2.2 PRELIMINARY DESIGN NOTES - MADRID STORMWATER L.I.D. PROJECT

This report summarizes several collection and conveyance alternatives to manage stormwater drainage in Madrid. Proposed storm water collection and conveyance facilities were organized into a series of six (A through F) storm water systems. In general, the proposed concepts do not specifically address coal waste sedimentation in the Ice House Road area nor reduce coal waste movement downhill toward Firehouse Lane. The following paragraphs summarize the design concepts that were proposed.

SYSTEM "A" - IMPROVEMENTS TO CONCRETE BOX CULVERT:

System "A" alternatives address an existing concrete box culvert that runs under the Mineshaft Tavern and discharges to two NMDOT drop inlets (catch basins).

Alternative No. 1 – Repair and Replace Mine Shaft Drain System (Completed)

This alternative has been completed and involved replacement of an existing drop inlet with a new 48-inch by 48-inch drop inlet that discharges to a rehabilitated 4-foot by 4-foot box culvert. This system captures a portion of Sub-basin 3 (approximately 6.5 acres of the 28-acre area) and diverts it away from an area north of the Mineshaft Tavern area.

Strength: This improvement reduces the flow entering the Firehouse Lane area. The reach could be expanded upstream along the east-slope to provide additional drainage and erosion control benefit. This concept addresses the following project goals and design guidelines:

- Reduces flooding and coal waste sedimentation in homes, businesses, and roads
- Ensures safe and sustainable conveyance of stormwater into the Madrid Arroyo

Weakness: No weaknesses are identified. It appears that this improvement was successful.

Alternative No. 2 – Abandon the Existing Box Culvert

The two drop inlets would need similar modifications to improve efficiency as completed for Alternative 1 and the same grading work would be needed in Madrid Creek. Since Alternative No. 1 appears to be effective, no further consideration of this alternative is recommended.

SYSTEM "B" – ICE HOUSE (EAST-WEST) ROAD AND MAIN STREET IMPROVEMENTS:

System "B" alternatives address collection at the south end of Ice House Road and conveyance along Main Street (Highway 14)

Alternative No. 1 – New Storm Drain System: The entire System B storm drain flows to the north and connects with the proposed System C storm drain approximately 100 feet north of Cave Road.

Alternative No. 2 – Main Street Curb and Gutter manages stormwater from the System B watershed along Main Street (Highway 14). This option is viable as a "mountable" curb.

Strength: Both System "B" alternatives 1 and 2 were carried forward but need to be considered as a combined approach. The storm drain system provides a diversion of stormwater from the houses and business below it. The curb and gutter along NM 14 ("Main Street") would be needed to convey stormwater away from center of town. This concept addresses the following project goals and design guidelines:

- Addresses flooding at the low point on Highway 14 and assists with conveyance of stormwater past private properties to the Madrid Arroyo
- Ensures safe and sustainable conveyance of stormwater into the Madrid Arroyo in conjunction with System "C".

Weakness: No weaknesses are identified.

SYSTEM "C" - ICE HOUSE ROAD AND THE LOW POINT WATER CROSSING OF HIGHWAY 14:

System "C" alternatives address conveyance of stormwater along Ice House Road and diversion to a catch basin along Highway 14 as follows:

Alternative No. 1- Storm Drain and Collection Basin collects water on Ice House Road in an inverted crown and then into drop inlets along the road, draining to a collection system near Bethlehem Hill Road.

Alternative No. 2 – Roadside Ditch and Collection Basin collects water off of Ice House road with a surface ditch along the east side of the road with the ditch draining north to the collection basin.

Strength: Both Alternatives 1 and 2 are considered viable options but need to be considered as a combined approach. The storm drain system provides a diversion of storm water from the houses and business below it. The curb and gutter along NM 14 ("Main Street") would be needed to convey storm water away from center of town. This concept addresses the following project goals and design guidelines:

- Reduces flooding in homes, businesses, and roads
- Addresses emergency vehicle access in east Madrid during large storm events
- Addresses flooding at the low point on Highway 14 and assists with conveyance of stormwater past private properties to the Madrid Arroyo
- Ensures safe and sustainable conveyance of stormwater into the Madrid Arroyo in conjunction with System "B".

Weakness: No weaknesses are identified.

SYSTEM "D" – STORM DRAIN FROM HIGHWAY 14 WEST BETWEEN LOTS 384 AND 393:

System "D" alternatives address improvement of the conveyance capacity of storm water under Highway 14 and to a conveyance structure between two private lots as follows:

Alternative No. 1 - Replace the existing system with new drop inlets on both sides of Highway 14 to increase conveyance capacity. Install a new buried pipeline routed to Cave Road. Align in the existing open channel concrete and rock lined ditch.

Alternative No. 2 - would improve the collection and conveyance capacity at Highway 14 as described for Alternative 1, but would discharge stormwater into the existing rock lined ditch part way down the hill towards Cave Road. This ditch has limited capacity but would suffice if storm drain System "E" is constructed.

Strength: Both alternatives 1 and 2 will be considered further. These alternatives are, for the most part, captured on the preliminary designs discussed in the following section. This concept addresses the following project goals and design guidelines:

- Addresses flooding at the low point on Highway 14 and assist conveyance of stormwater past private properties to the Madrid Arroyo
- Ensure safe and sustainable conveyance of stormwater into the Madrid Arroyo

Weakness: No weaknesses are identified.

SYSTEM "E" – STORM DRAIN DIVERSION AT BALL FIELD TO VALLEY BOTTOM:

System "E" collects storm water from Highway 14, north of town before it reaches the developed part of Town. It involves installation of a buried storm drain aligned between the old school building and the ball field. This location cannot easily accommodate an open storm water channel.

Strength: This concept is considered a viable approach to diverting storm water away from the center of Town which would reduce the impact on new storm water structures. This concept addresses the following project goals and design guidelines:

- Addresses flooding at the low point on Highway 14 and assist conveyance of stormwater past private properties to the Madrid Arroyo
- Ensures safe and sustainable conveyance of stormwater into the Madrid Arroyo

Weakness: No weaknesses are identified.

SYSTEM "F" - BRIDGE ROAD DRAINAGE

System "F" Alternatives 1 and 2 would include grading Bridge Road with an inverted crown cross section to convey stormwater down the center of the road. Both alternatives would remove the existing drainage pipe crossing Bridge Road since it is thought to have no drainage control benefit.

Alternative No. 1 - involves installation of a drop inlet at the low spot in the road and a storm drain that would convey water to the west and then north to the storm drain in Cave Road.

Alternative No. 2 - involves construction of an open channel to collect water at the low point on Bridge Road then convey it west in the road and then north towards Cave Road.

Strength: These alternatives are considered viable options for collecting and conveying stormwater through the residential area and discharging into Madrid Arroyo. This concept addresses the following project goals and design guidelines:

- Reduces flooding in homes, businesses, and roads facing Cave Road.
- Provides for safe and sustainable conveyance of stormwater into the Madrid Arroyo

Weakness: The inverted crown road concept needs additional evaluation for sediment accumulation. A standard crown road with drainage structures should be evaluated as well.

2.3 MADRID STORMWATER IMPROVEMENT PROJECT - PRELIMINARY DESIGNS

Stormwater system improvements are documented on five drawings sheets (Riverbend et.al. 2013) which are provided in Appendix B. These conceptual plans depict an open channel alternative and buried stormwater alternative to address drainage issues. These plans reflect a more comprehensive plan for addressing the drainage issues and build on some of the concepts identified in the documents summarized above.

Strengths: Overall, the design concepts presented on these plans are viable solutions and all could be carried forward. Where called out, it may take a combination of open channel and pipe conduits to efficiently divert water to Madrid Arroyo. The concepts shown on these plans address the project goals described above.

Weakness: No weaknesses are identified.

2.4 MADRID GULCH OPEN SPACE - PRELIMINARY DESIGN FOR DRAINAGE IMPROVEMENTS

The proposed Madrid Arroyo improvements consist of grading the existing channel to the historic alignment. The channel will be graded with a 20-foot bottom width and aligned with low sinuosity meanders protected with rock grade control structures. Primary flow will be routed to a new culvert crossing with high flows (secondary flow) routed to another culvert crossing via a grade control structure. The design is intended to route storm water into the open space property and reduce adverse impacts to property, resources and infrastructure. Additionally, it will allow reliable access to Cave Road on the west side of the arroyo.

The design addresses the conceptual improvements to Madrid gulch (arroyo) by realigning and grading the arroyo to the historic alignment with flood plains, flow deflectors, grade control structures and a pedestrian trail. The plans also address re-alignment of Cave Road to improve drainage to the arroyo. Similar the design allows for conveyance of surface drainage from Main Street to the arroyo.

Strengths: Conceptually, the overall arroyo improvement plan is sound. Similar designs have shown to be effective with proper construction. The design allows for vehicle access to the west side of Madrid. Plans for Cave Road incorporate design concepts proposed in previous work such as an inverted crown road and porous paving. This concepts provided on these plans address the following project goals and design guide lines:

- Assists with conveyance of stormwater past private properties to the Madrid Arroyo
- Ensures safe and sustainable conveyance of stormwater into the Madrid Arroyo

Weakness: None are apparent. The system will perform best if the plantings in flood plain areas are allowed to establish before large flows enter the channel.

2.5 PRELIMINARY ENGINEERING REPORT FOR THE COMMUNITY OF MADRID, SANTA FE COUNTY FIRE SUPPRESSION SYSTEM

An existing 100,000 gallon in ground concrete storage tank that is located on the east side of Madrid Arroyo at the end of Firehouse Lane supplies water to Madrid's fire suppression system. The tank reportedly leaks and provides insufficient water pressure (Occam 2016). It is within 20 feet of the high bank wall of the arroyo where settlement has caused the tank walls to crack.

The tank supplies six fire hydrants from this tank. The current system is producing an average pressure at the hydrants of 28 psi, with a maximum flow rate at the lowest elevation hydrant of approximately 800 gpm. According to the report, the flow rates and pressures produced at the hydrants do not meet the standards of the Uniform Fire Code and requires upgrade to the fire suppression system. The required scope of the PER provides an analysis of only existing facilities without expansions or additional fire protection coverage.

- Strengths: Provides the minimum evaluation of the fire suppression system. The proposed system would be the goal of improved security and reliability of stored water that supplies Madrid's fire hydrants.

Weakness:

- This PER does not contain the content required in the standard guidance, RUS Bulletin 1780-2 "*Preliminary Engineering Reports for the Water and Waste Disposal Program.* This guidance is a standard requirement for many state and federal funding agencies including the New Mexico Environment Department.
- Lacks data and calculations to demonstrate flow and residual pressure at existing fire hydrants under demand.
- As stated in the report, the current system is producing an average pressure at the hydrants of 28 psi with a maximum flow rate at the lowest elevation hydrant of approximately 800 gpm. This rate can be justified under the Insurance Service Office Public Protection Classification system if other means of fire suppression are available.
- Costs do not address annual operating or net present worth costs.

3. INITIAL DATA GAPS

For the concept level of design proposals, the current information is sufficient to assess preliminary feasibility of options. However, data gaps that currently limit the ability to design efficient improvements include the following:

- Terrain data within the Ice House Road and Firehouse Lane areas to include topography, property boundaries and utility features. These data and analysis are needed to properly design stormwater structures to a level that can be bid out for construction.
- Refinement of the URS hydrology analysis to size drainage structures.
- Residual flow and pressure calculations of the water distribution system with the new water tank during a fire scenario. A new PER that meets state and federal funding agency requirements may be required.

4. ALTERNATIVE DESIGN CONCEPTS

4.1 ICE HOUSE ROAD AND FIREHOUSE LANE AREAS

Following a detailed review of past reports and conceptual designs, many of the concepts and approaches are considered feasible and would address most of the AML Program's design guidelines and goals. The previous reports and plans did not refine the concepts to address alternate means of stormwater control such as infiltration (galleries or wells) or alternate methods of stormwater detention such as underground systems. Additionally, a few properties are in need of slope protection or stabilization to prevent localized flooding and protection from coal waste movement.

Provided in Appendix D (Alternative Design Summaries) are these additional stormwater control and slope stabilization concepts. Each summary includes a brief narrative of the facility's purpose, a short list of management objectives, the typical benefits and effectiveness, an estimate of annual costs, a successful case study and location maps where the feature could be implemented.

4.2 WATER STORAGE TANK AREA

The concrete tank currently leaks and is at risk of being undermined by bank erosion of the Madrid Arroyo. A portion of Firehouse Lane has already eroded into the arroyo and exposed a portion of the water main. Alternatives to improve stability of the tank site, security and reliability of access for operations and maintenance personnel for fire suppression system water storage tank are provided below. Note that assessment of hydraulics and operation will be addressed by others.

Design Alternative 1 – Protect Existing Tank

Rehabilitating the existing concrete water storage tank requires foundation stabilization, sealing the interior to stop leakage and bank protection. A segment of Firehouse Lane would also need to be rebuilt with bank protection to prevent future washout.

Foundation stabilization would require lifting the tank, over excavating the foundation subgrade and replacing with a stable foundation material such as sand, crushed gravel or concrete. Options to seal the concrete tank include pressure grouting, coating with high strength mortar followed with structural epoxy and flexible synthetic fabric liner systems. Coating and lining materials would be specified for public drinking water use.

Possible bank protection measures include rock-filled gabions, modular block, reinforced shotcrete or large boulders grouted into place designed to withstand high flow events in the arroyo and retain ten or more feet of soil on the bank side. A deep key would be constructed below the maximum scour depth and also into the bank on both the upstream and downstream side to prevent erosion from flanking the structure.

Design Alternative 2 – Abandon and Replace Tank

Construction of a new tank on the other side of NM-14 requires abandoning the concrete water storage tank. The roof would be removed and disposed and the tank must be filled with sand to secure the abandoned structure. The inlet and outlet pipelines would be abandoned in place and capped. A new steel water storage tank and water main would be constructed on the west side of NM-14 as available and connected to the existing water distribution network.

5. CONCLUSION

Design concepts that were previously identified are based on high-level consideration of basic stormwater management approaches that include detention, infiltration, and diversion or conveyance. These concepts were further developed as a comprehensive approach in the *Madrid Stormwater Improvement Project, Preliminary Design* (Appendix B) plans. These plans contain the strongest ideas and would serve as the basis to advance the design phase. Similarly, the *Madrid Gulch Open Space, Preliminary Design for Drainage Improvements* (Appendix C) plans address the recommended overall approach to arroyo improvements as well as those to Cave Road.

Reduction of flooding and coal waste sedimentation in homes, businesses, and roads on the eastern areas require improvement of Ice House Road, Bridge Street and Cave Road. Inverted crown roads with porous paving has been proposed and is considered a viable solution. Consideration would be given to standard crowned roads with stormwater drainages or underground conveyance where space permits.

The proposed detention ponds would address flooding primarily at the low point on Highway 14 and assist conveyance of stormwater through private properties to Madrid Arroyo. Conceptually, detention concepts would collect the 24-hour stormwater flow and release it at a lower rate into the existing or new drainage structures on either side of NM 14 to reduce flooding. The structures would be sized so that the capacity of catch basins and conveyances are not exceeded. Since previous work did not fully develop the detention concept, consideration of underground storage and/or infiltration to maintain available space for other uses is proposed (see Appendix D).

Reduction in coal waste movement downhill would be addressed with further development of diversion conveyance concepts that route the upland stormwater away from the piles reducing saturation from run-off. Improvements to these concepts would include low impact designs to increase water retention and infiltration on east slope near concentrated coal waste areas.

Previous work did not specifically address problem slope stability issues in the Ice House road or along Madrid arroyo in the Firehouse Lane area. The concepts proposed in this report would generally prevent further erosion of hill sides and prevent coal was from reaching houses or business structure.

6. REFERENCES

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- DETENTION POND
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- ROLLING DIP DIVERSION
- DROP INLET
- CONCRETE BOX CULVERT
- ROCK CHECK DAM
- EARTHEN DITCH

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CONCEPTUAL
DESIGNS
NOT FOR
CONSTRUCTION

MADRID STORMWATER & EROSION SAFETY PROJECT
SUMMARY OF PRELIMINARY DESIGN CONCEPTS

FIGURE
1

APPENDIX A: DETAILED REPORT REVIEW NARRATIVES

Storm Water Study (URS, 2011)

The following paragraphs provide recommendations and rationale regarding the design concepts presented in the Stormwater Study (URS, 2011). Those concepts that deserve ongoing consideration as well as any concepts that have been determined to be infeasible are identified.

Detention Ponds

The report proposed detention ponds to control drainage from Sub-Basins 1, 3 and 6 (See Figure A-1) and was sized to contain the 100-year stormwater flow. Detention ponds would be located at the terminus of the defined natural channel created in Sub-basin 1 and a new channel that routed towards Firehouse Lane (Sub-basin 3).

Considerations: Detention pond options were not a preferable solution to Santa Fe County and rejected from further consideration. However, detention ponds are considered a viable option when considering stormwater control and infiltration. They may be needed if it necessary to control the flow entering existing drainage structures such as the crossing under Highway 14 or to control sediment.

The detention pond proposed near Firehouse Lane would control the water entering Madrid Arroyo and trap sediment. The detention pond could reduce the flow entering Firehouse Lane if it was located further upland and used as part of the diversion system.

Drainage Channels/Ditches

Drainage channels or ditches were proposed for Ice House Road to convey drainage from Sub-basin 1, 2, and 6 and another at upper portion of Sub-basin 3 to Firehouse Lane.

Ice House Road Drainage Channel (Sub-basins 1, 2 and 6). A proposed ditch along Ice House Road would convey the runoff away from homes below Ice House Road that are subject to flooding. One alternative was a ditch located along Ice House Road and another was to create a more defined ditch along the established flow path that travels under NM 14. Although the drainage ditch was rejected due to limited easement space, modifications to the conceptual design that incorporate an inverted crown road and/or storm drains would divert runoff away from the homes below Ice House Road.

The Ice House Road drainage channel was proposed to convey the 100-year flows from sub-basins 1, 2, and 6. It requires construction of a trapezoidal channel with a 12-foot bottom width graded at a 0.01 ft/ft slope to the west that follows the natural slope of the east slope drainage area. The channel would be designed to allow for vehicle use (*ie*. inverted crown road).

Drainage Channel (Sub-basin 3). A 10-foot trapezoidal channel with a 7-foot driving lane was proposed along the private road behind the Mineshaft Tavern. The channel empties into a 400 square foot sediment trap in the location of the abandoned culvert. After exiting the sediment trap, the runoff would enter a 5-foot trapezoidal channel.

The report identifies a system of flow channels. The channel proposed east of the Mine Shaft and along a private access road could be extended above the gob piles. The channel would capture the upland drainage and route it to the existing catch basin. If extended to the north to the grade break, it would protect the gob pipe and reduce the drainage that reaches Ice House Road.

Considerations: The drainage channel concepts were advanced, for the most part, in later conceptual designs prepared by AML. The drainage channel proposed for Ice House Road as well as the diversion channel to Firehouse Lane will be advanced since they are viable approaches to reducing the flow that reaches Madrid.

Plunge Pools

It was proposed that plunge pools be located along the defined low point of Sub-basin 1 to channelize runoff from the sub-basin. The plunge pools would temporarily store a portion of the runoff until the capacity of each plunge pool is reached then the runoff would cascade over the top of one pool and flow into the next pool.

Four plunge pools with a ditch to Ice House Road were proposed within the channelized portion of Sub-basin 1. These plunge pools were assumed to be four feet high. These plunge pools were reported to reduce the flow that exits the sub-basin by approximately fifteen percent. Runoff from the downstream plunge pool is intended to be directed to the Ice House Road channel.

Considerations: The proposed plunge pools are viable method to dissipate energy and control erosion. The stormwater flow reduction benefit is considered negligible. The plunge pool concept may be utilized as stepped drop structures where erosion control and energy dissipation are needed. They can easily be designed as an aesthetic feature.

Madrid Arroyo Stream Meander. A 1,125 foot stream meander with a downstream sediment basin was proposed for Madrid Arroyo within the Madrid Greenbelt. The sediment basin was proposed for smaller storm events. As acknowledged in the report, the meander would be an aesthetic feature to the community and not provide any significant benefit in flood inundation, channel stability or sediment removal.

Considerations: The stream proposed meander is not justified by the geomorphology of this stream. Given the slope of the valley at this location, a very low sinuosity system is a more sustainable solution. A preliminary design that meets this condition was prepared by Riverbend Engineering for Santa Fe County (Riverbend 2019).

Figure A-1. East Slope Sub-Basins

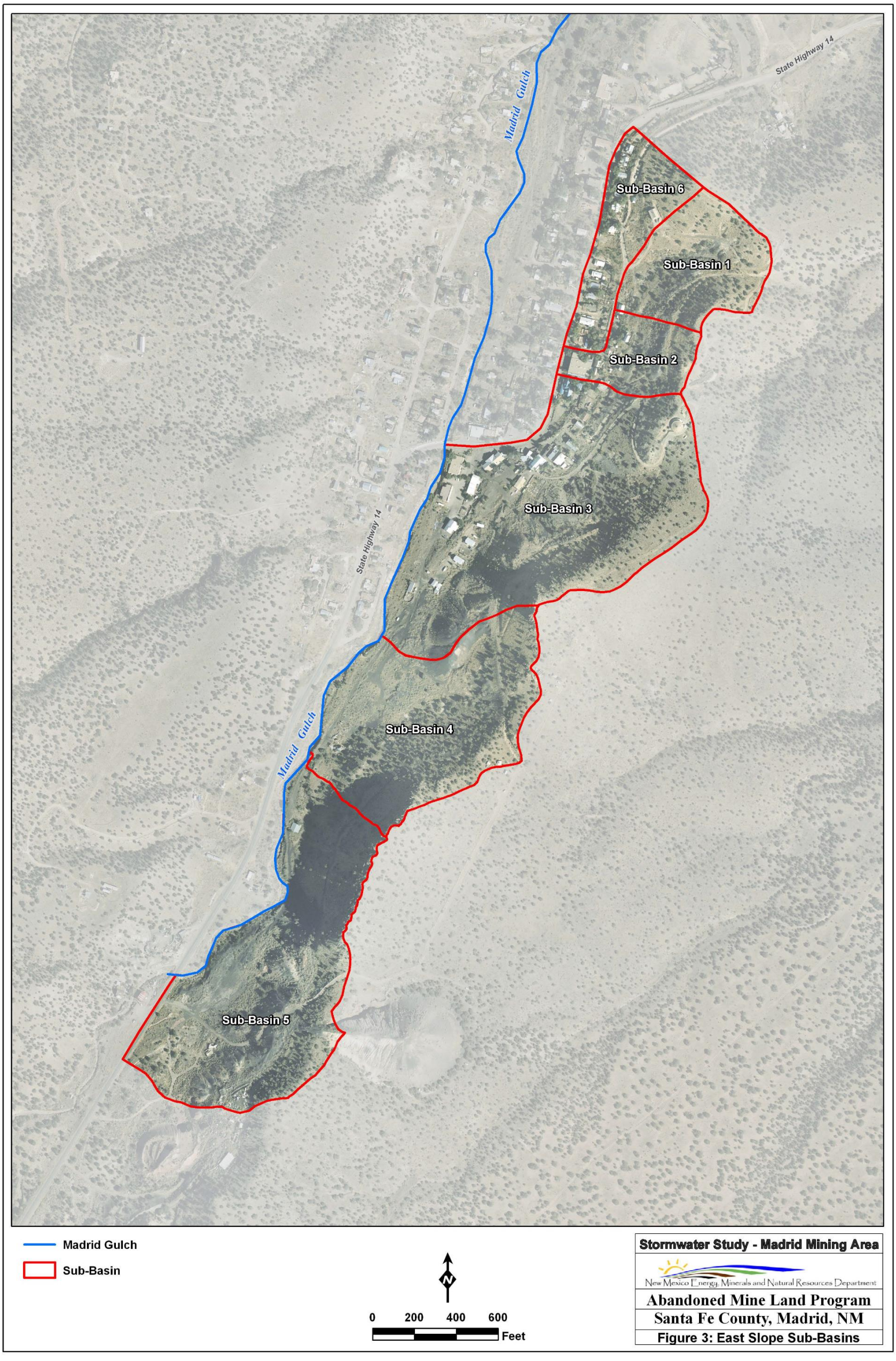


Figure A-2. Proposed Detention Pond Locations

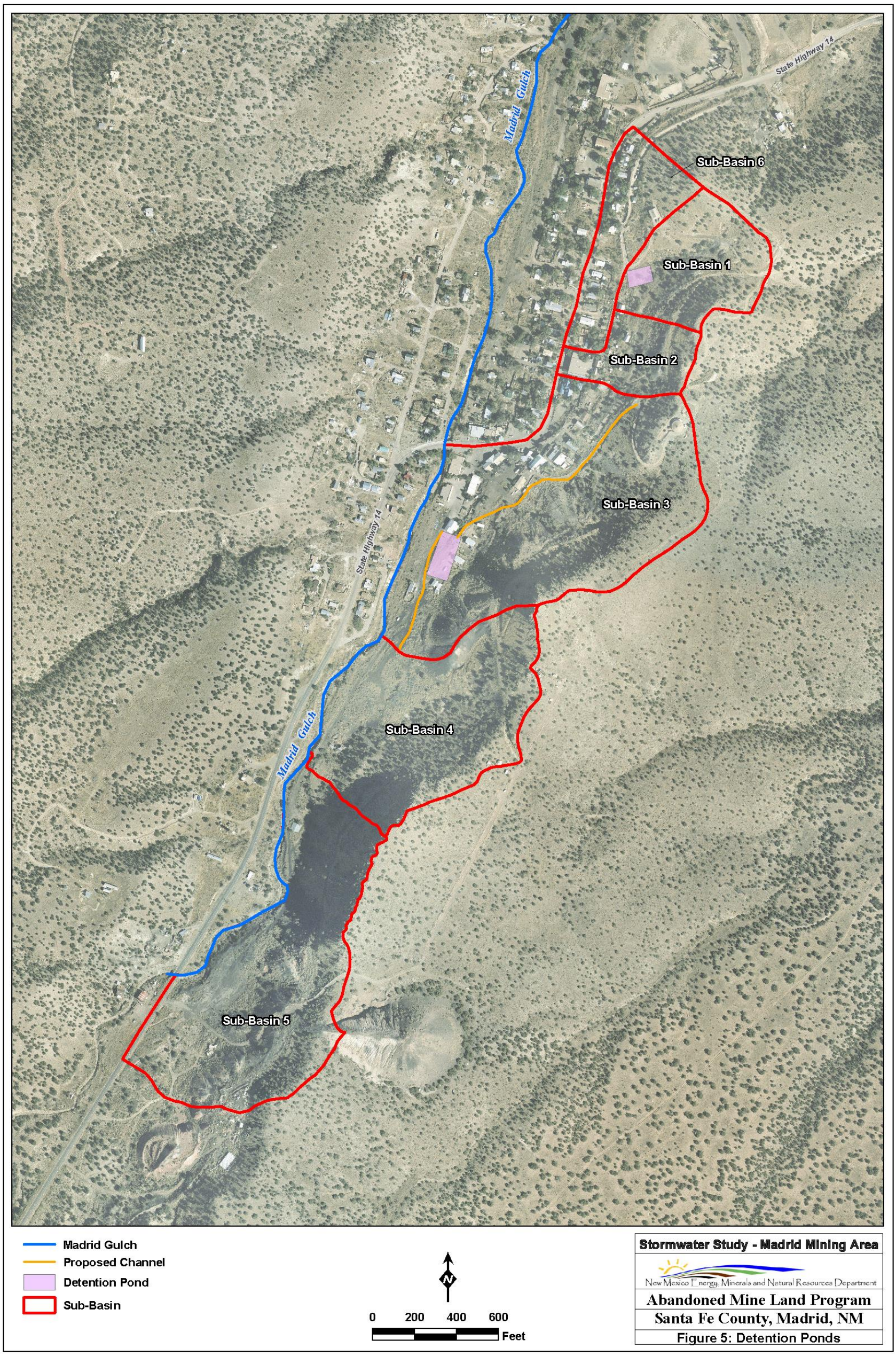


Figure A-3. Proposed Ice House Road Drainage Channels

Figure A-4. ***Proposed Fire House Road Drainage Channels (Sub-basin 3)***

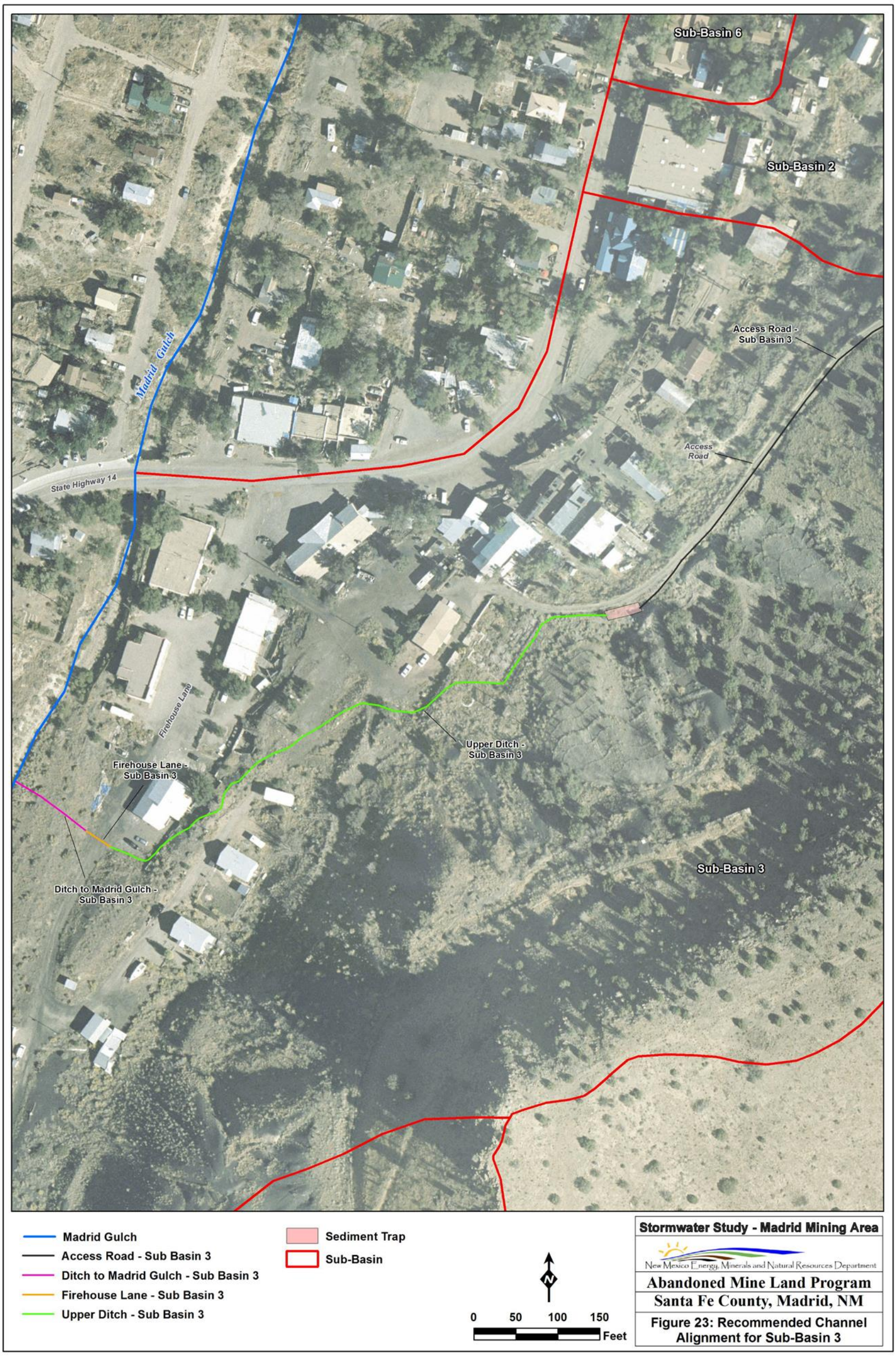
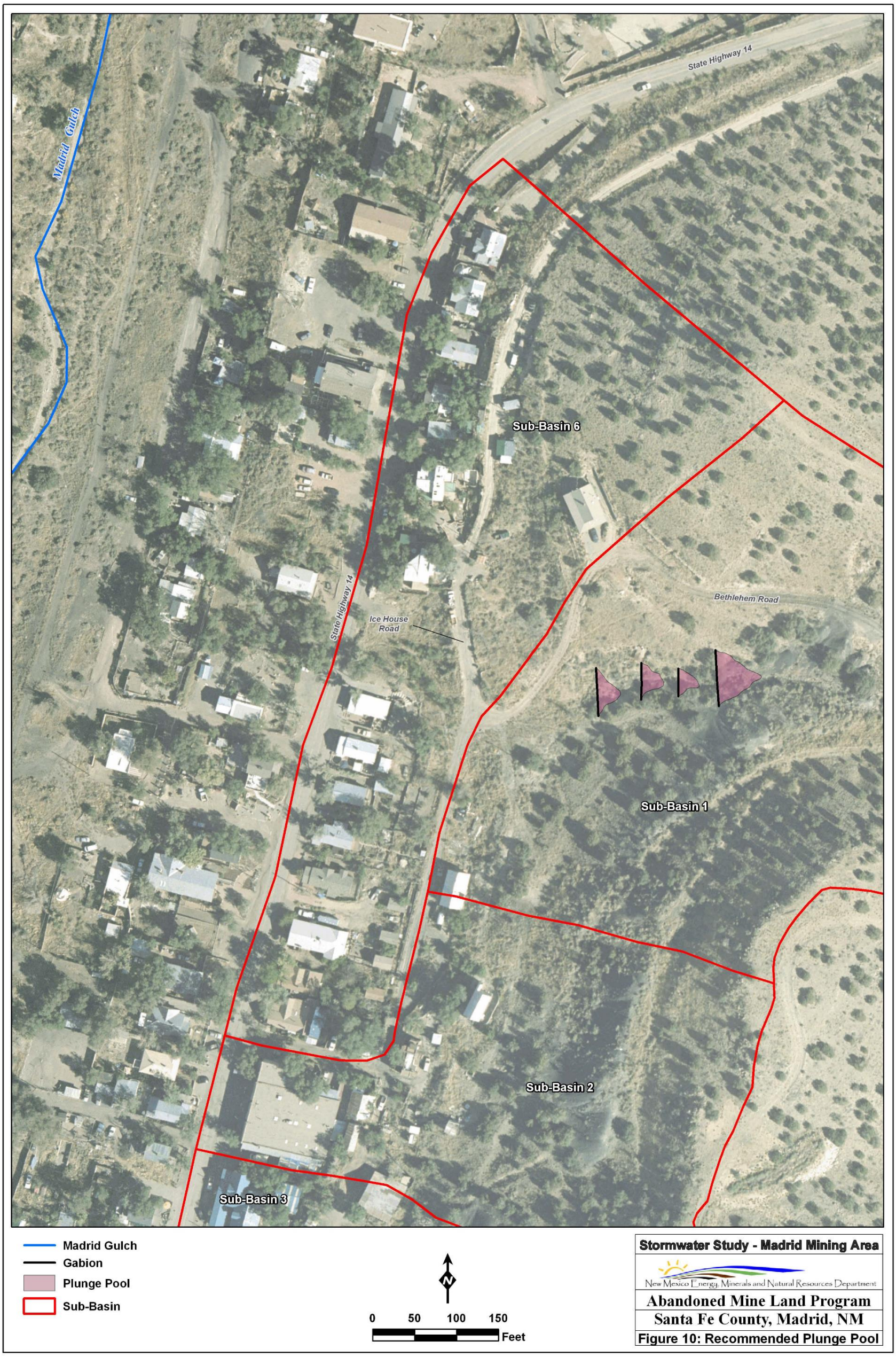


Figure A-5. Plunge Pools in the Ice-House Road Area



Preliminary Design Notes - Madrid Stormwater L.I.D. Project

The proposed storm drainage improvements are illustrated on the Madrid Stormwater Improvement Project Preliminary Design Drawings (AML et.al. 2013). The following paragraphs summarize the design concepts that were proposed.

SYSTEM "A" - IMPROVEMENTS TO CONCRETE BOX CULVERT

These alternatives address an existing concrete box culvert the runs under the Mineshaft Tavern and to discharges to two NMDOT drop inlets (catch basins).

Alternative No. 1 – Repair and Replace Mine Shaft Drain System (Completed)

This alternative has been completed by AML and is comprised of the following features:

- Repaired and replaced the existing storm drain system that runs under the Mineshaft Tavern and exits at an NMDOT drop inlet next to Highway 14. The existing box culvert was slip-lined with a fiberglass pipe liner fitted inside the culvert.
- Constructed a 4 foot by 4 foot steel grate at the upstream end of the box culvert (above the Mine Shaft).
- Removed and replaced the existing 28-inch by 20-inch corrugated metal pipe arch with a 42-inch pipe that matches the cross section area of the lined box culvert immediately downstream of the Mine Shaft tavern
- Modified two catch basin with interior training walls to direct flow from the inlet pipe to the outlet pipe. Two NMDOT area inlets remain in place.

Considerations: This alternative captures a portion of Sub-basin 3 (approximately 6.5 acres of the 28-acre area) and diverts it away from the Firehouse Lane area. This improvement reduces the flow entering the Firehouse Lane area.

Alternative No. 2 – Abandon the Existing Box Culvert

This alternative was proposed to plug and replace the existing CBC described in Alternative 1 as follows:

- Construct a new 24-inch diameter storm drain around the buildings to the south of the Mine Shaft, then connect to the existing NMDOT drop inlets.
- Place a new drop inlet upstream end of the system as with Alternative No. 1.

Considerations: The two drop inlets would need the same type of modifications to improve efficiency as completed for Alternative 1 and the same grading work would be needed in Madrid Creek. Since Alternative No. 1 appears to be effective, no further consideration of this alternative is recommended.

SYSTEM "B" – ICE HOUSE (EAST-WEST) ROAD AND MAIN STREET IMPROVEMENTS

These alternatives address collection at the south end of Ice House Road and conveyance along Main Street (Highway 14)

Alternative No. 1 – New Storm Drain System:

- Place a new storm drain pipe system and drop inlets in the east-west alignment of Ice House road.
- Position drop inlets in the low spots of the center of the road
- Grade the road as an inverted crown and surface with gravel.
- Connect a new storm drain pipe and drop inlets along the east side of NM 14. The pipe and drop inlets would be constructed next to the existing pavement in the public right-of-way.

The entire System B storm drain flows to the north and connects with the proposed System C storm drain approximately 100 feet north of Cave Road.

Alternative No. 2 – Main Street Curb and Gutter manages stormwater from the System B watershed along Main Street (Highway 14).

- Construct mountable curb and gutter along both sides of the highway to convey stormwater to the north and routed west to Cave Road. The curb on the west side of the road would serve to prevent stormwater from flowing off the road and into private property.
- Divert stormwater off of Main Street wherever possible to Bridge Road, Cave Road and at the natural low spot on Lot No. 355.

Considerations: Both alternatives 1 and 2 were carried forward but need to be considered as a combined approach. The storm drain system provides a diversion of stormwater from the houses and business below it. The curb and gutter along NM 14 ("Main Street") would be needed to convey stormwater away from center of town.

SYSTEM "C" - ICE HOUSE ROAD AND THE LOW POINT WATER CROSSING OF HIGHWAY 14

These alternatives address conveyance of stormwater along Ice House Road and diversion to a catch basin along Highway 14 as follows:

Alternative No. 1- Storm Drain and Collection Basin

- Construct a buried storm drain in the north-south section of Ice House Road. Grade the road with an inverted crown (slopes to the middle).
- Place a series of drop inlets in the middle of the road to capture stormwater.
- Construct a new collection basin at the intersection of Ice House Road and Bethlehem Hill Road to collect hillside and road runoff.

- Convey stormwater from the collection basin north and west down the hillslope in a buried pipe.
- Construct a drop inlet at the Highway 14 crossing to collect road drainage water.
- Align the buried pipe after crossing Highway 14 south to Cave Road and then west and north in the road right-of-way (ROW). Once the buried storm drain reaches Cave Road, it would be routed to the north to daylight at the ground surface.

Alternative No. 2 – Roadside Ditch and Collection Basin collects water off of Ice House Road with a surface ditch along the east side of the road with the ditch draining north to the collection basin.

- Construct a new collection basin at the intersection of Ice House Road and Bethlehem Hill Road to collect hillside and road runoff. The collection basin is much the same as with Alternative No. 1.
- Place a new pipe culvert from the collection basin under Ice House Road that would take stormwater to the west and then a new open channel would convey water down to SR 14.
- Construct a concrete or grouted rip-rap lined open channel.
- Install a concrete box culvert to convey water under SR 14
- Construct a concrete or grouted riprap lined channel aligned to the west.

The proposed alignment for this alternative follows the path of least surface disturbance. It is not possible to get this water to the east-west section of Cave Road. Once the stormwater has reached the north-south alignment of Cave Road, the water would be discharged to the surface and flow north in the road where it will eventually reach Madrid Arroyo.

Considerations: Both alternatives 1 and 2 were carried forward but need to be considered as a combined approach. The storm drain system provides a diversion of stormwater from the houses and business below it. The curb and gutter along NM 14 (“Main Street”) would be needed to convey stormwater away from center of town.

SYSTEM "D" – STORM DRAIN FROM HIGHWAY 14 WEST BETWEEN LOTS 384 AND 393

These alternatives address improvement of the conveyance capacity of stormwater under Highway 14 and to a conveyance structure between two private lots as follows:

Alternative No. 1. Replace the existing system with new drop inlets on both sides of Highway 14 to increase conveyance capacity. Install a new buried pipeline routed to Cave Road. Align in the existing open channel concrete and rock lined ditch.

Alternative No. 2 would improve the collection and conveyance capacity at Highway 14 as described for Alternative 1, but would discharge stormwater into the existing rock lined ditch part way down the hill towards Cave Road. This ditch has limited capacity but would suffice if storm drain System "E" is constructed.

Considerations: Both alternatives 1 and 2 will be considered further. These alternatives are, for the most part, captured on the preliminary designs discussed in the following section.

SYSTEM "E" – STORM DRAIN DIVERSION AT BALL FIELD TO VALLEY BOTTOM

System "E" would collect stormwater from Highway 14, north of town before it reaches the developed part of Town. It involves installation of a buried storm drain aligned between the old school building and the ball field. This location cannot easily accommodate an open stormwater channel.

Considerations: This concept is considered an approach to diverting stormwater away from the center of Town which would reduce the impact on new stormwater structures. These alternatives are, for the most part, captured on the preliminary designs discussed in the following section.

SYSTEM "F" - BRIDGE ROAD DRAINAGE

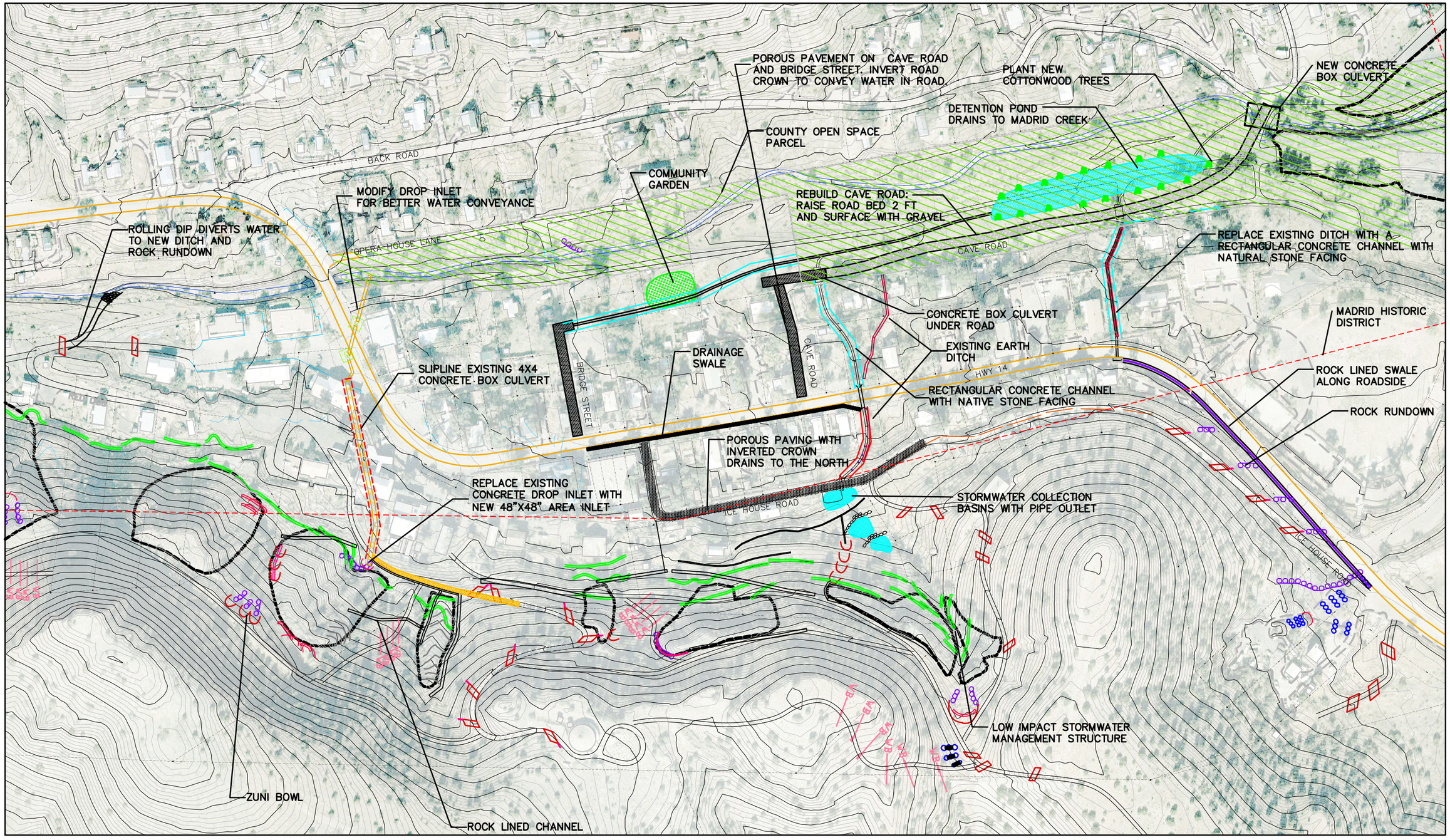
Alternatives 1 and 2 would include grading Bridge Road with an inverted crown cross section to convey stormwater down the center of the road. Both alternatives would remove the existing drainage pipe crossing Bridge Road since it is thought to not benefiting the drainage system.

Alternative No. 1 - involves installation of a drop inlet at the low spot in the road and a storm drain that would convey water to the west and then north to the storm drain in Cave Road.

Alternative No. 2 - involves construction of an open channel to collect water at the low point on Bridge Road then convey it west in the road and then north towards Cave Road.

Considerations: These alternatives are, for the most part, captured on the preliminary designs discussed in the following section.

APPENDIX B: PRELIMINARY DESIGN PLANS FOR THE MADRID STORMWATER IMPROVEMENT PROJECT



N

100 200 400

SCALE IS 1" = 200'

Dekker/Perich/Sabatini

New Mexico Abandoned Mine Land Program EMNRD - MMD

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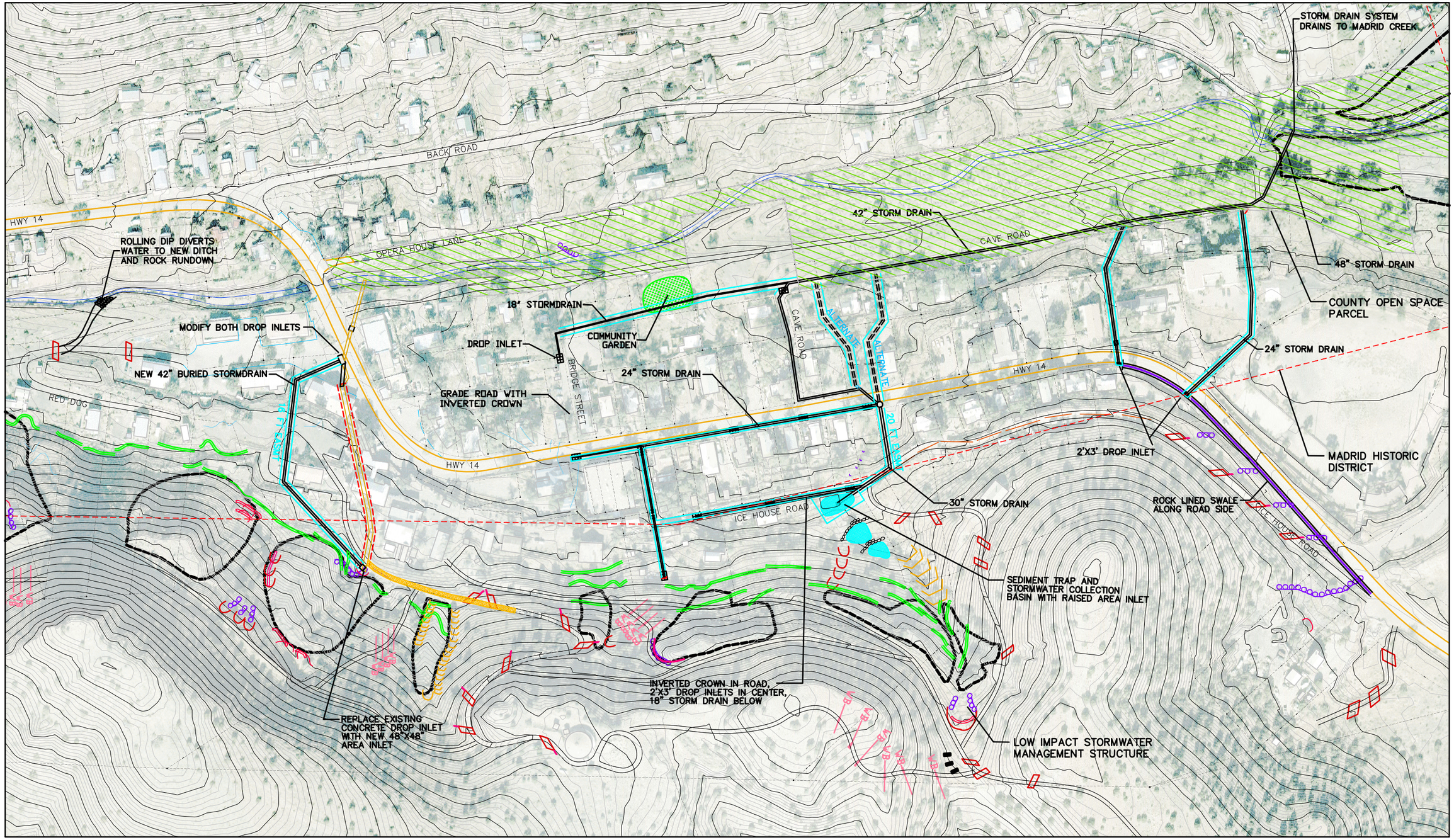
MADRID STORMWATER IMPROVEMENT PROJECT

PRELIMINARY DESIGN
OPEN CHANNEL ALTERNATIVE
(PREFERRED)

SHEET 1
OF
5

Scale: 1" = 200 ft | 6/26/13



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100 200 400

SCALE IS 1" = 200'

Dekker/Perich/Sabatini

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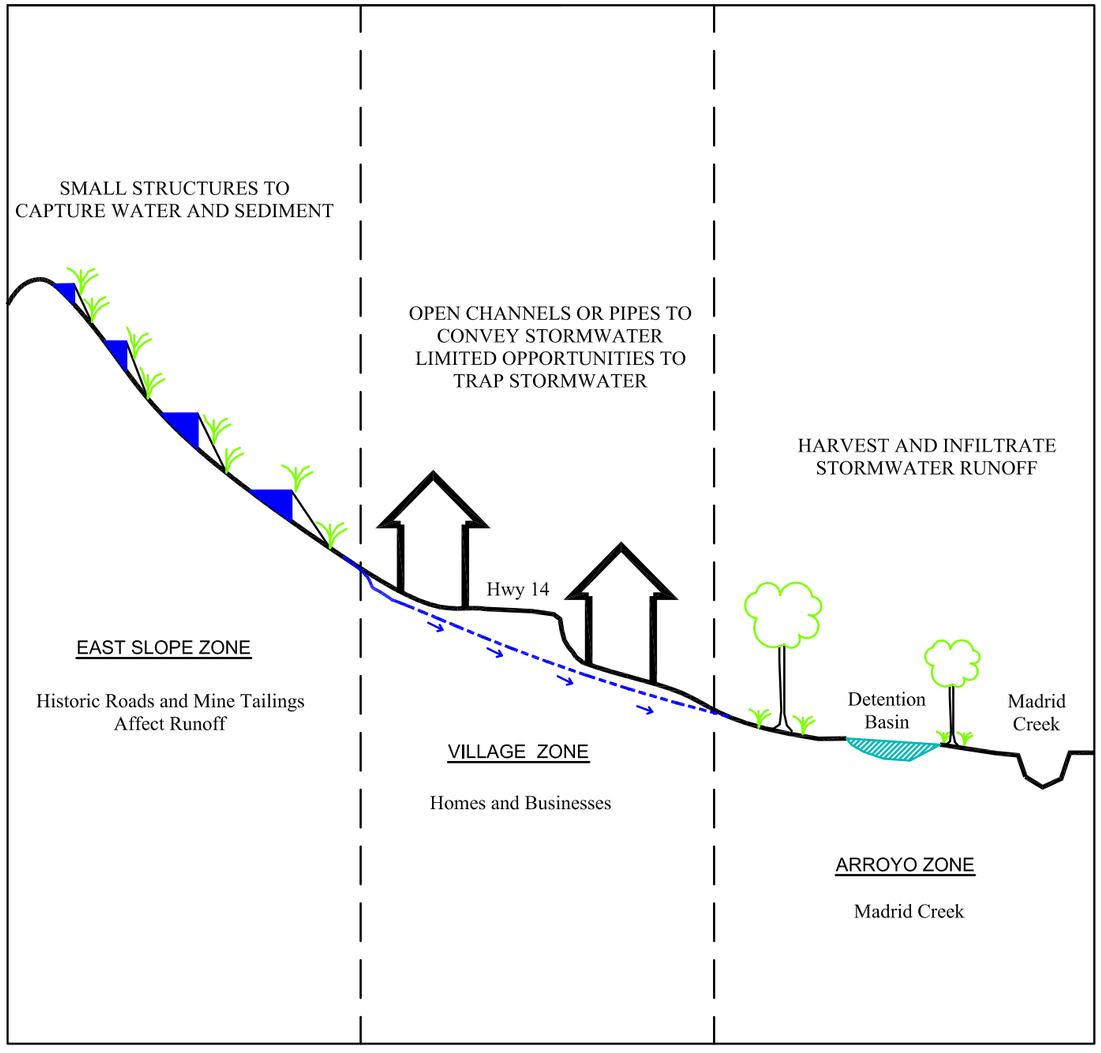
MADRID STORMWATER IMPROVEMENT PROJECT

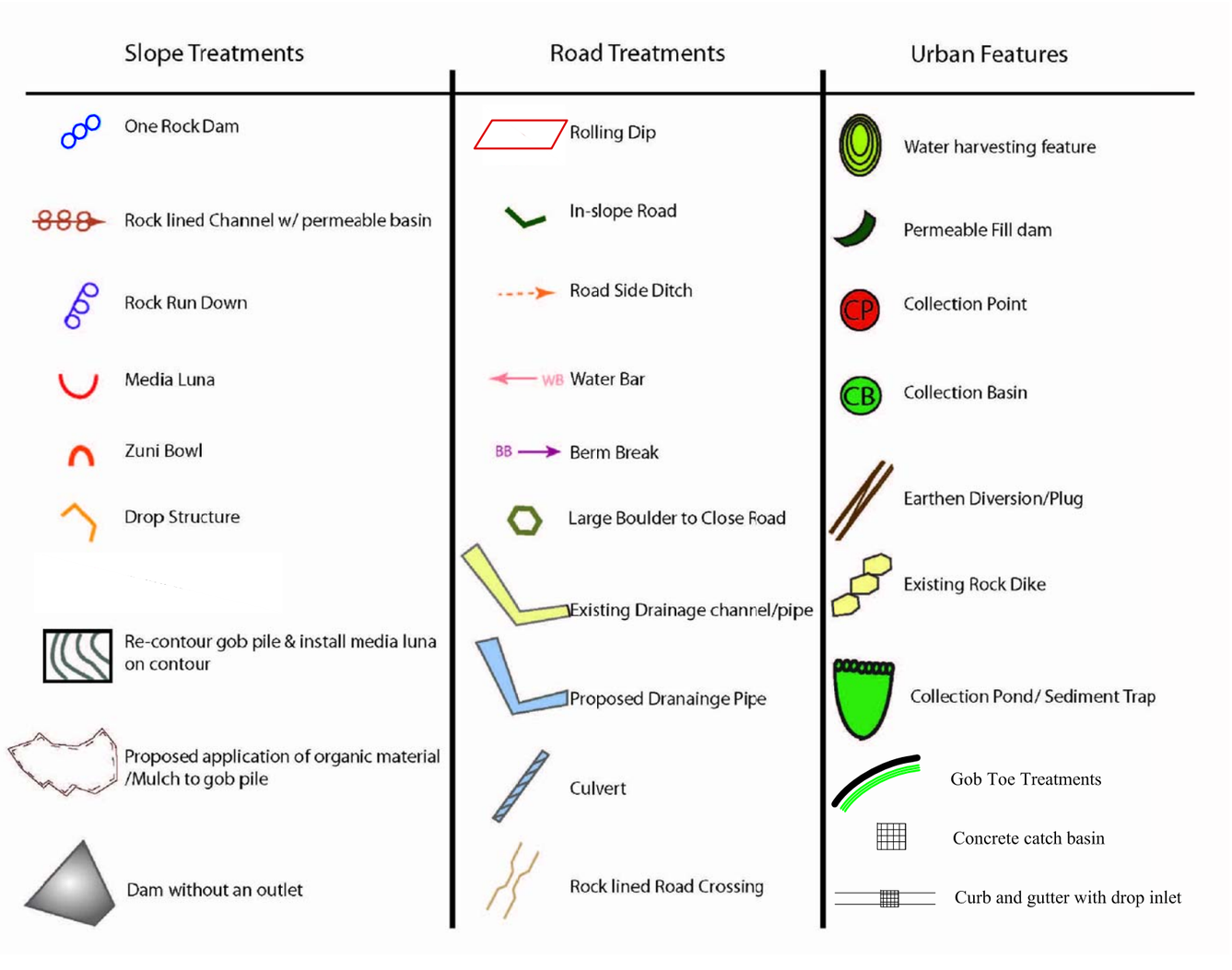
PRELIMINARY DESIGN
BURIED STORMDRAIN ALTERNATIVE

SHEET 2
OF
5

Scale: 1" = 200 ft | 6/26/13



ZONE DIAGRAM
MADRID EAST SLOPE CATCHMENT



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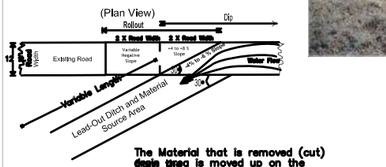
MADRID STORMWATER IMPROVEMENT PROJECT

SHEET LAYOUT
AND MAP LEGEND

3
OF
5

6/26/13

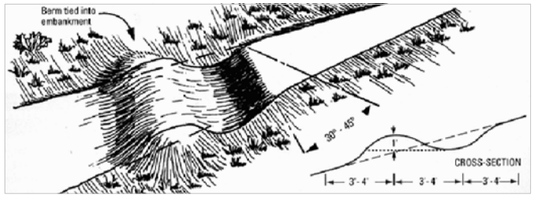
ROLLING DIP



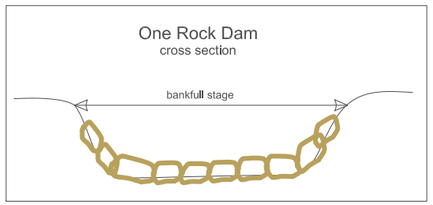
The Material that is removed (cut) from this area is moved up on the headcase side to fill for the elevated portion of the rolling dip. In some instances, fill is brought in.

ROCK RUNDOWN

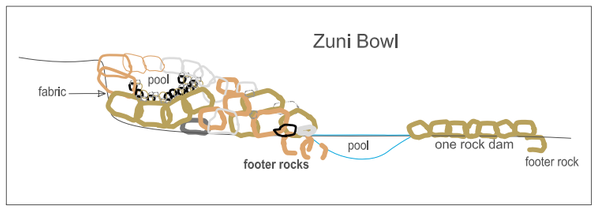
WATER BAR



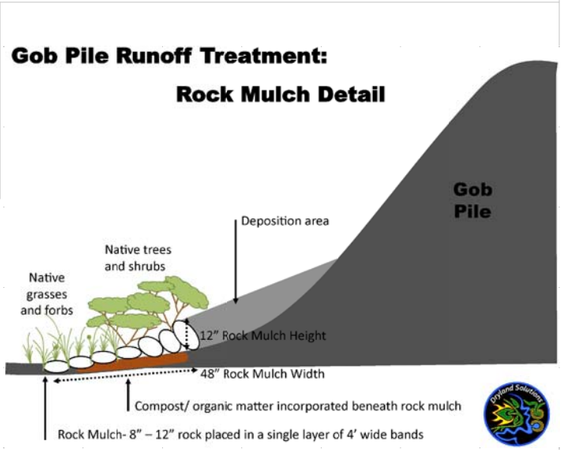
ONE ROCK DAM



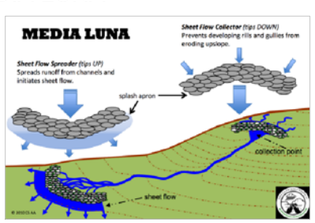
ZUNI BOWL



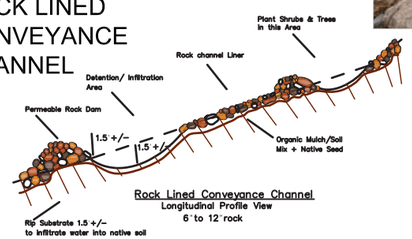
GOB TOE TREATMENT



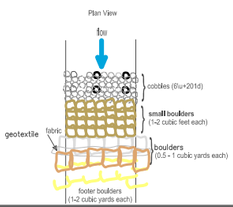
MEDIA LUNA

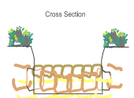


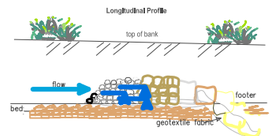
ROCK LINED CONVEYANCE CHANNEL



DROP STRUCTURE







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MADRID NEW MEXICO	SHEET
MADRID STORM WATER IMPROVEMENT PROJECT	4 OF 5
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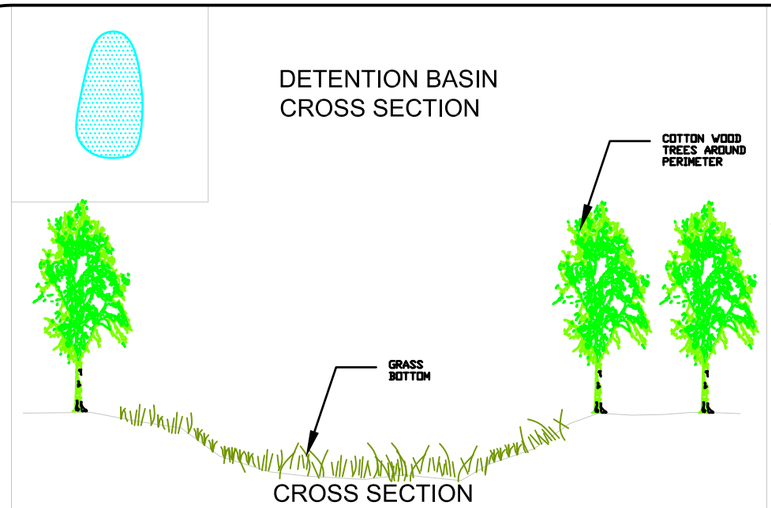
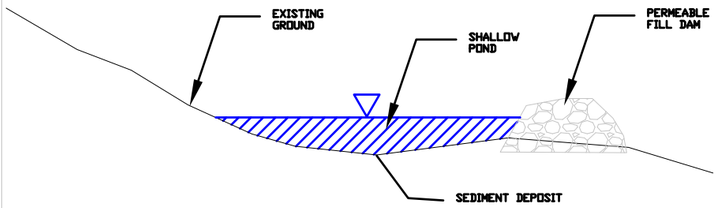
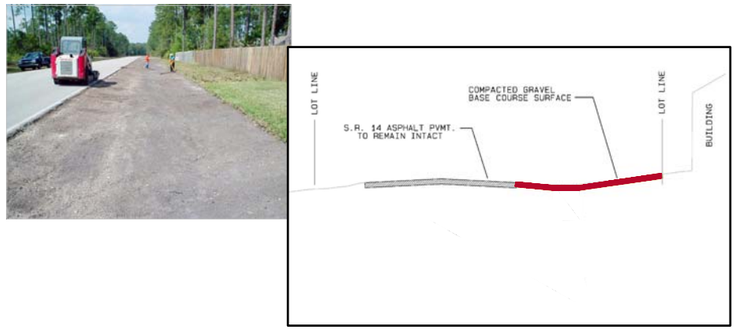


DETENTION BASIN
CROSS SECTION

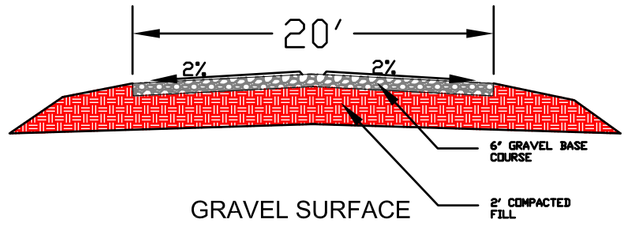
CROSS SECTION



SEDIMENT TRAP
CROSS SECTION

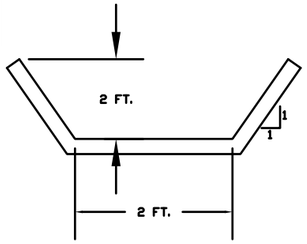


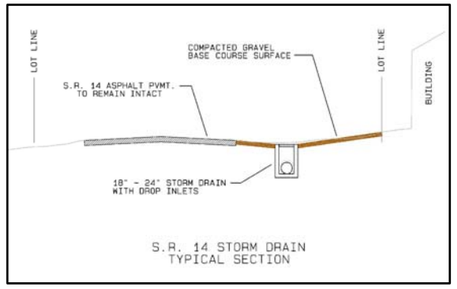
COMPACTED GRAVEL SWALE
WITHOUT STORMDRAIN



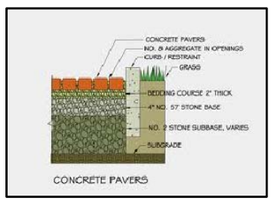
GRAVEL SURFACE
ROAD

CONCRETE CHANNEL
WITH ROCK LINING

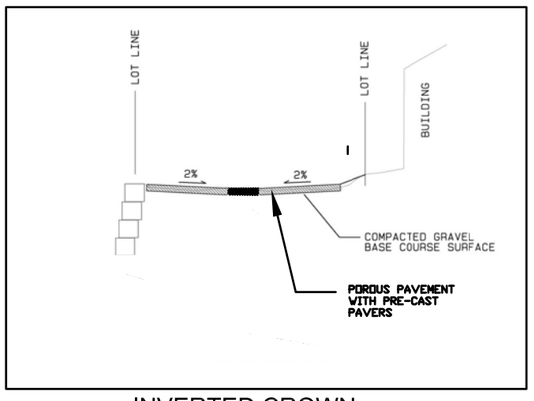




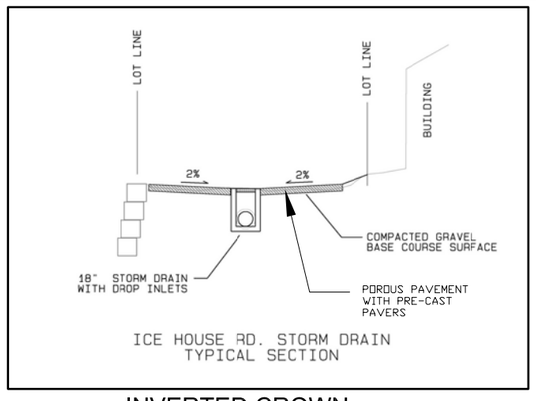
COMPACTED GRAVEL SWALE
WITH STORMDRAIN



CONCRETE PAVER DETAIL



INVERTED CROWN
PAVED ROAD WITH OUT STORMDRAIN



INVERTED CROWN
PAVED ROAD WITH STORMDRAIN

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New Mexico Abandoned Mine Land Program AML EMNRD - MMD

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MADRID STORMWATER IMPROVEMENT PROJECT

TREATMENT LEGEND

SHEET 5 OF 5

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APPENDIX C: PRELIMINARY DESIGN PLANS FOR MADRID GULCH

Madrid Gulch Open Space
Preliminary Design for Drainage Improvements

LOCATION MAP

Prepared For:

Santa Fe County Open Space,Trails & Parks

Index of Drawings

RIVERBEND ENGINEERING, LLC

Madrid Open Space Drainage Study		
Madrid Gulch at Madrid, NM		Sheet
COVER SHEET & LOCATION MAP		1 of 10
NTS	1-30-2019	

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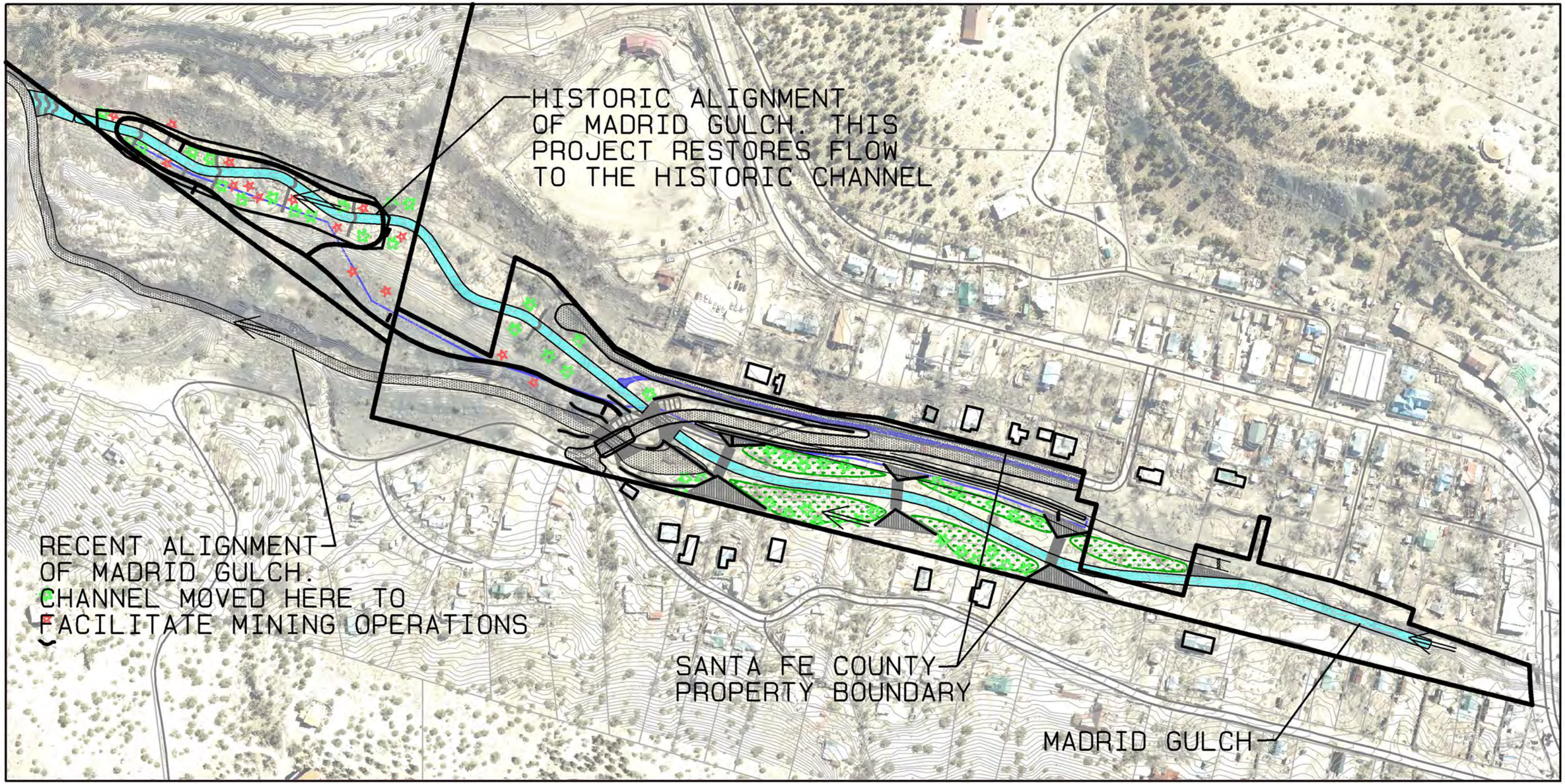

0 200' 400' 800'

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Madrid Open Space Drainage Study

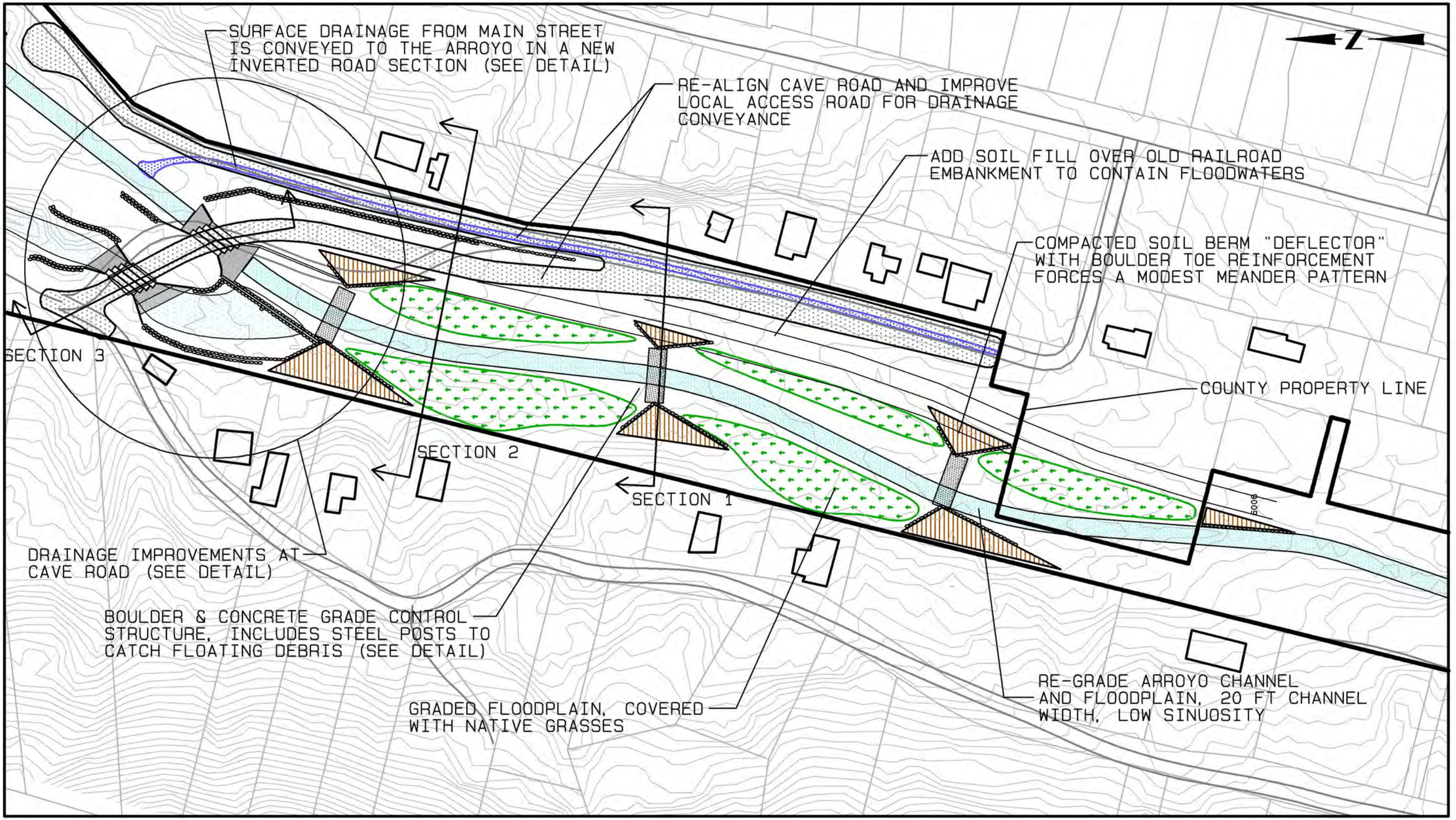
Madrid Gulch at Madrid, NM

Sheet 2 of 10

PROJECT OVERVIEW

Scale: 1" = 200 ft

1-30-2019



0 100' 200' 400'

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Madrid Open Space Drainage Study

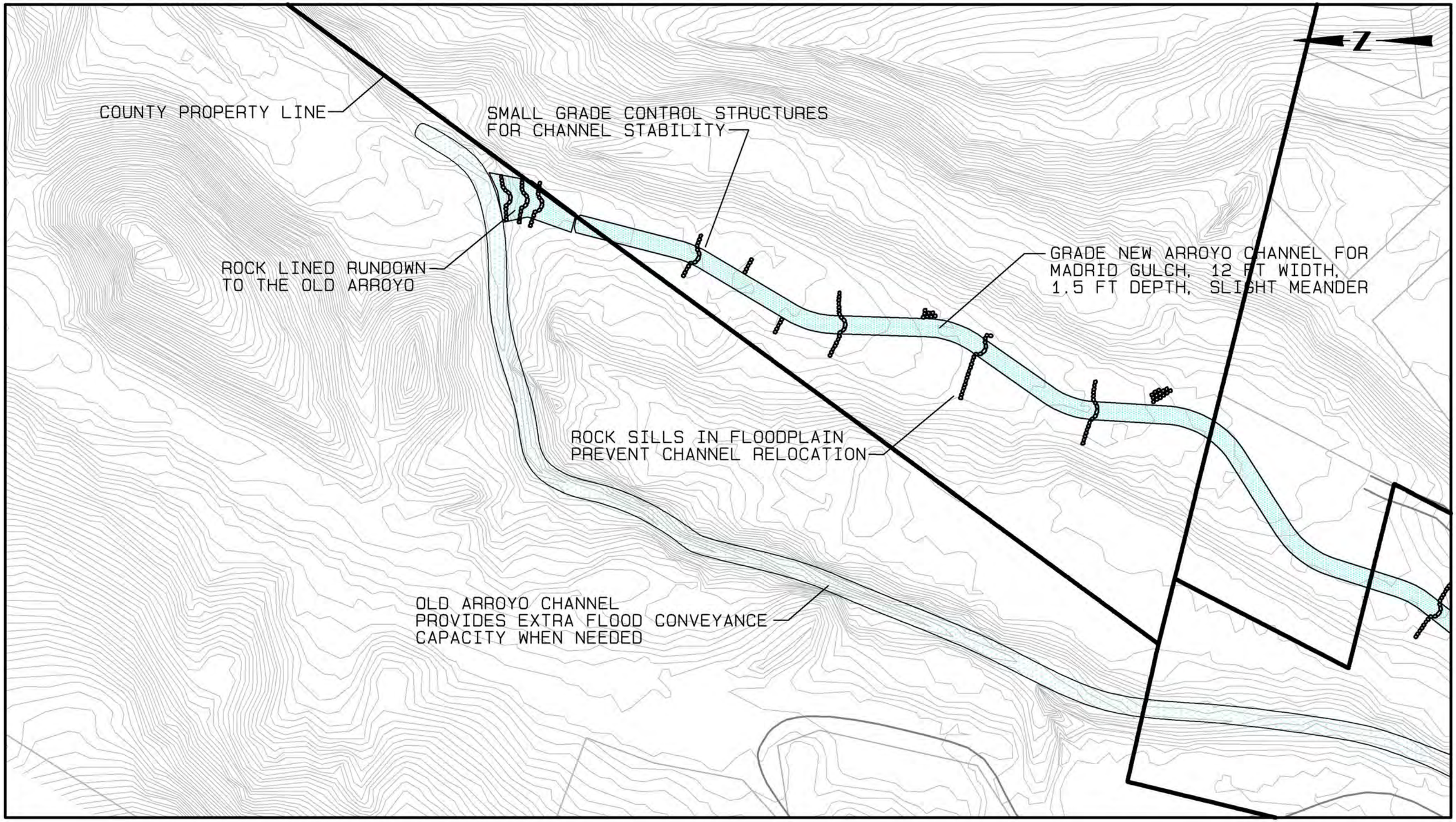
Madrid Gulch at Madrid, NM

Sheet 3 of 10

PHASE 1 SITE PLAN SOUTH HALF

Scale: 1" = 100 ft

1-30-2019



0 100' 200' 400'

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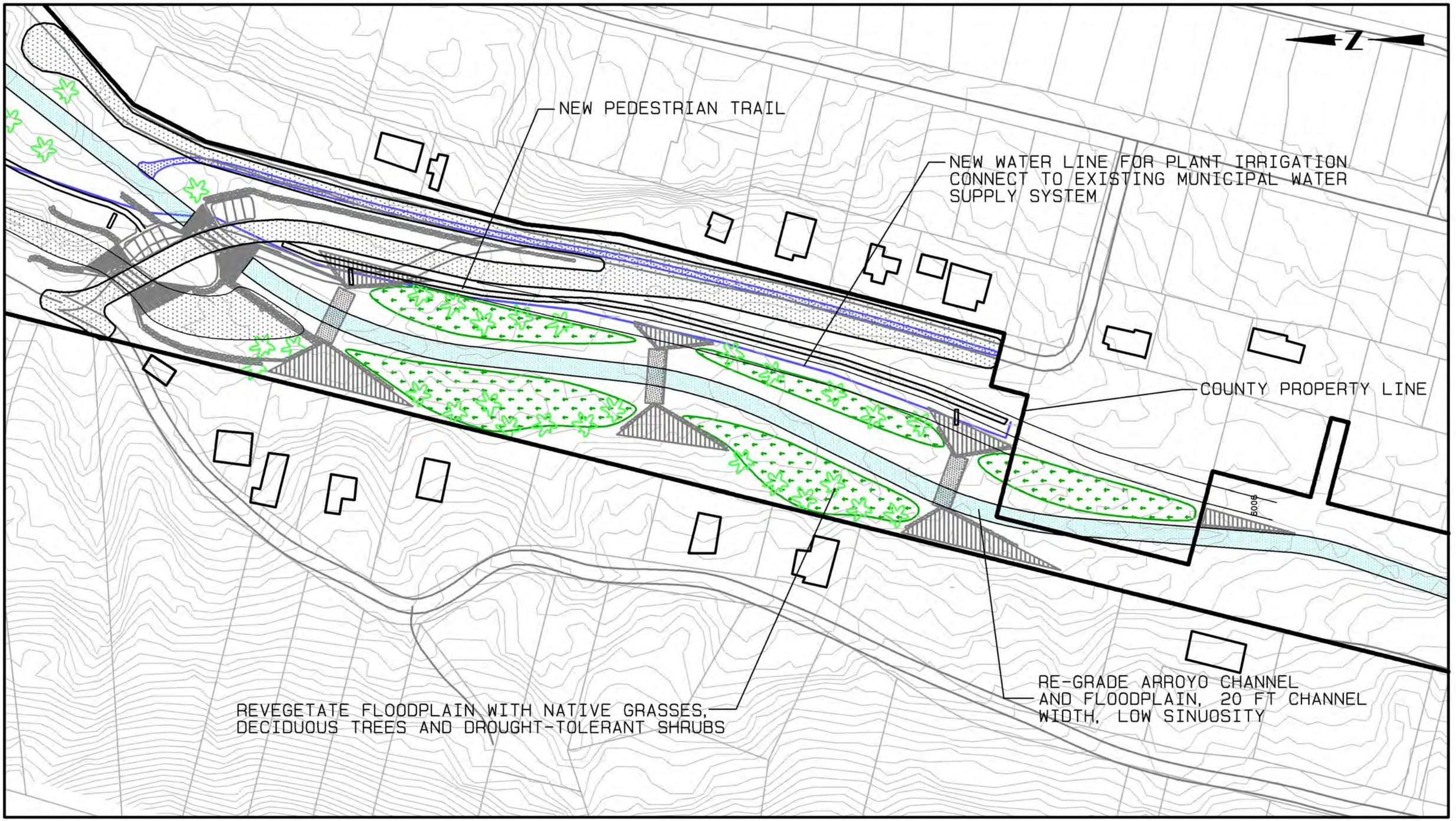
Madrid Open Space Drainage Study

Madrid Gulch at Madrid, NM | Sheet

PHASE 1 SITE PLAN NORTH HALF | 4 of 10

Scale: 1" = 100 ft | 1-30-2019



0 100' 200' 400'

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Madrid Open Space Drainage Study

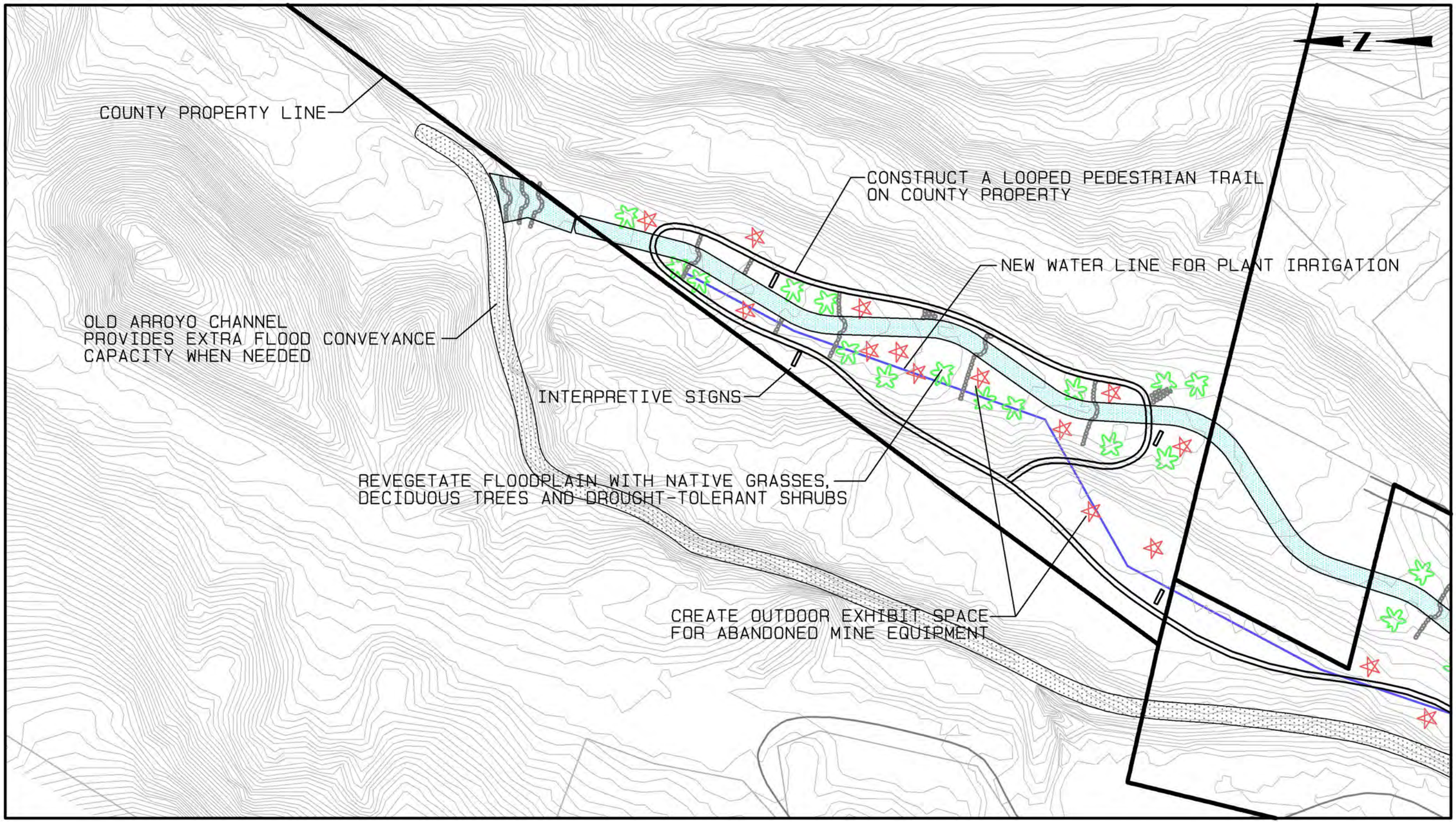
Madrid Gulch at Madrid, NM

Sheet 5 of 10

PHASE 2 SITE PLAN
SOUTH HALF

Scale: 1" = 100 ft

1-30-2019



0 100' 200' 400'

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Madrid Open Space Drainage Study

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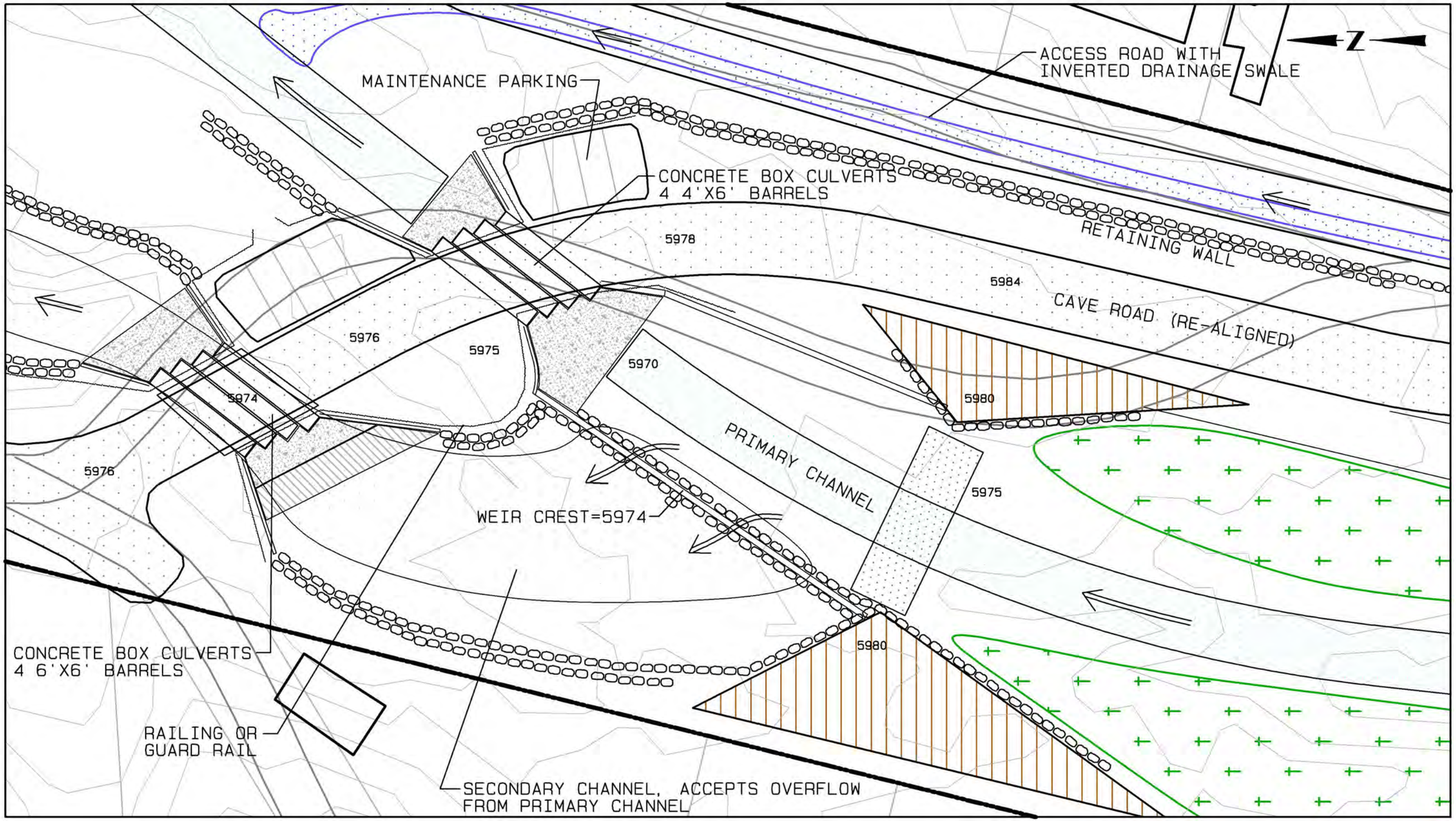
Sheet 6 of 10

PHASE 2 SITE PLAN
NORTH HALF

Scale: 1" = 100 ft

1-30-2019



0 30' 60' 120'

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Madrid Open Space Drainage Study

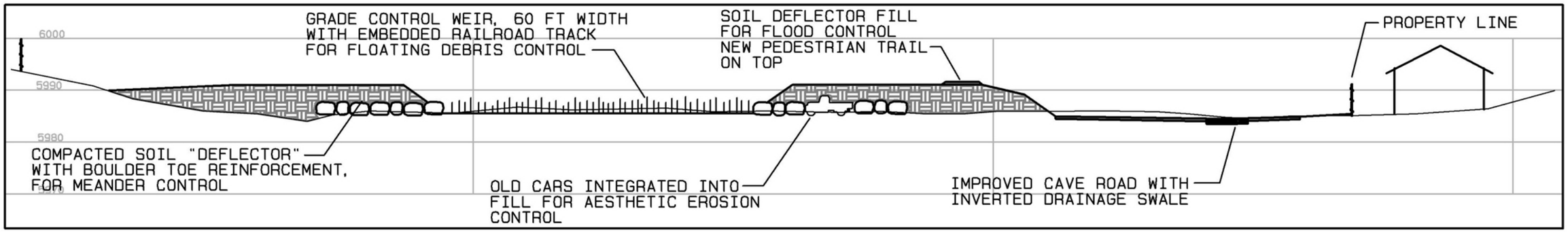
Madrid Gulch at Madrid, NM

Sheet 7 of 10

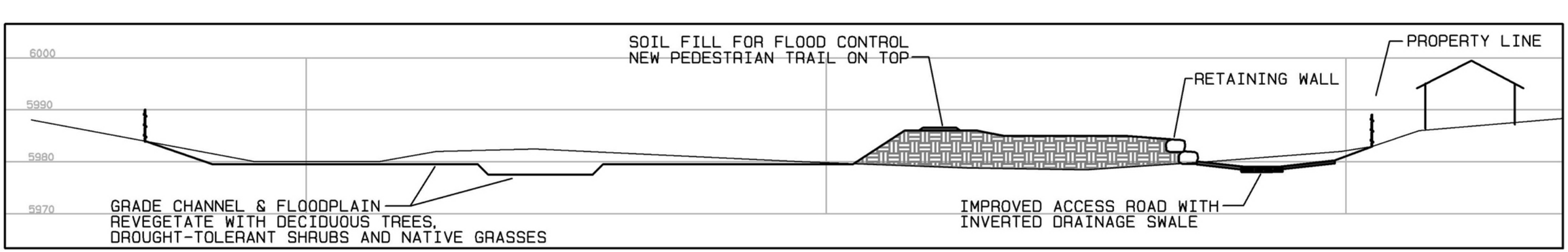
DRAINAGE IMPROVEMENTS AT CAVE ROAD

Scale: 1" = 30 ft

1-30-2019



SECTION No. 1, MADRID GULCH AT NEW GRADE CONTROL & DEFLECTOR STRUCTURE



SECTION No. 2, IMPROVED CHANNEL & FLOODPLAIN, BERM FOR FLOOD PROTECTION

0 20' 40' 80'

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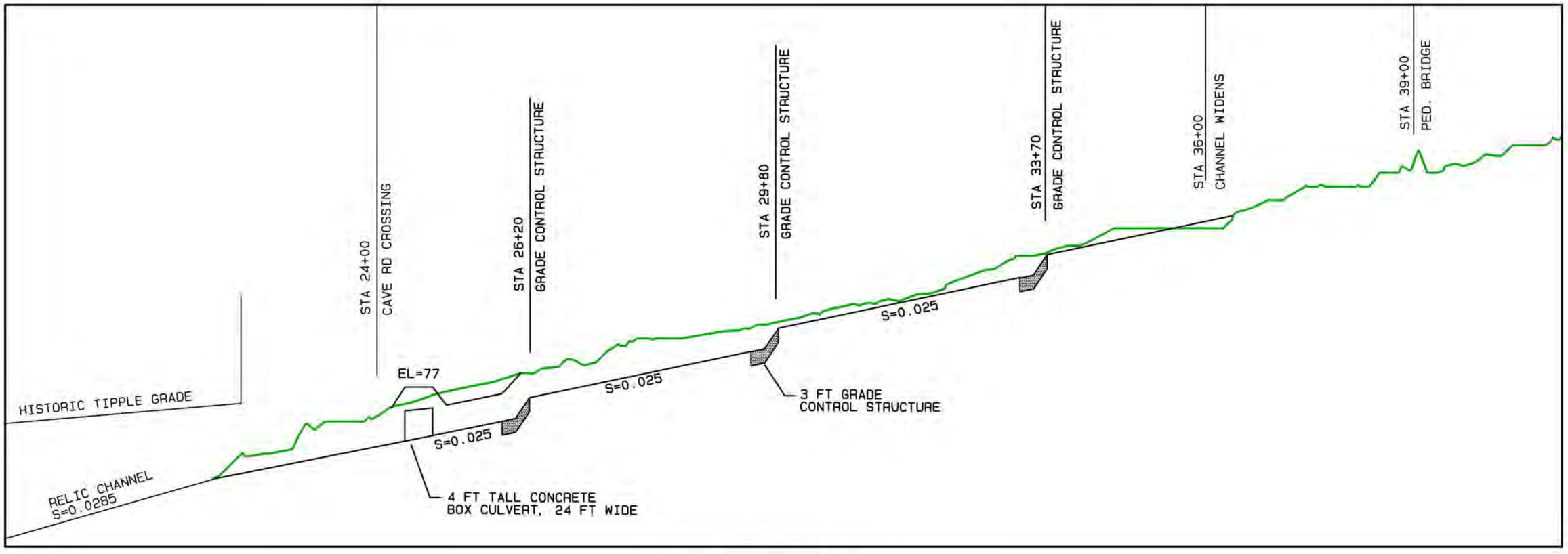
Madrid Open Space Drainage Study

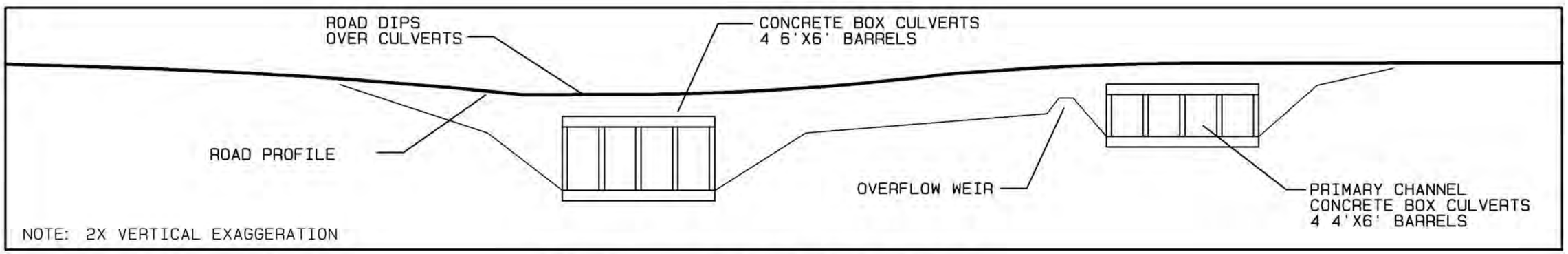
Madrid Gulch at Madrid, NM | Sheet 8 of 10

MADRID GULCH ARROYO SECTIONS

Scale: 1" = 150 ft | 1-30-2019



ARROYO PROFILE



SECTION No. 3, CAVE ROAD PROFILE

Riverbend Engineering, LLC

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Tel: 505.344.3315 FAX: 505.344.0698 Email: cphilips@frontier.net

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Madrid Open Space Drainage Study

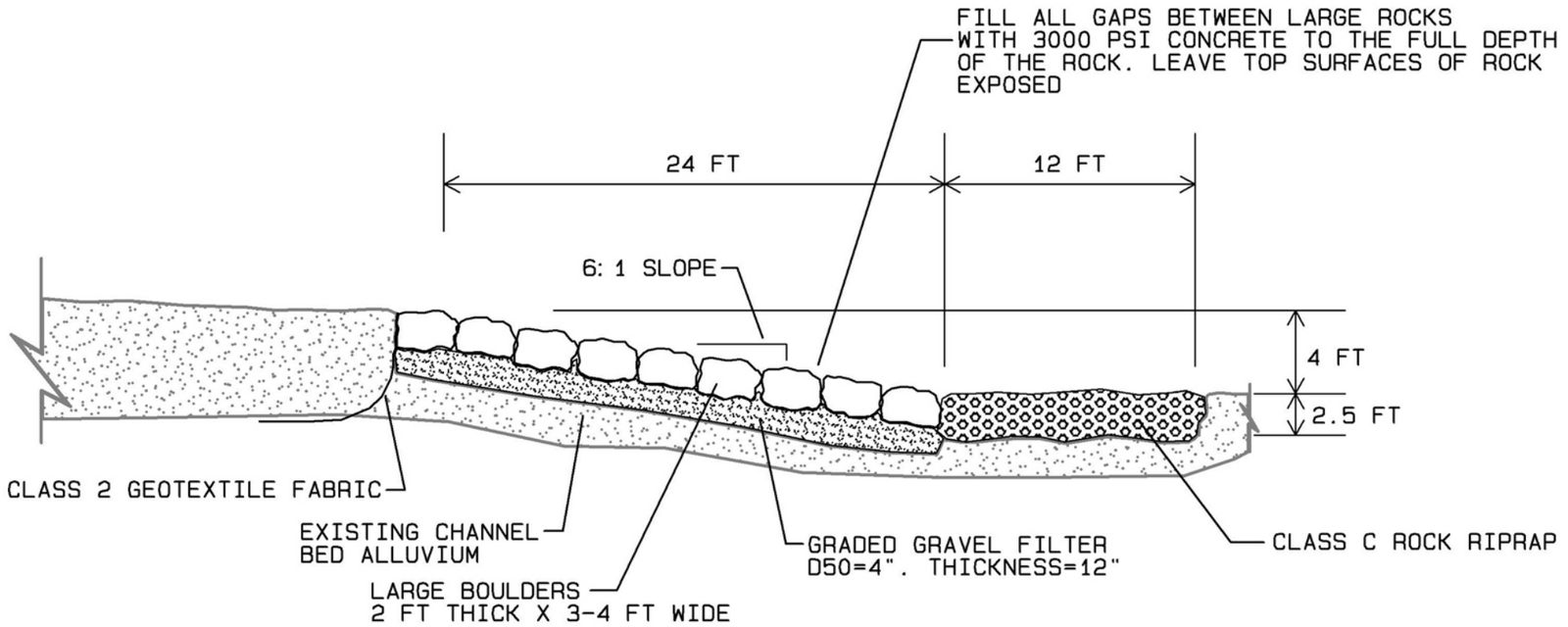
Madrid Gulch at Madrid, NM

Sheet 9 of 10

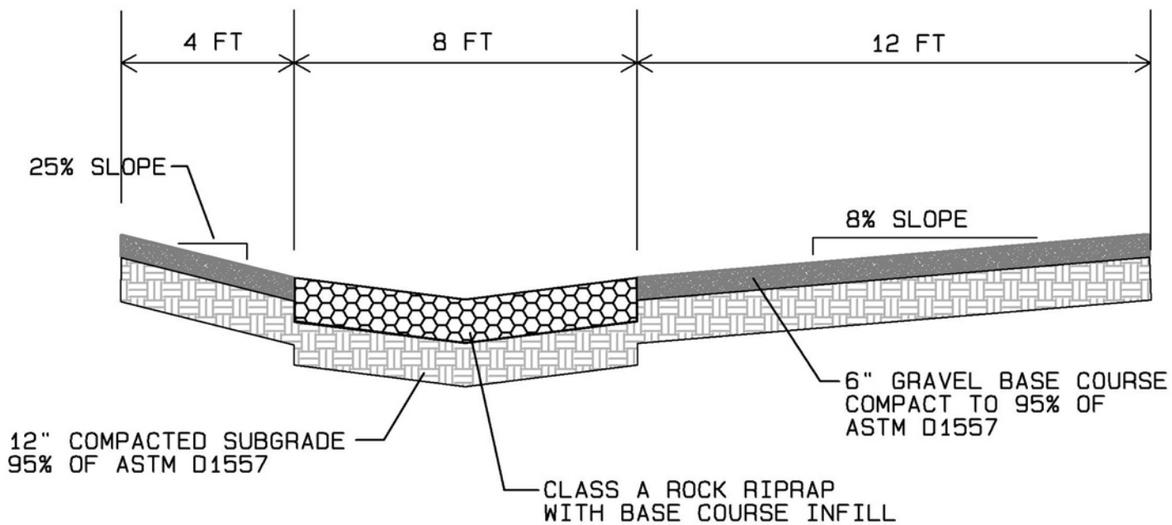
MADRID GULCH ARROYO PROFILE

Scale: Varies

1-30-2019



GRADE CONTROL STRUCTURE PROFILE



GRAVEL ROAD WITH INVERTED DRAINAGE SWALE, SECTION

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Madrid Open Space Drainage Study

Madrid Gulch at Madrid, NM | Sheet

DRAINAGE DETAILS | 10 of 10

Scale: Varies | 1-30-2019

APPENDIX D: ALTERNATIVE DESIGN SUMMARY SHEETS

SUBSURFACE DETENTION

Subsurface detention allows for stormwater runoff to be captured and temporarily stored in below-ground structures while being slowly discharged into downstream facilities. This type of structure reduces downstream runoff flows and volumes while maintaining usable land space for functional purposes such as parking lots or open space.

Photograph courtesy of Contech ES

Management Objectives

- Reduce stormwater runoff peak flow rates to downstream structures
- Maintain usable land space above stormwater facilities
- Divert and collect excess runoff from surrounding area into single facility
- Reduce sediment load to the Madrid Arroyo

Benefits and Effectiveness

- Reduces the peak flow rates downstream of the detention facility which reduces downstream flooding and allows downstream structures to be smaller in size and fewer in number.
- In comparison with a typical detention pond, subsurface detention has the ability to maintain reasonable usable of the land area above the facility. This type of detention facility is ideal to place beneath parking lots or open space where a traditional detention pond would require the land footprint for only stormwater purposes.
- By diverting, collecting, and storing the stormwater runoff from the surrounding area, a large regional detention facility can reduce the number of stormwater facilities and focus maintenance efforts to a single location that might otherwise be distributed between several smaller structures.
- Detention will allow sediment suspended in stormwater to drop out of suspension and collect in the detention structure, reducing sediment loads in downstream facilities. The subsurface structure will require regular sediment removal, which can be done using a vacuum truck.
- Operations and Maintenance costs are expected to be $600.00 per vacuum truck visit.

SUBSURFACE DETENTION

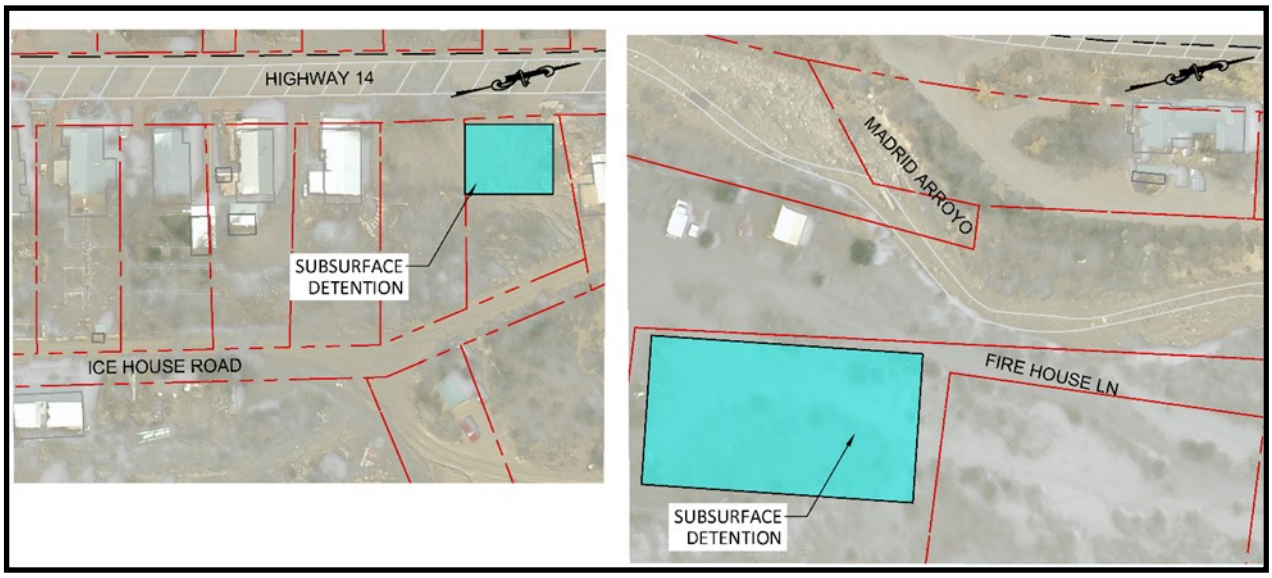
Case Study: Steel Bender Brewyard, Albuquerque, New Mexico

The Steel Bender Brewyard in Albuquerque, New Mexico installed a subsurface detention system in 2014. The 5-acre property, which includes mostly impervious areas, drains into a pretreatment system before flowing into several hundred feet of 96" corrugated aluminum below the parking areas. The total system volume is approximately 88,000 cubic feet, and includes risers for cleaning and for drop inlets in the parking lot.

The pretreatment included a system to reduce sediment into the subsurface pipe gallery, as well as trash and debris.

Case Study and Photographs Courtesy of Contech ES

Potential Locations for Implementation



Ice House Road Area

Firehouse Lane Area

SUBSURFACE INFILTRATION

Subsurface infiltration allows for stormwater runoff to be captured and temporarily stored in below-ground structures while being slowly infiltrated into the ground. This type of structure reduces downstream runoff flows and volumes while maintaining usable land space for functional purposes such as parking lots or open space.

Photograph courtesy of Contech ES

Management Objectives

- Reduce stormwater runoff peak flow rates to downstream structures.
- Maintain usable land space above stormwater facilities.
- Increase recharge of the local water table.
- Divert and collect excess runoff from surrounding area into single facility.

Benefits and Effectiveness

- Stormwater infiltration galleries have a detention component to temporarily store runoff which reduces the peak flow rates to downstream structures. This allows for reduction in downstream flooding, smaller structures and fewer in number.
- An infiltration gallery maintains usable land area above the facility. This type of infiltration facility is ideal to place beneath parking lots or open space where a traditional infiltration pond would require the land footprint for only stormwater purposes.
- Infiltration will reduce not only the downstream peak flow rates, but also the downstream stormwater volumes. Infiltration also provides recharge of the local groundwater.
- An infiltration gallery will cause sediment suspended in stormwater to drop out of suspension and collect in the structure. A pretreatment facility may be recommended to reduce the sediment accumulation in the infiltration gallery, reducing maintenance costs and effort.

Estimated Operations and Maintenance (O&M) Cost

Description	Quantity	Unit Cost	Units	Extended Cost
Vacuum Truck	3	$570	Days	$1,710.00
Vacuum Truck Operator	3	$520	Days	$1,560.00
Miscellaneous Annual Expenses	1	$1,000	Annual	$1,000.00
			Estimated Annual O&M Cost	**$4,270.00**

SUBSURFACE INFILTRATION

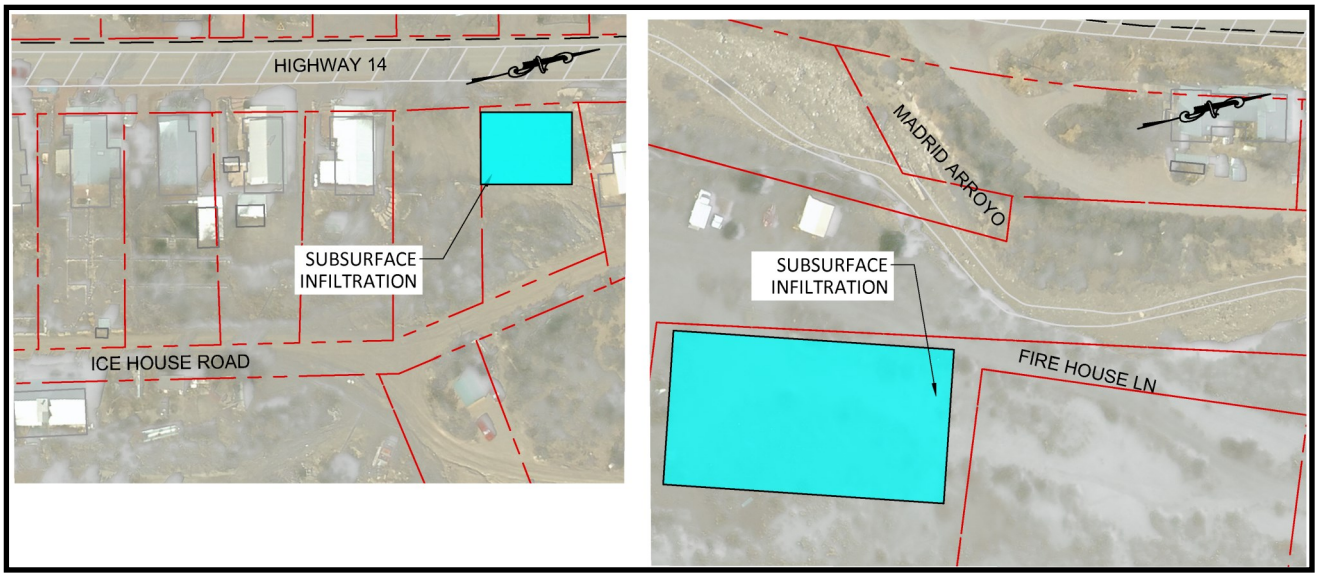
Case Study: The Streets at South Glenn, Centennial, Colorado

This shopping center underwent renovations that included reworking the site's previous stormwater system which had caused flooding in nearby roadways.

To correct the flooding issue and maintain current parking availability, a subsurface infiltration system was installed to capture stormwater from the 77 acre site. Sediment was prevented from entering the infiltration system via a sediment trap. The sediment trap was designed to prevent buildup in the infiltration system.

Photograph courtesy of Contech ES

Potential Locations for Implementation



Ice House Road Area

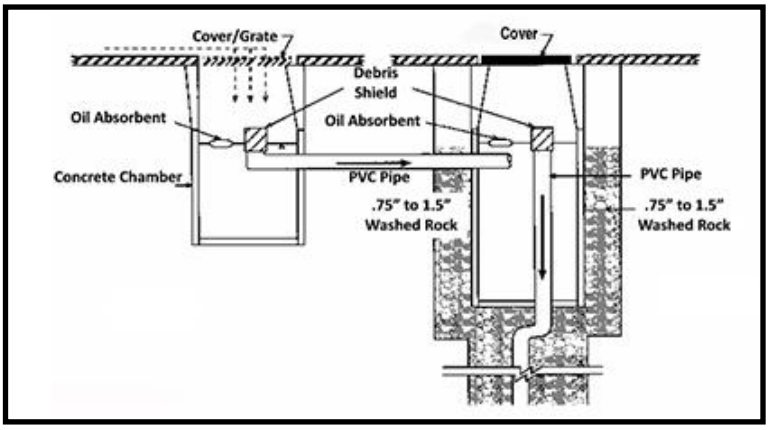
Firehouse Lane Area

STORMWATER DRAINAGE WELL

A stormwater drainage well, also known as a dry well, allows for stormwater runoff to be captured and stored below ground as it slowly infiltrates into the ground. This type of stormwater capturing method reduces downstream runoff flows and volumes while maintaining usable land space for functional purposes such as parking lots or open space.

Management Objectives

- Reduce stormwater runoff peak flow rates to downstream structures.
- Maintain usable land space above stormwater facilities.
- Increase recharge of the local water table via infiltration.
- Divert and collect excess runoff from surrounding area into single facility.



Photograph courtesy of US EPA

Benefits and Effectiveness

- Stormwater drainage wells have a retention component to store runoff which reduces the peak flow rates downstream of the facility. This allows for downstream structures to be smaller in size, lower in cost, and fewer in number.
- A stormwater drainage well is similar to an infiltration pond with the difference between the two being where the water is stored. Where the pond has a large footprint, the well has a small footprint by storing water underground vertically.
- Infiltration will reduce not only the downstream peak flow rates, but also the downstream stormwater volumes. Infiltration also provides recharge of the local groundwater.
- A pretreatment facility is required in order to reduce the sediment accumulation and harmful environmental contaminates from entering the well and infiltrating into the ground.

Estimated Operations and Maintenance (O&M) Cost

Description	Quantity	Unit Cost	Units	Extended Cost
Groundwater Sample Testing	4	$1,000	Days	$4,000.00
Field Engineer	4	$900	Days	$3,600.00
Vacuum Truck	3	$570	Days	$1,710.00
Vacuum Truck Operator	3	$520	Days	$1,560.00
			Estimated Annual O&M Cost	**$10,870.00**

STORMWATER DRAINAGE WELL

Case Study: Chandler, Arizona

Chandler, Arizona uses stormwater drainage wells intensively. A 2005 report studying the affects of groundwater recharge using stormwater drainage wells found the use of wells to collect stormwater increased groundwater recharge. The study found that in the area of Chandler, groundwater recharge went from a pre-development recharge rate of 191 acre-feet of water per year (af/yr) to a rate of approximately 2,100-3,100 af/yr.

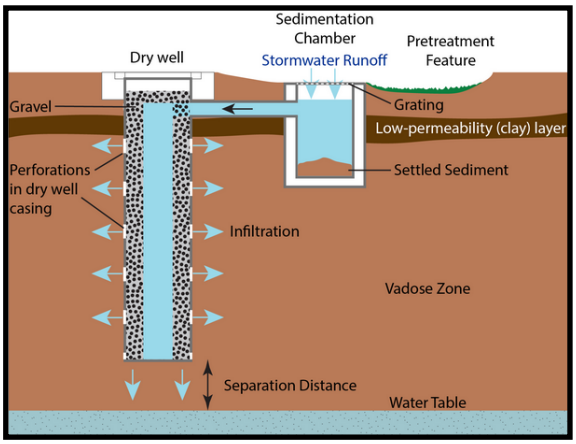
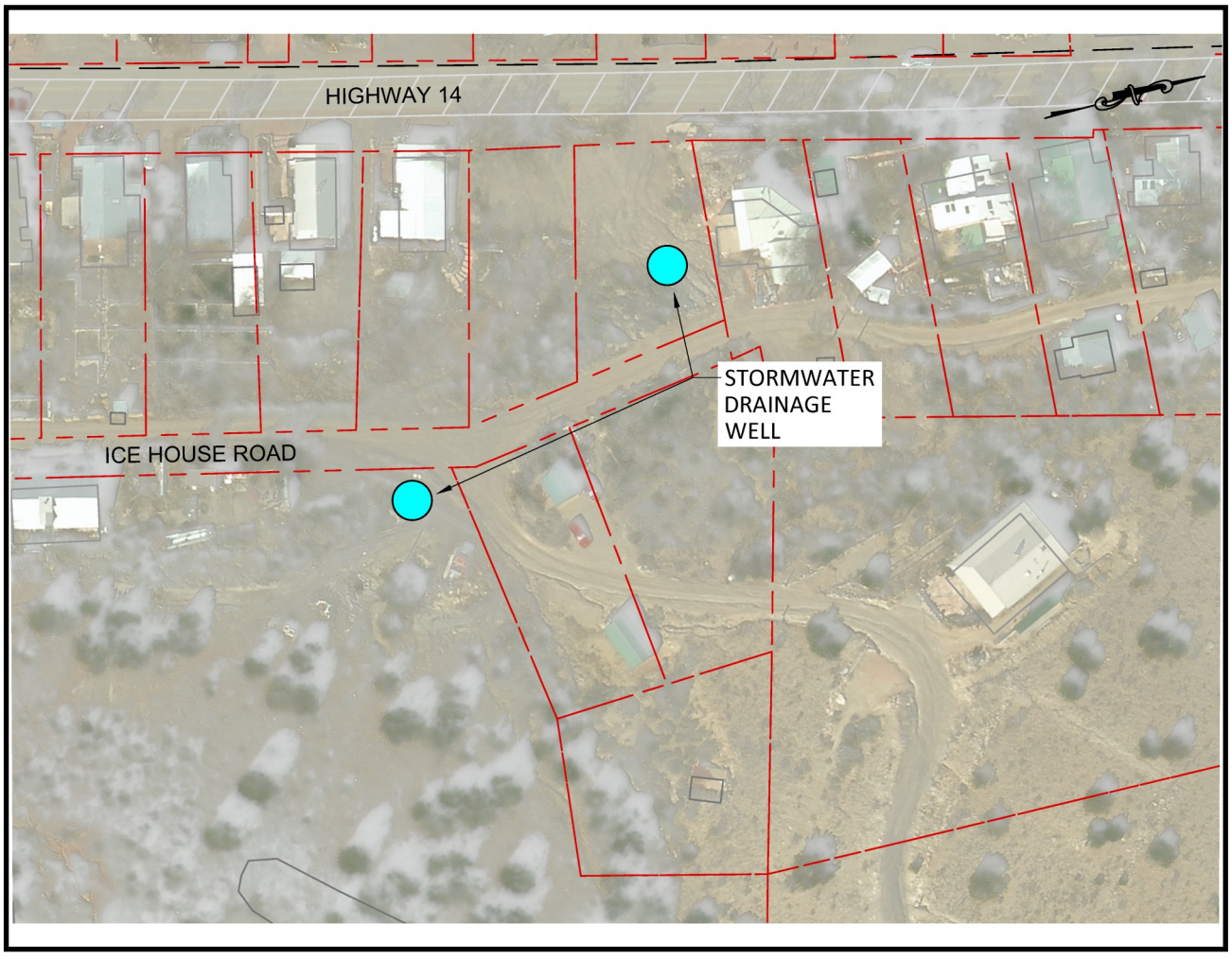


Image from the American Geosciences Institute

Potential Locations for Implementation



SHOTCRETE SLOPE STABILIZATION

Slope stabilization is used to prevent the failure of slopes from shear forces and erosion. Various methods can be used for slope stabilization such as soil fabrics, soil nails, and application of cementious materials. Depending on the situation, an engineer will recommend the appropriate option for a site. The stability of a slope is controlled by the shear strength of soil and the acting shear stress. If the shear stress is greater than the shear strength, a slope will fail. To increase the strength of a slope against shear stress, slope stabilization practices are used.

Management Objectives

- Prevent slope failure
- Protect property
- Maintain the aesthetic of the locale
- Easy to install

Benefits and Effectiveness

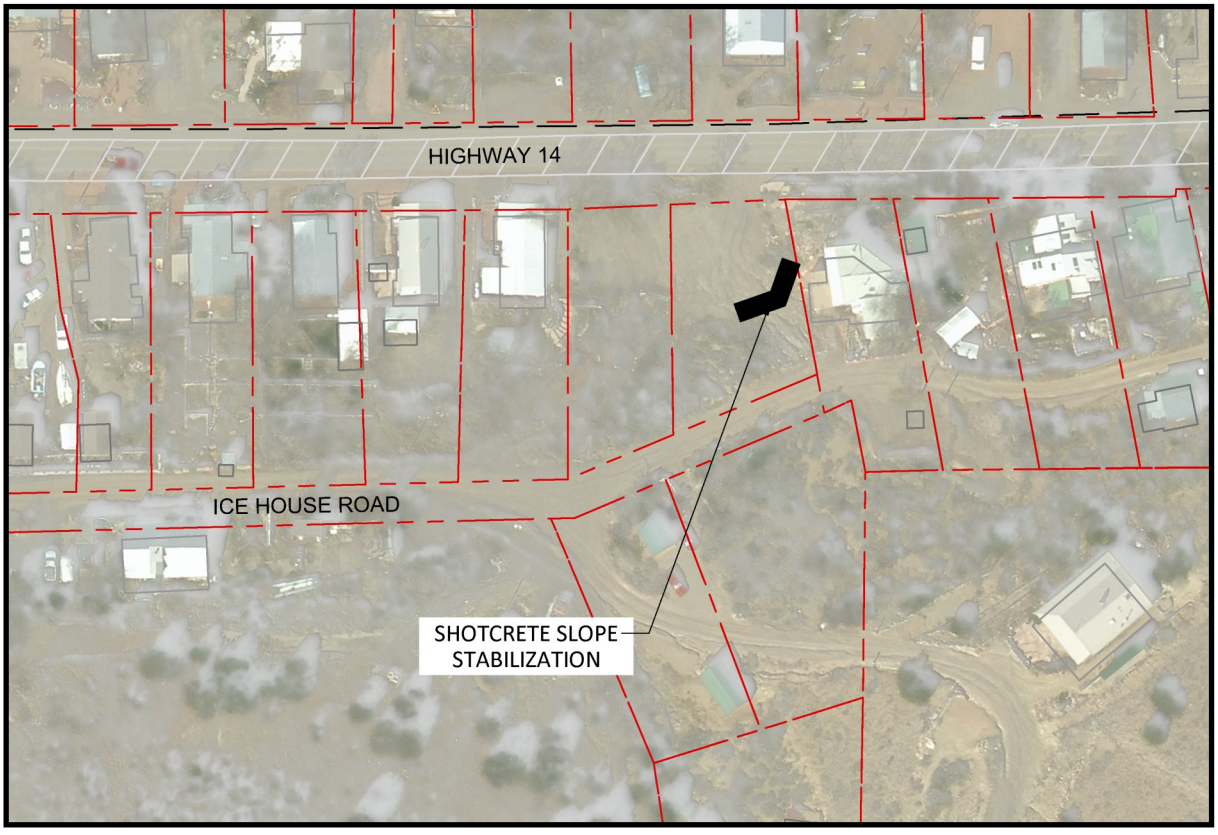
- Slope stabilization methods reinforce slopes helping maintain the natural slope or man-made from erosion by providing armoring. Shotcrete slopes are reinforced with either rebar, wire mesh, or fiber depending on soil conditions and the steepness of the slope.
- Shotcrete is applied via spraying. Therefore, the material is compacted against the surface to fill cracks and fissures and prevent loose material from falling. Shotcrete can act both as a protective coating over the slope's surface. It can also act as an 'anchoring surface' onto which bolts and other support systems can be fastened.
- A combination of anchors or soil nails are usually used in combination with shotcrete to increase the stability and strength of the slope stabilization.
- The way shotcrete is applied allows it to be applied to uneven surfaces. This means less work needs to be performed to prepare the slope for the application of shotcrete. Thereby reducing cost.

SHOTCRETE SLOPE STABILIZATION

Case Study: Shotcrete Wall, Santa Fe River Trail and River Restoration

Several reaches of the Santa Fe River trail and channel required innovative approaches to slope stabilization to maintain the architectural aesthetic of the trail while effectively preventing bank erosion and slope failure. A section of the river had a number of locations where a property owner had build a structure along the bank with cars lodged into the bank of the river. It was determined that the cars could not be removed without damaing the structure. In order to protect the slope, it was decided that a slope stabilization method using dyed shotcrete and earth anchors would be implemented.

Potential Locations for Implementation



RETAINING WALL STRUCTURES

Retaining walls are common engineered structures used to stabilize earth embankments for a number of purposes including preserving the amount of useable space. Retaining walls are constructed of reinforced concrete, modular concrete masonry units and rock-filled gabion baskets to suit the aesthetics of an area.

Management Objectives

- Prevent slope failure.
- Protect property.
- Increase the amount of useable land.

Benefits and Effectiveness

- Prevents down slope movement of earth and supports vertical or near vertical grade changes.
- Constructed from materials to match the structural design requirements and project aesthetics. Materials include stone, reinforced concrete, wood and earth reinforced with geotextile materials.
- Rock or rock-filled gabions can be used to allow for runoff to drain through the wall.
- Visual effects include terracing to allow for greenspaces.
- Prevents erosion in areas with few trees and shrubs to hold soil in place.

RETAINING WALL STRUCTURES

Case Study:
Modular Block Wall,
Santa River Trail and River Restoration

Several reaches of the Santa Fe River trail and channel required innovative approaches to slope stabilization to maintain the architectural aesthetic of the trail while effectively preventing bank erosion and slope failure. The modular block product selected was chosen based on the maximum allowable un-reinforced height.

Potential Locations for Implementation