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Brook Mine
Permit Application
Volume XI

/OLUME XI
Mine Plan

BROOK MINING CO., LLC.
BROOK MINE
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Brook Mine
Permit Application
Volume XI

Mine Plan

DEQ Exhibit 12

RAMACO

VOLUME TOC

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VOLUME TOC

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MINE PLAN TEXT

MINE PLAN

Prepared by:
WWC Engineering

October 2015

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RECD OCT 23, 2015

MP.1 GENERAL DESCRIPTION OF MINING OPERATIONS

RAMACO, LLC (RAMACO) intends to mine coal at the proposed Brook Mine within Sheridan County, Wyoming approximately 8.5 miles north of the City of Sheridan, Wyoming. The proposed Brook Mine is located within the Sheridan Coal Field of the Powder River Basin. A general location view of the Brook Mine is shown on Figure MP.1-1.

MP.1.1 Type of Mine

The proposed Brook Mine will be a combination of highwall and surface mining operations to extract sub-bituminous coals. Sub-bituminous coals are intermediate in rank between lignite and bituminous coals. The sub-bituminous coals of the property have typically low sulfur and high moisture content. The coal seams on RAMACO's property are characterized as single-bench coal horizons with little in-seam parting material, or non-coal material within the seam. Coal seam thicknesses vary from 1 foot to 20 feet. Major coal seams on the Brook Mine include: Monarch, Upper Carney, Lower Carney, Carney, and Masters. The seams are primarily in the Fort Union Formation, Tongue River Member. Below the Tongue River Member is the Lebo Shale Member of the Fort Union Formation which contains the Wall Seam (Cardno MM&A, October 2013).

The basic steps and sequence of activities for highwall operations of the Brook Mine operation are:

- Removal of topsoil materials;
- Removal of overburden material for trench mine;
- Mining of coal in trench mine;
- Mining of coal in highwall mine;
- Replacement and contouring of spoil material;
- Replacement of topsoil material;
- Revegetation of the reclaimed surface.

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The basic steps and sequence of activities for surface operations of the Brook Mine operation are:

- Removal of topsoil material;
- Removal of overburden in surface area mines;
- Mining of coal in surface area mines;
- Replacement and contouring of spoil material;
- Replacement of topsoil material;
- Revegetation of the reclaimed surface.

MP.1.2 Method of Mining

The mine will use two techniques to mine coal; highwall mining and surface mining. The highwall mining method using the continuous miner system (or equivalent) will be the primary method for mining coal. To prepare for highwall mining, the mine will initially construct a trench to allow for the continuous miner system.

MP.1.2.1 Highwall Mining

To prepare for highwall mining, the mine will first construct a trench mine to create working areas for highwall mining equipment. Excavated trenches are also referred to as slots. The coal will be removed from the trench area. Trenches are generally located in areas of low strip ratios, or those locations where coal seams are closer to the existing surface. Trenches will be as straight as possible to minimize highwall continuous miner alignment changes. The minimum trench floor width will be 150 feet. This width is governed by the Mine Safety and Health Administration (MSHA). This pit floor width will also provide sufficient room during highwall mining to maneuver the highwall mining launch vehicle, store associated cars, and load stockpiled coal. Large equipment should be able to pass between the launch vehicle and the trench wall. The highwalls will have a 65-degree bench slope to provide a stable trench environment. Where the trench intersects the burnt Monarch

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coal seam, a minimum 35-foot wide safety bench will be added. Benches will be constructed with a width appropriate to soil type and conditions, and will comply with all MHSA design and safety standards. When the Carney and Masters coal seams come close to convergence, a near vertical wall 1H:8V will be used to maintain the desired pit width. A schematic of a generalized trench cross section is shown on Figure MP.1-2.

The trench mining operations will attempt to maintain a consistent distance in front of the highwall mining activities. Trench construction activities will primarily be in a separate part of the trench away from the highwall mining activities. As overburden is removed, it will be hauled to a location in the trench behind the continuous miner and placed as spoil. The initial trench material may need to be stockpiled and stockpiling will be necessary when there is insufficient backfill room. After the highwall miner has completed mining, the surface mining equipment will switch places with the highwall mining equipment within the same trench. The highwall mining equipment will mine in the newly excavated trench, and the surface mining equipment will replace spoil where the highwall mining equipment has completed mining activities.

To minimize stockpiling, spoil may be hauled from the initial excavation in one trench to the final highwall area of another pit. Ramps will generally be constructed of spoil material end-dumped at a 6-percent to 8-percent grade to the trench surface depending on haul equipment used. A dozer will assist spoil dumping activities. End-dumping will connect with previous backfilling efforts and a dozer will complete leveling of the backfilling.

A continuous miner, or a machine that mines remotely from the operator, will be used to mine the coal roughly perpendicular to the trench. The coal is transported from the continuous miner back to the open surface by a conveyance system that is incrementally increased in length as the continuous miner advances further into the coal seam. The conveyance cars transport the coal to a stacking conveyor in the trench. The continuous miner advances the

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tunnel to the maximum length allowed by equipment design and geologic conditions, usually up to penetration depths of approximately 1,500 to 2,000 feet. Cutting heights for the tunnel vary with the coal seam and the cutter head chosen but typically range from 30" to 28'. The tunnel width will also vary based on the cutter head chosen but is typically 11.5'. After the continuous miner reaches the desired penetration depth, it is then retracted from the tunnel to mine another parallel to the previous. Protective coal pillars are left between the tunnels to support the weight of the overburden typically 5-8 ft thick with protective barrier pillars 6-12 ft thick which protect against collapse. When possible, continuous miner panels will be driven on both sides of the trench. Continuous miner tunnel's will usually be completed without delay once started. No workers are exposed to any underground workings at any time. Figure MP.1-3 shows a generalized schematic of the highwall mining operation. The coal will be transported from the stockpiles created by the continuous miner using loaders and trucks.

MP.1.2.2 Surface Mining

The Brook Mine contains reserves of relatively low strip ratios (maximum of 5 to 1) where surface mining will be conducted. The method used for surface mining is a dozer push. Figure MP.1-4 is a generalized schematic showing the manner in which overburden will be moved to expose coal during the surface area mining operations. The coal will be removed using loaders and trucks. Additionally surface mining will be conducted to expose the highwall for mining by the continuous miner. Brook will utilize one of three methods, contour mining, trench mining, or open cast mining. Figure MP.1-5 depicts these methods. Contour mining consists of exposing a highwall while following a coal seam along the side of the hill. Trench mining is used to mine ore coal from both sides of the trench and is used when an open pit is not an option. Open cast is used to mine coal from underneath the final highwall, which is typical of open pit operations that have reached their stripping limit.

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MP.1.3 Acreage to Be Affected Annually

Surface disturbance acreage at the Brook Mine will result from trench mining activities, surface area mining activities, and construction of facilities. Highwall mining will not cause surface disturbance other than the associated disturbance caused by trench mining. Table MP.1-1 lists the projected disturbance. Exhibit MP.1-1 provides a visual representation of the surface acreage to be disturbed. Exhibit MP.1-1 also shows the disturbance limit boundary and the affected area boundary within the Brook Mine Permit Area.

The disturbance boundary includes all lands that will be physically and directly disturbed during mining. The affected area boundary includes all lands within the disturbance boundary plus additional lands that have the potential to be disturbed by mining. The majority of these lands include those lands which are above continuous miner activities with the potential for subsidence which is addressed in Section MP.13.

MP.1.4 Overburden Handling

Initial overburden box cut material will be stockpiled for use as fill in adjacent void areas. Overburden will be hauled to the point of previous excavation adjacent to the ongoing highwall mining activity. The overburden will be loaded into trucks using rubber-tired front-end loaders. The trucks will convey the overburden to the back fill or stockpiles. End-dumping will connect with previous backfilling efforts. A bulldozer will complete leveling of the backfill material. As new trenches are developed, overburden will be hauled to preceding trenches behind the continuing highwall mining activity. Some stockpiling of overburden outside of the trenches will be required until highwall mining has been completed and the trench has been completely abandoned by highwall mining operations. By the end of mining activities, all spoil material will be backfilled into trenches or other surface mining excavation areas.

MP.1.5 Mineral Handling

Coal from both highwall and surface mining production will be crushed by portable, in-pit crushers. Coal will either be temporarily stored in the pit or

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directly hauled off site. The coal will be loaded into trucks using rubber-tired front-end loaders.

MP.1.6 Permit Term

Mining will occur over a 12-year period beginning in 2016 (corresponds to Year 0 in all Exhibits, Figures, Tables, and text), and completing in 2027. From 2028 through 2031, only reclamation activities will occur. The permit will be renewed on a five year cycle based on the approval date of the permit.

MP.1.7 Annual Production

Estimated annual production (in tons) is shown in Table MP.1-2. The total estimated production over the life of the mine is also presented in Table MP.1-2.

MP.1.8 Mine Equipment

Similar equipment will be used for the construction of the trench and the surface mining. Table MP.1-3 lists the anticipated mining equipment used to construct the trench and surface mining. Table MP.1-4 lists the equipment anticipated for the highwall mining operation. Equipment manufacturers and types are shown for size or capacity reference only. Some of the equipment listed on table MP.1-3 will also be used for the highwall mining operation such as the bus and pickup trucks.

MP.1.9 Relationship and Impact of Operations on Existing Structures and Adjacent Mining Operations

The Brook Mine will only have marginal impact on existing man-made structures. Oil and gas wells, rights-of-way, roads, and surface ownership are listed in the Adjudication File. Refer to the Adjudication File for these locations.

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Any structure within the Brook Mine Permit Area that is directly affected by mining activities will be properly abandoned and removed or relocated before mining activities commence. Relocation and/or abandonment criteria and procedures will be established to minimize significant impacts to the postmining land use plan.

If mining operations disrupt power or phone lines, the lines will be relocated and put into service before the old lines are abandoned. This will be done to minimize power or phone interruptions.

Relocation of roadways will be coordinated with Sheridan County or the road owner for design and relocation procedures. Interruption to traffic flow will be mitigated through previously formulated plans.

The Brook Mine will operate in conjunction with Taylor Quarry (Permit No. SP-757). The Taylor Quarry Permit Boundary is shown on Exhibit MP.1-1. The mine will work with Taylor Quarry to minimize impacts on Taylor Quarry's operation. Details regarding dual permitted areas are provided in Section MP.22.

The Brook Mine will not obstruct Big Horn Coal's (Permit 231-T8) Shop, Bridge, and Rail Road Siding as they exist in Big Horn Coal's 2015 Annual report. An access road equivalent to the existing improved road will be provided if proposed stockpiles or pits should restrict the existing access as shown on Exhibit MP.1-1.

MP.2 MINE FACILITIES

MP.2.1 Personnel and Equipment Facilities

The approximate locations of mine facilities are shown on Exhibit MP.2-1. As facilities are designed and constructed they will be added to the exhibit.

MP.2.1.1 Administration Building

The administration building will be located in Sheridan. The administration building will contain offices, a conference room, and training facilities.

MP.2.1.2 Change House and Equipment Service Shop

The change house includes offices, shower facilities for employees, and a large meeting area and equipment service facility. Waste oil and lubricants will be temporarily stored in the equipment service facility until they can be transported to an offsite disposal facility. The equipment facility area will

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include wash bays. Wash down water will be routed to a wastewater impoundment.

MP.2.1.3 Additional Facilities

Additional facilities required for mine operation that will be located in the vicinity of the change house and shop facilities will include a truck tire shop, a lab/sample building, and a substation for power. A truck ready line will also be located near the change house. The truck ready line will be large enough to accommodate the number of rock trucks and coal trucks required to conduct operations. A parking lot near the entrance of this facility area will be used for employees and visitors to park personal vehicles.

MP.2.1.4 Fuel Station

The fuel station will store both diesel fuel and gasoline in aboveground tanks. Should the aboveground tanks store more than 1,320 gallons of petroleum products, the Spill Prevention, Control, and Countermeasure (SPCC) plan will be available onsite at the Brook Mine for review and inspection by the Environmental Protection Agency (EPA) according to 40 CFR Part 112.

MP.2.1.5 Cistern

A cistern will be installed near the change house and equipment service facilities for storage of potable water.

MP.2.1.6 Septic Tank and Leach Field

Sewage wastewater will be handled by means of a septic tank and leach field. Leach field(s) will handle sewage wastewater from the change house and equipment service shop. The sewage wastewater will flow by gravity to the leach field(s). Holding tanks for sewage wastewater from any area away from the septic tank will be emptied and treated by approved waste disposal contractors. The septic tank and leach field will be designed and constructed in accordance with applicable WDEQ/Water Quality Division (WDEQ/WQD) rules and regulations.

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MP.2.2 Coal Handling Facilities

Portable, in-pit crushers will be used at the Brook Mine. Therefore, crusher facilities will not be constructed. The crushed coal will be loaded in the pit and hauled using coal trucks. A certified scale will measure coal tonnage.

MP.2.3 Explosive Storage

Prior to the receipt of explosives material and storage, the mine will be required to obtain a permit from the Department of Alcohol, Tobacco and Firearms. The permit will require a pre-inspection of the explosive magazines construction and location specifications to meet the distance requirements for storage of explosives in 27 CFR 555.

The explosives materials will be stored in two secure, and fire proof buildings, constructed on concrete pads to meet the Type 1 magazine specifications in 27 CFR Part 555. The locations of the explosive material storage will be according to appropriate regulations. One magazine will contain boosters and the other magazine located at least 60 feet away will contain detonating cord, detonators, and other initiation products.

The explosive magazines will be located in accordance with 27 CFR 555.218, Table of Distances for Storage of Explosive Materials. This will ensure that the magazines will be located a safe distance from all inhabited buildings, public roads, and other explosive storage facilities. The buildings will be constructed with noncombustible and reasonably bullet-resistant material with screened ventilation openings near the floor and ceiling. The buildings will be locked and posted with danger signs showing the building is an explosive storage area in such a way that a bullet passing through the face of the sign will not hit the magazine. These magazines will be used exclusively for the storage of detonators and related materials, such as safety fuse and detonating cord. Bulk storage of ammonium nitrate-fuel oil (ANFO) components will be separated from the magazine area as required under 30 CFR 77.1301. Any

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emulsions, water gels, and slurry explosives will be stored separately from detonators, initiator products, and ANFO. Locations of explosive storage will be according to regulations.

MP.2.4 Power Transmission and Communication Lines

Electrical power will be transmitted to the mine property by a 3-phase 4160-Volt line.

Electric power will be purchased from Powder River Energy Corporation. Power distribution and electrical equipment will be constructed to comply with applicable federal, state, and local codes. Power lines within the Brook Mine Permit Area will be constructed to minimize impacts on raptors, as discussed in the Plan to Minimize Adverse Impacts on Fish and Wildlife.

Telephone service will be installed by tapping into a local communications carrier. Communications within the Permit Area will be by mobile business band radios.

MP.2.5 Stockpiles

Separate topsoil and overburden stockpiles will be required for reclamation activities. The design of stockpiles is discussed in Section MP.4. Stockpile locations are shown on Exhibit MP.4-3.

MP.2.6 Access Control Features

The mine will control access to the Brook Mine to protect the health and safety of the mine workforce, general public, wildlife, and livestock. A guardhouse will be installed at the entrance to the Brook Mine. Fencing will be constructed around mining activities to prevent wildlife, livestock, and the general public from mistakenly entering as shown on Exhibit MP.1-1. Access will be allowed for existing cattle operations as needed in the NWNE of section 21 T57N R84W and SE of section 8 T57N R84W as shown on Exhibit MP.1-1. Fencing construction will follow recommendations found in WDEQ/LQD Guideline Number 10 and/or WYDOT standard 607-1A: Fencing, Signs and markers will be placed to alert the general public to the active mining area. Signs, markers, and buffer zones are discussed in Section MP.12. Locations of access control features are shown on Exhibit MP.2-1.

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MP.2.7 Hydrologic Control Structures

Sedimentation, wastewater, and flood control reservoirs, diversion ditches, and mine pit dewatering are discussed in Section MP.5.

MP.2.8 Solid Waste Disposal

Refuse disposal is discussed in Section MP.10.

MP.3 ROADS, RAILROADS AND OTHER TRANSPORT SYSTEMS

MP.3.1 Roads

Roads are defined in WDEQ/LQD Rules and Regulations (R&R) Chapter 1, Section 2(ds) (12/17/2012). All roads will be classified in one of two general road categories according to the WDEQ/LQD road classification system in Chapter 4, Section 2(j)(i)(12/17/2012): primary roads or ancillary roads. Primary roads are any road used for transporting mineral or spoil, or frequently used for access or other purposes for a period in excess of six months, or roads to be retained for postmining use. Ancillary roads are all other roads not classified as primary roads. The road system at and adjacent to the Brook Mine will consist of public access roads, primary access roads, primary haul roads, and ancillary roads.

Roads will be designed and constructed as outlined in Chapter 4, Section 2(j) of the WDEQ/LQD R&R (12/17/2012). Approval will be obtained from the WDEQ/LQD prior to new road construction activities outside of the immediate mining area which are not detailed in this document. Primary access roads located outside of the immediate mining area will be designed and constructed in accordance with good engineering and environmental practice, and will comply with applicable state and federal regulations. All roads will be closed to vehicular traffic when no longer needed, and then reclaimed unless retention is part of the approved post mining land use.

MP.3.1.1 Public Access Roads

Public roads are defined in WDEQ/LQD R&R Chapter 1, Section 2(di) (12/17/2012). Public roads are: 1) designated public pursuant to laws of the

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jurisdiction; 2) maintained with public funds; 3) substantially used by the public (more than incidental use); and 4) subject to meeting road construction standards for other public roads of the same classification in the local jurisdiction.

Wyoming State Highway 338 provides general access to the Brook Mine entrance. Wyoming State Highway 339 connects 338 to Interstate 90 (I-90) near the entrance to the mine. The permit area is adjacent to I-90. Wyoming State Highway 345 runs parallel to I-90 until it intersects U.S. Highway 14, and provides additional access to the permit area. County roads that provide access to the permit area include Slater Creek Road, Ash Creek Road, Monarch Road, Acme Road, and Kleenburn Road. Public roads in the vicinity are described in detail in Appendix D1 "Land Use." Public roads that provide access to the Brook Mine are shown on Exhibit MP.3-1.

MP.3.1.2 Primary Access Roads

Access roads by WDEQ/LQD definition are primary roads. Being primary roads, design of access roads will be certified in a report by a registered professional engineer. Access to the Brook Mine will be provided by existing roadways. Locations of the access roads are shown on Exhibit MP.3-1.

Access roads will be surfaced with adequate material considering volume of traffic, and weight and speed of vehicles using the road. Standards regarding location and drainage control for primary roads are outlined in WDEQ/LQD R&R Chapter 4, Section 2(j)(vii)(C & D) (12/17/2012).

Design and specifications of access roads joining with public roads will be coordinated with the Wyoming Highway Department.

MP.3.1.3 Primary Haul Roads

By WDEQ/LQD definition in R&R Chapter 4, Section 2(j)(i)(B) (12/17/2012), any road used for transporting mineral or spoil is a primary road. Therefore, haul roads are classified as primary roads. Design of haul roads will be certified by a registered professional engineer.

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Haul roads will be designed with consideration for traffic volumes and the weight and speed of vehicles using the road, and will be surfaced accordingly with appropriate material. Standards regarding location and drainage control for primary roads are outlined in WDEQ/LQD R&R Chapter 4, Section 2(j)(vii)(C & D) (12/17/2012).

Primary haul roads will vary in width, depending upon the vehicular traffic using the road. The width will be adjusted to provide sufficient passing room. Haul roads will be crowned with a high center and the travelled way generally sloping at a two-percent grade from the center to each respective drainage ditch. Shoulders will generally slope at a 3H:1V grade to the drainage ditch. Cut and fill slopes will be stable at no steeper than 2H:1V grades. Curves will be superelevated, and protective berms will be placed in required areas along the road surface edge. Profile grades will be no greater than eight percent. Exhibit MP.3-1 shows the locations of primary haul roads at the Brook Mine. Exhibit MP.3-2 provides the designs for the haul roads showing the plans, profiles, and typical cross sections.

MP.3.1.4 Ancillary Roads

Ancillary roads are all roads not classified as primary roads according to WDEQ/LQD R&R Chapter 4, Section 2(j)(i)(C) (12/17/2012). Roads located within the immediate mining area are exempt from mine plan design considerations and include ramps, roads associated with the coal removal and spoil areas, roads where topsoil and overburden are being moved and areas undergoing active reclamation. These roads are generally considered ancillary roads, and move frequently as mining progresses. The roads will be developed with consideration given to the type of equipment operating on the road, safety considerations, and surrounding conditions. Safety berms will be installed on all elevated road edges.

MP.3.2 Railroad

The Burlington Northern Santa Fe (BNSF) railway borders and traverses through portions of the Brook Mine Permit Area. The location of the BNSF

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railway in relation to the Brook Mine Permit Area is presented on Exhibit MP.3-1. However, there are no currently planned railways in association with the Brook Mine.

MP.3.3 Conveyor System

There are no currently planned conveyor systems at the Brook Mine.

MP.4 MINING METHODS, SCHEDULES, AND ASSESSMENTS

MP.4.1 Mining Sequence

The expected coal removal sequence is displayed on Exhibit MP.4-1. Details regarding mining activities will be presented in the annual report. Exhibit MP.15-1 shows the areas within the permit boundary that will be mined using surface mining techniques as well as the areas that will be mined using highwall mining methods.

MP.4.2 Topsoil

The composition and nature of topsoil within the Brook Mine Permit Area is detailed in the baseline soil assessment of Appendix D7.

MP.4.2.1 Salvage and Handling

All suitable topsoil will be salvaged by typical earth moving equipment. Topsoil will likely be salvaged and handled with dozers, loaders, and trucks. WDEQ/LQD Guideline Number 1: Topsoil and Overburden recommends three steps to guarantee all suitable topsoil is salvaged:

1. Sampling will be conducted ahead of topsoil stripping activities. This will be accomplished through drilling or test pits. This data will be used to conduct depth staking prior to salvage operations. Staking will be conducted on 500 foot grid centers.

2. The equipment operators will be trained in the proper soil salvage techniques such as recognizing color and texture changes that differentiate topsoil from overburden.

3. As topsoil is salvaged, qualified personnel will supervise the stripping activities to ensure that all topsoil is being salvaged and unsuitable materials are being separated.

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According to WDEQ/LQD R&R Chapter 4, Section 2(c), topsoil may be mixed with subsoil if the subsoil is determined to be a suitable plant-growth medium, but topsoil must be segregated to prevent mixture with spoil and waste material. RAMACO will follow the recommendations provided in Appendix D7 for the salvage depths of topsoil, and the separation of topsoil from subsoil if subsoil is considered unsuitable. As noted in Appendix D7, the topsoil and subsoil for Map Units A, B, C, G, H and U are recommended to be stockpiled separately as some areas of the subsoil exhibit characteristics that are close to a "marginal" rating as set by the WDEQ/LQD Guideline 1 Suitability Criteria. However, the subsoil is still considered "suitable" to the depths specified. Therefore, the subsoil may be mixed with the topsoil according to WDEQ/LQD R&R Chapter 4, Section 2(c). Separate topsoil and subsoil stockpiles will not be used. If subsoil is suitable it will be salvaged, and will be mixed with topsoil. If subsoil is not suitable, the subsoil will not be salvaged. If approved, topsoil may remain on areas of minor disturbance such as installation of signs, power poles, light traffic, fence lines, monitoring stations, or drilling. This is providing that such activities of minor disturbance do not destroy protective vegetation cover. The topsoil removal sequence is shown on Exhibit MP.4-2. The average topsoil salvage depth for the Brook Mine is based upon the total disturbance acreage and the total volume of topsoil removed. The average topsoil salvage depth is approximately 16 inches for the permit area.

Suitable topsoil and subsoil salvage will be conducted in a manner that minimizes the area of disturbance and soil handling. Digging pits to confirm the depth of topsoil before removal begins, as well as leaving small islands of topsoil to verify soil removal depth during the salvaging process will help ensure that only suitable soil is salvaged. Once the topsoil has been salvaged it shall remain in place until such time that it is needed for reclamation in order to reduce handling and disturbance.

Topsoil salvage will be scheduled in such a way that removal during winter months will be minimized. Topsoil salvage that may occur during winter

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months will only commence if the depth of the topsoil salvaged can be accurately determined to be the recommended depths of removal. Topsoil will not be salvaged in winter months if high antecedent moisture conditions have led to deep frost cementing the topsoil to the overburden. Topsoil will be salvaged ahead of planned winter mining activities to avoid complications with deep frost.

MP.4.2.2 Volumetric Analysis

Volumetric analysis for topsoil was completed using depths of topsoil provided in Appendix D7. The depth of topsoil was multiplied by the surface area to be stripped of topsoil to provide a volume of topsoil to be stockpiled. Table MP.4-1 provides a summary of the topsoil volume removed over the life of the mine, and the name of the destination stockpile. Table MP.4-2 anticipated end of year volume balance of topsoil stockpiles over the life of the mine.

MP.4.2.3 Stockpiles

The locations of topsoil stockpiles are shown on Exhibit MP.4-3. Stockpiles will be placed on stable areas and in such a way to minimize wind and water erosion and unnecessary compaction. Stockpiles will not be constructed on unsuitable backfill. Additionally, no stockpiles will be constructed on areas of known cultural or wildlife significance that require protection or mitigation measures. Any accumulation of topsoil that meets the definition of a stockpile will be mapped with volumes accounted for in the Annual Report.

Accumulations of topsoil less than six months will be considered temporary topsoil stockpiles. These stockpiles will be left in a roughened condition at the natural angle of repose to reduce wind and water erosion. Containment ditches will be constructed around the stockpile. Temporary signs saying "Topsoil" will be placed on all approaches to the topsoil stockpile at no more than 150 feet from the stockpile location. These signs must be in place before stockpiling begins and remain in place as long as the stockpile remains.

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Stockpiles left in place for greater than six months but less than one year will be considered short-term stockpiles. Stockpile slopes will be graded to 3H:1V. Signs saying "Topsoil" will be placed on all approaches to the topsoil stockpile within 150 feet of the pile. These signs must be in place before stockpiling begins and remain in place as long as the stockpile remains. The stockpile will be seeded the first available seeding season, and have containment ditches running around them as necessary to prevent undo water erosion. Short-term stockpile volumes will be included in the Annual Report for bond calculation purposes. Careful record-keeping will ensure that all topsoil is accounted for.

Topsoil stockpiles kept in place for more than one year will be considered long-term stockpiles. These stockpiles will be permitted and an identification number will be assigned. Slopes will be graded to a maximum of 3H:1V. Signs will be placed on all approaches to the topsoil stockpile within 150 feet of the stockpile saying "Topsoil and the pile identification number." These signs must be in place before stockpiling begins and remain in place as long as the stockpile remains. Containment ditches will be constructed around the stockpile to prevent undo water erosion and permanent loss of topsoil. WDEQ/LQD approved vegetation will be seeded as the first available seeding season. Topsoil stockpile design parameters for each stockpile are provided in Table MP.4-3.

MP.4.2.4 Stockpile Conservation and Erosion Control

Topsoil stockpiles will be designed and placed to minimize wind and water erosion. Topsoil stockpiles will have associated sediment control established in advance of construction. Topsoil stockpiles in place for more than six months will be seeded with WDEQ/LQD-approved seed mixtures. Containment ditches will be placed around the base of stockpiles when necessary to prevent loss of topsoil. Stockpiles will not be placed in natural or man-made drainages. Vehicles and equipment will not be allowed to drive on topsoil stockpiles. The material will not be handled when it is excessively wet.

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Topsoil will be segregated from overburden and other unsuitable materials such as trees and large rocks.

MP.4.3 Overburden

The overburden assessment is contained in Appendix D5. Refer to Appendix D5 for a detailed description of overburden material. As required by WDEQ/LQD additional overburden suitability samples and analysis will be conducted prior to mining related disturbance. Sampling frequency will consist of at least one sample at both ends of a trench and at least one sample every 1,500 feet of trench length.

MP.4.3.1 Overburden Removal Methods

Overburden removal begins after topsoil has been stripped and stockpiled. Overburden will be removed through the process of drilling, blasting, loading, and hauling. Standard drilling and blasting methods will be used. The drilling and blasting process is described in detail in Section MP.14. Due to frequent moving requirements, front-end loaders will be used to load the blasted overburden material into haul trucks. The trenches are located in relatively low strip ratios to minimize the amount of overburden requiring movement to expose the coal seam to allow for highwall mining. Overburden will generally be hauled along the trench floor from the excavation area to the location of the last highwall mining activities. When the volume of excavated overburden exceeds that which can be backfilled behind the highwall mining activities, overburden will be stockpiled. Overburden materials will not be placed or allowed on to native topsoil during overburden removal operations.

MP.4.3.2 Overburden Removal Sequence

The overburden removal sequence is shown on Exhibit MP.4-4. This exhibit shows overburden removed for trenches and surface mine areas.

MP.4.3.3 Compaction and Stabilization

Overburden will be compacted through heavy equipment traffic. Operating history in the Powder River Basin area has indicated that stability is achieved in the spoil through heavy equipment traffic without any special compaction efforts.

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MP.4.3.4 Volumetric Analysis

Table MP.4-4 presents the overburden mass balance for the life of mine while Table MP.4-5 presents the overburden stockpile summary. The overburden thickness is shown on Exhibit D5-4, Exhibit 1. The surface mining has an average strip ratio of 2.0:1 bank cubic yards of overburden per ton of coal removed (bcy/t). The average strip ratio is 10.5:1 bcy/t for the trench cuts. No strip ratio is calculated for highwall mining.

A swell factor of 16 percent was assumed for the Brook Mine and is taken from the Standard Handbook of Civil Engineers. Table MP.4-9 lists typical swell and load factors of materials. Using this swell factor, postmining contours were developed. Subsequent calculations using the postmining pit volume and available backfill material were run to adjust and verify the postmining contours. The mine will monitor the backfilling operation to compare bank volumes with backfilled volumes, and also to determine the amount of settling as a function of time. The mine will also establish a system of bench marks, or other suitable reference points, on the reclaimed surfaces in order to determine if uneven settling is occurring. Within 12 months after an area of at least 120 acres in surface area has been rough graded to final design, the mine will evaluate the swell for the backfill. If the swell significantly differs from the anticipated swell factors, the postmining topography will be revised. Revising the postmining topography will not require a permit revision to the Reclamation Plan unless the revised postmine topography differs from the approved topography by 20 feet or greater. Data collected from the monitoring programs will be submitted to WDEQ/LQD in the Annual Report.

MP.4.3.5 Stockpiles

Standard procedures for overburden handling are outlined in WDEQ/LQD R&R Chapter 4, Section (2)(c)(xi). Overburden stockpiles will be segregated from all topsoil and subsoil materials. Overburden stockpiles will be placed to facilitate reclamation activities. Overburden stockpiles will avoid obstructing ephemeral, intermittent, and perennial drainages to minimize loss

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by water erosion. Overburden stockpiles will only block ephemeral drainages if runoff control and sediment control measures are made and approved by WDEQ/LQD. Any overburden materials determined to be unsuitable, as discussed in Section MP.4.6, will be stored in separate stockpiles from suitable materials. Overburden determined to be suitable as a topsoil substitute will be segregated from topsoil and overburden piles and shall be identified as substitute material by signs no more than 150 feet from the stockpiles of substitute material. Material from temporary stockpiles will be placed as soon as possible in accordance with the Reclamation Plan.

Temporary overburden stockpiles will be in place less than a year. Stockpiles will not be placed on slopes that exceed 20 degrees; or with proof that the factor of safety of the stockpile stability will be greater than 1.5, and approved by WDEQ/LQD. The side slope of temporary stockpiles will be the natural angle of repose.

Overburden stockpiles in place longer than a year will have additional measures made to ensure stability such as benching. The locations of proposed longer term stockpiles are shown on Exhibit MP.4-3. The locations will be on moderately sloping and naturally stable areas. The side slopes will be the natural angle of repose.

MP.4.4 Coal

Coal targeted by the Brook Mine operation primarily exists in the Fort Union Formation, Tongue River Member. The Carney Seam is the base of the Tongue River Member. Below the Tongue River Member is the Fort Union Formation, Lebo Shale Member. The coal of the property is sub-bituminous in rank. The coal has typically low sulfur and high moisture content. The coal seams are characterized as single-bench coal horizons with little in-seam parting material. Coal seam thicknesses vary from 1 foot to 20 feet. Geology is discussed in detail in Appendix D5. Figure MP.4-1 is a generalized schematic of the stratigraphic section.

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MP.4.4.1 Reserves

At the Brook Mine, reserves can be split into several categories. Table MP.4-6 breaks the coal reserves down by seam. The coal seams targeted at the Brook Mine are: Monarch, Upper Carney, Lower Carney, Carney, and Masters.

MP.4.4.2 Removal and Recovery

Exhibit MP.4-1 displays the coal removal sequence for the life of the mine. Coal will be removed from the trenches excavated to prepare for the highwall mining; from the highwall mining tunnels; and from surface mining. Any seams greater than 4 feet in thickness encountered during either trench mining activities or surface mining activities will likely require drilling and blasting to induce breakage of the coal prior to removal. The coal will be crushed using portable in-pit crushers, and screened to ensure consistency. It will be loaded using a front-end loader with a coal bucket. The front-end loader will load the coal into trucks. The trucks will haul the coal offsite. Any coal not immediately hauled from the site will be temporarily stored in the pit. It is assumed the mineable recovery efficiency for surface area mining and trench mining will be ninety percent. The process flow diagram for surface mining is shown on Figure MP.4-2.

In the highwall mining operation, coal will be recovered by a remote-controlled continuous miner and conveyor system. A variety of cutting heads can be used with the continuous miner depending upon the thickness of the coal seam. The recovery efficiency for the highwall mining operation is assumed to be forty to sixty-five percent. Recovery efficiency for highwall mining is dependent upon seam thickness and reserve area. Recovery efficiency for highwall mining is reduced from surface mining because protective web pillars of coal are left in place between each tunnel to support the overburden. The process flow diagram for highwall mining is shown on Figure MP.4-3.

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MP.4.5 Other Minerals

Scoria is the only other mineral anticipated to be recovered at the Brook Mine. Scoria is created when a coal seam burns underground and the heat from the burning coal bakes the minerals and rocks above the coal. The baking results in an erosion-resistant, natural brick-like material. A majority of the Monarch seam is burnt, which led to the formation of scoria. Scoria will be used as a base or sub-base material for roads. Scoria will be obtained from Taylor Quarry (Permit No. SP-757). The Taylor Quarry Permit Boundary is located within the proposed Brook Mine Permit Boundary see Section 22 for the discussion of the dual permitted use.

MP.4.6 Unsuitable Overburden Materials

Sampling procedures will be performed at the Brook Mine to ensure that overburden materials that exhibit toxic-forming or acid potential characteristics will be separated from plant growth media. Such overburden materials are considered unsuitable for revegetation purposes. WDEQ/LQD specifies specific constituent concentrations in soils that deem the soils unsuitable. The following subsections discuss the manner in which unsuitable overburden materials will be identified and isolated from plant growth media, ephemeral drainages, permanent impoundments, and 100-year flood plains.

MP.4.6.1 Overburden Sampling Program

Overburden quality sampling was conducted at the Brook Mine during baseline investigations. These baseline studies were discussed in Appendix D5. Any additional overburden quality sampling will be submitted to WDEQ/LQD in the mine's annual reports. Table MP.4-7 lists constituents and the concentrations, levels, or properties of these constituents that make overburden materials unsuitable for revegetation purposes.

During mining operations, an overburden sampling program will be used to identify the presence of unsuitable material. The sampling program will include one drill hole sample taken every 40 acres (16 sample locations per

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square mile) within areas where surface operations will cause removal of overburden down to the level of the coal seam to determine if mining operations will encounter unsuitable materials when overburden are excavated. If an area of unsuitable material is encountered during this sampling program, then additional holes will be drilled to delineate the zone of unsuitable material.

Samples will be taken and analyzed for each 40-acre sampling unit (WDEQ/LQD, 1994). Samples will be obtained by using a drill rig to sample the overburden directly in front of the advancing face of the mine area. Samples may also be obtained from developmental drilling. For cored drill holes, a sample will be obtained to represent each 10 feet of overburden depth. Drill holes where chip samples are collected, a composite sample for each 5 feet of overburden will be collected.

Each sample will be analyzed for the constituents listed in Table MP.4-7. WDEQ/LQD Guideline Number 1 lists the recommended procedures for analyzing soils and overburden. Should any strata be considered unsuitable based upon the criteria, overburden stripping and backfilling operations will then be scheduled so that the identified unsuitable strata are not placed in the uppermost four feet (rooting zone) of the final backfill thickness; not within six feet of the spoil surface beneath ephemeral channels; and not within 10 feet of the spoil surface beneath permanent impoundments or major channels and their 100-year floodplains.

Baseline data will be used as a general guide to locations and suspect strata for the overburden sampling program. The primary purpose of overburden sampling is to further delineate suspect strata and supplement baseline data. Based on the baseline investigations presented in Appendix D5, it is anticipated that no unsuitable overburden will be encountered. If unsuitable overburden materials are encountered, they will be immediately placed outside of the aforementioned zones during ongoing reclamation activities or stockpiled for future placement to ensure that the materials won't be placed within the aforementioned root zones, drainages, and floodplains.

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MP.4.6.2 Backfill Sampling Program

The quality of the replaced backfill will be monitored prior to the replacement of topsoil to ensure that unsuitable materials have been successfully excluded from the surface four feet of backfilled overburden for uplands, six feet for ephemeral channels, and 10 feet for permanent impoundments or major channels and their 100-year floodplains. Sampling will include the collection of two composite samples taken over a depth of four feet (0-2 foot and 2-4 foot intervals), with the sampling grid set on 500-foot centers. The total depth of suitable material in stream channels and impoundments will be sampled by 2-foot increments in the first four feet, and 3-foot increments for any sample depths greater than four feet. The samples will be analyzed for the constituents mentioned in the previous section, and according to the methods listed in WDEQ/LQD Guideline Number 1.

If any spoil located in the surface four feet of the backfilled spoil, or within the other critical depths described previously, is found to exceed the suitability limitations in Table MP.4-7, an enhanced sampling program will be implemented to determine the extent of unsuitable material. The enhanced sampling program will collect additional samples using a 100-foot grid radiating away from the hole where unsuitable materials were found until the extent of the unsuitable materials can be determined. A mitigation program will be implemented to treat the unsuitable material in-place, cover the material with sufficient suitable material to bring the depth into compliance, or remove the unsuitable material and replace it with a comparable amount of suitable backfill material. Following mitigation, the sampling and analysis will be repeated to assure the mitigation was successful.

The results of the overburden sampling and backfill sampling programs will be included in the annual report to WDEQ/LQD. Details reported will include the following:

1. The location of the overburden and backfill sampling sites,
2. The lithology of the overburden at the sampling site, and
3. The results of all chemical and physical analyses run on the samples.

MP.4.7 Spoil Backfilling

Spoil backfilling will occur progressively during mining to reduce the time required for final reclamation, and to return the land to more natural

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topography in an expedient manner. The spoil backfilling sequence is shown on Exhibit MP.4-5. Spoil will be backfilled primarily within the trench from which it was originally removed and/or in areas in which the spoil has similar characteristics to the surrounding material.

Using WDEQ/LQD's recommended calculation in the Coal Standard Operating Procedure (SOP) 3.1 (March 1998), the Brook Mine is considered an Approximate Original Contour (AOC) mine. The Brook Mine's volume replacement ratio has been calculated at 1.03. The calculations to determine this ratio are shown in Table MP.4-8.

Postmining topography (PMT) is discussed in the Reclamation Plan, and is illustrated on Exhibit RP.3-1. The PMT was developed to conform to the postmining land use plan, to facilitate natural drainage, to be erosionally stable, to be physically stable, and to blend with the natural topography.

MP.5 MINING HYDROLOGY

Premining hydrology is described in detail in Appendix D6. The following subsections describe hydrology during mining activities at the Brook Mine.

MP.5.1 Surface Drainage and Erosion Control Plan

Surface drainage plans have been prepared so that runoff from disturbed lands passes through sedimentation controls before being discharged in the Tongue River, Goose Creek, or undisturbed portions of Slater Creek, Hidden Water Creek, and East Fork Early Creek. Runoff from disturbed lands will be treated by sediment control measures before leaving the permit area. Reservoir sizes will be minimized by, where practical, conveying undisturbed runoff away from disturbed areas. Exhibit MP.5-1 shows the hydrologic control plan. Erosion from small areas will be controlled using alternative sediment control measures (ASCMs) as discussed in Addendum MP-1. In addition to ASCMs, mine trenches will also serve as sediment control. The locations of ASCMs and the appropriate type used according to conditions, as well mine trench locations are shown on Exhibit MP.5-1. As per Guideline Number 15, ASCMs will not be used as the primary form of sediment control for drainage

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from facilities areas, coal stockpiles, mine pits, and other forms of process water within one half of a mile of channel distance from Class 1 or Class 2 streams, which include the Tongue River and Goose Creek. Exhibit MP.5-1 shows the half-mile buffer from the Tongue River and Goose Creek in which ASCMs will not be used as the primary sediment control.

As stated in Addendum MP-1, ASCMs with drainage areas of greater than 30 acres will require additional design information submitted to WDEQ/LQD, as specified by Guideline Number 15. Any ASCMs with drainage areas greater than 30 acres are shown with the associated drainage areas on Exhibit MP.5-1. If any ASCMs have drainage areas of greater than 30 acres, the designs are provided in Addendum MP-2. According to Guideline Number 15, any ASCMs that drain to large receiving streams with a drainage area of greater than 1.0 square mile, additional monitoring will be required to include one, or both, of the following:

a. Repeat surveys of representative permanently benchmarked stream channel cross sections located within the disturbed reach of the channel and continuing into the receiving stream channel.

b. Upstream and downstream sediment yield monitoring stations.

For ASCMs that drain to large receiving streams such as Slater Creek, the Tongue River, or Goose Creek (providing the ASCMs are further than a half-mile from the Tongue River or Goose Creek), RAMACO commits to monitoring the stream channel cross sections or having upstream and downstream sediment yield monitoring stations to ensure the ASCMs are functioning properly.

MP.5.2 Sedimentation and Wastewater Impoundments

Sediment and wastewater impounds at the Brook Mine will be designed as described in the following subsections that describe the typical design criteria and construction standards for sediment and wastewater impoundments. The designs for sedimentation and typical wastewater reservoirs required for mining operations within five years of ensuing operations are provided in Addendum MP-2. The locations of sedimentation impoundments in relation to the permit area are shown on the hydrologic control plan in Exhibit MP.5-1. The location for the wastewater impoundment is not shown on Exhibit MP.5-1 and has not been determined yet, but the typical design is shown in Exhibit 12 in Addendum MP-2.

MP.5.2.1 General Design Criteria

The designs of sedimentation and wastewater reservoirs are based on the following criteria:

- WDEQ/LQD regulations, WDEQ/WQD regulations, Office of Surface Mining (OSM) regulations, and Wyoming State Engineer's Office (SEO) regulations.

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- Provide the required storage volume to contain the runoff volume from the 10-year, 24-hour precipitation event and three years of sediment accumulation. If the reservoir is associated with a discharge permit (the storage volume is not categorically required to contain the 10-year, 24-hour event), any storm smaller than the 10-year, 24-hour event resulting in discharge must attain either the Total Suspended Solids effluent limits or the Total Settleable Solids effluent limits (WDEQ/LQD 2003).
- Provide an emergency spillway that is capable of safely passing the peak discharge from a 25-year, 6-hour precipitation event (WDEQ/LQD, 2003).
- Maintain a minimum of 1.5 feet of freeboard.
- Trap the sediment as near the source as possible.
- Bypass surface runoff from undisturbed areas to avoid contamination from disturbed areas where practical.
- Minimize the number of reservoirs which receive mine pit water.
- Segregate sewage from industrial pit water.
- Demonstrate that wastewater ponds cause no impact to groundwater and/or line wastewater ponds and institute a monitoring regime to reduce the impact to groundwater (WDEQ/LQD, 2003).

Runoff hydrographs for reservoir design are generated using rainfall runoff models based on Soil Conservation Service (SCS) triangular hydrograph methods. Precipitation duration-frequency information used is shown in Table D6.1-4. Versions of the Universal Soil Loss Equation (USLE), and an appropriate sediment delivery ratio, are used to determine sediment accumulation. Reservoirs are designed to settle out sediment by gravity separation. Stored water may be used for dust suppression.

MP.5.2.2 General Construction Standards

Topsoil will be removed from the sediment storage level and dam foot print and stored in topsoil stockpiles prior to construction of reservoirs. Suitable fill material for embankments will generally be obtained by excavating within the reservoir basin and/or facilities area. Fill will be free of all vegetative matter, trash, and frozen soil. Suitable material for earth-fill embankments consists of the following:

- materials of relatively low compressibility and low permeability,
- no rocks larger than 6 inches within 5 feet of the interior slope surface of the embankment,
- rocks larger than 6 inches, but smaller than 12 inches in the largest dimension, may occur in the remainder of the embankment if their overall volume is less than 25% of the total volume, and
- embankment faces and surrounding areas will be vegetated unless riprapped (WDEQ/LQD, 2003).

The embankment, its foundation, and its abutments will be designed to be stable. The fill material will be compacted at optimum moisture content until a specified soil density is achieved. Anti-seep collars or seepage control

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drains will be provided around pipe spillways to avoid piping (WDEQ/LQD, 2003).

Reservoirs will be inspected during construction by a professional engineer (P.E.) registered in the state of Wyoming. A post-construction P.E. certification must be on file at the mine site. If the P.E. determines the reservoir was constructed according to the original designs and follows prudent engineering practices, an as-built engineering drawing is not required. If the post-construction inspection determines the reservoir was not constructed according to the original P.E.-certified designs, the P.E. must determine if the difference is within prudent engineering practices. If this is the case, a simple post-construction P.E. certification statement is adequate. Should post-construction deviations exceed normal engineering practices, P.E.-certified as-built drawings will be required. The as-built drawings will then replace the original designs via the WDEQ/LQD revision process (WDEQ/LQD, 2003).

MP.5.3 Flood Control

Flood control structures have no sediment control or process water functions. They receive no waters from lands disturbed by mining activities. According to WDEQ/LQD Guideline Number 13, flood control structures are not required by LQD or WQD statutes, and therefore have no specific design standards. Flood control structures are only required to be designed with current and prudent engineering practices. Topsoil protection, road construction, and design criteria will be incorporated in the Permit to Mine. Topsoil will be salvaged below the high water line (WDEQ/LQD, 2003). The mine may request to salvage topsoil to the normal water line when water is held above the normal water level for less than 30 days.

Flood control reservoirs will be designed for appropriate precipitation events based on their expected lifespan and other risk factors. Should a flood control reservoir be used for sediment control, all regulations regarding sediment control structures will apply (see Section MP.5.2). The reservoirs will be dewatered following significant runoff events to maintain the desired flood

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capacity. The water may be used for dust control and other purposes within the mine area, or captured in pit sumps and pumped to sedimentation reservoirs for treatment and discharge. Each reservoir will have an emergency spillway capable of safely discharging the peak flow from a 25-year, 6-hour precipitation event, unless the impoundment is completely incised. The general construction standards for flood control reservoirs will follow those outlined in Section MP.5.2.2 for sediment control reservoirs. Designs for flood control reservoirs required within the five years of ensuing mining operations are provided in Addendum MP-2. The locations of flood control reservoirs in respect to the permit area are provided in Exhibit MP.5-1.

MP.5.4 Diversions

Diversions may be used to control runoff, prevent uncontaminated runoff from entering disturbed areas, and prevent the flow of natural streams from entering the trenches or pits. The reasons for using diversions include controlling water pollution; controlling unnecessary erosion; protecting the on-going operation; and protecting the water rights of downstream users. Diversions will be designed to assure public safety, prevent material damage outside of the permit area, and minimize adverse impacts to the hydrologic balance. Any permanent diversions of intermittent and perennial streams will be designed to be erosionally and geomorphically compatible with the natural drainage system. Permanent diversion designs will be certified by a P.E. All currently planned diversions within the Brook Mine permit boundary are temporary. Whenever diversions are no longer needed for the original purpose, the diversion will be removed and the disturbed land will be regraded and revegetated (WDEQ/LQD, December 2012). Diversions will be designed for a minimum flow from the 2-year, 6-hour event (see Appendix D6 for precipitation duration-frequency values specific to the Brook Mine). However, WDEQ/LQD Guideline Number 8 recommends that the design flow for diversions be chosen based on the diversion's expected lifetime. Table MP.5-1 lists the recommended event return period based on the expected life of the diversion. Diversions with a design life greater than a 20 years but not permanent, the

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mine will submit design methodology, criteria, assumptions, and calculations. The erodibility of channel materials will be evaluated. If the design life is less than 20 years, the mine will demonstrate that the design discharge will not exceed permissible velocities (WDEQ/LQD, 2005). Permissible velocities are 5.0 feet per second (fps) in non-erosive material and 3.0 fps in erosive material. Should velocities exceed the recommended velocities, diversions will be protected or armored in various ways to prevent erosion of the channel. When practical, a minimum velocity of 2.0 fps will be designed for to prevent sediment deposition in the channel. According to WDEQ/LQD R&R Chapter 4, Section 2(e)(iv), the steepest allowable sideslope is one-and-a-half horizontal to one vertical (1½H:1V) in soils or other unconsolidated material. However, diversions will normally be designed with 3H:1V sideslopes to ensure structural integrity. Diversions will typically be trapezoidal or triangular in cross-sectional shape.

As presented on Exhibit MP.5-1, diversion ditches are planned for Hidden Water Creek. As shown on this exhibit, all three diversions on Hidden Water Creek will be needed for less than 2 years. The second diversion will have an anticipated life of less than 6 months. Since these diversions are required for such short periods they are designed accordingly. Also, it should be noted that the native channel slope for Hidden Water Creek is approximately 0.01 ft/ft, there, obtaining non-erosive slopes for the diversion is almost impossible, since the native slope produces erosive velocities. Exhibit MP.5-2 provides the designs for the diversions showing the plan, profile, and typical cross section.

MP.5.5 Ditch and Culvert Design

MP.5.5.1 Collector Ditches

Collector ditches will be used to collect disturbed runoff and convey the water to other sediment control structures. Ditches constructed in non-erosive material will have a maximum design velocity of 5.0 fps. Ditches constructed in erosive material will have a maximum design velocity of 3.0 fps. When

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practical, ditches will be designed with a minimum velocity of 2.0 fps to avoid sediment deposition in the channel. The steepest allowable sideslope is 1½H:1V in soils or other unconsolidated material. However, ditches will normally be designed with 3H:1V sideslopes to ensure ditch structural integrity. The cross-sectional shape of collector ditches will be either trapezoidal or triangular.

Collector ditches will be vegetated as much as possible. Topsoil will be salvaged before constructing any collector ditch. At locations where maximum allowable velocities will be exceeded, riprap or erosion control matting will be used to line the channel.

MP.5.5.2 Bypass Ditches

Bypass ditches will be constructed, where practical, to divert runoff from undisturbed areas away from disturbed areas. The design event for each ditch will depend upon the anticipated life of the ditch, but will be no less than the 2-year, 6-hour event. Design velocities will match those for collector ditches discussed in Section MP.5.5.1. Ditch sideslopes will be no steeper than 1½H:1V according to WDEQ/LQD R&R Chapter 4, Section 2(e)(iv). Generally, bypass ditch sideslopes will be designed at 3H:1V. Bypass ditches will be either trapezoidal or triangular in shape. Bypass ditch designs will be submitted to WDEQ/LQD prior to construction.

MP.5.5.3 Culverts

Culverts are designed to conform to the terrain, and to avoid unnecessary disturbance. The design of culverts will help prevent erosion by reducing the opportunity for ponding of runoff in unnatural and undesirable areas, and to aid in natural drainage where mining activities have interrupted flow.

Culverts will be designed to pass the design flood peak flow using the head available at the entrance. The minimum design event for culverts will be the 2-year, 6-hour event. However, culverts with longer lifespans will normally

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be designed for larger events. The general method for choosing the appropriate design event will follow that outlined for diversions in Table MP.5-1. The minimum culvert diameter suggested by WDEQ/LQD is 18 inches. When appropriate, trash racks will be placed at or near the entrance of culverts to prevent clogging (WDEQ/LQD, 2005). Culvert design parameters and locations are shown on Exhibit MP.3-2.

The selection and design of culverts will be completed through numerous computer runoff programs, culvert sizing utilities, and industry-accepted design guidelines. The type of culvert will be selected based upon economics, expected lifespan, and physical conditions. If flow velocites exceed those discussed in the previous sections for ditches, additional protection measures may be required to prevent erosion, such as riprap or erosion control matting. Periodic inspection and maintenance of all culverts installed will take place in order to ensure culverts are able to function properly.

MP.5.6 Impoundment Maintenance Plan

All total-containment impoundments (i.e., those designed to contain the 10-year, 24-hour event and not to spill) will be maintained with a minimum of one year's available sediment storage capacity and enough capacity to contain the 10-year, 24-hour event's volume. These impoundments will be equipped with a 10-year, 24-hour event and sediment storage marker (staff gauge) to signify when sediment must be removed or when the impoundment should be dewatered. Sediment accumulation will be monitored on an annual basis as per WDEQ/LQD rules and regulations.

If any of the inspections detailed in Section MP.5.7 find water and/or sediment elevations which exceed the elevation of the 10-year, 24-hour event and/or sediment storage marker in total containment ponds, the following methods will be used to restore the 10-year, 24-hour event and sediment storage capacity:

- Provide adequate detention for all impoundments receiving mine pit pumpage to meet applicable effluent standards.

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- Dewater the 10-year, 24-hour volume from total containment sedimentation reservoirs as soon as possible but not prior to the time the discharge will comply with effluent standards.
- Sediment removed from impoundments servicing the mine facilities, overburden stockpiles, or disturbed areas void of topsoil will be disposed of in the highwall trenches or surface area mine pits or on overburden stockpiles. Sediment removed from impoundments servicing only topsoil stockpiles, undisturbed lands, or other topsoiled areas will be salvaged for reuse if the material is found suitable. The method used for removal of sediment from the impoundment will be the most practical method available to minimize environmental damage to surrounding areas.
- A written log documenting repairs made to impoundments will be filed at the mine site and submitted in the Annual Report.

MP.5.7 Impoundment Inspection Plan

The following section addresses impoundment certification and inspection procedures to be followed at the Brook Mine.

MP.5.7.1 Regulations

WDEQ/LQD regulations pertaining to impoundment inspections are described in R&R Chapter 4, Section 2(g) (12/17/2012).

Impoundments requiring inspection by federal regulations will meet size and other criteria of Title 30: Mineral Resources Code of Federal Regulations (CFR) 77.216(a). Inspections of impoundments will conform to 30 CFR 77.216-3.

MP.5.7.2 Facilities

Facilities covered under this program include all impoundments constructed during the entire mining operation. Also addressed under this program are associated spillways, outlet facilities, flow monitoring equipment, and associated ditches.

MP.5.7.3 Embankment Inspections

According to WDEQ/LQD R&R Chapter 4, Section 2(g)(iv), all impoundments will be inspected annually after completion of construction and

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until final bond release or removal by a qualified registered professional engineer in the state of Wyoming, or by a qualified professional specialist under the direction of a qualified professional engineer. The individual(s) responsible for inspecting the impoundments will be experienced in impoundment construction and structural integrity. In addition, all impoundments will be inspected during each of the intervening calendar quarters by a qualified individual. A qualified person is defined as one trained to recognize specific signs of structural instability and other hazardous conditions by visual observation and, if applicable, to monitor instrumentation.

Should an impoundment meet the criteria of 30 CFR 77.216-3, all impoundments will be inspected at intervals according to the MSHA-regulated impoundment for signs of structural weakness or hazardous conditions. In addition, all instruments will be monitored at intervals according to the MSHA-regulated impoundment. These inspections will be conducted by a qualified person. Conditions observed during inspections will be documented and kept on file at the mine site. If any hazardous conditions are observed at an MSHA-regulated impoundment, the conditions will be immediately reported to the MSHA District Manager.

MP.5.7.4 Reporting

An Annual Inspection Report will be completed immediately following the annual inspection and submitted to WDEQ/LQD as part of the Brook Mine Annual Report. Additionally, a copy of this report and all of the following observations during inspections will be kept on file at the Brook Mine office. Each Annual Inspection Report will be certified by a registered professional engineer, and contain the following information on each impoundment within the Brook Mine permit area:

1. Existing and required monitoring procedures and instrumentation to determine depth of water, existing storage capacity, and discharge flow rates;

2. Elevation of the average and maximum depths of the impounded water over the annual report period;

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3. Depth and elevation of any water impounded and existing storage capacity with a comparison to the designed 10-year, 24-hour event volume storage capacity for total containment reservoirs;

4. Aspects of the impoundment embankment that may affect its stability, and results of any previous stabilization methods;

5. Condition of the internal embankment slope;

6. Status of erosion control measures;

7. Conditions of inlets and outlets of the impoundment describing any hazardous conditions or maintenance items; and

8. A statement that the annual and quarterly inspections were completed in accordance with the current WDEQ/LQD R&R Chapter 4, Section 2(g)(iv).

As stated in Section MP.5.7.3, quarterly inspections will be conducted for all impoundments at the Brook Mine. The quarterly inspections will include the following information:

1. Condition of the embankment with discussion of any observed instability or hazardous conditions, if applicable;

2. Condition of internal slopes with regard to slope failure and erosion;

3. Conditions of inlets and outlets of the reservoir, and any maintenance required; and

4. Depth of water in the impoundment (for use in determining average depth of water for the annual reports).

The quarterly reports will be completed by a qualified inspector, and signed or cosigned by the mine foreman, the assistant superintendent of the mine, the superintendent of the mine, or the person designated by the mine as responsible for health and safety at the mine. The quarterly inspections will be retained at the mine site for WDEQ/LQD inspection purposes.

"Post-event inspections" will be performed after any significant runoff (1.5 inches) event within 10 working days of the event. These inspections will evaluate any potentially hazardous conditions as a result of the significant

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event, and will verify that the proper storage capacity is maintained. Post-event inspections will use quarterly inspection criteria. Determination of a "significant runoff event" will be made at the discretion of mine personnel.

As specified by WDEQ/LQD regulations, inspections will be performed during and after construction of any new impoundments, or during changes to existing impoundments. These inspections will be conducted by, or under the supervision of, a registered professional engineer to ensure that the construction is in compliance with WDEQ/LQD regulations and WDEQ/WQD effluent limitation standards.

After the post-construction inspection, a registered professional engineer will certify that the impoundment has been constructed according to the designs and plans approved by the WDEQ/LQD. This will occur immediately (typically within 30 days) of completion of construction, and prior to the impoundment receiving disturbed area runoff or pumped water. If the impoundment has not been constructed according to the certified designs, the professional engineer will decide if the changes were made within current, prudent engineering practices. If this is the case, a simple post-construction certification statement by the professional engineer is adequate. If significant changes have been made to the impoundment which exceed current, prudent engineering practices, the professional engineer will also include with the post-construction certification as-built drawings detailing the changes (within 60 days of completion of construction). Reports detailing the construction inspections will be retained at the Brook Mine office and included in the Brook Mine Annual Report.

If any inspection finds water or sediment elevations which exceed the designed volumes, and thus decreases the impoundment stability or efficiency, the impoundment will be dewatered or excavated as described in Section MP.5.6.

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MP.5.7.5 Hazardous Conditions

Rigid criteria for determining when conditions are hazardous cannot be defined because safety must be evaluated by considering the conditions at each site, and specific factors involved. Effectively evaluating the specifics of each site will be accomplished through employment of competent, experienced personnel that can recognize the difference between hazardous and nonhazardous conditions.

When a condition develops which the inspector considers hazardous to the stability of the embankment, a foreman or superintendent will be immediately notified through the most expedient method. The foreman, superintendent, or mining engineer will personally inspect the hazardous condition and advise the General Mine Manager of remedial measures. In the absence of a foreman, superintendent, or mining engineer, the inspector will contact the General Mine Manager directly, and recommend corrective action.

When a hazardous condition is thought to constitute an immediate hazard to life or property, evacuation of the affected area will be initiated immediately by the inspector or supervisor available. The most immediate concern will be with the safety of mining personnel in the affected area. If the situation is considered hazardous to any downstream property owners, the appropriate authorities or property owners will be notified immediately. In addition to these procedures, WDEQ/LQD will be notified within 5 days following the recognition of a hazardous condition.

Permanent corrective measures will be initiated as early as possible. Plans will be submitted to the WDEQ/LQD, WDEQ/WQD, and the Wyoming SEO prior to initiating corrective measures for any enlargement, reduction in size, reconstruction, or other modification of embankments, unless the modification is necessary to eliminate an emergency condition constituting a hazard to public health, safety or the environment. If any hazardous conditions are observed at an MSHA-regulated impoundment, the conditions will be immediately reported to the MSHA District Manager.

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MP.5.7.6 Diversions and Ditches

The inspection frequency for diversions and ditches will be at least twice a year, with additional unscheduled inspections after every storm that produces runoff. The inspection will be performed in sufficient detail to determine that the ditches are functioning as intended, and that no severe erosion is occurring; that the drop structures or riprap areas are functioning properly; and that the ditch capacity has been maintained.

MP.5.8 Mine Pit Dewatering Plan

During the mining operation, groundwater inflow and surface water entering the pit will be treated within the trench. Any water in contact with ore is effectively wastewater and will be treated prior to discharge.

A sump will be located in the pit bottom to collect groundwater inflow and surface runoff entering the pit. A pump located in the sump will operate to dewater the pit. The pump will be sized to dewater the maximum pit volume following the 10-year, 24-hour precipitation event within approximately 7 days of the event occurring.

Pit sumps are considered to be wells by the Wyoming SEO, and therefore each sump requires its own groundwater permit. The permits and their current locations will be available for review at the mine site.

Approximations of groundwater inflows over the course of mining were obtained from the groundwater model. A table is provided in the groundwater model report that approximates the pit inflows. The groundwater model report is provided in Addendum MP-3. It is assumed these inflow rates are the rates the mine will need to dewater the pits. The highest dewatering rate according to the groundwater model will be approximately 75 gallons per minute (gpm). The lowest dewatering rate will be less than 1 gpm (approximately 0.3 gpm).

If any adjudicated water rights are determined to be effected by the dewatering process of the Brook Mine, that water right will be replaced with a water source of similar quantity and quality as required by Wyoming Statute § 35-11-415(b)(xii), until such time that the original surface water right's functionality is restored.

MP.5.9 Dewatering Wells

A premine dewatering program may be implemented to reduce or nearly eliminate the inflow of groundwater into the excavation area during mining operations to ensure continuity and efficiency of such operations, and to safeguard highwall stability and safety. Dewatering wells will be installed ahead of the mining operations at a distance designed to maximize the

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drawdown of the coal seam's potentiometric surface at the active pit. The groundwater drawdown analyses performed for the coal seam aquifer as a result of pit dewatering and mining are not expected to be unlike lowering the potentiometric surface prior to mining by means of a groundwater dewatering well field. In effect, the drawdown extent would not differ, although the timing at which the drawdown occurs may actually be somewhat sooner than predictions performed without the use of premine dewatering wells.

A premine dewatering plan will be evaluated if necessary and as needed. The location of each dewatering well will be determined to obtain maximum interference with adjacent wells to efficiently lower the coal seam's (and/or underburden's) potentiometric surface at the pit with a minimum rate of well discharge. It may become necessary to add or subtract wells and adjust pumping rates in response to actual conditions once mining activities have begun and the results of the dewatering program are observed.

Groundwater that will be pumped from the dewatering wells, and the residual inflow to the pits that is collected in sumps and removed by sump pumps, will be used for dust suppression and/or routed to sedimentation ponds. Currently, all water is intended to be used, and discharge from the permit area is not anticipated. It is anticipated that the quality of the groundwater removed for dewatering will be similar to that of the established baseline as discussed in Appendix D6. As discussed in Appendix D6, the water quality in the coal can be somewhat variable. This is attributed to the strike and dip of the coal, the presence of faults, the location of coal recharge areas next to outcrops, and the transition of coal aquifers from confined to unconfined. However, even with the variability in water quality (which can be observed in Appendix D6), there are no constituents that are expected to pose a concern during dewatering and potential contact with the surface when used for dust abatement or other industrial purposes. The groundwater within the permit area is suitable for livestock watering according to WDEQ/WQD Rules and Regulations Chapter 8. During mining operations, RAMACO will monitor the water quality to confirm it matches the trends observed during baseline studies and to ensure that there are no constituents of concern that could cause issues while dewatering the mine pits into potential surface containment.

The basic construction of the dewatering wells will be similar to that of the coal monitoring wells, although well casings will likely be 5-inch PVC. The total depths will equal the depth to the base of the coal seam, and the perforation interval will be from the top of the coal seam to the base of the coal seam. Perforations will likely be 0.020 inch factory saw slots, and an 8-12 size sand pack will be provided around the entire perforation interval.

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The dewatering field will be installed similar to developmental drilling sites. Whenever possible, wells will be accessed over native ground, and construction of roads will be avoided to minimize environmental effects. Similarly, drill pads and mud pits are not generally constructed. If either of these structures is needed, the topsoil will be salvaged from the site prior to construction. If roads are deemed necessary, approximately 6 inches of the surface topsoil will be windrowed to the protected side of the roadbed. Drilling will be conducted by a truck- or track-mounted rotary drill rig. Excess non carbonaceous drill cuttings will be spread to a depth of less than one inch, or removed from the site. All excess carbonaceous drill cuttings will be removed from the site or placed in the pit. Drilling fluid will be minimized where possible and fluid collection points will be diluted by final wash down operations at each site. If necessary, disturbed areas will be scarified and seeded within one year using the seed mixtures described in the Reclamation Plan. Access ruts will be scarified and seeded if, after one season, vegetation has not naturally been reestablished. The minimum amount of stripping necessary to develop the field, including well sites, pipelines and access corridors, will be conducted so that the potential for erosion is minimized. If topsoil removal is necessary, the stripping will be conducted as discussed in Section MP.4.2. Appropriate sediment control will be utilized during and after construction.

Prior to initiating a dewatering plan, WDEQ will be notified by a letter describing the plan, including the number of wells, well construction details, well types (i.e. active or passive), and anticipated total production. A map will be included showing the locations of the wells, access corridors, and pipeline routes. The dewatering activities will be summarized in the Annual Report including a map showing the location of the wells. The annual report bond calculations will also be updated to reflect the abandonment of these wells. Abandonment procedures for dewatering wells that won't be mined out will be similar to those for monitor wells (monitor well reclamation is described in Section MP.9).

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The appropriate SEO permits will be obtained for the wells included in any dewatering program initiated by the mine.

MP.6 PROBABLE HYDROLOGIC IMPACTS

MP.6.1 Surface Water

The impacts to surface water at the Brook Mine will be considerably less than those of a conventional surface, or strip, mine in the Powder River Basin. As previously discussed, the highwall mining operation will open trenches from which the highwall continuous miner will extract coal from underneath the undisturbed overburden. Therefore, this method of mining leaves a majority of the surface undisturbed. With a majority of the surface undisturbed, runoff characteristics, infiltration, sediment yield and geomorphology will remain unchanged in most of the watershed. However, some temporary surface water impacts will likely occur in response to the trenches and the limited areas of surface mining, as can be seen on Exhibit MP.1-1. During any case in which sediment transport is expected, the Universal Soil Loss Equation (USLE) (Wischmeier & Smith, 1978) will be used to quantify sediment yield. Table MP.6-1 tabulates the estimated soil erodibility (K) factors for each soil type presented in Appendix D7 for the Brook Mine Permit Area. The following text discusses the potential impacts to surface water from the operations at the Brook Mine, and the manner in which these impacts will be mitigated. Exhibit MP.5-1 shows the hydrologic control plan.

As seen on Exhibit MP.1-1, the first trench (TR-1) will be mined in Sections 15 and 22, T57N, R84W near the confluence of Goose Creek and the Tongue River. In addition, facilities level disturbance will also occur throughout this area. This trench will be located in surface that drains both to Goose Creek and the Tongue River. It will have no impact on the channel geomorphology of either Goose Creek or the Tongue River. Minor surface disturbance will occur, and little runoff will enter the trench since the trench is oriented near the upper divide of minor drainage areas. However, the Big Horn No. 2 Reservoir (SEO Permits P9257R and P10952R) and Big Horn No. 14 Reservoir (SEO Permit P8478R) will be disturbed by facility disturbance. These will be reclaimed as specified in the Reclamation Plan.

Three trenches (TR-2, TR-3A, and TR-3B) will be mined in the second and third years along Hidden Water Creek. The trenches will be oriented parallel to the flow in Sections 9 and 15, T57N, R84W. Streamflow from

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Hidden Water Creek will be controlled to avoid contact with the trench mines as much as possible through the use of a diversion ditch. This diversion ditch will be designed as discussed in Section 5.4. This ditch will maintain flow, and will minimize impacts to the geomorphology of Hidden Water Creek. Any surface runoff to come in contact with mining disturbance will be treated in the pits or retained in sedimentation control structures in the vicinity of Hidden Water Creek to meet water quality standards before being discharged from the Permit Area. The appropriate WDEQ/WQD discharge permits will be obtained prior to the discharge of any water.

In the fourth and fifth years, mining occurs east of the Slater Creek watershed and west of the Hidden Water Creek watershed. Mining will occur primarily in minor drainages of the Tongue River in Sections 8, 17, and 18, T57N, R84W, as seen on Exhibit MP.1-1. Trench cuts (trenches TR-4 and TR-5) will primarily be oriented perpendicular to the flow path of the minor Tongue River drainages. The trenches will capture runoff in these ephemeral drainages. Due to the short life span of trench's (<3 yrs) peak flow rate from 10-yr, 24-hr precipitation events will be used when designing the pit drainage plan. Though flow to the Tongue River from precipitation events and snowmelt could be reduced slightly, the change will be minimal due to the ephemeral nature of the drainages and the short period of time that the trenches will be open. The trenches will be located near the upper reaches of the minor drainages. Therefore, the majority of the minor drainages in this area will remain unaffected by mining activities. As previously discussed, any runoff coming into contact with mining activities will be captured in a sedimentation impoundment or ASCM to meet water quality standards prior to discharge from the Permit Area. The appropriate WDEQ/WQD discharge permits will be obtained prior to the discharge of any water. Minimal, if any, changes will be made to infiltration in this area. Ground cover will only be altered in the area of the trench. The geomorphology of these ephemeral channels will not be altered significantly. The open trench will be promptly backfilled behind the ongoing highwall mining activities.

In the sixth through tenth years, surface disturbance will primarily occur in the Slater Creek drainage, as shown on Exhibit MP.1-1. One trench (TR-6) will be oriented parallel to Slater Creek's flow in Section 18, T57N, R84W. This trench will capture some runoff from minor tributaries of Slater Creek, which will tend to attenuate flows to Slater Creek and reduce the total runoff volume.

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To the west of Slater Creek, a surface mine (SM-1) will target the Monarch Seam in Section 13, T57N, R85W. A trench (TR-7) will also be in close association with the surface mine. Both will be near the top of a hill near a drainage divide and will have little impact on the hydrologic balance other than water which is captured directly during precipitation events. Another trench (TR-8) will be oriented parallel to Slater Creek's flow nearer the channel bottom in Sections 11, 12, and 13, T57N, R85W, but still outside of the Slater Creek channel. This will only obstruct a moderate amount of runoff in the Slater Creek drainage. Slater Creek will still flow naturally around all of the trenches. Measures will be taken to ensure that the trench is protected from storm event flows in the Slater Creek channel. During mining, runoff from the undisturbed portions of the Slater Creek watershed will be diverted from mining activities as much as possible to avoid contamination. Sedimentation impoundments will capture runoff that has come in contact with mining activities, and will treat the water to meet water quality standards before discharge. The appropriate WDEQ/WQD discharge permits will be obtained prior to the discharge of any water. The surface disturbance activities adjacent to the Slater Creek channel will have temporary impacts on the Slater Creek drainage including temporary loss of ground cover and a slight increase in soil erodibility. However, these impacts will not be in the Slater Creek channel itself, and the bed and banks will remain undisturbed. The temporary increase in soil erodibility and loss of ground cover in disturbed locations will be controlled with ASCMs and other sediment and runoff control measures to prevent sediment transport to Slater Creek. The only anticipated direct disturbance to the Slater Creek channel is in Section 13, T57N, R85W, where the channel will be redirected to flow through a culvert under a proposed haul road. However, these changes will be temporary. A 100 foot buffer boundary of the Slater Creek channel will be marked in the field at select locations prior to commencing mining related disturbance. Those areas within the Slater Creek channel and watershed affected by surface mining activities will be restored according to the Reclamation Plan. Because Slater Creek's flow will not come into contact with surface or highwall mining activities, no impact will be made to water quality. The existing Permanent Impoundment # 1 Reservoir (SEO Permit P12986R and Certificate Record CRCR22074) and Legerski #1 Stock Reservoir (SEO Permit P6850S) will be impacted by mining activities during this time period. These impoundments will be reclaimed as detailed in the Reclamation Plan.

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As seen on Exhibit MP.1-1, mining activities at the Brook Mine will conclude in the western portion of the Permit Area with highwall mining trenches. These trenches (TR-9A, TR-9B, TR-10, TR-11, and TR-12) will be oriented parallel to and along the channel of an ephemeral drainage that empties directly into the Tongue River. This minor drainage basin is designated "TRD5" on Exhibit D6-2 of Appendix D6. Due to the relatively small area of trench open at any one time, surface water impacts will be minimal. Surface water runoff from undisturbed lands will either be diverted before entering the trench, or will be allowed to enter the trench and will be treated in the trench. Waters that don't enter disturbed lands will continue draining to the Tongue River. Because these waters will not enter the trench or other disturbed lands associated with mining, the sediment yield and chemical make-up will be nearly identical to that before mining. The infiltration rate throughout the majority of the watershed will remain unchanged because most topsoil and overburden will remain undisturbed throughout mining operations. Through runoff being diverted to avoid disturbed areas, or by small quantities of runoff being allowed to enter the trench, the peak flow and storm volume will tend to be slightly reduced or remain nearly identical to that modeled in Appendix D6. Any runoff that does enter disturbed areas will be captured in a sedimentation pond or treated in the trenches to meet water quality requirements before being discharged from the Permit Area. The appropriate WDEQ/WQD discharge permits will be obtained prior to the discharge of any water. The existing Upper 10 Stock Reservoir (SEO Permit P8206S) and Welch #4 Stock Reservoir (SEO Permit P8133S) will be impacted by surface mining during this phase. At the conclusion of mining operations they will be reclaimed as detailed in the Reclamation Plan.

As described above, the Brook Mine is expected to have an extremely small effect on surface water quality in the Tongue River and other major streams adjacent to the permit boundary of the Brook Mine. As such, no effect on the designated uses present on major streams adjacent to the permit boundary is expected. There is no anticipated impact to water rights downstream of the permit boundary either. The implementation of ASCMs and sediment impoundments as discussed in Section MP.6.3 will be an important part of minimizing any possible impacts to surface water quality in the surrounding area that the Brook Mine may have. Additionally, the minimal reduction of any surface water runoff in the upper reaches of drainages in the

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Brook Mine permit area will not likely have any impact on downstream water rights. Table MP.8-1 shows the estimated water required for specific uses at the Brook Mine and the water sources. As indicated in Table MP.8-1, surface water rights may supply up to 227,000 gpd, or 69 percent of the mines water supply needs. Water rights for use within the permit boundary will be obtained by utilizing historical active Sheridan Wyoming Coal rights dating before 1950, purchasing water rights from downstream users potentially including those in Montana with excess rights, or obtaining new rights on the Tongue River which will be subject to the Yellowstone Compact. Surface water use is anticipated to continue much as it has before mining with additional water retained within the permit boundary as it is used for dust abatement and pollution control. Section MP.8 discusses the amount of water that may be potentially used for dust abatement. Water may also be temporarily detained in sediment ponds prior to the release of water downstream after effluent criteria are met. Any surface water right that is disturbed or affected by the mining operations of the Brook Mine, shall have that water right replaced with a water source of similar quantity and quality as provided by Wyoming Statute § 35-11-415(b)(xii), until such time that the original surface water right's functionality is restored.

Discussion of the potential mining impacts to the alluvial valley floors (AVFs) within the permit area and adjacent areas is presented in Mine Plan Section MP.25.

MP.6.2 Groundwater

MP.6.2.1 Introduction

Mining activities will affect the groundwater within and outside of the Permit area. The Target Coal seams are predominantly dry in the western portion of the permit area and eastern portions have been affected by CBNG development. Mining will remove portions of the coal aquifer. There will be groundwater inflow into the contour/trench cuts and well as the auger cuts where the aquifers are saturated. Drawdown of the potentiometric surfaces in

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the aquifers surrounding the contour/trench cuts is expected. The impacts of the drawdown in the coal aquifers and the expected rate of inflows are discussed in Addendum MP-3, which contains the groundwater modeling investigation conducted in 2013-2014, and are summarized in this section. The effects of possible subsidence on groundwater and the hydrologic system are minimal during mining operations as the area where subsidence would be most likely to occur will be dewatered during operation. Once mining operations are completed, any subsidence that occurs would have a minimal, temporary impact on groundwater quality before stabilizing after a number of pore volumes passes through the material. Alterations to recharge rates are expected to be minimal. However, RAMACO will monitor groundwater levels according to the monitoring plan in Section MP.7, and will provide in the annual reports any significant fluctuations in groundwater levels that could be attributed to altered recharge rates.

MP.6.2.2 Drawdown in the Coal

Drawdown in the coal was predicted using the numerical groundwater model utilizing the USGS modular finite-difference groundwater model MODFLOW and the pre/post processor Groundwater Vistas Version 6. A detailed discussion of the modeling process is presented in Addendum MP-3. Figures depicting the extent of the drawdown can be found in Appendix A Simulated Impacts from Operations of Addendum MP-3 for 5-year, 10-year, 20-year, and 50 year recovery.

MP.6.2.3 Drawdown in the Overburden

The overburden encountered when installing the monitoring network was primarily dry and is indicative of the Tongue River Member of the Fort Union Formation in this area. Drawdowns of the overburden were not modeled and only isolated sands where encountered are expected to be affected.

MP.6.2.4 Groundwater Rights

Groundwater rights within and adjacent to the Permit Area are discussed in Appendix E of the Adjudication File. Wells completed within and adjacent to

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the Permit area provide water for stock and domestic uses. The majority of private wells are completed in geologic structures below the coals proposed to be mined and impacts to domestic users are expected to be low. Table ES-1 in Addendum MP-3 describes the maximum drawdown impacts of wells completed within and adjacent to the target coal seams.

MP.6.3 Plan to Mitigate Impacts on Surface Water and Groundwater

MP.6.3.1 Plan to Mitigate the Impacts on Surface Water

The surface water monitoring program discussed in Section MP.7.1 will provide evidence to determine the effect mining operations at the Brook Mine have on surface waters. The monitoring program includes surface flow recording stations and water quality sampling.

Other methods to mitigate impacts to surface water will include the use of sediment impoundments and ASCMs. These methods are included on the hydrologic control plan on Exhibit MP.5-1. The use of sediment impoundments and ASCMs will reduce the potential of increase sediment loading downstream from the Brook Mine. This will be confirmed through the operational monitoring program discussed in Section MP.7.1.

As soon as feasible, trenches and surface mines will be backfilled with spoil, topsoiled, and revegetated to conform to the approved Reclamation Plan. Ongoing and expedient reclamation will ensure that the surface water hydrologic balance and flow characteristics are returned to resemble premining conditions as soon as possible. Postmining monitoring discussed in the Reclamation Plan will confirm the mitigation of impacts once mining and reclamation have concluded.

In addition, surface water rights that are disturbed or affected by the mining operations of the Brook Mine, shall have an alternate water source of similar quantity and quality provided in accordance with Wyoming Statute § 35-11-415(b)(xii), until such time that the original water right's functionality is restored.

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MP.6.3.2 Plan to Mitigate the Impacts on Groundwater

Wells will be properly abandoned to prevent adverse changes in water quality or quantity and to prevent a hazard to people, livestock, and wildlife. Procedures outlined in Chapter 11, Section 70 of Water Quality Rules and Regulations will be utilized for well abandonment, as well as those methods described in Guideline No. 8. In addition, any adjudicated water right that is disturbed or affected by the mining operations of the Brook Mine, shall have that water right replaced with a water source of similar quantity and quality as provided by Wyoming Statute § 35-11-415(b)(xii), until such time that the original water right's functionality is restored.

MP.7 OPERATIONAL MONITORING PROGRAM

MP.7.1 Surface Water Monitoring

Surface water monitoring during mining operations will be a continuation of the baseline monitoring program discussed in Appendix D6. Operational monitoring locations are shown on Exhibit MP.7-1. The surface water monitoring network will consist of surface water monitoring stations and reservoirs. Any downstream reservoir that could potentially be impacted by mining will have water quality data collected prior to disturbance. The data will be submitted in the Annual Reports. Table MP.7-1 summarizes the sites for the surface water monitoring network.

For establishment of any new surface water monitoring stations, several steps will be taken to choose a location and properly set the station up. The following procedure will be followed for the establishment of surface water monitoring stations:

1. A field investigation will be conducted to determine the best location for the stations. Criteria to choose the best location will include:
   a. Straight reach of the channel;
   b. Reach of channel that is close to an elevated bank that has a fairly steep grade to ensure the instruments will not be flooded;
   c. The distance from the center of the channel to the instruments is less than 50 feet (length of sensor cable); and

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d. Avoidance of submerged channel reaches (pools).

2. Instruments and equipment will be installed (instrument shelter, sampler, flow monitor, solar panel, battery, sensors, and sample tubing).
3. A survey of the channel cross section and profile (channel geometry and slope) and an evaluation of the channel roughness.
4. Development of a rating curve.
5. Programming of the instruments (flow meter and sampler).

Surface water quantity data in the form of peak daily flow rate will be measured continuously between April and October. The mine will conduct maintenance checks, and download data on a quarterly basis at all surface water monitoring stations. In addition, direct discharge measurements of surveyed cross sections will be obtained when possible. The discharge data collected will then be reported in the annual report and evaluated, when possible, to developed rating curves. Existing gage sites operated by USGS will be used to monitor surface water upstream of the planned mine facilities in Section 15 T57N, R84W, as well as downstream of the mine facilities on the Tongue River.

Water quality samples will be collected from a single surface water monitoring station during precipitation events via an ISCO automatic sampler located at station SM578409-SW-1 located on Slater Creek near the southern permit boundary. In addition, grab samples will be collected quarterly at monitoring stations and all other surface water monitoring sites. All existing reservoirs, stockponds, and proposed reservoirs that will be disturbed by surface mining activities, as discussed in Section MP.6.1, will be monitored for water quality through grab samples to ensure mining minimizes disturbance, prevents material damage, ensures waters remain suitable for all uses for which they were suitable prior to mining, and that the water rights of other users are protected. The samples will be analyzed for the constituents listed in Table MP.7-2 based upon WDEQ/LQD Guideline Number 8, Appendix 7. Field parameters that will be measured during both grab sample events and from

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events activating the automatic sampler include: pH, electrical conductivity (EC), temperature, turbidity, dissolved oxygen, oxygen reduction potential (ORP), and discharge of water level (where appropriate). Field observations (including photographic documentation) will be recorded on the water quality sampling field forms. Laboratory analysis of collected grab and precipitation event water samples will be conducted by a contract laboratory. A quality assurance and quality control program will entail duplicate samples (approximately 10%), sample preservation blanks (approximately 10%), relative percent difference statistical analysis on duplicates, comparison of field EC to laboratory EC, comparison of field turbidity to laboratory turbidity, comparison of measured total dissolved solids (TDS) to calculated TDS, ion balance analysis, and holding time/preservation evaluations. Baseline monitoring has not indicated any interactions between surface water and groundwater. However, data will continue to be compared to groundwater monitoring data to determine if any surface water and groundwater interactions exist that weren't found in baseline studies. Surface water monitoring results will be presented to WDEQ/LQD in the Annual Report. The Annual Report will also include laboratory reports, field sheets, and chain of custodies (COCs) for the surface water monitoring samples.

MP.7.2 Groundwater Monitoring

Groundwater monitoring during mining operations will be a continuation of the monitoring program initiated during baseline monitoring, as discussed in Appendix D6. The operational groundwater monitoring locations are shown on Exhibit MP.7-1. Specific site information for groundwater monitoring wells is listed in Table MP.7-3. The site information for alluvial monitoring wells is listed in Table MP.7-4. Groundwater quality samples and static water levels will be obtained and measured quarterly. Water level data from alluvial monitor wells will also be obtained quarterly. Water quality samples will be tested for the constituents listed in Table MP.7-2 based upon WDEQ/LQD Guideline Number 8 recommendations.

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The mine will adhere to the following procedures and protocols for groundwater quality and quantity monitoring:

- A static water level, total depth measurement, and well head inspection will be completed during each monitoring event for each well monitored.
- All wells will be pumped at the rate required to evacuate the casing of stagnant water and draw in at least three casing volumes of formation water.
- In low yield wells (those that produce 0.5 gpm or less during well development), it may not be practical to purge three casing volumes prior to sampling. In low yielding wells, low flow sampling methods will be employed.
- Field observations will be recorded on the water quality sampling field forms.
- Field parameters such as pH, EC, temperature, dissolved oxygen, and turbidity will be measured throughout purging to determine geochemical stability. Three values with less than 10% difference will indicate that the water is stable, representative of the aquifer, and samples will thereby be collected.
- Field filtered and preserved sampled will be collected in clean, unused plastic or glass containers provided by the contract laboratory.
- Samples will be kept on ice until arrival at the laboratory (no more than two days following sample collection).
- A quality assurance and quality control program will entail duplicate samples (approximately 10%), sample preservation blanks (approximately 10%), relative percent difference statistical analysis on duplicates, comparison of field EC to laboratory EC, comparison of field turbidity to laboratory comparison of measured TDS to calculated TDS, ion balance analysis, and holding time/preservation evaluations. All quality control data, including COCs, will be provided in the Annual Report.

In the event that a groundwater monitoring well is discontinued or damaged during the mining process, it will be replaced with another monitoring well so that the total number of working groundwater monitoring wells remains the same.

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MP.8 WATER USE

Water to be used at the Brook Mine will be supplied from various sources. Reverse osmosis units, trucking water, or other sources will be the source of potable water. Industrial water will be obtained from pit inflows, surface water rights, water collected in sediment and flood control reservoirs, or others sources. Water obtained will be used under appropriate permits from the State Engineers Office.

Water used in the Brook Mine facilities will include potable water and industrial water. The potable water will be produced from trucking water, reverse osmosis, or from other sources on an as needed basis at points of use.

Industrial water will be used for dust suppression on the haul roads, truck wash down, wash down of the facilities, and for the highwall miner. This water will be supplied from surface water rights and from water which is collected in the pit and sediment and flood control reservoirs.

It is estimated that the total water use will be approximately 120 million gallons per year (approximately 328,200 gallons per day) with an expected variability of plus or minus 20 percent. This equates to approximately 368 acre-feet of water per year. According to the *Task 1B Report for the Powder River Basin Coal Review Current Water Resources Conditions* (AECOM Environment, May 2014) submitted to the Bureau of Land Management, most mines in the Powder River Basin pump between 300 and 920 acre-feet of groundwater per year. If this is assumed to approximate the water usage of typical coal mines, the Brook Mine will be on the lower end of average water usage for coal mines. This value may vary year to year depending on conditions, the mine plan, and other variables. Enough water is available from surface water rights that variations in pit inflows, runoff in sediment or flood control reservoirs, or other sources will easily be supplemented or not taken from the surface water rights see section MP.6.1. Table MP.8-1 provides an estimate of the water used by specific use at the Brook Mine. Table MP.8-1 also provides the expected quantity of water taken from each source.

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RAMACO is aware of the Yellowstone River Compact and will act in accordance with the guidelines outlined by obtaining WSEO permits for impoundments.

MP.9 RECLAMATION OF EXPLORATION HOLES AND WELLS

MP.9.1 Developmental Drilling and Plugging Plan

All drilling activities within the permit area (and potential exploration activities) will be conducted according to the following procedures. Typical backfilling procedures for exploration holes or wells are illustrated on Figure MP.9-1. Where procedural differences exist for developmental and exploration drilling, they are discussed separately.

The mine will properly permit each drilling program with WDEQ/LQD and the Bureau of Land Management (BLM) prior to the initiation of the program.

The overburden analytical results from all drilling programs will be presented in the appropriate annual report to WDEQ/LQD. General information on site descriptions, drilling procedures, and reclamation procedures are discussed in the following subsections.

MP.9.2 Drill Site Access and Initial Disturbance

Whenever possible, sites will be accessed over native ground and construction of roads will be avoided, minimizing environmental effects. Similarly, drill pads and mud pits are not generally constructed. If either of these structures are needed, the topsoil will be salvaged from the site prior to construction. If roads are considered necessary, approximately 6 inches of the surface topsoil will be windrowed to the protected side of the roadbed. Roads will not be located on hillsides with greater than 40 percent slopes; roads will not exceed 10 percent; roads will not be constructed near or up a stream channel; any necessary stream crossings will be designed to minimize disturbance; adequately designed culverts and ditches will be installed as needed, and culverts will be covered with a minimum of 12 inches of material.

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Drill pads and mud pits will not be located on hillsides with greater than 40 percent slopes.

MP.9.3 General Drilling Procedures

Drilling will be conducted by a truck- or track-mounted rotary drill rig. The average hole diameter will generally be 5⅛ inches. Drill hole depths will vary, ranging from less than 25 feet to more than 375 feet for overburden; coal drilling will average an additional 15 feet. The time required to complete each hole varies substantially with total depth, material encountered, whether coring or auguring operations are being conducted, geohydrologic features encountered, experience of the drilling staff, and several other variables. Generally, equipment will be on any site less than a day; this may be extended when completing the hole for a monitoring well.

MP.9.4 General Drill Site Reclamation

Excess noncarbonaceous drill cuttings will be spread to a depth of less than one inch or removed from the site. All excess carbonaceous drill cuttings will be removed from the site. Drilling fluid will be minimized where possible and fluid collection points will be diluted by final wash down operations at each site. If necessary, disturbed areas will be scarified and seeded within one year using approved WDEQ/LQD seed mixtures described in the Reclamation Plan. Access ruts will be scarified and seeded if, after one season, vegetation has not naturally been reestablished.

Drill hole abandonment shall be completed within three months after drilling is completed on a site. During the time of open holes, surface plugs will be placed in the hole. See the following discussion for specific plugging methods and details of drill hole reclamation.

Drill pads and mud pits generally are not required. Any drill pads needed will be recontoured, retopsoiled, and seeded. Mud pits will be filled, contoured, retopsoiled, and seeded. Predug pit specifications and revegetation details are discussed in greater detail in the following subsections.

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Road construction is avoided whenever possible; any necessary drill site access roads will be reclaimed by removal of any culverts, removal, and respreading of any fill onto cut areas, replacement of topsoil, and seeding. See the following discussion for revegetation specifications.

Due to differences in the regulations of the different agencies and the distinction between developmental drilling and exploratory drilling, the following drill hole abandonment and reclamation methods will be used.

MP.9.5 Drill Hole Locations

Areas within One Year of Trench or Surface Mine Advance

Developmental drill holes in areas within one year of the topsoil removal will not require any abandonment procedures due to the imminent alteration caused by advance of trenches or surface area mines.

Areas within Two Years of Trench or Surface Area Mine Advance

Developmental drill holes in areas beyond a year but within two years of topsoil removal will be backfilled with drill hole cuttings, or when an aquifer is penetrated, the zone will be sealed with abandonment materials. A dry cement plug will be placed from two to seven feet below ground surface, and the hole backfilled with soil to original ground surface.

Areas within the Perimeter Fence Surrounding the Active Mine Operations

Developmental drill holes in areas within the perimeter fence and not included in the above areas will be filled with drill hole cuttings. A wet-mixed cement plug will be placed from two to seven feet below ground surface, and the hole will be backfilled to the original ground surface with topsoil. If a single aquifer is encountered, an abandonment material will be used in conjunction with drill hole cuttings (abandonment material is specified in Section MP.9.7). If two or more aquifers are encountered, the hole will be sealed off with abandonment materials. Reseeding will be conducted in areas outside the two-year mining advance.

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All Other Areas Outside the Perimeter Fence

All other areas described in this discussion include exploration holes, monitoring wells, and production wells. All other drill holes that don't meet the characteristics of the drill holes previously discussed in this section will follow these procedures:

1. Holes that are known not to encounter aquifers as defined in Appendix D6 will be filled with drill hole cuttings to within seven feet of the surface and a wet-mixed cement plug will fill the hole to two feet below ground surface. The remainder of the hole will be filled with topsoil.

2. Holes that are known to encounter non-artesian aquifers will be filled with abandonment material (as specified in Section MP.9.7) through the aquifer to within seven feet of the surface. A five-foot wet-mixed cement plug beginning at seven feet and filling to two feet below ground surface will be topped with two feet topsoil graded flush to match the existing ground.

3. Holes that are known to encounter an artesian but not a surface flowing aquifer will be filled with abandonment material (as specified in Section MP.9.7) throughout the aquifer to within seven feet of the surface. A five-foot wet-mixed cement plug beginning at seven feet and filling to two feet below ground surface will be topped with two feet of topsoil and graded flush to match the existing ground.

4. Holes that are known to encounter a surface flowing artesian aquifer will be cemented from the bottom of the hole to within 2 feet of the surface and topped with topsoil graded flush to match the existing ground.

MP.9.6 Monitor Wells

Abandonment procedures for monitoring wells will be similar to those for exploration holes. The difference will be that casings will be cut off to a depth of at least two feet below ground surface, followed by backfilling with abandonment materials (as specified in Section MP.9.7), and utilizing the aforementioned reclamation procedures. A schematic illustrating the general abandonment procedure is shown on Figure MP.9-1.

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MP.9.7 Abandonment Material Specifications

Abandonment material shall consist of bentonite chips and drill cuttings. Bentonite chips shall be placed in and around the zone(s) of aquifer(s) encountered to assure prevention of fluid communication between aquifers. Drill cuttings shall be placed in the intermediate zones.

MP.9.8 Excess Cuttings Disposal

If excess cuttings are composed of toxic material, the cuttings will be removed from the location and disposed of in proper areas of the backfill, or pits will be dug after drilling to bury the material at least four feet below the surface.

MP.9.9 Predug Pit Specifications

Pit locations will be stripped to the base of the topsoil to the extent that pit materials can be stockpiled without encroaching on the native surface. Topsoil will be handled in accordance with Section MP.4.2. In areas where the use of drilling muds or additives require disposal, a pit shall be dug the width of a back-hoe bucket at least ten feet long and six feet deep. Any pit that will remain open for a length of time will be fenced to exclude livestock. A minimum of four feet of suitable overburden material will be placed on the disposed material. Areas disturbed by pits will be scarified, topsoiled, and revegetated. Reclamation shall occur in a manner that will best restore the surface to its pre-disturbance condition.

MP.9.10 Revegetation of Roads, Drill Pads, and Predug Pits

Seeding will be performed in the fall or in the spring using WDEQ/LQD-approved seed mixtures and methods described in the Reclamation Plan. Seeding will not be conducted when the ground is frozen.

MP.9.11 Bonding and Reporting

Bonding and reporting for all drilling will be part of the Annual Report process. The bond estimate in the Annual Report will contain a line item for drilling. The drill sites for the report year and the anticipated drill sites for

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each forthcoming year will be illustrated on exhibits submitted as part of the Annual Report. Specific drill hole abandonment information will be presented in the Annual Report. Brook Mine will also complete federal reporting requirements under separate cover to the Bureau of Land Management.

MP.10 REFUSE DISPOSAL

A refuse disposal and solid waste management plan is presented in Addendum MP-4.

MP.11 FIRE CONTROL PLAN

A fire control plan is presented in Addendum MP-5.

MP.12 SIGNS, MARKERS AND BUFFER ZONES

Clear, visible, and durable signs and markers will be placed in and around the permit area, applicable to the areas or activities to which they pertain. The following subsections discuss the various signs that will be utilized in the Brook Mine permit area.

MP.12.1 Mine Permit and Identification Signs

Mine permit and identification signs will be located at the public entrance to the mine. Information on the sign will include the identification number of the Brook Mine Permit, the name of the mine manager, and the name, address, and telephone number of the mine operator. This sign will not be removed until the release of all bonds.

MP.12.2 Perimeter Markers

Signs or line-of-sight T-posts will be located around the perimeter of the Permit Area indicating the permit boundary. These signs or markers will be placed on a maximum ½-mile spacing so as to be visible from one to another.

MP.12.3 Stockpile Markers

Each topsoil and overburden stockpile will be marked with identification signs and will show the numerical designation of the stockpile. These signs will be placed no more than 150 feet from the stockpile. They will be located on

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the approach roads to stockpile locations and will be in place when stockpiling begins and remain until all such material has been redistributed.

MP.12.4 Buffer Zones

No buffer zones have been identified at this time.

MP.12.5 Mine Facilities

Mine facilities and features will be marked with appropriate identification signs. These identification signs will include, but are not limited to:

- Sedimentation Pond
- Wastewater Reservoir
- Flood Control Reservoir
- Reference Area
- Explosives Storage
- Temporary Solid Waste Stockpile
- Fuel Storage Area

MP.12.6 Blasting Signs

Blasting signs will be displayed at the edge of the blasting area within the trench or surface area mine, and on roads leading to the blast area. A blasting sign explaining the blast warning signals and all-clear signals used at the Brook Mine will be posted at public entrances to the mine property.

MP.13 SUBSIDENCE CONTROL

Subsidence control was prepared by Cardno MM&A of Bluefield, Virginia. Addendum MP-6 contains the subsidence control measures at the Brook Mine.

MP.14 BLASTING PLAN AND SCHEDULE

MP.14.1 Introduction

To help maximize production and minimize loading equipment maintenance, both the coal and overburden will be blasted. Blasting fragments and displaces the ground for easier and faster material handling. Blasting

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practices will be conducted in a manner to prevent injury to persons, and prevent damage to private and public property outside the Permit Area. In order to ensure that explosives are safely used, the mine will comply with all federal, state, and local laws and their regulations pertaining to their storage, handling, preparation, and use.

MP.14.2 Explosives

A mixture of ammonium nitrate and fuel oil (ANFO) will be the principle blasting agent used at the Brook Mine. However, if blast holes are filled or partially filled with water, then emulsions or prepackaged ANFO may be used. High density ANFO may also be used in order to increase the degree of fragmentation.

The blasting agents will be primed with Pentolite (PETN & TNT), or other types of cast boosters with or without bagged water gel, or a high explosive water gel. A sensitized slurry booster may also be used for proper detonation. A cast booster will not function as a primer for blasting agents until a detonator (blasting cap, detonating cord, etc.) is attached to it.

MP.14.3 Blasting Operations

The three basic operations for blasting in either coal or overburden are:

- Drilling
- Blasthole Loading
- Explosive Detonation

MP.14.3.1 Drilling

Blast holes in coal will vary in diameter according to depth of the blast hole. Coal blast hole diameters will range from 3 inches to 9 inches. Depths will vary from 4 feet to 20 feet.

Blast holes in overburden will also vary in diameter according to depth of the blast hole. Overburden blast hole diameters will vary from 6¾ inches to 12¼ inches. Overburden blast hole depths will be up to 375 feet depending on overburden depth.

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MP.14.3.2 Loading

After the blast holes have been drilled, they will be loaded with priming systems (cast booster with detonator), explosives, and stemming. The stemming ratio will be approximately 0.7 to 1.0 (0.7 foot to 1.0 foot of stemming for every foot of burden). The stemming ratio used in blast design may be adjusted to less than 0.7 if experience at the Brook Mine indicates that air blast and flyrock control can be achieved with a lower stemming ratio. The powder factors used will be appropriate to adequately fragment coal or overburden, depending upon which is being blasted at the time.

MP.14.3.3 Detonation

Detonation of the explosives will be done by using non-electric or electric systems, which may include electronic detonators, shock tube detonators, detonating cord, electronic detonators, or a combination thereof.

MP.14.4 Explosive Storage and Transportation

The explosive storage facilities will be constructed to comply with all applicable federal, state, and local laws and regulations. Explosive storage facilities for the Brook Mine may be as follows:

- Elevated bins for bulk ammonium nitrate prills
- Drop tank storage for emulsions and/or prepackaged ANFO
- Magazine storage for water gels and dynamite classified as high explosives
- Magazine storage for caps and connectors
- Magazine for other explosives (primers, primer cord, etc.)

Explosives will be delivered to the mine site by trucks owned and operated by licensed, experienced contractors. The bulk ammonium nitrate and fuel oil may be mixed to make ANFO on the mine site or at the contractor facilities, and taken to the blast area by trucks.

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MP.14.5 Applicable Laws and Regulations

The Brook Mine will comply with all federal, state, and local laws and regulations pertaining to the storage, handling, preparation, and use of explosives. Applicable WDEQ/LQD R&R include the most current versions of Chapter 2 and Chapter 6. Additionally, blasting at the Brook Mine will meet requirements of the Surface Mining Control and Reclamation Act of 1977.

All blasting operations will be supervised by certified personnel who understand the hazards involved and have demonstrated knowledge and a willingness to comply with all local, state, and federal laws and regulations pertaining to blasting operations. A certificate of completion of training and qualification will be obtained by all personnel supervising blasting operations before any blasting activities are engaged. These personnel will meet the requirements of WDEQ/LQD R&R Chapter 6, Section 1(c).

Proper permits for the transportation, storage, handling, and use of explosives which are not covered by licensed explosive suppliers will be obtained by the mine.

MP.14.6 Preblast Survey

It is anticipated there will be a need for preblast surveys at the Brook Mine. Several inhabited buildings (residences) exist within one-half mile of the Permit Area. Should any of the residents or owners of the man-made dwellings or structures within one-half mile of the mine request a preblast survey, or if the proper regulatory authority requests a preblast survey, one will be made. The blasting schedule will notify any resident or owner of a man-made dwelling within one-half mile of any part of the permit boundary to contact WDEQ/LQD and the permittee to request a preblast survey.

If a preblast survey is requested, the permittee is responsible for completing the survey. A qualified person will conduct the preblast survey that will include any preblast damage or other physical factors that may be reasonably affected by blasting operations. Assessments of structures such as

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pipes, cables, transmission lines, and wells and other water systems shall be limited to surface condition and other readily available data. A written report of this survey will be submitted to the LQD Administrator and the person requesting the survey. Any recommendations of special conditions or proposed adjustments to blasting operations will be followed by the Brook Mine.

MP.14.7 Blast Monitoring and Distance To Structures

Oil wells, pipelines, and other engineered structures within one-half mile of the permit boundary which are not owned by the mine will need to be protected through limiting peak particle velocity. Additionally, according to WDEQ/LQD R&R Chapter 6, Section 4(c), a blasting plan will be submitted if blasting operations will be conducted within 1,000 feet of any building used as a dwelling, public building, school, church, or community or institutional building; or if blasting activities occur within 500 feet of an active or abandoned underground mine. Flyrock will not be cast from the blasting vicinity more than half of the distance to the nearest occupied structure or beyond the Permit Area. WDEQ/LQD R&R Chapter 6, Section 4(b)(iv) outlines the allowable scaled distance factors for structures should there be no seismic monitoring. Table MP.14-1 lists these distance factors for a range of distances from the blasting site.

All uninhabited structures not owned by the mine within the Permit Area, and one-half mile adjacent to the Permit Area, will be adequately protected at peak particle velocities up to 5 inches per second based upon the following investigations and LQD recommendation:

1. Peak particle velocity of 9.8 inches per second is deemed adequate to protect high pressure pipelines. J.F. Wiss "Construction Vibration: State-of-the-Art", J. Geotechnical Engineering Division, American Society of Civil Engineers, Volume 107, No. GT2, February 1981; and V. Langefors, "The Modern Techniques of Rock Blasting", Third Edition, John Wiley, 1978.
2. Pipelines are relatively resistant to blast vibrations. No pressurization failures occurred at over 20 inches per second. *Response of Pressurized Pipelines to Production Size Mine Blasting*, David E.

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Siskind and Mark J. Stagg, U.S. Bureau of Mines, Twin Cities Research Center, 1992 Society of Explosives Engineers Conference.

3. No damage was reported in a high pressure test pipeline at ppv of 63 inches per second and no damage found in another test at 100 to 150 inches per second. *Vibration and Ground Rupture Criteria for Buried Pipelines*, Lewis L. Oriard, Huntington Beach, California, 1993 Society of Explosives Engineers Conference.
4. Cased drill holes begin to show signs of damage at 15.0 inches per second; prefabricated metal building on pad at 60 inches per second. *Explosives and Rock Blasting*, Atlas Powder Company.

The mine may hire a contractor to conduct seismographic monitoring within the Permit Area at these structures to assure that the maximum limit was not exceeded. Based on the regression analysis of the data from this monitoring, at the upper 95% confidence interval, as well as the development of a vibration study, a modified scaled distance may be developed to show compliance with this limit. However, this will require the vibration study be submitted with seismograph records from shots in the mining area which will not be available until such time that blasting has occurred at the mine.

As specified by WDEQ/LQD R&R Chapter 6, Section 4(b)(iv), the following scaled distance equation will be used to determine the maximum weight of explosives that can be detonated within any eight millisecond interval:

Where: $W = (D/D_S)^2$

W = The maximum weight of explosives, in pounds that can be detonated in any eight (8) millisecond period.

D = The distance, in feet, to the nearest dwelling, school, church, or commercial or institutional structure.

D_S = Scaled distance factor.

MP.14.8 Overburden and Coal Blasts

Overburden and coal blasting is expected to take place within the Brook Mine. The following section gives an overview of the typical components and parameters of a conventional overburden or coal blast. Blasting that occurs at the Brooks Mine will be done in a manner that maximizes safety and the

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effectiveness of the blasts. As such, the components and parameters used in the field will likely vary from the conventional blasts described below.

MP.14.8.1 Overburden Blast

The overburden blast designs will be chosen based on the conditions encountered for each blast. Both emulsions and ANFO will be used in a typical blasting pattern. The blast pattern will be designed to utilize the minimum amount of explosive to break up the largest volume of overburden while minimizing fly rock and dust emissions from the area being blasted.

A stemming length of 0.7 to 1.0 times the burden will be the general design standard for blasting. Bench heights, bench widths, drill hole diameters, and drill patterns will all be dependent upon the equipment used for operations and the material encountered. Therefore, blasting parameters will be chosen appropriately for encountered conditions.

The blast holes will be loaded with ANFO or emulsion blend to a total column height which maintains a stemming length of 0.7 to 1.0 times the burden. If water is found in the drill holes, then part or all of the powder column will be loaded with an emulsion/ANFO blend with good water resistance.

The amount of ANFO or emulsion blend loaded into the hole should result in powder factors that will be high enough to adequately fragment the overburden. The total explosives to be shot in any eight millisecond period for this overburden blast plan would be limited by the scaled distance equation, the distance to the nearest structure, and the type of structure.

MP.14.8.2 Coal Blast

Coal bench heights, bench widths, drill hole diameters, and drill patterns will be designed appropriately the equipment used for mining operations and the encountered conditions. A stemming length of 0.7 to 1.0 times the burden will be the general design standard. To minimize coal dilution, the coal bench will not be subdrilled.

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If water is encountered, the entire powder column may be filled with an emulsion/ANFO blend with a high water resistance. The powder factor will be sufficient to fragment the coal for the prime movers.

The total explosive to be shot in any eight millisecond period for this coal blast plan will be limited by the scaled distance equation, the distance to the nearest structure, and the type of structure.

MP.14.9 Blasting Logs

A record of each blast will be prepared and a copy retained for a minimum of three years. The logs will include any seismograph reports. These logs will be made available to regulatory authorities and the public on request. Each log will contain all the required items listed in WDEQ/LQD R&R Chapter 6, Section 5(a). An example of the minimum information to be recorded on the blaster's log is provided in Addendum MP-7.

MP.14.10 Blasting Schedule

In a period of not less than 30 days or more than 60 days before beginning blasting operations in which more than 5 pounds of explosives or blasting agent are detonated, the mine will publish a blasting schedule in the local newspaper. Copies of the schedule will be sent to local governments, public utilities, and each residence within one-half mile of the blasting area. An example of the blasting schedule is provided in Addendum MP-7. The schedule will be republished and redistributed at least every 12 months.

The blasting schedule will be written and distributed in accordance with WDEQ/LQD R&R Chapter 6, Section 3(a). The blasting schedule will include the following:

- Operator – Name, address, and telephone number of the operator.
- Blasting Area – The blasting schedule will identify specific areas to be blasted.
- Dates and Times of Blasting – Blasting detonation will take place between sunrise and sunset, seven days a week.

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- Methods to Control Access to Blast Areas – Entrance signs will be posted to warn people that they are entering a blasting area. Ten minutes preceding a blast, mine personnel will guard the access roads into the mine area, and access to the immediate blast area will be limited to authorized individuals involved with the blast. After the blast, access will be restricted until an authorized individual has determined the area is safe.

- Areas which contain charged holes will be flagged and entry will be restricted to authorized personnel only.

- Warning Signals – Warning signals of an ensuing blasting operation will consist of one siren blast given for one minute, five minutes prior to the explosives blast. One minute prior to the blast, a siren blast will be given ending with blast detonation. A 15-second siren blast will be given as an all-clear signal after the blast site has been inspected by authorized personnel for proper detonation of explosives. All sirens will be audible for one-half mile from the blast site. Meanings of the signals will be displayed in accordance with WDEQ/LQD R&R Chapter 6, Sections 1 and 4.

- Possible Emergency Situations – At times, because of unavoidable hazardous conditions, rescheduling of blastings may become necessary. Possible hazardous conditions that warrant the rescheduling of blasts include electric storms and any other climatic conditions which could cause excessive airblast and interference with air traffic.

MP.14.11 Traffic Control Plan

Should blasting operations potentially have an effect on public roads, the mine will gain permission and follow guidelines from WYDOT and Sheridan County to block the potentially affected roads. The plan will outline signage, blocking type(s), number of blockers, blocking location(s), media notification, emergency agency notification, approximate blocking duration, emergency conditions, and any other pertinent information.

MP.14.12 Unauthorized Access Control

Unauthorized access to the blasting area will be controlled in the following ways:

- Publication of the Blasting Schedule, as previously discussed in Section MP.14.10;

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- Written notification to all residents within one half of a mile of the Brook Mine Permit Boundary;
- Fences surrounding the active mining areas;
- Signs describing the warning signals referred to in Section MP.14.10;
- Patrols of blasting personnel prior to blasting; and
- Restriction to the blasting area through the use of signs, berms, and road blocks set up by blasting personnel.

MP.15 SURFACE MINING ACTIVITIES NEAR UNDERGROUND MINES

Historically, significant mining activities have occurred within the Brook Mine permit boundary and the adjacent area. These mining activities began as early as the late nineteenth century, as discussed in Appendix D2. Most of the historic mining activities were underground mines. Therefore, several networks of underground mines are near mining activities proposed by the mine. Some of these networks are within 500 feet of proposed mining activities by the mine. A representation of the approximate location of these underground mines is shown on Exhibit MP.15-1, as well as a 500-foot offset from the historic underground mining networks. As shown on Exhibit MP.15-1, only limited areas of proposed activities will be within 500 feet of historic underground mines. The historic underground mines are completely abandoned. The vertical distance between the historic underground mines and the highwall mining operations is sufficient to ensure structural integrity. Workers associated with the highwall mining operations will never be underground.

As discussed, the majority of mining activities at the Brook Mine will be highwall mining in which a continuous miner extracts coal from underneath the undisturbed overburden. There will also be typical surface mining activities. Surface mining activities will not typically occur over the top of highwall mining activities. However, in one location, surface mining will target the Monarch Seam above the highwall mining operations targeting the Upper Carney and Lower Carney. The nearest vertical distance between the surface mining and the highwall mining will be approximately 70 feet. The distance

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will be sufficient to provide for the health and safety of the workers, and to prevent surface water from entering the highwall proceedings (WDEQ/LQD, July 2009). Exhibit MP.15-2 shows the location and profile for the site where surface mining will occur over highwall mining operations. The surface mining will occur approximately one year prior to the highwall mining activities. Highwall mining workers will never be underground.

MP.16 PROTECTION OF OTHER RESOURCES, STRUCTURES AND SURFACES

MP.16.1 Minerals

Scoria is the only other mineral known to exist within the Permit Area above the coal seams. Due to the mining methods and typical location of scoria (top of hills) scoria will not typically be encountered during mining. Therefore, mining will not affect any other mineral deposits likely to be targeted. The Brook Mine and Taylor Quarry will continue to mine concurrently.

MP.16.2 Oil and Gas Operations

Owners of oil and gas wells in the Brook Mine Permit Area are listed in the Adjudication File, and the locations of wells within two miles of the permit boundary are listed in Appendix D1.

There are no producing oil and gas wells within the Permit Area.

MP.16.3 Air Quality Protection Plan

The Brook Mine will incorporate air pollution control equipment and operating practices into the life of the mine.

Air quality protection will be primarily directed to the control of particulate matter (predominately fugitive dust). During operations, dust control on haul roads and access roads will be accomplished by frequent watering and/or chemical dust suppressants.

Process related emissions will be controlled by several methods. Baghouses will be employed in the facility area where coal is transferred or crushed.

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An Air Quality Permit will be submitted to Wyoming Department of Environmental Quality/Air Quality Division (WDEQ/AQD). The application demonstrates the use of Best Available Control Technology on all emission sources. The application also demonstrates that the National Ambient Air Quality Standards will be maintained during operation of the Brook Mine.

MP.16.4 Surface and Groundwater Rights

The protective measures of surface and groundwater rights are discussed in Section MP.6. The mine will minimize the impacts of mining on groundwater and surface water in the design and construction of hydrologic control structures.

MP.16.5 Structures

There are no structures in the Permit Area that will interfere with, or be affected by, mining operations. Consequently, structures will not need to be relocated or abandoned. Should power and communication lines need to be relocated, the appropriate companies will be contacted and plans will be made to relocate the lines to minimize unnecessary interruptions. Replacement lines will be constructed according to applicable state, federal, and local codes.

If mining activities require relocating a county road, plans will be submitted to and approved by Sheridan County and the affected surface land owners, if applicable. Any approved road relocation will be constructed and approved prior to the existing road being disturbed by mining operations.

MP.16.6 Public Access

Public access to the Brook Mine will be limited to the main access route, and will be controlled by the guardshack. The Brook Mine is located entirely on private lands. Therefore, public access to lands will not be granted. Later in the mine life, county roads will be adjacent to the mining activities. Measures will be taken at that time to ensure the public safety and allow the public to pass through the mine area on the county roads.

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MP.16.7 Health and Safety

An ambulance will be readily available to respond to emergencies at the mine. In order to reduce the incidence of accidents, employees will be instructed in First Aid and the use of safe work practices. Employees will be certified and current with MSHA training, and mine specific safety rules.

An active health and safety program will be initiated and monitored at the mine to provide a safe and healthful workplace. The mine intends to comply with all applicable health and safety regulations.

MP.17 EXISTING STRUCTURES FACILITATING OPERATIONS

There are few existing structures facilitating the mine's planned operations. There are no telephone lines, power lines, or other utilities that will be readily available for the Brook Mine's use. There are no reservoirs that will facilitate flood or sediment control.

Ash Creek Road and Hidden Water Road will facilitate transportation within the Permit Area. Some existing fence could facilitate mining activities through restricting livestock and unauthorized public access to the mine area. The former Big Horn Mine shop building may facilitate operations, providing negotiations allow the mine to acquire use of the building.

MP.18 PLAN TO MINIMIZE ADVERSE IMPACTS ON FISH AND WILDLIFE

A baseline assessment of wildlife in the Brook Mine Permit Area, and the vicinity, is provided in Appendix D9. The impact and mitigating measures are also discussed in Appendix D9. The Wildlife Monitoring Plan is presented in Addendum MP-8. The greatest impact to wildlife at Brook Mine will be temporary loss of habitat, but temporary loss of habitat will be considerably less at the Brook Mine compared to conventional surface mines due to the lesser degree of surface disturbance. Habitat will be returned to wildlife use as soon as possible after reclaimed areas are determined to be stabilized.

Active mine areas will be fenced with a five-strand, sheep-tight fence with 8-inch ground clearance to exclude livestock and wildlife from mine and

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reclamation activities, and to protect newly seeded vegetation and reclaimed areas.

Pesticides and herbicides used during mining and reclamation activities will be approved prior to application, and will be applied by a certified applicator. Should persistent pesticides be required, approval by state (WDEQ/LQD), federal, and county agencies will be obtained. Herbicides are expected to be used to control Wyoming State-listed noxious or other weeds. Herbicides will be used so as not to danger terrestrial or aquatic wildlife.

Toxic materials are not anticipated to be in ponds or waterways. Permanent hydrologic features will be constructed for wildlife habitat and for livestock use. Therefore, permanent hydrologic features will be constructed in locations to avoid contamination by toxic sources. ASCMs and other sediment control measures discussed in Section MP.5 will be used to control sedimentation during mining and reclamation. Should contamination occur, the contamination will be cleaned prior to being released for use by wildlife.

Mine employees will be instructed not to harass wildlife, or unnecessarily damage habitat on the mine site. Speed limits will be set on all roads for safety and to reduce road kills and will typically be 45 mph. Any areas where animals cross roads on a regular basis will be marked. Only authorized persons will be allowed to access active mining areas.

Illegal hunting (poaching) detected on the Brook Mine will be reported to the proper authorities. Wildlife using the Permit Area will be monitored to determine if any overgrazing of newly reclaimed areas is occurring. Limited hunting may be considered for the purpose of dispersing these animals.

If the monitoring program described in Addendum MP-8 indicates adverse impacts on wildlife, approved changes will be implemented to mitigate damage. Should any threatened or endangered (T&E) species begin to use the Permit Area, appropriate state and federal authorities will be notified.

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Electric power lines will be designed to lessen the chance of raptor electrocution. A Special Purpose Permit will be obtained for the U.S. Fish and Wildlife Service prior to the disturbance of any raptor nests.

A Raptor and Migratory Birds of High Federal Interest (MBHFI) mitigation plan is included as Addendum MP-9. This plan identifies raptor and MBHFI use of the Permit Area and surrounding buffer zones, and identifies mitigation measures. The plan was reviewed and approved by the U.S. Fish and Wildlife Service.

MP.19 PROTECTION OF HISTORICAL AND ARCHAEOLOGICAL RESOURCES

The Brook Mine Permit Area has been used for livestock grazing and extraction of energy resources in more recent years. In the late nineteenth century to the mid twentieth century, considerable coal mining operations occurred within the Permit Area and the vicinity. Several coal camps existed to provide accommodations for the miners and their families. The land uses and the history of the area are discussed in Appendix D1 and Appendix D2, respectively.

If, during mining operations, previously unidentified cultural or paleontological remains should be discovered, the mine will notify the surface rights holder and appropriate regulatory authority within five days, ensure that the site is not disturbed, and will immediately cease land disturbance activities within the vicinity of the site. The mine will ensure that the resource(s) is properly evaluated and salvaged, if necessary, in terms of the National Register of Historic Places (36 CFR 60.6). Should a resource be determined eligible for listing in the National Register of Historic Places in consultation with the Regulatory Authority and the State Historic Preservation Office, the mine will consult with and obtain the approval of the Regulatory Authority and the State Historic Preservation Officer concerning the development and implementation of mitigation measure as appropriate.

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MP.20 UNDERGROUND MINING

No "conventional" underground mining will occur. Highwall coal recovery is an underground mining technique, but no personnel work underground. Underground recovery is the only operation that would be similar to underground mining and requires that a recovery plan be submitted to the MSHA district manager and that this plan is reviewed and approved prior to the beginning of the underground recovery.

MP.21 AUGER MINING

The highwall mining method using a continuous miner is a similar method to auger mining. Both methods use a machine to remotely remove coal from underneath the overburden without disturbing it. For a detailed discussion of highwall mining, which will comply with similar mining methods as auger mining, refer to Section MP.1.2.2.

MP.22 DUAL PERMITTED AREAS

The Taylor Quarry Permit Boundary of Taylor Investments, LLC is located within the Brook Mine Permit Area, as shown on Exhibit MP.1-1. Additionally, portions of the Big Horn Coal Mine's permit boundary are within the Brook Mine's permit boundary, as shown on Exhibit MP.1-1. Where lands are located in both permit boundaries, all mining operations are covered under the individual Permits to Mine. Activities conducted by Taylor Quarry are under Taylor Quarry Permit No. SP-757. Activities conducted by Big Horn Coal are under Big Horn Coal's Permit No. 213-T7. Agreement between the permitees are located in the Adjudication File.

MP.23 PLAN IN CASES OF TEMPORARY CESSATION OF OPERATIONS

Should the mine temporarily suspend coal production and concurrent reclamation activities due to the coal market, or any other unforeseen circumstances, for greater than 30 days, the mine will contact WDEQ/LQD and confirm the format of the formal request for temporary cessation of operations (TCO), report, or permit revision as required by WDEQ/LQD.

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Should the mine permanently cease mining operations, all disturbances will be reclaimed in accordance with the approved Reclamation Plan. Overburden stockpiles will be removed and used as backfill. Topography will be regraded to match the approved postmining topography (PMT) where necessary. Topsoil will be replaced, and disturbed areas will be reseeded with the WDEQ/LQD-approved seed mixtures. Any equipment, facilities, or buildings not needed for reclamation or environmental monitoring will be removed or properly discarded. Reclaimed areas will be monitored according to the monitoring plan in the approved Reclamation Plan.

MP.24 PROTECTION OF PUBLIC SAFETY, HUMAN OR ANIMAL LIFE, PROPERTY, AND THE SURFACE OWNER'S ONGOING OPERATION

The mine has several plans to mitigate the hazards to public safety, human or animal life, property, and the surface owner's ongoing operation. Among these plans are: the blasting plan (Section MP.13); the air quality protection plan (Section MP.16.2); the surface water and groundwater protection plans (Section MP.6); the protection of other structures and surfaces plan (Section MP.16); the refuse disposal plan (Section MP.10); the fire control plan (Section MP.11); the subsidence control plan (Section MP.14); and the plan to minimize adverse impacts on fish and wildlife (Section MP.18).

The permit boundary will not be fenced specifically around the entire perimeter. However, active mine areas in particular will be fenced to prevent unauthorized humans and animals from entering to protect life and safety

The main access road and facilities area will be fenced to prevent unauthorized access to the Brook Mine. Visitors will be required to gain permission and check in to be allowed lawful entrance to the mine.

Signs and markers are discussed in Section MP.12. Signs and markers will be placed in several places throughout the Brook Mine Permit Area to alert people to activities and/or hazards in the vicinity.

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MP.25 ALLUVIAL VALLEY FLOORS

> In 1979, OSM stated that:
> "...the designation of an area as an alluvial valley floor does not preclude mining as a matter of law. Mining will only be prohibited where there is an alluvial floor and (1) where mining will interfere with or preclude farming; (2) where mining will materially damage the water supply to an alluvial valley floor; or (3) where the essential hydrologic functions cannot be restored after mining." (OSM, March 13, 1979)

While the aforementioned standard would preclude surface mining from occuring in an alluvial valley floor, it does not necessarily preclude underground mining from occuring in an alluvial valley floor. However, underground coal mining in an alluvial valley floor may be prohibited if it is demonstrated that material damage to the alluvial valley floor would result from mining operations. In addition to underground coal mining being allowed in alluvial valley floors by federal laws, Wyoming laws also allow underground mining to occur in alluvial valley floors. However, the Surface Mining Control and Reclamation Act (SMCRA), the Wyoming Environmental Quality Act (1977), and federal and state regulations do require additional permitting and operational performance standards on underground coal mines operating in alluvial valley floors. Therefore, the mine will maintain the option to use underground mining methods in alluvial valley floors with the understanding that additional permitting and operational performance standards will be required. Though the mine maintains this option, the mine does not currently have plans to underground mine in alluvial valley floors.

As discussed in Appendix D11, no direct mining is planned on the AVFs located in the Tongue River and Goose Creek valleys. Therefore, the essential hydrologic functions within Tongue River and Goose Creek AVFs shall be maintained. Minor disturbance of the declared Big Horn Mine AVF extent is planned in Section 21 of Township 57 North, Range 84 West. The disturbance includes placement of an overburden pile (OB-1) and a sedimentation impoundment (SP-1). AVF material planned for disturbance will be special handled and stockpiled seperately with the appropriate signage in accordance

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with WDEQ Rules and Regulations. This disturbance will not affect the essential hydrologic funtions of the AVF as the area planned for disturbance is very minor and the conveyance of flow throughout the AVF will not be interrupted.

In addition to the natural subirrigation provided by the Tongue River, the Tongue River Ditch north of the Tongue River provides artificial subirrigation to the agricultural lands located along the Tongue River. The ditch will continue to provide irrigation to these lands during mining and the only potential impact to the Tongue River AVF will be the minor loss of surface flow from ephemeral tributaries to Slater Creek and then to Tongue River. As discussed in Section MP.6, Slater Creek channel will only experience minor temporary disturbance due to the construction of a haulroad crossing with culverts, which won't preclude surface flows from Slater Creek from reaching the confluence with the Tongue River. This minimal interruption of flow should not preclude agricultural use of the AVFs of the Tongue River and Goose Creek as these areas will continue to receive irrigation from the Tongue River Ditch.

The expected alluvial groundwater impacts are minimal as discussed in the groundwater model in Addendum MP-3. The Tongue River and Goose Creek alluvium are hydrologcially seperated from the Masters and Carney coal seams by a layer of claystone generally with a very low permeability. Therefore, any future losses incurred in the groundwater alluvium would likely be a function of evapotranspiration occuring. As discussed in Addendum MP-3, alluvial drawdowns are more of a result of instability occuring in the model due to the inability for dry cells within the model to rewet themselves. As no major drawdowns are expected in the Goose Creek and Tongue River alluvium, interruption to the agricultural activities along these areas is not expected.

The Tongue River and Goose Creek alluvium will continue to be monitored regularly. During mining and reclamation operations color infrared aerial photography will be obtained annually and analyzed as an indicator to ensure the continued essential hydrologic functions of the Tongue River and

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Goose Creek AVFs are maintained by observing evapotranspiration. In addition, a series of monitoring wells is proposed along the Tongue River and Goose Creek. These wells will be installed prior to commencing any mining related disturbance. Monitoring will follow the procedures described in Section MP.7.2. A list and location of the proposed and installed alluvial wells within the permit area and adjacent areas are presented in Table MP.7-4 and Exhibit MP.7-1, respectively.

MP.26 SEPARATION AND REPLACEMENT OF SOILS FOR PRIME FARMLANDS

The prime farmland assessment is discussed in Appendix D7. No prime farmlands will be affected by mining operations. Soil separation and replacement methods for prime farmlands will not be required.

MP.27 REQUEST FOR VARIANCE FROM ENVIRONMENTAL PERFORMANCE STANDARDS

The mine does not currently plan to conduct any operations that deviate from conventional environmental performance standards at the Brook Mine. Should the mine develop plans to conduct experimental environmental practices, requests for WDEQ/LQD approval will be submitted prior to implementation of such experimental practices.

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MP.28 REFERENCES

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MINE PLAN TABLES

Table MP.1-1. Annual Surface Disturbance Acreage

Year of Permit Term	Trench Mining Disturbance (ac)	Area Mining Disturbance (ac)	Facilities Disturbance (ac)[1]	Total Surface Disturbance (ac)
0	0.0	0.0	321.3	321.3
1	30.5	0.0	140.7	171.2
2	22.9	0.0	24.8	47.7
3	26.3	0.0	68.2	94.5
4	33.0	0.0	52.5	85.5
5	33.0	0.0	22.8	55.8
6-10	97.2	47.0	213.9	358.1
11-12	58.4	0.0	7.0	65.4
Total	**301.3**	**47.0**	**851.2**	**1199.5**

Note:[1] Facilities disturbance includes disturbance acreage caused by buildings, roads, diversions and stockpiles.

[2] Year 0 corresponds to the year 2016.

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Table MP.1-2. Estimated Annual Production

Year	Production (tons)
1	548,000
2	1,796,000
3	1,890,000
4	2,028,000
5	2,070,000
6-10	9,999,000
11-12	1,941,000
Total	**20,272,000**

Note:[1]Year 0 corresponds to the year 2016
Source: Cardno MM&A, October 2013

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Table MP.1-3. Surface Mining Equipment

Equipment Designation	Power	Quantity
992K Wheel Loader	Diesel	2
777G Off-Highway Rock Truck	Diesel	4
MD6240 Rotary Drill	Diesel	1
D11T Crawler Tractor	Diesel	1
D10T Crawler Tractor	Diesel	2
16G Motor Grader	Diesel	2
988K Wheel Loader	Diesel	1
Coal Truck (Mack Titan w/ Pup)	Diesel	4
Water Truck	Diesel	1
Fuel/Lube Truck	Diesel	1
Maintenance Service Truck	Diesel	2
Light Plant	Diesel	6
Bulk Prill Truck	Diesel or Gas	1
Explosives Supply Truck	Diesel or Gas	1
3/4 Ton Pick-Up	Diesel or Gas	3
Bus	Diesel	1
Office Trailer	N/A	1
Maintenance Tent	N/A	1
Portable In-Pit Crusher	Electric or Diesel	1

Note: Actual quantities of equipment may vary as needs change.

Source: Cardno MM&A, October 2013

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Table MP.1-4. Highwall Mining Equipment

Equipment Designation	Power	Quantity
ADDCAR Highwall Mining System	Electric	1
988H Loader - 9.0 cy bucket	Diesel	1
988H Loader - pizza pan attachment	Diesel	1
Coal Truck (Mack Titan w/ Pup)	Diesel	12
Office Trailer	N/A	1
Portable In-Pit Crusher	Electric or Diesel	1

Note: Actual quantities of equipment may vary as needs change.

Source: Cardno MM&A, October 2013

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Table MP.4-1. Topsoil Volume Removed Over the Life of Mine

Year	Stripping Area Name[1]	Area (acres)	Average Cut[4] (ft)	Volume Removed (bcy)	Destination Stockpile Name[2]	Volume Stockpiled (bcy)	Running Volume Stockpiled (bcy)
0	TR-1A	128.7	1.2	249,200	TS-1a	249,200	249,200
0	TR-1A	190.8	1.5	461,700	TS-1b	461,700	461,700
0	OB-3	13.8	1.8	40,100	TS-1b	40,100	501,800
1	TR-1	30.5	1.5	73,800	TS-1b	73,800	575,600
1	OB-1	4.7	1.8	13,600	TS-1b	13,600	589,200
1	OB-2	8.6	1.8	25,000	TS-1b	25,000	614,200
1	HR-2	5.7	1.7	15,600	TS-2	15,600	15,600
1	HR-3	52.2	1.2	101,100	TS-2	101,100	116,700
1	OB-4	31.4	1.6	81,100	TS-2	81,100	197,800
1	SP-3	5.7	1.8	16,600	TS-2	16,600	214,400
1	DD-1	14.2	1.3	29,800	TS-2	29,800	244,200
2	DD-2	24.8	1.2	48,000	TS-2	48,000	292,200
2	TR-2	22.9	1.7	62,800	TS-2	62,800	355,000
3	TR-3A	16.7	1.3	35,000	TS-3a	35,000	35,000
3	TR-3B	9.6	1.3	20,100	TS-3a	20,100	55,100
3	FC-1	3.4	1.3	7,100	TS-3a	7,100	62,200
3	OB-5	9.2	1.3	19,300	TS-3a	19,300	81,500
3	OB-7	10.3	1.0	16,600	TS-3b	16,600	16,600
3	HR-3	29.6	0.9	43,000	TS-3b	43,000	59,600
3	OB-6	10.5	0.7	11,900	TS-3b	11,900	71,500
4	HR-3	32.7	1.1	58,000	TS-4	58,000	58,000
4	TR-4	33.0	0.8	42,600	TS-5	42,600	42,600
4	FC-2	3.0	1.1	5,300	TS-5	5,300	47,900
4	OB-8	14.4	1.2	27,900	TS-5	27,900	75,800
5	TR-5	33.0	1.0	53,200	TS-5	53,200	129,000
5	FC-3	3.2	1.2	6,200	TS-5	6,200	135,200
5	FC-4	1.8	1.1	3,200	TS-5	3,200	138,400
5	SP-7	11.8	1.2	22,800	TS-5	22,800	161,200
6-10	HR	41.8	1.1	74,200	TS-5	74,200	235,400
6-10	HR	28.8	0.9	41,800	TS-6	41,800	41,800
6-10	TR-6	36.2	1.0	58,400	TS-6	58,400	100,200
6-10	OB-9	10.6	1.2	20,500	TS-6	20,500	120,700
6-10	OB-10	6.6	1.2	12,800	TS-6	12,800	133,500
6-10	TR-7/SM-1	54.7	1.5	132,400	TS-6	132,400	265,900
6-10	TR-8	28.7	1.4	64,800	TS-6	64,800	330,700
6-10	OB-12	13.7	1.4	30,900	TS-6	30,900	361,600
6-10	OB-13	3.3	1.3	6,900	TS-6	6,900	368,500
6-10	HR	8.0	1.4	18,100	TS-7	18,100	18,100
6-10	OB-11	8.5	1.4	19,200	TS-7	19,200	37,300
6-10	HR	16.8	1.4	37,900	TS-8	37,900	37,900
6-10	OB-14	7.4	3.0	35,800	TS-8	35,800	73,700
6-10	HR	16.4	1.4	37,000	TS-9	37,000	37,000
6-10	OB-15	4.2	1.5	10,200	TS-9	10,200	47,200
6-10	HR	15.4	1.3	32,300	TS-11	32,300	32,300
6-10	TR-9A	24.6	1.4	55,600	TS-10	55,600	55,600
6-10	OB-16	3.9	1.0	6,300	TS-10	6,300	61,900
11-12	TR-9B	24.0	1.2	46,500	TS-10	46,500	108,400
11-12	TR-10	11.2	1.3	23,500	TS-10	23,500	131,900
11-12	TR-11	15.5	1.2	30,000	TS-10	30,000	161,900
11-12	TR-12	7.7	1.2	14,900	TS-10	14,900	176,800

Note: [1] Stripping area nomenclature is shown on Exhibit MP.4-2.

[2] Stockpile nomenclature is shown on Exhibit MP.4-3.

[3] Year 0 corresponds to the year 2016.

[4] Average cut obtained from grid files reflecting Appendix D7 soil polygons within Mine Plan stripping areas. Cut depths are a weighted average of recommended depths for specific soil types. Depths don't match specific depths in Appendix D7.

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Table MP.4-2. Topsoil Volume (bcy) Balance

Stockpile Designation[1]	0	1	2	3	4	5	6-10	11-12
TS-1a	249,200							
TS-1b	472,800	614,200						
TS-2	-	244,200	355,000					
TS-3a	-	-	-	81,500				
TS-3b	-	-	-	71,500				
TS-4	-	-	-	-	58,000			
TS-5	-	-	-	-	75,800	161,200	235,400	
TS-6	-	-	-	-	-	-	368,500	
TS-7	-	-	-	-	-	-	37,300	
TS-8	-	-	-	-	-	-	73,700	
TS-9	-	-	-	-	-	-	47,200	
TS-10	-	-	-	-	-	-	61,900	176,800
TS-11	-	-	-	-	-	-	32,300	

Note: [1] Stockpile nomenclature is shown on Exhibit MP.4-3.
Refer to the Reclamation Plan for topsoil replacement.

[2] Year 0 corresponds to the year 2016.

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Table MP.4-3. Topsoil Stockpile Design

Stockpile Designation[1]	Estimated Capacity (cy)	Approximate Basal Area[2] (acres)	Average Height[2] (ft)	Side Slope (H:V)
TS-1a	249,200	6.4	48	3:1
TS-1b	614,200	13.3	45	3:1
TS-2	355,000	6.2	63	3:1
TS-3a	81,500	2.8	39	3:1
TS-3b	71,500	2.4	34	3:1
TS-4	58,000	2.4	32	3:1
TS-5	235,400	6.0	42	3:1
TS-6	368,500	7.0	75	3:1
TS-7	37,300	1.4	26	3:1
TS-8	73,700	2.5	44	3:1
TS-9	47,200	1.8	25	3:1
TS-10	176,800	5.6	42	3:1
TS-11	32,300	1.4	20	3:1

Note: [1] Stockpile nomenclature is shown on Exhibit MP.4-3.

[2] Basal area and average height have been calculated using 3D grid files in AutoCAD. Therefore, basal area and average height are impacted by changing topography, and do not reflect stockpiles with flat bases.

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Table MP.4-4. Overburden Volume (bcy) Balance

Stockpile Designation[1]	0	1	2	3	4	5	6-10	11-12
OB-1	-	300,000	0	0	0	0	0	0
OB-2	-	500,000	0	0	0	0	0	0
OB-3*	350,000	950,000	350,000	350,000	350,000	350,000	350,000	350,000
OB-4*	-	500,000	1,000,000	500,000	500,000	500,000	500,000	500,000
OB-5	-	-	-	730,000	500,000	0	0	0
OB-6*	-	-	-	400,000	400,000	400,000	400,000	400,000
OB-7*	-	-	-	400,000	400,000	400,000	400,000	400,000
OB-8	-	-	-	-	550,000	1,100,000	1,100,000	0
OB-9	-	-	-	-	-	-	510,000	0
OB-10*	-	-	-	-	-	-	260,000	260,000
OB-11*	-	-	-	-	-	-	100,000	100,000
OB-12*	-	-	-	-	-	-	1,200,000	600,000
OB-13	-	-	-	-	-	-	165,000	0
OB-14	-	-	-	-	-	-	122,000	0
OB-15*	-	-	-	-	-	-	76,000	76,000
OB-16*	-	-	-	-	-	-	104,000	104,000

Note: [1] Stockpile nomenclature is shown on Exhibit MP.4-3.

[2] Year 0 corresponds to the year 2016.

*Those overburden stockpiles that are still in existence at the end of mining will be used for reclamation of the roads and final trenches.

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Table MP.4-5. Overburden Stockpile Design

Stockpile Designation[1]	Estimated Capacity[2] (cy)	Approximate Basal Area[2] (acres)	Average Height[2] (ft)	Side Slope
OB-1	300,000	4.7	55	Angle of Repose
OB-2	500,000	9.4	55	Angle of Repose
OB-3	950,000	13.4	95	Angle of Repose
OB-4	1,000,000	21.4	85	Angle of Repose
OB-5	730,000	9.2	70	Angle of Repose
OB-6	400,000	8.3	55	Angle of Repose
OB-7	400,000	8.9	70	Angle of Repose
OB-8	1,100,000	14.2	75	Angle of Repose
OB-9	510,000	8.7	55	Angle of Repose
OB-10	260,000	5.6	45	Angle of Repose
OB-11	100,000	4.1	50	Angle of Repose
OB-12	1,200,000	14.0	95	Angle of Repose
OB-13	165,000	4.2	45	Angle of Repose
OB-14	122,000	5.6	55	Angle of Repose
OB-15	76,000	3.2	30	Angle of Repose
OB-16	104,000	3.6	20	Angle of Repose

Note: [1] Stockpile nomenclature is shown on Exhibit MP.4-3.

[2] Basal area and average height have been calculated using 3D grid files in AutoCAD. Therefore, basal area and average height are impacted by changing topography, and do not reflect stockpiles with flat bases.

TFN 6 2/025
RECD OCT 23, 2015

DEQ 12-105

Table MP.4-6. Coal Reserve Estimates

Seam	Tons (x1,000,000)
Monarch	1.1
Carney Upper	1.9
Carney Lower	9.7
Carney	6.3
Masters	1.3
Total	**20.3**

TFN 6 2/025
RECD NOV 14, 2014

DEQ 12-106

Table MP.4-7. Criteria to Establish Overburden Suitability

Parameter	Surface (Potential Root Zone) Unsuitable
pH	<5.0 or >9.0
EC (Conductivity) (mmhos/cm)	>12
SAR	>12[1] >15
Boron (ppm)	>5.0
Acid-Base Potential (tons $CaCO_3$ equiv/1000 tons)	<-5
Organic Carbon	>10%

Note: [1] For fine-textured soils (clay >40%).

Source: WDEQ/LQD Guideline No. 1 Topsoil and Overburden

TFN 6 2/025
RECD NOV 14, 2014

DEQ 12-107

Table MP.4-8. Mass Balance Determining Overburden Classification

Overburden Classification Calculations	
Overburden Stripping Volume (x1000 bcy)	26,700
Total In Situ Coal Volume Removed (x1000 bcy)	3,500
Total Initial Pit Volume (x1000 bcy)	**30,200**
Non-Swelled Spoil Placed in Pit (x1000 bcy)	**26,700**
Swell Factor (%)	16.0
Total Swelled Backfill Volume (x1000 lcy)	**30,972**
Volume Replacement Ratio (Swelled Vol/Pit Vol)	**1.03**

Note: Approximate original contour (AOC) mines are approximated using the "rule-of-thumb" that the volume replacement ratio is between 0.8 and 1.2 (WDEQ/LQD C-SOP 3.1, 1998). Coal volume removed using the continuous miner was not included in these calculations due to the fact that this volume will not have an impact on backfill.

TFN 6 2/025
RECD NOV 14, 2014

DEQ 12-108

Table MP.4-9. Typical Swell and Load Factors of Materials

Material	Swell (%)	Load Factor
Clay		
dry	40	0.72
wet	40	0.72
Clay and Gravel		
dry	40	0.72
wet	40	0.72
Coal, anthracite	35	0.74
Coal, bituminous	35	0.74
Earth, loam		
dry	25	0.80
wet	25	0.80
Gravel		
dry	12	0.89
wet	12	0.89
Gypsum	74	0.57
Hardpan	50	0.67
Limestone	67	0.60
Rock, well blasted	65	0.60
Sand		
dry	12	0.89
wet	12	0.89
Sandstone	54	0.65
Shale and Soft Rock	65	0.60
Slate	65	0.60
Traprock	65	0.61

Note: Adapted from Standard Handbook for Civil Engineers (Lindeburg, 2008)

TFN 6 2/025
RECD OCT 23, 2015

DEQ 12-109

Table MP.5-1. Design Events for Diversions

Life of Diversion	Storm Event Return Period
<3 years	10-year
3-10 years	25-year
11-20 years	50-year
>20 years	100-year

Source: WDEQ/LQD Guideline No. 8 Hydrology

TFN 6 2/025
RECD JUL 30, 2015

DEQ 12-110

Table MP.6-1. Soil Erodibility Factors

Soil Type	Erodibility Factor (K)
Cambria Loam	0.34
Zigweid Loam	0.34
Forkwood Loam	0.34
Shingle Channery Loam	0.24
Samday Clay Loam	0.25
Bauxson Loam	0.34
Haverdad Loam	0.34
Ulm Clay Loam	0.25
Worthenton Clay Loam	0.25
Wibaux Channery Loam	0.24
Reclaimed Land	0.34
Disturbed Land	0.50

TFN 6 2/025
RECD JUL 30, 2015

DEQ 12-111

Table MP.7-1. Operational Surface Water Monitoring Locations

Site ID	Facility Name	Location	Northing (WY83ECF)	Easting (WY83ECF)	Monitoring Device	Type and Frequency of Measurement
SM578512-SW-1	SM578512-SW-1	SESW, Sec. 12, T57N, R85W	1940409	1381960	R	C, Q
SM578418-SW-1	SM578418-SW-1	SESW, Sec. 18, T57N, R84W	1935703	1386326	R, PS	C, E, M
SM578409-SW-1	SM578409-SW-1	SWNW, Sec. 09, T57N, R84W	1942831	1395621	R	C, Q
SM578415-SW-1	SM578415-SW-1	SENW, Sec. 15, T57N, R84W	1938209	1402426	R	C, Q
SP578415	BIG HORN NO. 14 RESERVOIR	SESE, Sec. 15, T57N, R84W	1934849	1405707	NONE	Q
SP578415	BIG HORN NO. 2 RESERVOIR	SESE, Sec. 15, T57N, R84W	1935770	1404829	NONE	Q
SP578512	Legerski Bros #1 Stock Reservoir	SENE, Sec. 12, T57N, R85W	1943327	1384643	NONE	Q
SP578511	Hall Reservoir	NWSE, Sec. 11, T57N, R85W	1942009	1378053	NONE	Q
SP578418	PERMANENT IMPOUNDMENT #1 RESERVOIR	NWSW, Sec. 18, T57N, R84W	1936477	1385023	NONE	Q
SP578514	LEGERSKI #1 STOCK RESERVOIR	SENE, Sec. 14, T57N, R85W	1938177	1380047	NONE	Q
SP578510	Upper 10 Stock Reservoir	NWSE, Sec. 10, T57N, R85W	1941591	1373000	NONE	Q
SP578514	Welch #4 Stock Reservoir	NWNW, Sec. 14, T57N, R85W	1939512	1375721	NONE	Q
SP578514	Black Mountain No. 1 Stock Reservoir	SENW, Sec. 14, T57N, R85W	1937816	1376975	NONE	Q
USGS 06299980	Tongue River at Monarch, WY	SWNE, Sec. 20, T57N, R84W	1931759	1393149	USGS Stream Gage Site	Q
USGS 06306300	Tongue River at State Line near Decker MT	NWNW, Sec. 33, T9N, R40E	1971782	1440972	USGS Stream Gage Site	Q

Monitoring devices

R=Flowmeter

PS=Pump sampler

Type and Frequency of Measurements

C=Continuous flowmeter

E=Pump sampler water quality sample based on precipitation event

M=Monthly grab sample if water is present

Q=Quarterly grab sample if water is present

Note: 1. Flowmeters and pump samplers inactive from first hard freeze or October 1, whichever is first, through approximately April 30, weather permitting.

2. Monitor locations are displayed on Exhibit MP.7-1 except for the Tongue River station at the Wyoming-Montana State Line.

TFN 6 2/025
RECD DEC 18, 2015

DEQ 12-112

Table MP.7-2. Water Quality Constituents (WDEQ/LQD Guideline Number 8)

Constituent	Source	Holding Time	Analytical Method
pH	GW, SW	At time of Sample	SM 4500 H B
Electrical Conductivity	GW, SW	28 Days	SM 2510B
Total Dissolved Solids (180)	GW, SW	7 Days	SM 2540
Sodium Adsorption Ratio (SAR)	GW, SW	NA	Calculation
Alkalinity, Total (as $CACO_3$)	GW, SW	14 Days	SM 2320B
Alkalinity, Carbonate (as CO_3)	GW, SW	14 Days	SM 2320B
Alkalinity, Hydroxide (as OH)	GW, SW	14 Days	SM 2320B
Ammonia Nitrogen (as N)	GW, SW	28 Days	EPA 350.1
Total Suspended Solids	SW	7 Days	SM 2540
Turbidity	SW	48 Hours	SM 2130
Nitrate+Nitrite as N	GW, SW	28 Days	EPA 353.2
Alkalinity, Bicarbonate as HCO_3	GW, SW	14 Days	SM 2320B
Boron	GW, SW	180 Days	EPA 200.7
Barium	GW, SW	180 Days	EPA 200.8
Copper	GW, SW	180 Days	EPA 200.8
Fluoride	GW, SW	28 Days	SM 4500FC
Sulfate	GW, SW	28 Days	EPA 300.0
Aluminum	GW, SW	180 Days	EPA 200.7
Arsenic	GW, SW	180 Days	EPA 200.8
Cadmium	GW, SW	180 Days	EPA 200.8
Calcium	GW, SW	180 Days	EPA 200.7
Chloride	GW, SW	28 Days	EPA 300.0
Chromium	GW, SW	180 Days	EPA 200.7
Iron	GW, SW	180 Days	EPA 200.7
Total Iron	GW, SW	180 Days	EPA 200.7
Lead	GW, SW	180 Days	EPA 200.8
Magnesium	GW, SW	180 Days	EPA 200.7
Manganese	GW, SW	180 Days	EPA 200.7
Total Manganese	GW, SW	180 Days	EPA 200.7
Molybdenum	GW, SW	180 Days	EPA 200.8
Nickel	GW, SW	180 Days	EPA 200.7
Potassium	GW, SW	180 Days	EPA 200.7
Selenium	GW, SW	180 Days	EPA 200.8
Sodium	GW, SW	180 Days	EPA 200.7
Mercury	GW, SW	28 Days	EPA 245.1
Total Mercury	GW, SW	28 Days	EPA 245.1
Zinc	GW, SW	180 Days	EPA 200.7

TFN 6 2/025
RECD JUL 30, 2015

DEQ 12-113

Table MP.7-3. Operational Groundwater Monitoring Locations

Cluster ID	Monitor Well ID	Depth (ft)	Qtr-Qtr	Section	Township	Range
SM578510	SM578510-CRN-1	76	NWSE	10	T57N	R85W
	SM578510-MST-1	103				
SM578511	SM578511-CRN-1	70	SWSE	11	T57N	R85W
	SM578511-MST-1	120				
SM578512	SM578512-CRN-1	50	SENW	12	T57N	R85W
	SM578512-MST-1	120				
SM578513	SM578513-CRN-1	30	SENW	13	T57N	R85W
	SM578513-MST-1	65				
SM578408	SM578408-CRN-1	70	NWSE	8	T57N	R84W
	SM578408-MST-1	120				
SM578409	SM578409-CRN-1	70	SWSE	9	T57N	R84W
	SM578409-MST-1	120				
SM578415	SM578415-CRN-1	100	NWSE	15	T57N	R84W
	SM578415-MST-1	120				
SM578417	SM578417-CRN-1	70	NESW	17	T57N	R84W
	SM578417-MST-1	120				
SM578418	SM578418-CRN-1	140	SENW	18	T57N	R84W
	SM578418-CRN-OB-1	140				
	SM578418-MST-1	280				
	SM578418-MST-OB-1	280				
	SM578418-UNB-1	300				

Note: Monitoring well locations are displayed on Exhibit MP.7-1.

TFN 6 2/025
RECD JUL 30, 2015

DEQ 12-114

Table MP.7-4. Operational Alluvial Monitoring Locations

Monitor Well ID[1]	Qtr-Qtr	Section	Township	Range
SM578418-AL-1	SESW	18	T57N	R84W
SM578513-AL-1	SWNE	13	T57N	R85W
SM578512-AL-1	SWSW	12	T57N	R85W
578433-AL-1	NENE	33	T57N	R84W
578434-AL-1	SENW	34	T57N	R84W
578434-AL-2	SESW	34	T57N	R84W
578524-AL[2]	NWNE	24	T57N	R85W
578420-AL[2]	NWSE	20	T57N	R84W
578415-AL[2]	NESW	15	T57N	R84W

Notes: [1] Alluvial well locations are displayed on Exhibit MP.7-1.
[2] Proposed alluvial monitoring well.

TFN 6 2/025
RECD OCT 23, 2015

DEQ 12-115

Table MP.8-1. Estimate of Water Used by Specific Use and Source at the Brook Mine

Specific Water Use	Volume (gpd)
Potable Water	21,000
Dust Control	220,000
Truck Wash	8,500
Highwall Miner	24,000
Subtotal	**273,500**
Misc. 20% Additional	54,700
Total	**328,200**

Water Source	Volume (gpd)
Trucking Potable Water/Reverse Osmosis	21,000
Pit Inflows*	53,000
Sediment/Flood Control Reservoirs	7,200
Surface Water Rights	227,000
Other Sources	20,000
Total	**328,200**

*The pit inflow volume is an average of the pit inflows over the life of the mine. Refer to the groundwater model report in Addendum MP-3 for a more detailed estimate of pit inflows during mining.

TFN 6 2/025
RECD OCT 23, 2015

DEQ 12-116

Table MP.14-1. Scaled Distance Factors without Seismic Monitoring

Distance (D) from the Blasting Site (feet)	**Maximum Allowable Peak Particle Velocity (V_{max}) (inches/second)**	**Scaled Distance Factor (D_S)**
0 to 300	1.25	50
301 to 5000	1.00	55
5001 and beyond	0.75	65

Source: WDEQ/LQD R&R Chapter 6, Section 4(b)(iv)

TFN 6 2/025
RECD OCT 23, 2015

DEQ 12-117

MINE PLAN FIGURES

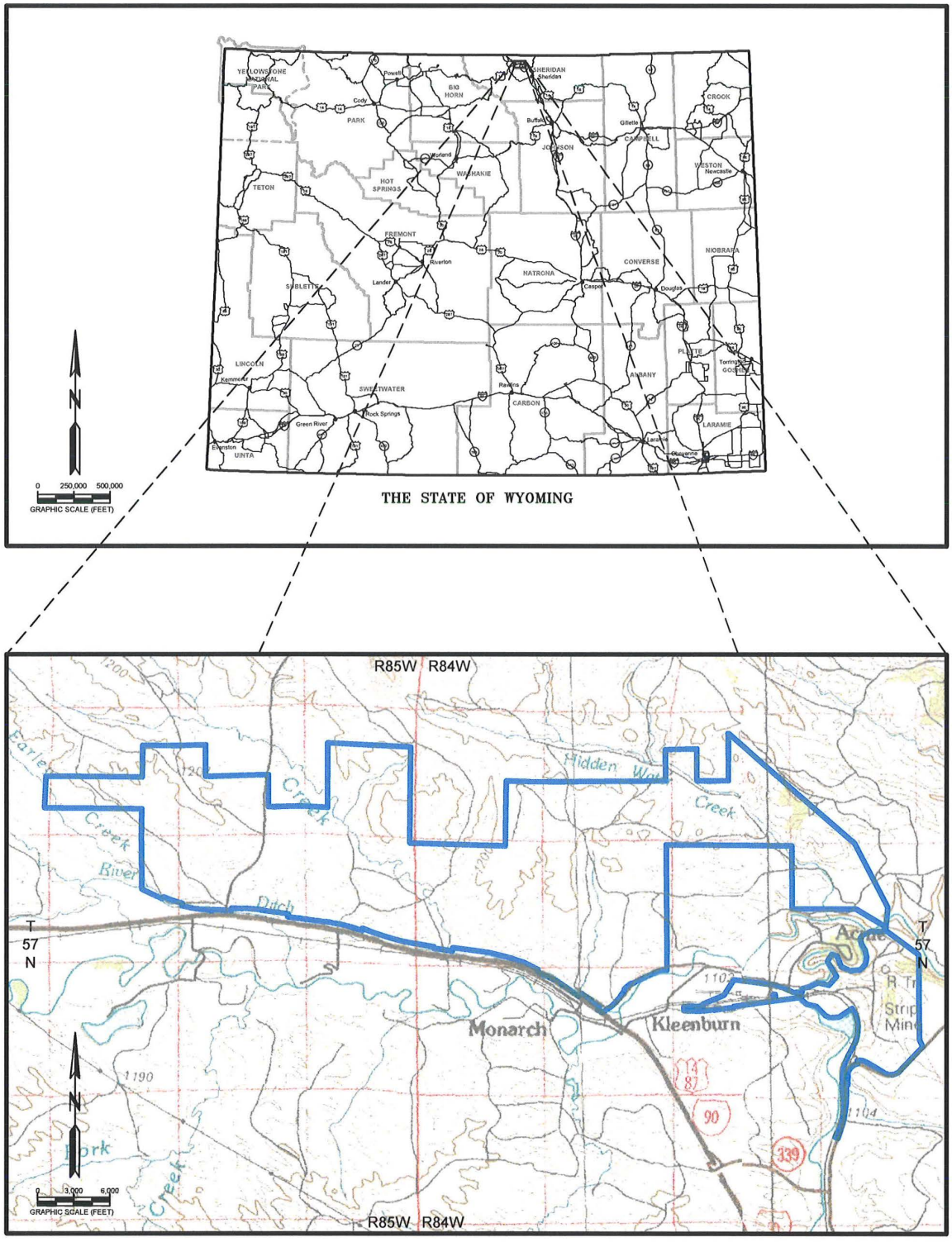
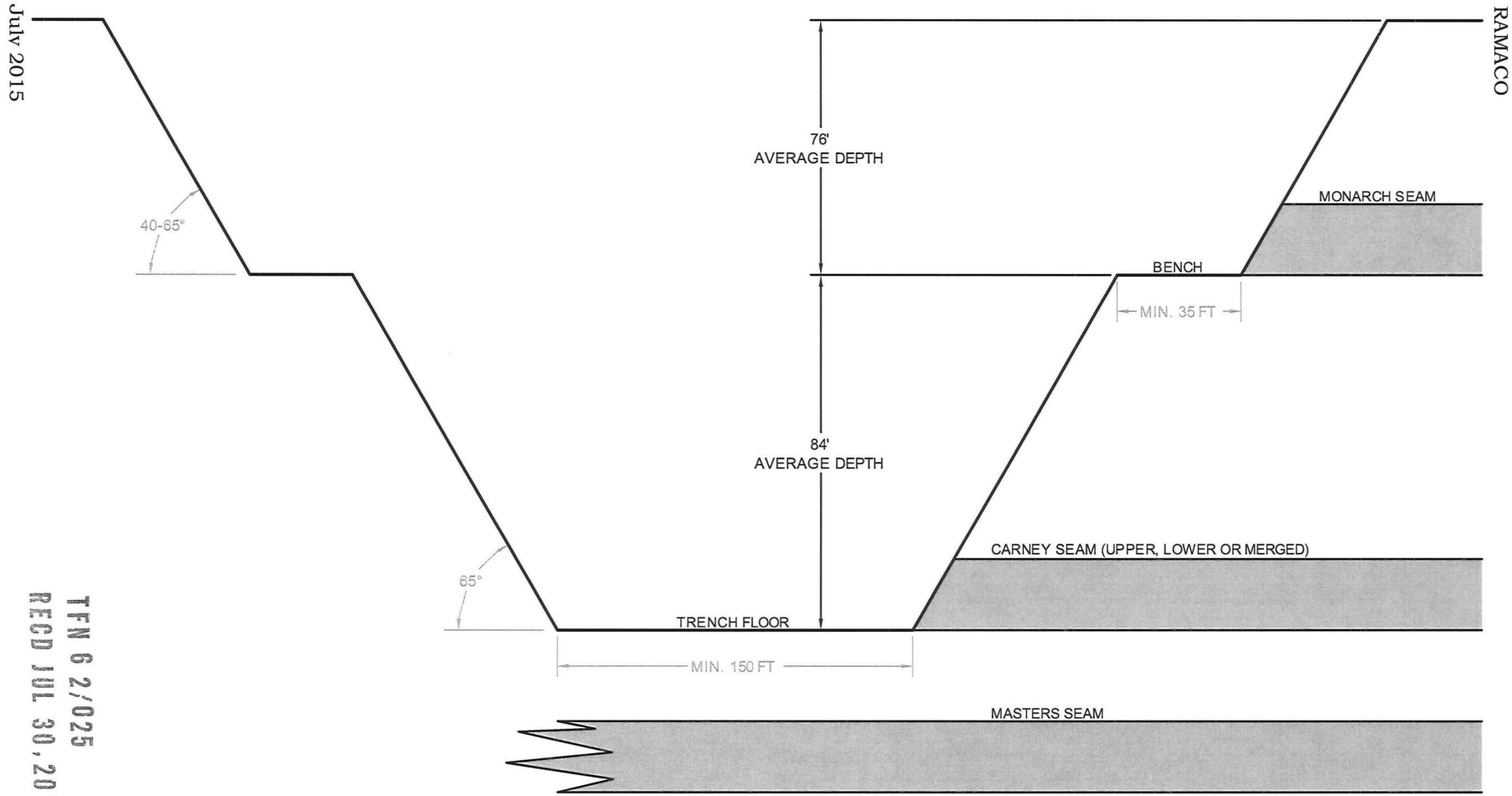


Figure MP.1-1. General Location Map

TFN 6 2/025
RECD NOV 14, 2014

DEQ 12-119



TFN 6 2/025
RECD JUL 30, 2015

Figure MP.1-2. Generalized Trench Cross Section

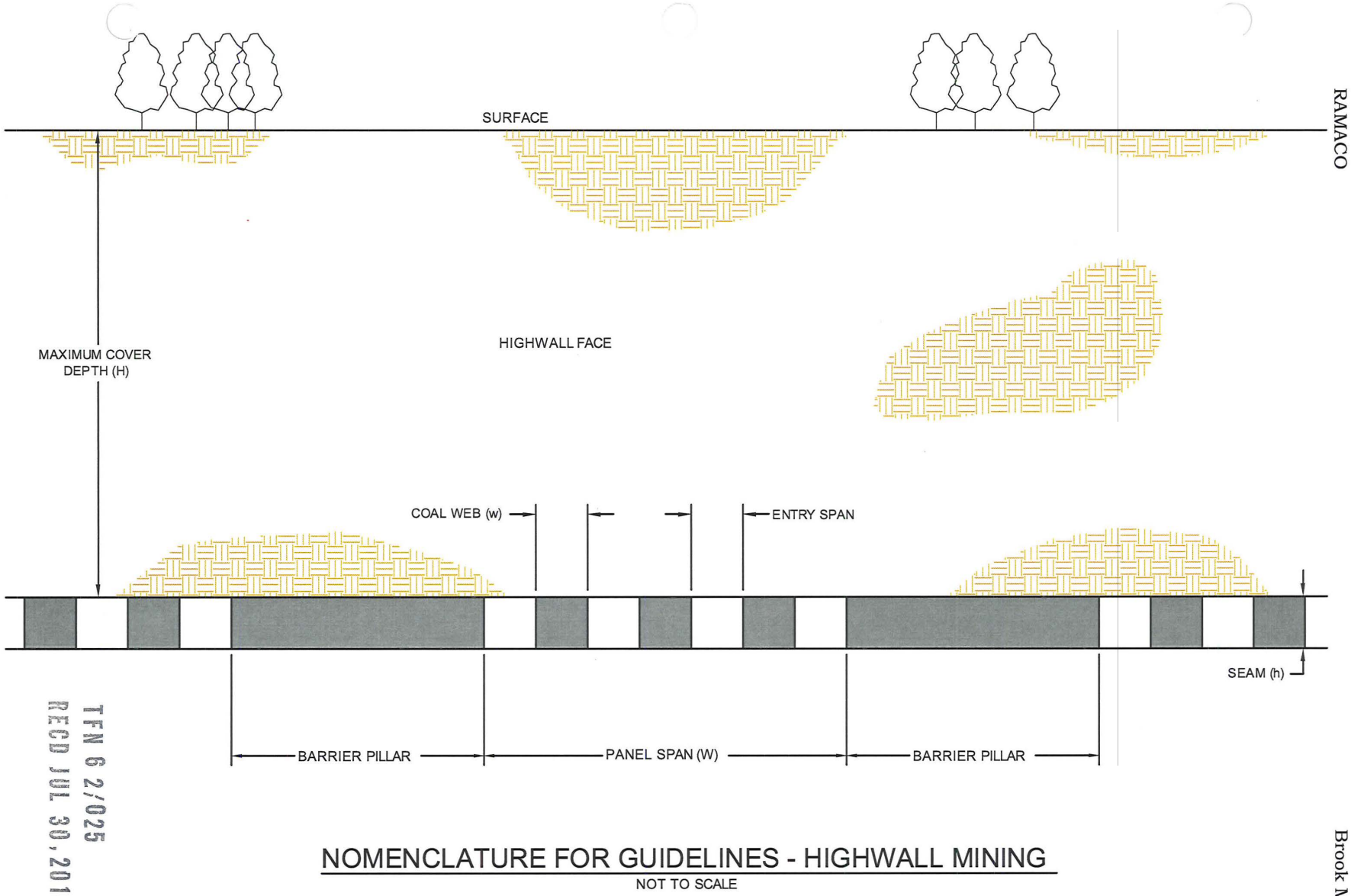
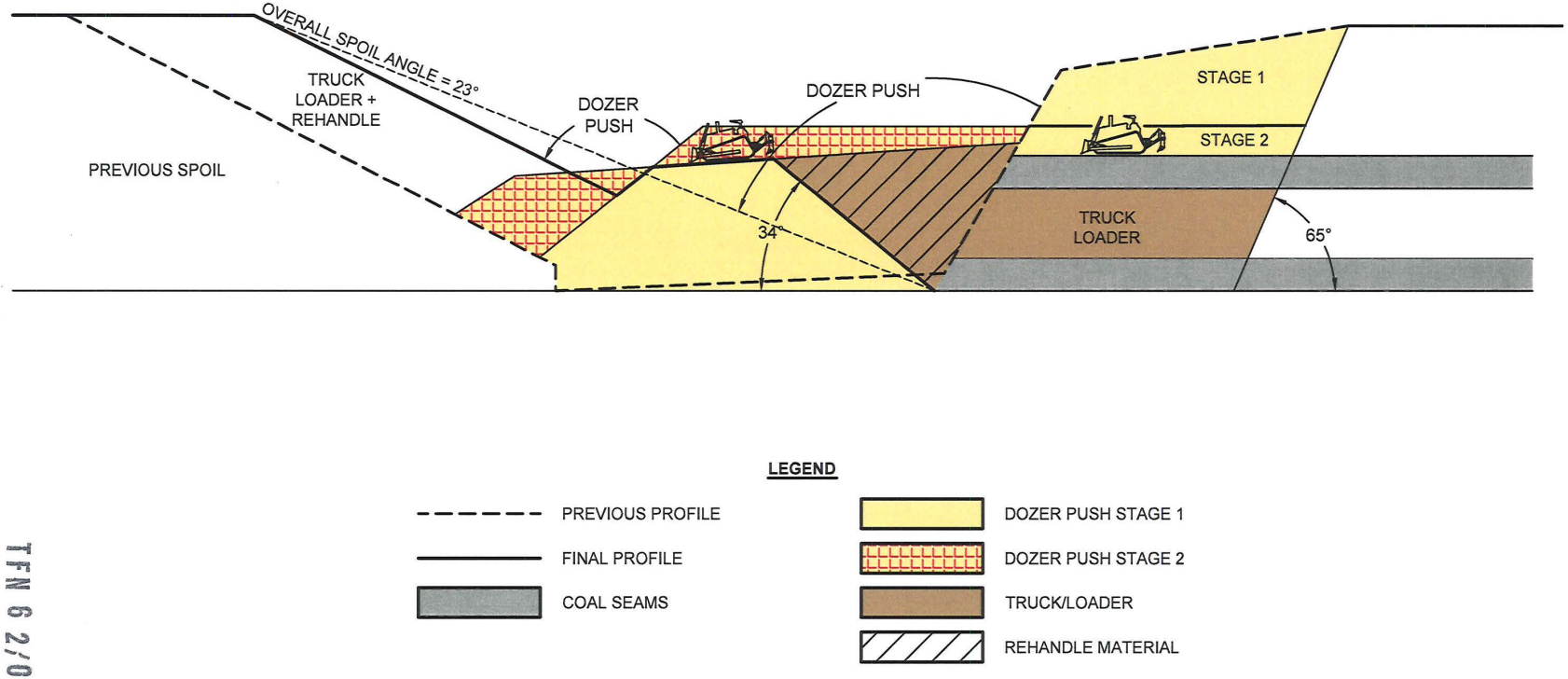
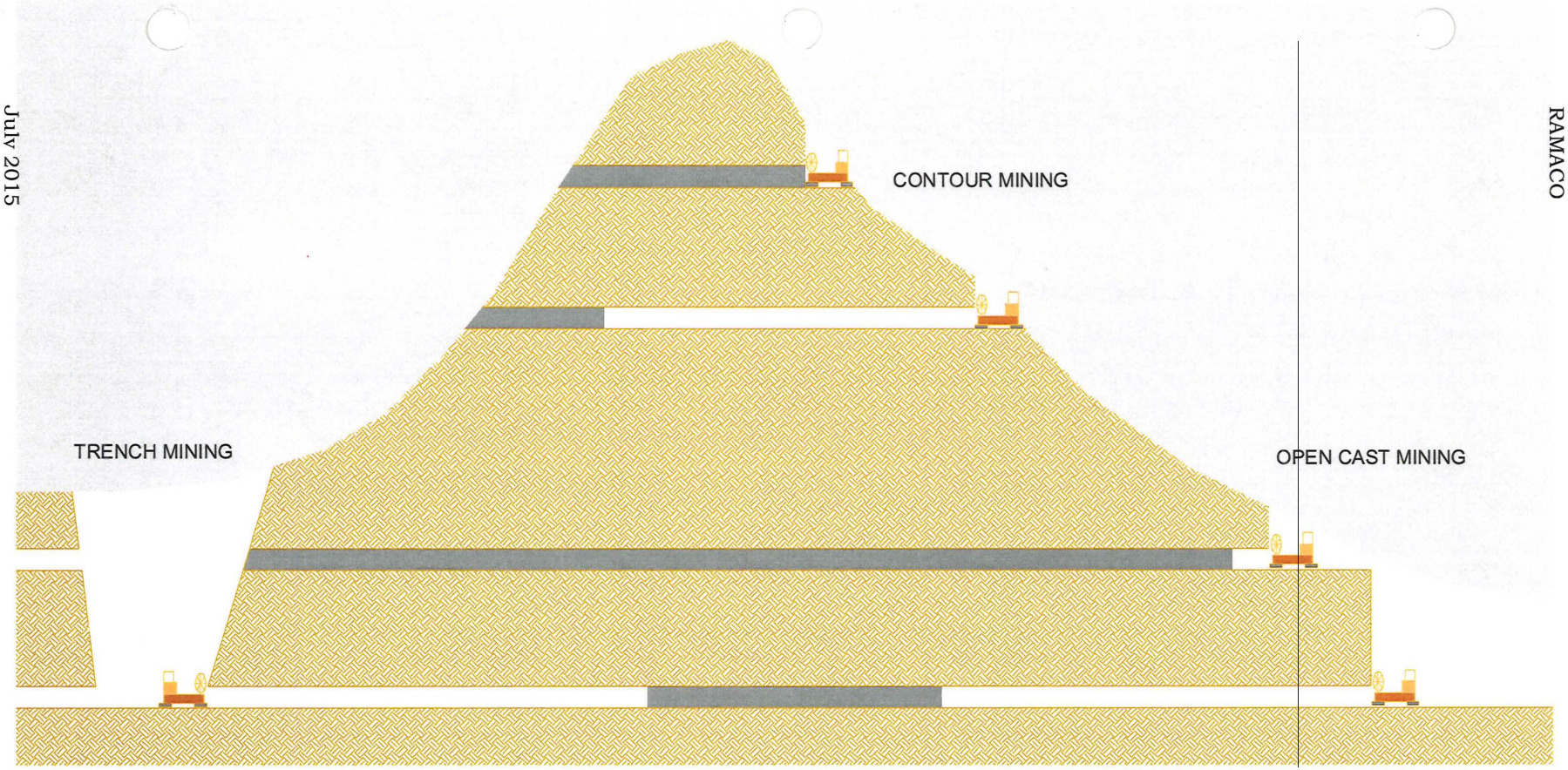


Figure MP.1-3. Generalized Schematic of Highwall Mining Operation



TFN 6 2/025
RECD JUL 30, 2015

Figure MP.1-4. Generalized Schematic of Surface Area Mining Operations



TFN 6 2/025
RECD JUL 30, 2015

Figure MP.1-5. Generalized Schematic of Surface Highwall Mining

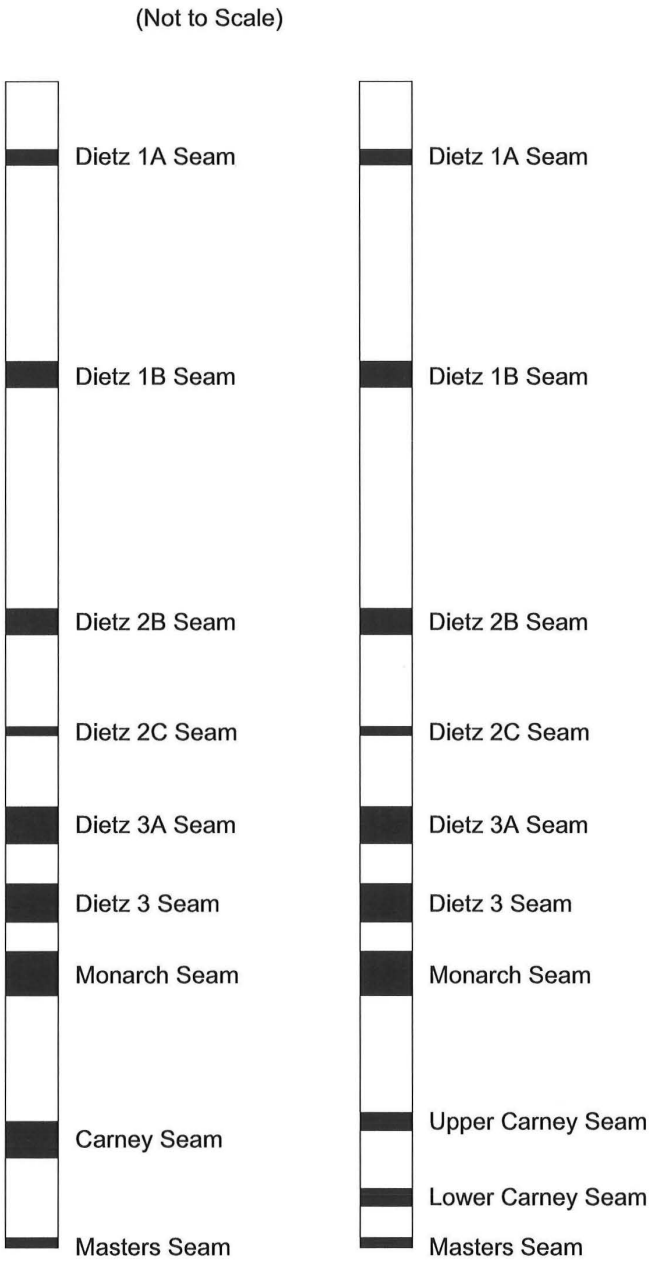


Figure MP.4-1. Generalized Stratigraphic Section with Coal Seams

TFN 6 2/025
RECD JUL 30,2015

DEQ 12-124

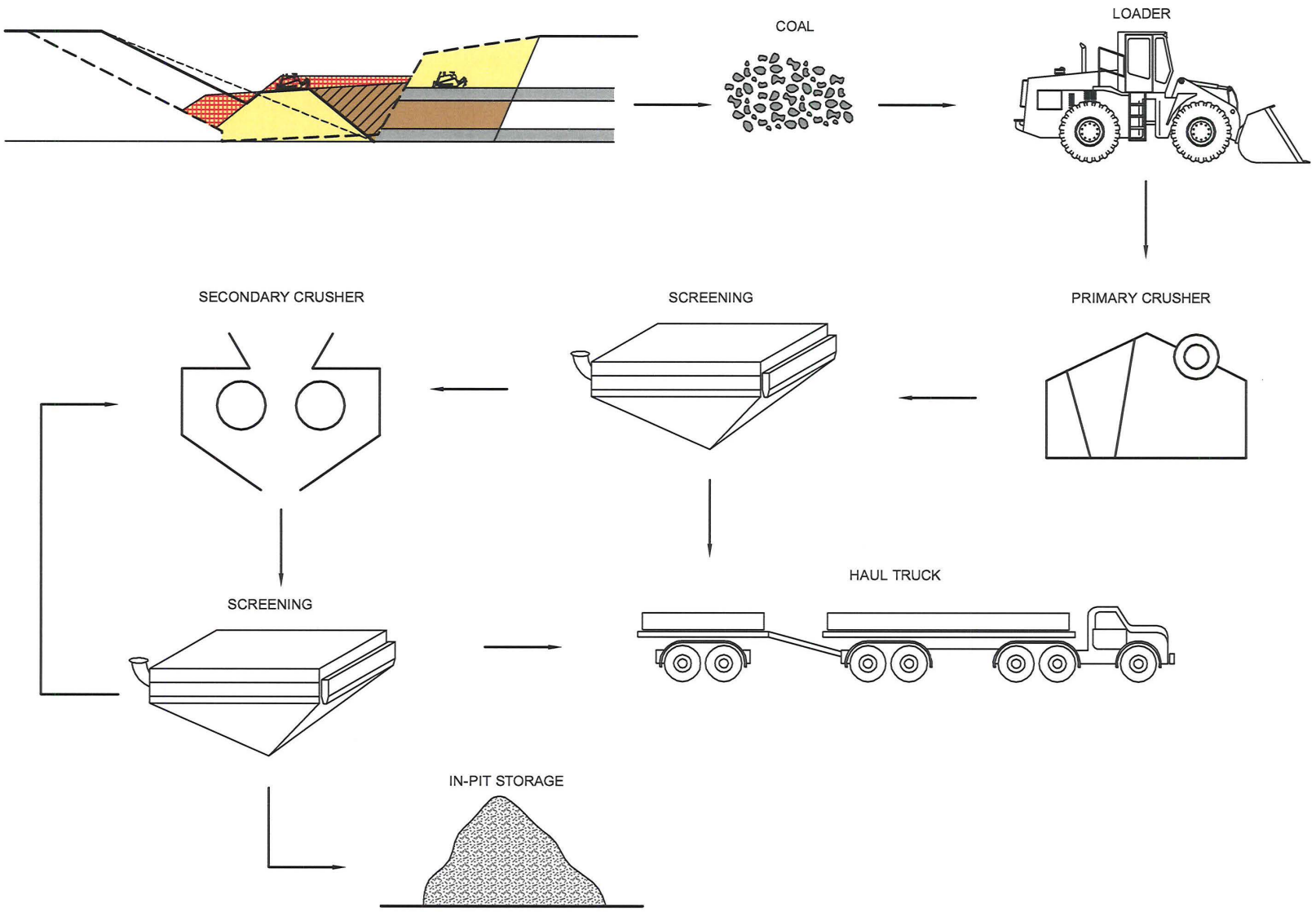
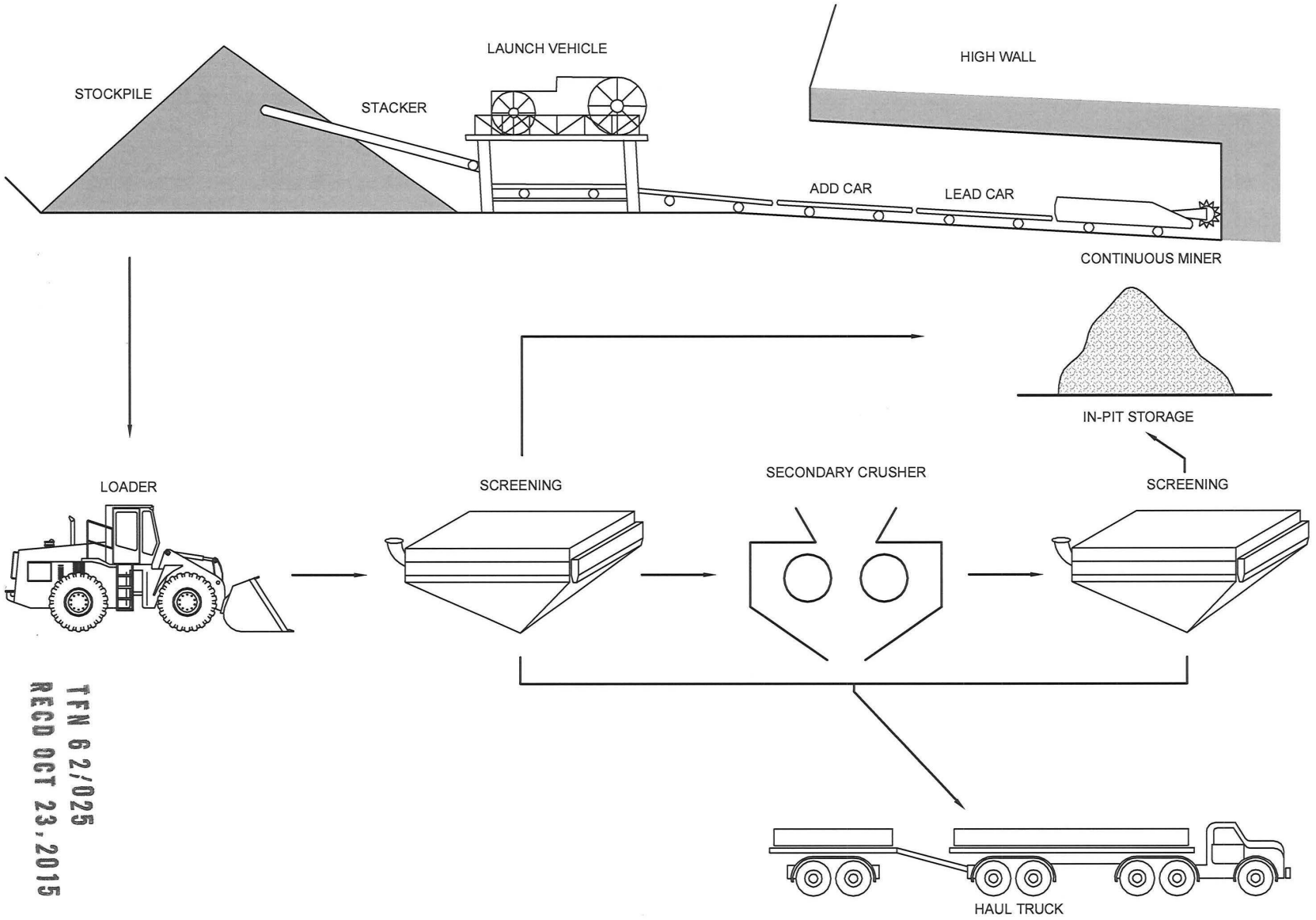


Figure MP.4-2. Surface Mining Process Flow Diagram

TFN 6 2/025
RECD OCT 23, 2015



TFN 6 2/025
RECD OCT 23, 2015

Figure MP.4-3. Highwall Mining Process Flow Design

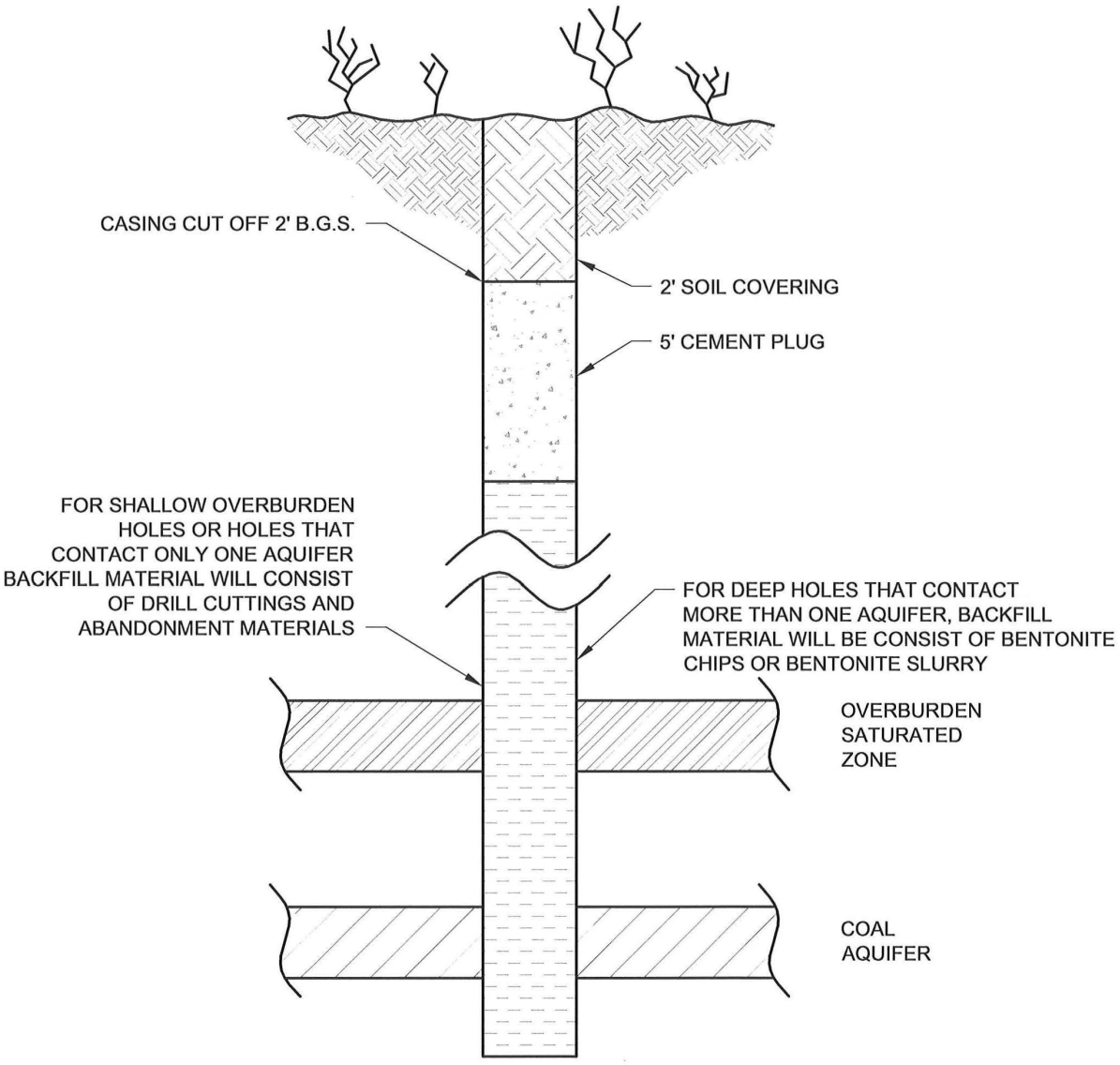
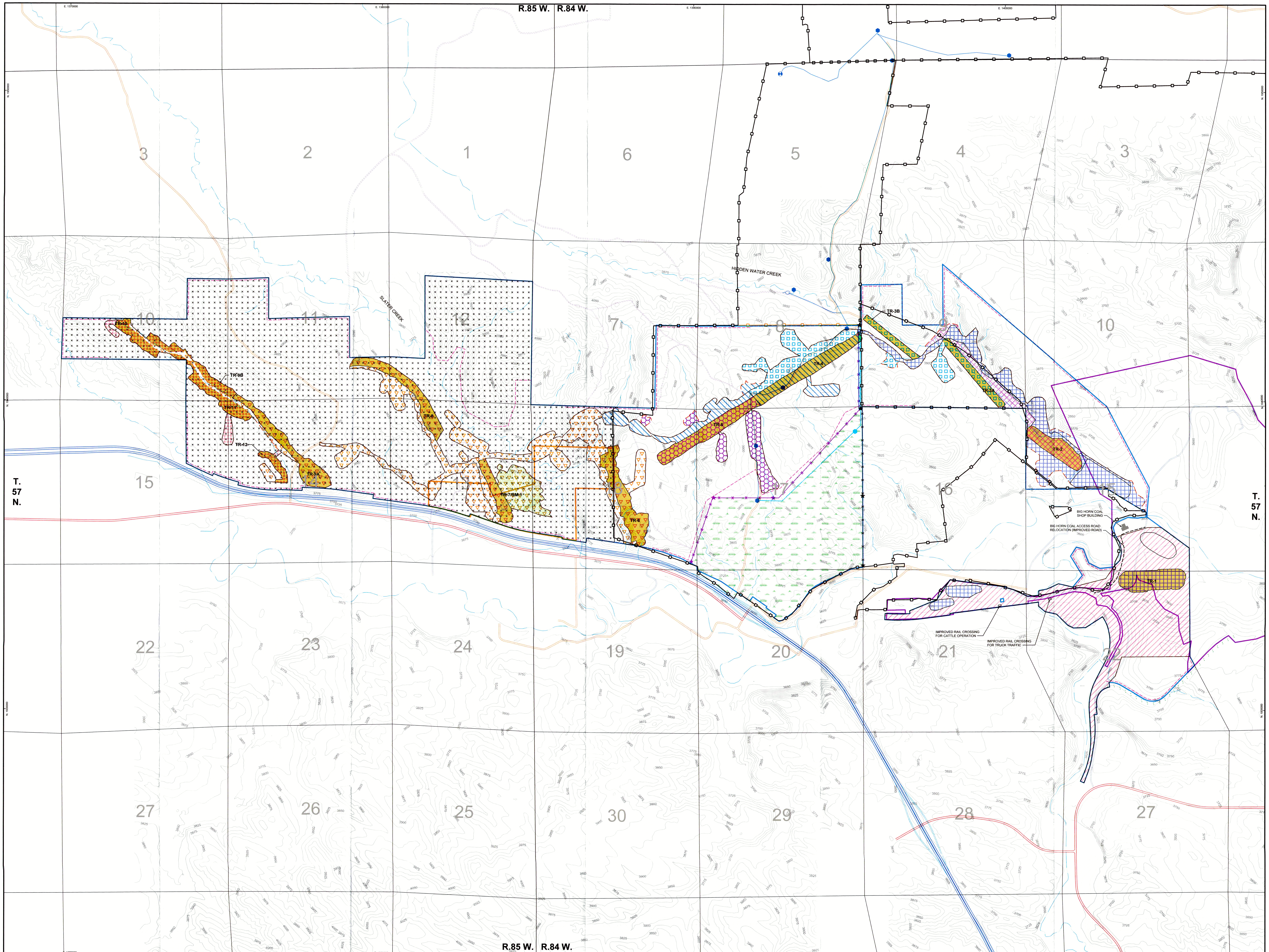


Figure MP.9-1. Typical Backfilling Procedures for Exploration Holes and Wells

TFN 6 2/025
RECD JUL 30,2015

DEQ 12-127



LEGEND

- BROOK MINE PERMIT BOUNDARY
- BIG HORN COAL PERMIT BOUNDARY (PERMIT NO. 213-T7)
- TAYLOR QUARRY PERMIT BOUNDARY (PERMIT NO. SP-757)
- DISTURBANCE BOUNDARY
- AFFECTED AREA BOUNDARY
- DISTURBANCE FOR YEAR 2016
- DISTURBANCE FOR YEAR 2017
- DISTURBANCE FOR YEAR 2018
- DISTURBANCE FOR YEAR 2019
- DISTURBANCE FOR YEAR 2020
- DISTURBANCE FOR YEAR 2021
- DISTURBANCE FOR YEARS 2022 - 2026
- DISTURBANCE FOR YEARS 2027 - 2028
- TRENCH LOCATION
- SURFACE MINE LOCATION
- COAL WITH RESTRICTED MOVEMENT, PROCESSING, LOADING AND SHIPPING
- EXISTING FENCE LOCATION
- UPGRADE TO WYDOT STANDARD PLAN 607-1A TYPE G
- PROPOSED FENCE LOCATION WYDOT STANDARD PLAN 607-1A TYPE G W /METAL T-POSTS AND WOODEN CORNER & BRACE POSTS
- PROPOSED ALT B FENCE LOCATION WYDOT STANDARD PLAN 607-1A TYPE G W/ METAL T-POSTS AND WOODEN CORNER & BRACE POSTS
- EXISTING STOCK TANK WATER LINE
- EXISTING STOCK TANK
- PROPOSED STOCK TANK WATER LINE (EQUIVALENT TO EXISTING)
- PROPOSED STOCK TANK (BURIED CONCRETE FROST FREE, EQUIVALENT TO EXISTING)
- PROPOSED GATE LOCATION (20FT METAL GATE)
- PROPOSED 100' WIDE CATTLE CORRIDOR
- UNIMPROVED ROAD
- IMPROVED ROAD
- COUNTY ROAD
- STATE HIGHWAY
- US HIGHWAY
- INTERSTATE HIGHWAY
- ABANDONED HIGHWAY
- NO MINING ACTIVITY WILL OCCUR IN THIS AREA. THIS AREA IS CONSIDERED QUARANTINED FROM 30 CFR PROGRAM POLICY AND RANCHING IN THE AREA WILL NOT BE EXPOSED TO ACTIVE MINING

N

0 500 1,000 1,500 2,000
GRAPHIC SCALE (FEET)
C.I. = 5'

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY

1101 SUGARVIEW DR. STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
06/15	ROUND 1 COMMENTS
10/15	ROUND 2 COMMENTS
12/15	ROUND 3 COMMENTS

EXHIBIT MP.1-1

SURFACE DISTURBANCE SEQUENCE

LQD
SEP 13 2016
RECEIVED
6/2/025

Drawn By: CIG
Checked By: JGB
Date: 10/08/14

FILE: EX_1-1_SURF_DISTURB_EQC.dwg

WWC ENGINEERING
www.wwcengineering.com

K:\Sheridan\RAMACO\13139\ACAD_WY83EC\DWGS_MINE_PLAN_RESPONSE_EQC\EX_1-1_SURF_DISTURB_EQC.dwg 9/7/2016 8:59:06 AM dave johnson

R.85 W. R.84 W.

MINE PERMIT AND IDENTIFICATION SIGN

EXISTING BUILDING ASSOCIATED WITH TAYLOR QUARRY

MINE PERMIT AND IDENTIFICATION SIGN

MINE PERMIT AND IDENTIFICATION SIGN

EXISTING OVERHEAD POWER

EXISTING SUBSTATION

MINE PERMIT AND IDENTIFICATION SIGN

T. 57 N.

T. 57 N.

TO SHERIDAN 7 MILES

R.85 W. R.84 W.

Drawing Coordinates: WY83ECF

LEGEND

- BROOK MINE PERMIT BOUNDARY
- BIG HORN COAL PERMIT BOUNDARY (PERMIT NO. 213-T7)
- TAYLOR QUARRY PERMIT BOUNDARY (PERMIT NO. SP-757)
- STATE HIGHWAY
- INTERSTATE
- UNIMPROVED ROADS
- RAILROAD

N

0 500 1,000 1,500 2,000

GRAPHIC SCALE (FEET)
C.I. = 20'

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY

1101 SUGARVIEW DR. STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
06/15	ROUND 1 COMMENTS
10/15	ROUND 2 COMMENTS

EXHIBIT MP.2-1

TFN 6 2/025
RECD OCT 23, 2015

FACILITIES MAP

Drawn By: DCJ
Checked By: JGB
Date: 10/08/2014

WWC ENGINEERING
www.wwcengineering.com

FILE: EX_2-1_RAMACO_BUILDING_LOC_R2.dwg

R.85 W. R.84 W.

E. 1375000 E. 1380000 E. 1385000 E. 1390000 E. 1395000 E. 1400000 E. 1405000

N. 1945000 N. 1940000 N. 1935000 N. 1930000 N. 1925000

T. 57 N.

HIDDEN WATER CREEK

SLATER CREEK

SLATER CREEK ROAD

SOUTH ASH CREEK ROAD

HIDDEN WATER ROAD

FUTURE HAULROAD

HAULROAD 3

HAULROAD 2

BRIDGE WILL NOT BE USED

WYO 345

ACME ROAD

SECONDARY INGRESS/EGRESS

KLEENBURN ROAD

BNSF MAIN RAILWAY

PRIMARY INGRESS/EGRESS

EXISTING ACCESS ROAD

WYO338

WYO339

NOTE: MAP COORDINATE PROJECTION IS WY 83 EC

LEGEND

- BROOK MINE PERMIT BOUNDARY
- BIG HORN COAL PERMIT BOUNDARY (PERMIT NO. 213-T7)
- TAYLOR QUARRY PERMIT BOUNDARY (PERMIT NO. SP-757)
- RAILROAD
- PRIMARY HAUL ROADS
- SURFACE MINING
- HIGHWALL MINING PANELS
- UNIMPROVED ROAD
- IMPROVED ROAD (USED FOR COAL HAULAGE)
- COUNTY ROAD
- STATE HIGHWAY
- US HIGHWAY
- INTERSTATE HIGHWAY
- ABANDONED HIGHWAY

GRAPHIC SCALE (FEET) 0 500 1,000 1,500 2,000 C.I. = 5'

LQD

SEP 1 2016

RECEIVED

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGARVIEW DR. STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
06/15	ROUND 1 COMMENTS
10/15	ROUND 2 COMMENTS
12/15	ROUND 3 COMMENTS

EXHIBIT MP.3-1

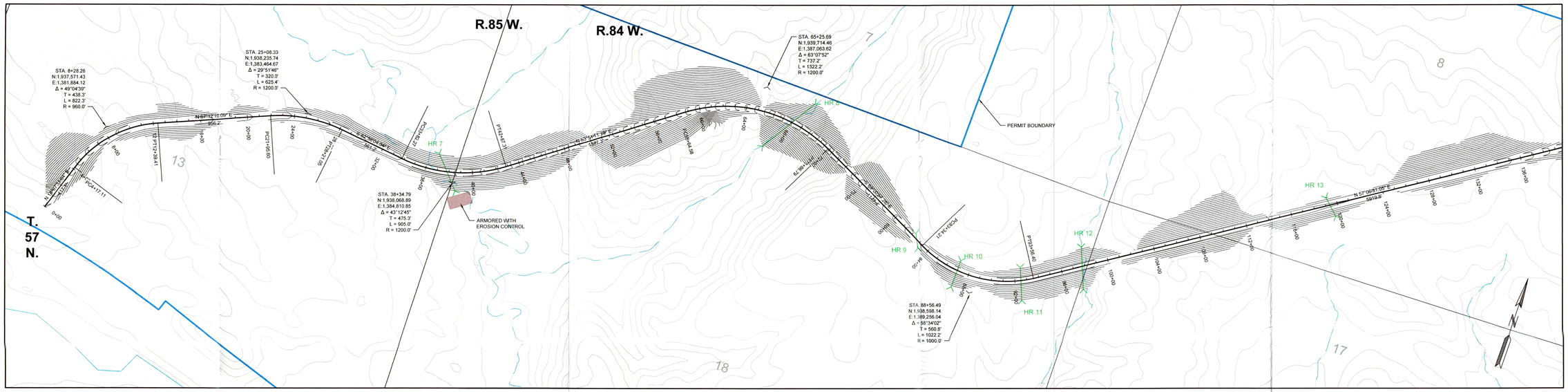
TRANSPORTATION NETWORK

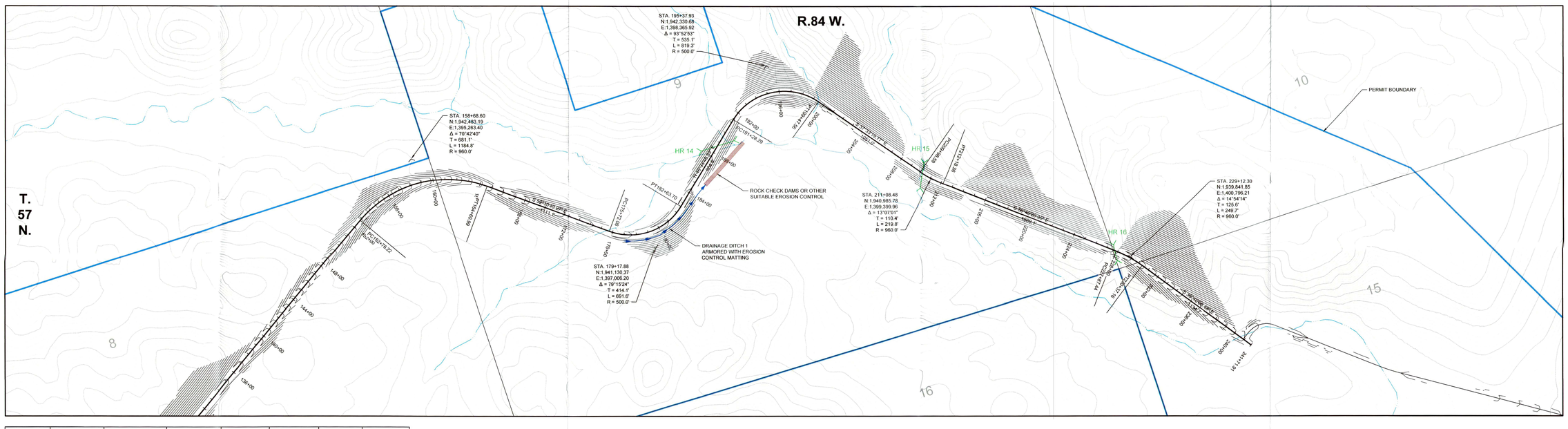
2/6/2025

Drawn By: DCJ
Checked By: JGB
Date: 10/08/2014

WWC ENGINEERING
www.wwcengineering.com

FILE: EX_3-1_HAUL_ROADS_LOC_EQC.dwg





Culvert No.	Location	Drainage Area (ac)	Peak Flow (cfs)	Design Storm	No. of Culverts	Diameter (in)	Approxmiate Length (ft)
HR 6	HAULROAD 3	41.1	45.4	10 YR, 24 HR	1	36	300
HR 7	HAULROAD 3	10530.0	1467.0	10 YR, 24 HR	4	72	345
HR 8	HAULROAD 3	137.0	108.9	10 YR, 24 HR	1	48	575
HR 9	HAULROAD 3	24.4	21.1	10 YR, 24 HR	2	24	125
HR 10	HAULROAD 3	5.7	9.5	10 YR, 24 HR	1	24	235
HR 11	HAULROAD 3	7.3	11.5	10 YR, 24 HR	1	24	280
HR 12	HAULROAD 3	96.4	71.4	10 YR, 24 HR	2	30	360
HR 13	HAULROAD 3	33.9	39.0	10 YR, 24 HR	1	36	180
HR 14	HAULROAD 3	98.2	892.4	10 YR, 24 HR	3	72	295
HR 15	HAULROAD 3	106.3	110.8	10 YR, 24 HR	1	48	225
HR 16	HAULROAD 3	43.2	54.0	10 YR, 24 HR	2	30	140
HR 17	HAULROAD 2	60.1	64.0	10 YR, 24 HR	2	30	50

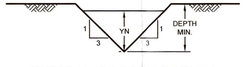
Notes: Peak flows were estimated using the rainfall/ runoff program HEC-HMS.

COLLECTOR DITCH HYDRAULICS

DRAINAGE DITCH 1

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$$

Q =	93.40 cfs	WP =	13.16 ft
n =	0.025	R =	0.99 ft
S =	0.0149 ft/ft	V =	7.19 fps
A =	12.99 ft^2	Yn =	2.08 ft



TYPICAL CROSS SECTION

NOT TO SCALE

HAULROAD 3 PLAN VIEW

SCALE: 1" = 400'
C.I. = 5'

LEGEND

BROOK MINE PERMIT BOUNDARY

HR 6 — CULVERT

CERTIFICATE OF ENGINEER

I, Jeffrey G. Barron, hereby certify that this drawing was prepared by myself or by engineers under my direct supervision and that it correctly represents the conditions described in the accompanying application which is designed to meet the requirements of the Wyoming Environmental Quality Act and its accompanying regulations.

Professional Engineer (Civil) — JEFFREY G. BARRON — 13033 — WYOMING — DATE: 7/10/2015

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGARVIEW DR, STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
06/15	ROUND 1 COMMENTS

EXHIBIT MP.3-2 — **SHEET 1 OF 2**

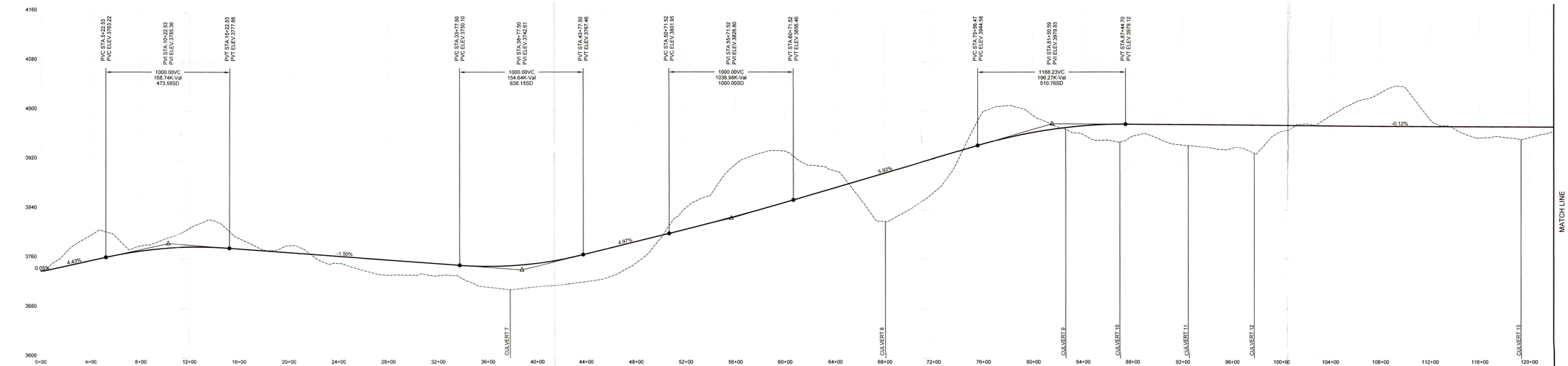
TFN 6 2/025
RECD JUL 30,2015

HAULROAD PLAN AND PROFILE

Drawn By: DCJ
Checked By: JGB
Date: 6-6-13

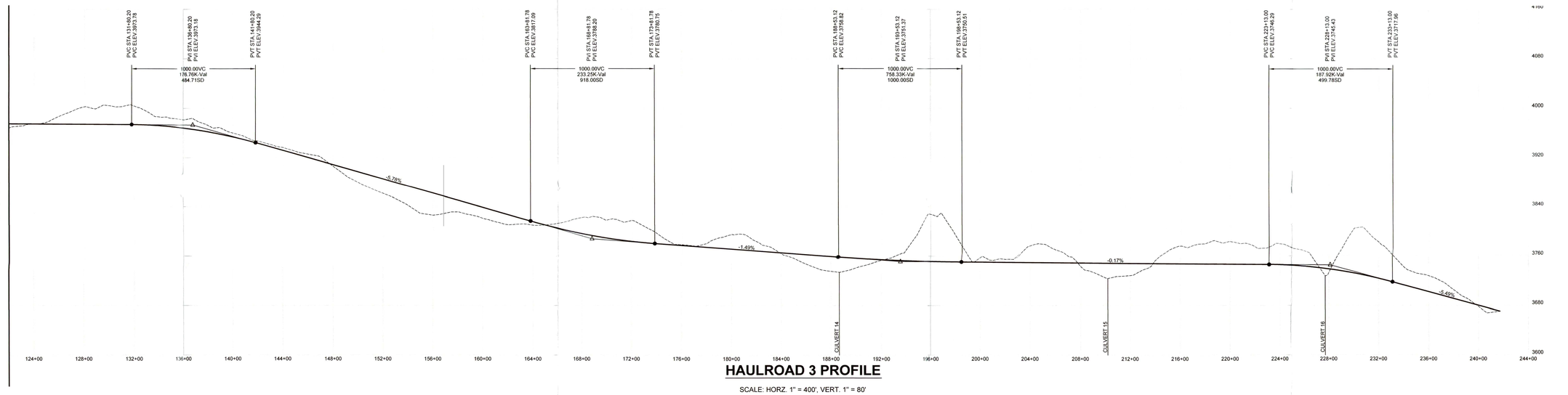
WWC ENGINEERING
www.wwcengineering.com

FILE: EX_3-2_HAUL_ROADS_R1.dwg



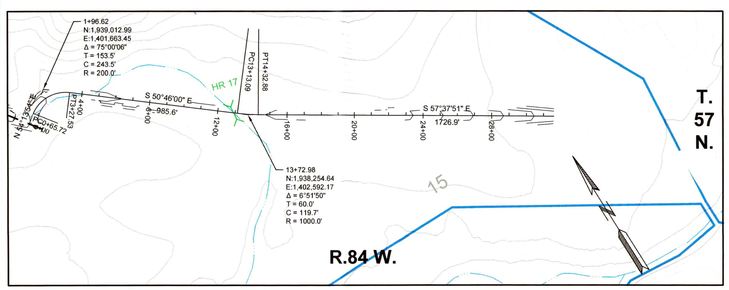
HAULROAD 3 PROFILE

SCALE: HORZ. 1" = 400', VERT. 1" = 80'



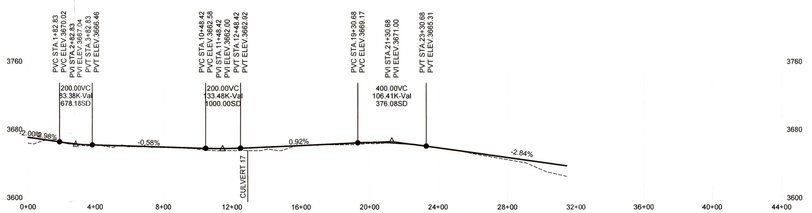
HAULROAD 3 PROFILE

SCALE: HORZ. 1" = 400', VERT. 1" = 80'



HAULROAD 2 PLAN VIEW

SCALE: 1" = 400'



HAULROAD 2 PROFILE

SCALE: HORZ. 1" = 400', VERT. 1" = 80'

LEGEND

- EXISTING GROUND
- FINISHED GROUND
- HR 6 — CULVERT

TFN 6 2/025
RECD JUL 30,2015

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGARVIEW DR, STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
06/15	ROUND 1 COMMENTS

EXHIBIT MP.3-2 — SHEET 2 OF 2

HAULROAD PLAN AND PROFILE

Drawn By:	DCJ
Checked By:	JGB
Date:	6-6-13

FILE: EX_3-2_HAUL_ROADS_R1.dwg

WWC ENGINEERING
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K:\Drawings\RAMACO\1119\MXD\AD_WWB\EXHIBITS\MP3_MINE_PLAN_RESPONSE\EX_3-2_HAUL_ROADS_R1.dwg - 7/8/2015 2:55:50 PM dave johnson

R.85 W. R.84 W.

T. 57 N.

T. 57 N.

R.85 W. R.84 W.

HIDDEN WATER CREEK

SLATER CREEK

TR-10

TR-9B

TR-11

TR-12

TR-9A

TR-8

TR-7/SM-1

TR-6

TR-5

TR-4

TR-3B

TR-3A

TR-2

TR-1

Drawing Coordinates: WY83ECF

LEGEND

- BROOK MINE PERMIT BOUNDARY
- BIG HORN COAL PERMIT BOUNDARY (PERMIT NO. 213-T7)
- TAYLOR QUARRY PERMIT BOUNDARY (PERMIT NO. SP-757)
- AFFECTED AREA BOUNDARY
- DISTURBANCE BOUNDARY

COAL REMOVAL SEQUENCE

- YEAR 1
- YEAR 2
- YEAR 3
- YEAR 4
- YEAR 5
- YEARS 6 - 10
- YEARS 11 - 12
- MONTH 1
- MONTH 2
- MONTH 3
- MONTH 4
- MONTH 5
- MONTH 6
- MONTH 7
- MONTH 8
- MONTH 9
- MONTH 10
- MONTH 11
- MONTH 12

NOTE:
YEAR 1 CORRESPONDS TO YEAR 2017.

GRAPHIC SCALE (FEET)
0 500 1,000 1,500 2,000
C.I. = 5

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGARVIEW DR, STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
05/15	ROUND 1 COMMENTS
10/15	ROUND 2 COMMENTS
12/15	ROUND 3 COMMENTS

EXHIBIT MP.4-1

TFN 6 2/025
RECD DEC 18, 2015

COAL REMOVAL SEQUENCE

Drawn By: CIG
Checked By: JGB
Date: 6/18/14

FILE: EX_4-1_COAL_REMOVAL_R3.dwg

WWC ENGINEERING
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K:\Sheridan\RAMACO\119\RACO_WYBECDW05_MINE_PLAN_RESPONSE_NOV_4-1_COAL_REMOVAL_R3.dwg 12/2/2015 11:53:17 AM steve johnson

R.85 W. R.84 W.

T. 57 N.

HIDDEN WATER CREEK

SLATER CREEK

R.85 W. R.84 W.

T. 57 N.

LEGEND

- BROOK MINE PERMIT BOUNDARY
- DISTURBANCE BOUNDARY
- AFFECTED AREA BOUNDARY
- BIG HORN COAL PERMIT BOUNDARY (PERMIT NO. 213-T7)
- TAYLOR QUARRY PERMIT BOUNDARY (PERMIT NO. SP-757)

TOPSOIL REMOVAL SEQUENCE

- YEAR 0
- YEAR 1
- YEAR 2
- YEAR 3
- YEAR 4
- YEAR 5
- YEARS 6 - 10
- YEARS 11 - 12

NOTE:
YEAR 0 CORRESPONDS TO YEAR 2016.

NAMING CONVENTION

HR	HAULROAD
TR	TRENCH/SURFACE MINING
OB	OVERBURDEN STOCKPILE
DD	DIVERSION DITCH
SP	SEDIMENT POND
FC	FLOOD CONTROL RESERVOIR

SOIL NAMING CONVENTION

MAP UNIT A: CAMBRIA LOAM, 2 TO 8% SLOPES
MAP UNIT B: ZIGWEID LOAM, IRRIGATED, 0 TO 3% SLOPES
MAP UNIT C: FORKWOOD LOAM, 4 TO 25% SLOPES
MAP UNIT D: SHINGLE CHANNERY LOAM, 2 TO 25% SLOPES
MAP UNIT E: SAMDAY CLAY LOAM, 2 TO 25% SLOPES
MAP UNIT F: SAMDAY-ROCK OUTCROP COMPLEX
MAP UNIT G: BAUXSON LOAM, 4 TO 25% SLOPES
MAP UNIT H: HAVERDAD LOAM, 2 TO 15% SLOPES
MAP UNIT U: ULM CLAY LOAM, IRRIGATED, 0 TO 3% SLOPES
MAP UNIT WO: WORTHENTON CLAY LOAM, 0 TO 3% SLOPES
MAP UNIT WX: WIBAUX CHANNERY LOAM, 2 TO 20% SLOPES
MAP UNIT WX-RO: WIBAUX-ROCK OUTCROP COMPLEX, STEEP
MAP UNIT RL: RECLAIMED LAND
MAP UNIT RO: ROCK OUTCROP
MAP UNIT W: WATER
MAP UNIT DL: DISTURBED LAND
MAP UNIT XXX: UNCLASSIFIED SOIL TYPE

N

0 500 1,000 1,500 2,000
GRAPHIC SCALE (FEET)
C.I. = 5'

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGARVIEW DR, STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
06/15	ROUND 1 COMMENTS
10/15	ROUND 2 COMMENTS
12/15	ROUND 3 COMMENTS

EXHIBIT MP.4-2

TFN 6 2/025
RECD DEC 18,2015

TOPSOIL REMOVAL SEQUENCE

Drawn By: CIG
Checked By: JGB
Date: 6/18/14

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FILE: EX_4-2_TOPSOIL_REMOVE_R3.dwg

X:\Division\RAMACO\2113\RACAD_MYRED\CIVIL\MINE_PLAN_RESPONSE_REC\4-2_TOPSOIL_REMOVE_R3.dwg 12/4/2015 11:58:22 AM dave.johnson

R.85 W. R.84 W.

T. 57 N.

HIDDEN WATER CREEK

SLATER CREEK

TS-11 TS-8 TS-10 TS-9 TS-7 TS-6 TS-4 TS-5 TS-3A TS-3B TS-2 TS-1A TS-1B

OB-14 OB-13 OB-12 OB-10 OB-16 OB-15 OB-11 OB-9 OB-8 OB-7 OB-6 OB-5 OB-4 OB-3 OB-2 OB-1

R.85 W. R.84 W.

Drawing Coordinates: WY83ECF

LEGEND

- BROOK MINE PERMIT BOUNDARY
- BIG HORN COAL PERMIT BOUNDARY (PERMIT NO. 213-T7)
- TAYLOR QUARRY PERMIT BOUNDARY (PERMIT NO. SP-757)
- AFFECTED AREA BOUNDARY
- DISTURBANCE BOUNDARY
- TS-1 TOPSOIL STOCKPILE
- OB-1 OVERBURDEN STOCKPILE

N

0 500 1,000 1,500 2,000
GRAPHIC SCALE (FEET)
C.I. = 5'

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGARVIEW DR, STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
05/15	ROUND 1 COMMENTS
10/15	ROUND 2 COMMENTS
12/15	ROUND 3 COMMENTS

EXHIBIT MP.4-3

TFN 6 2/025
RECD DEC 18, 2015

STOCKPILE LOCATIONS

Drawn By: DCJ
Checked By: JGB
Date: 7/8/14

FILE: EX_4-3_STOCKPILE_LOC_R3.dwg

WWC ENGINEERING
www.wwcengineering.com

R.85 W. R.84 W.

T. 57 N.

HIDDEN WATER CREEK

SLATER CREEK

TR-10 TR-9B TR-11 TR-12 TR-9A TR-8 TR-7/SM-1 TR-6 TR-5 TR-4 TR-3B TR-3A TR-2 TR-1

R.85 W. R.84 W.

Drawing Coordinates: WY83ECF

LEGEND

- BROOK MINE PERMIT BOUNDARY
- BIG HORN COAL PERMIT BOUNDARY (PERMIT NO. 213-T7)
- TAYLOR QUARRY PERMIT BOUNDARY (PERMIT NO. SP-757)
- AFFECTED AREA BOUNDARY
- DISTURBANCE BOUNDARY

YEAR 1
YEAR 2
YEAR 3
YEAR 4
YEAR 5

NOTE:
YEAR 1 CORRESPONDS TO YEAR 2017.

OVERBURDEN REMOVAL SEQUENCE

YEARS 6 - 10
YEARS 11 - 12

MONTH 1
MONTH 2
MONTH 3
MONTH 4
MONTH 5
MONTH 6
MONTH 7
MONTH 8
MONTH 9
MONTH 10
MONTH 11
MONTH 12

N

0 500 1,000 1,500 2,000
GRAPHIC SCALE (FEET)
C.I. = 5'

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY

1101 SUGARVIEW DR, STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
06/15	ROUND 1 COMMENTS
10/15	ROUND 2 COMMENTS
12/15	ROUND 3 COMMENTS

EXHIBIT MP.4-4

TFN 6 2/025
RECD DEC 18, 2015

OVERBURDEN REMOVAL SEQUENCE

Drawn By:	CIG
Checked By:	JGB
Date:	7/13/2015

WWC ENGINEERING
www.wwcengineering.com

FILE: EX_4-4_OVERBURDEN_REMOVE_SEQ_R3.dwg

R.85 W. R.84 W.

HIDDEN WATER CREEK

SLATER CREEK

T. 57 N.

T. 57 N.

R.85 W. R.84 W.

Drawing Coordinates: WY83ECF

LEGEND

- BROOK MINE PERMIT BOUNDARY
- BIG HORN COAL PERMIT BOUNDARY (PERMIT NO. 213-T7)
- TAYLOR QUARRY PERMIT BOUNDARY (PERMIT NO. SP-757)
- AFFECTED AREA BOUNDARY
- DISTURBANCE BOUNDARY

SPOIL BACKFILLING SEQUENCE

- YEAR 2
- YEAR 3
- YEAR 4
- YEAR 5
- YEARS 6 - 10
- YEARS 11 - 12
- MONTH 1
- MONTH 2
- MONTH 3
- MONTH 4
- MONTH 5
- MONTH 6
- MONTH 7
- MONTH 8
- MONTH 9
- MONTH 10
- MONTH 11
- MONTH 12

NOTE:
YEAR 2 CORRESPONDS TO YEAR 2018.

GRAPHIC SCALE (FEET)
0 500 1,000 1,500 2,000
C.I. = 5'

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGARVIEW DR, STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
06/15	ROUND 1 COMMENTS
10/15	ROUND 2 COMMENTS
12/15	ROUND 3 COMMENTS

EXHIBIT MP.4-5

TFN 6 2/025
RECD DEC 18, 2015

SPOIL BACKFILLING SEQUENCE

Drawn By: CIG
Checked By: JGB
Date: 6/18/14

WWC ENGINEERING
www.wwcengineering.com

FILE: EX_4-5_SPOIL_BACKFILL_R3.dwg

R.85 W. R.84 W.

T. 57 N.

DAN DRAW
SLATER CREEK
HIDDEN WATER CREEK
EAST FORK EARLEY CREEK
TONGUE RIVER DITCH
TONGUE RIVER
GOOSE CREEK

TS-1 TR-9A TR-9B TS-10 TR-10 TR-12 TS-9 TR-9A OB-16 OB-15 TS-8 OB-14 TR-8 OB-13 OB-12 TS-7 OB-11 OB-10 TS-6 TR-7/SM-1 TR-6 OB-9 FC-4 FC-3 TR-5 TS-4 FC-2 TS-5 OB-8 ST-7 TS-3B TS-3A OB-7 TR-4 OB-6 TR-3B FC-1 OB-5 TR-3A TR-2 TS-2 SP-6 OB-4 SP-3 OB-3 SP-8 TS-1A SP-4 TR-1 SP-1 OB-2 OB-1 SP-2 TS-1B SP-5

LEGEND

- BROOK MINE PERMIT BOUNDARY
- BIG HORN COAL PERMIT BOUNDARY (PERMIT NO. 213-T7)
- TAYLOR QUARRY PERMIT BOUNDARY (PERMIT NO. SP-757)
- AFFECTED AREA BOUNDARY
- DISTURBANCE BOUNDARY
- CLASS 1 AND CLASS 2 STREAM 1/2 MILE BUFFER
- INTERMITTENT STREAM 100 FOOT BUFFER
- SURFACE ROUGHENING
- COLLECTOR DITCH
- DIVERSION DITCH
- CHECK DAM
- SILT FENCE
- STRAW WATTLE
- SEDIMENT TRAPS
- SEDIMENT BASIN
- EROSION SEEDING
- EARTHEN BERM
- TS-1 TOPSOIL STOCKPILE
- OB-1 OVERBURDEN STOCKPILE
- IMPOUNDMENT
- DISTURBANCE FOR YEAR 2016
- DISTURBANCE FOR YEAR 2017
- DISTURBANCE FOR YEAR 2018
- DISTURBANCE FOR YEAR 2019
- DISTURBANCE FOR YEAR 2020
- DISTURBANCE FOR YEAR 2021
- DISTURBANCE FOR YEARS 2022 - 2026
- DISTURBANCE FOR YEARS 2027 - 2028
- TRENCH LOCATION
- SURFACE MINE LOCATION

NOTE: 1. REFER TO ADDENDUM MP-2 FOR IMPOUNDMENT DESIGNS.
2. ASCMS WILL NOT BE USED AS THE PRIMARY FORM OF SEDIMENT CONTROL WITHIN A HALF MILE OF CLASS 1 AND CLASS 2 STREAMS.
3. NO SHOWN ASCMS HAVE DRAINAGE AREAS GREATER THAN 30 ACRES.

CERTIFICATE OF ENGINEER

I, Jeffrey G. Barron, hereby certify that this drawing was prepared by myself or by engineers under my direct supervision and that it correctly represents the conditions described in the accompanying application which is designed to meet the requirements of the Wyoming Environmental Quality Act and its accompanying regulations.

Professional Engineer (Civil) JEFFREY G. BARRON 13033 REGISTERED DATE 12/17/15 WYOMING

0 500 1,000 1,500 2,000
GRAPHIC SCALE (FEET)
C.I. = 5'

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGARVIEW DR, STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
06/15	ROUND 1 COMMENTS
10/15	ROUND 2 COMMENTS
12/15	ROUND 3 COMMENTS

EXHIBIT MP.5-1

TFN 6 2/025
RECD DEC 18, 2015

HYDROLOGIC CONTROL PLAN

Drawn By: CIG
Checked By: JGB
Date: 10/05/14

WWC ENGINEERING
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FILE: EX_5-1_HYDRO_CONTROL_R3.dwg

DEQ 12-139

HIDDEN WATER CREEK

SLATER CREEK

TONGUE RIVER DITCH

TONGUE RIVER

TONGUE RIVER

YEAR 3 DIVERSION

YEAR 2 DIVERSION

YEAR 1 DIVERSION

T. 57 N.

11 12 7 8 9 10

14 13 18 17 15

23 24 19 20 21 22

26 25 30 29 28 27

LEGEND

- BROOK MINE PERMIT BOUNDARY
- BIG HORN COAL PERMIT BOUNDARY (PERMIT NO. 213-T7)
- AFFECTED AREA BOUNDARY
- DISTURBANCE BOUNDARY

CERTIFICATE OF ENGINEER

I, Dale E. Brown, hereby certify that this drawing was prepared by myself or by engineers under my direct supervision and that it correctly represents the conditions described in the accompanying application which is designed to meet the requirements of the Wyoming Environmental Quality Act and its accompanying regulations.

Professional Engineer (Civil) Dale E. Brown 6931 STATE OF WYOMING

DATE 10/14/2015

N

0 500 1,000 1,500 2,000

GRAPHIC SCALE (FEET)
C.I. = 5'

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY

1101 SUGARVIEW DR, STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
06/15	ROUND 1 COMMENTS
10/15	ROUND 2 COMMENTS

EXHIBIT MP.5-2 TFN 6 2/025 SHEET 1 OF 4
RECD OCT 23, 2015

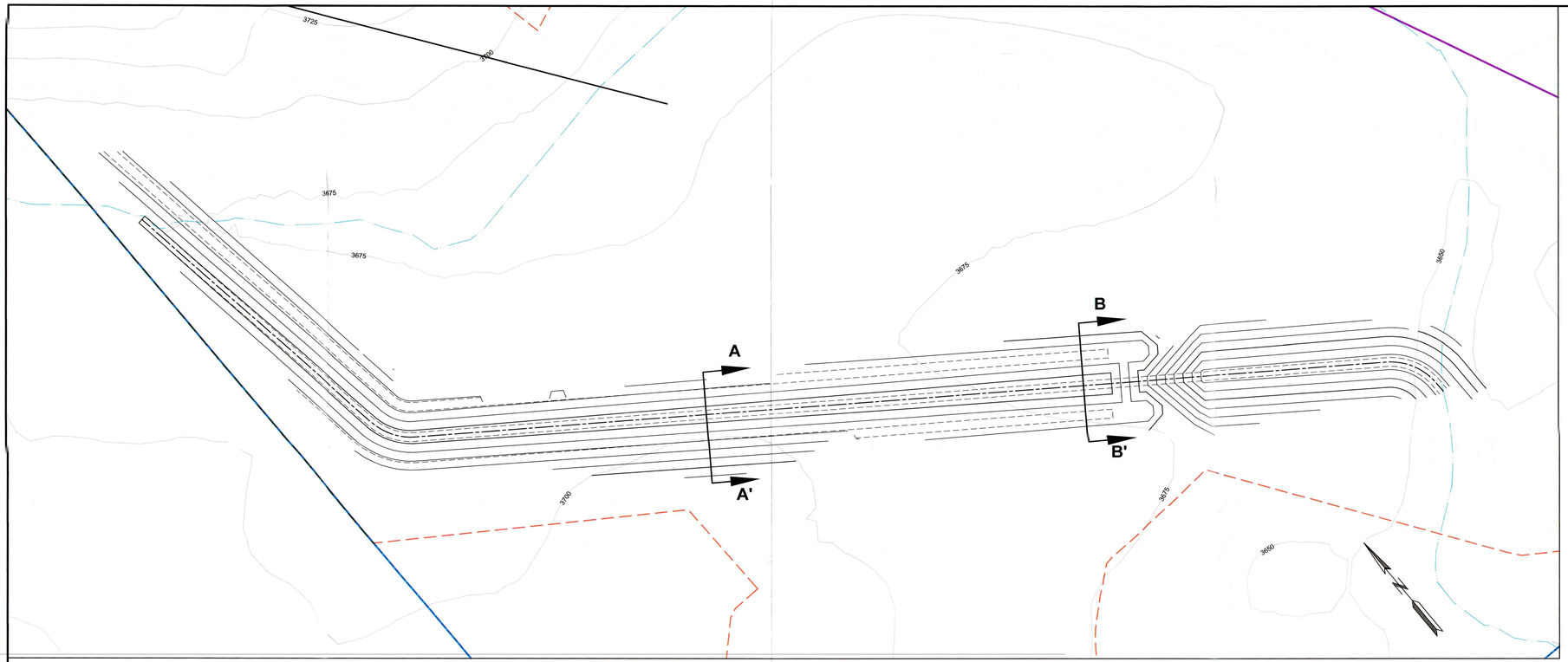
HIDDEN WATER CREEK DIVERSION LOCATIONS

Drawn By: DCJ
Checked By: JGB
Date: 7/2/14

WWC ENGINEERING
www.wwcengineering.com

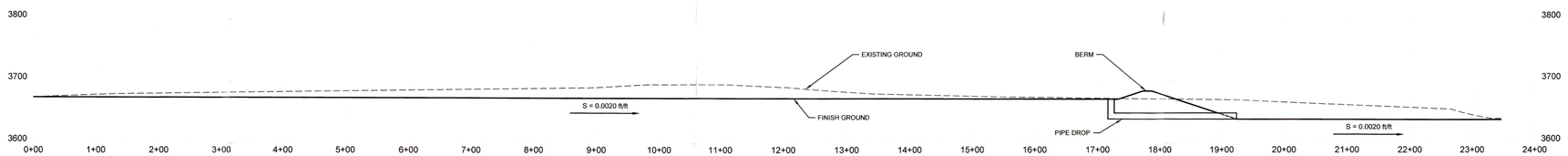
FILE: EX_5-2_HWC_DIV_R2.dwg

K:\Sheridan\RAMACO\31139\ACAD_WY83E\DGN\SS_MINE_PLAN_RESPONSE_2\EX_5-2_HWC_DIV_R2.dwg 10/13/2015 9:58:02 AM rod vanblog



PLAN VIEW

SCALE: 1" = 100'
C.I. = 5'



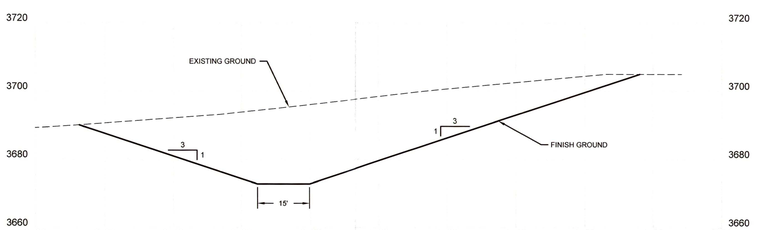
DIVERSION PROFILE

SCALE: 1" = 100'

HYDROLOGIC DESIGN STORM CALCULATIONS [1]

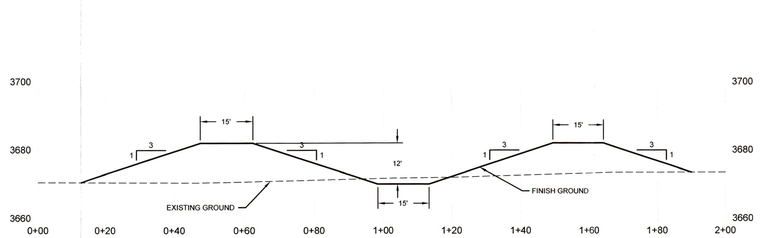
DRAINAGE BASIN PARAMETERS				10-YR, 24-HR STORM			100-YR, 24-HR STORM		
DRAINAGE AREA (sq-mi)	WATERCOURSE LENGTH (mi)	ELEVATION DIFFERENCE (ft)	CURVE NO. (CN)	10-YR, 24-HR PRECIP. (in)	PEAK INFLOW (cfs)	RUNOFF VOLUME (ac-ft)	100-YR, 24-HR PRECIP. (in)	PEAK INFLOW (cfs)	RUNOFF VOLUME (ac-ft)
4.70	2.3	179	76	2.35	586	251.3	3.57	1118.8	474.8

NOTE: 1. RUNOFF VOLUMES AND PEAK DISCHARGES WERE COMPUTED BY THE RAINFALL/RUNOFF PROGRAM "HEC-HMS" USING THE SCS TYPE II DISTRIBUTION.



SECTION A-A'

SCALE: 1" = 20'



SECTION B-B'

SCALE: 1" = 20'

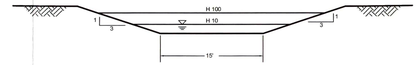
LEGEND

- BROOK MINE PERMIT BOUNDARY
- BIG HORN COAL PERMIT BOUNDARY (PERMIT NO. 213-T7)
- AFFECTED AREA BOUNDARY
- DISTURBANCE BOUNDARY

CHANNEL HYDRAULICS

$$Q = \frac{1.49}{n} A R^{2/3} \sqrt{S_f}$$

Q_{10} =	586.0 cfs	Q_{100} =	1118.8 cfs
H_{10} =	4.51 ft	H_{100} =	6.17 ft
A =	128.5 ft^2	A =	206.5 ft^2
R =	2.95 ft/ft	R =	3.82 ft/ft
S_f =	0.002	S_f =	0.002
n =	0.030	n =	0.030



TYPICAL CROSS SECTION

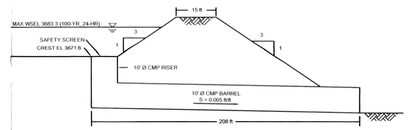
NOT TO SCALE

DIVERSION DROP HYDRAULICS

DISCHARGE GOVERNED BY ORIFICE FLOW CONDITIONS

$$Q = CA(2gH)^{1/2}$$

$Q_{100,24}$ =	1118.8 cfs
g =	32.2
C =	0.52
A =	78.54 ft
H =	11.65 ft



DIVERSION DROP SCHEMATIC PROFILE

NOT TO SCALE

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGARVIEW DR, STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
06/15	ROUND 1 COMMENTS
10/15	ROUND 2 COMMENTS

EXHIBIT MP.5-2 SHEET 2 OF 4

TFN 6 2/025
RECD OCT 23, 2015

HIDDEN WATER CREEK YEAR 1 DIVERSION

Drawn By: DCJ
Checked By: JGB
Date: 7/2/14

FILE: EX_5-2_HWC_DIV_R2.dwg

WWC ENGINEERING
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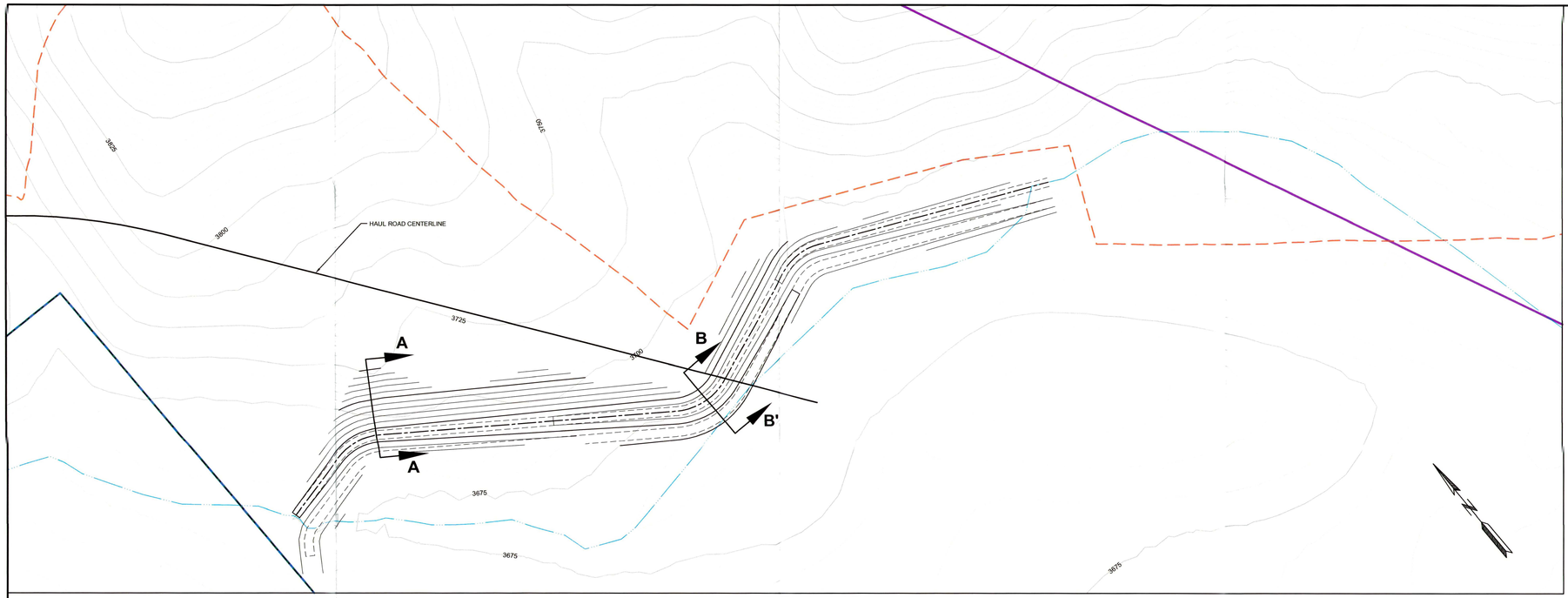


PLAN VIEW

SCALE: 1" = 100'
C.I. = 5'

LEGEND

- BROOK MINE PERMIT BOUNDARY
- BIG HORN COAL PERMIT BOUNDARY (PERMIT NO. 213-T7)
- AFFECTED AREA BOUNDARY
- DISTURBANCE BOUNDARY

CHANNEL HYDRAULICS

$$Q = \frac{1.49}{n} A R^{2/3} \sqrt{S_f}$$

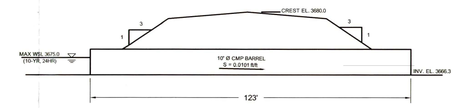
Q_{10} = 586.0 cfs
H_{10} = 3.17 ft
A = 67.57 ft^2
R = 2.32 ft/ft
S_f = 0.01
n = 0.030

TYPICAL CROSS SECTION

NOT TO SCALE

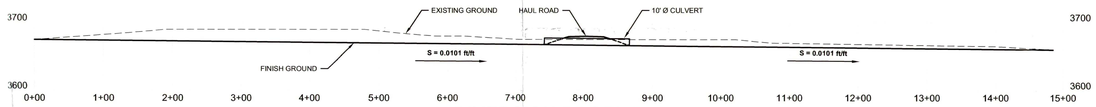
CULVERT HYDRAULICS

SOLVED BY USING FEDERAL HIGHWAY ADMINISTRATION NOMOGRAPH "HEADWATER DEPTH FOR C.M. PIPE CULVERTS WITH INLET CONTROL".



CULVERT SCHEMATIC PROFILE

NOT TO SCALE



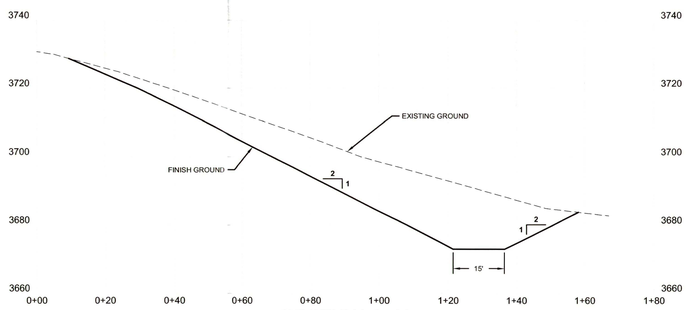
DIVERSION PROFILE

SCALE: 1" = 100'

HYDROLOGIC DESIGN STORM CALCULATIONS [1]

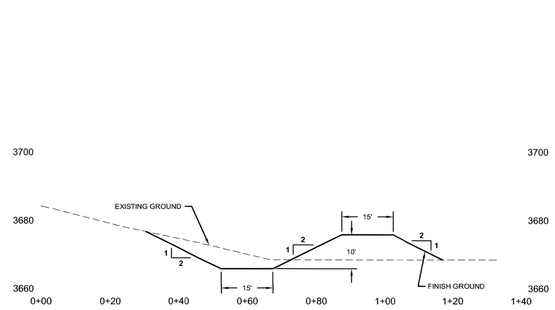
DRAINAGE BASIN PARAMETERS				10-YR, 24-HR STORM		
DRAINAGE AREA (sq-mi)	WATERCOURSE LENGTH (mi)	ELEVATION DIFFERENCE (ft)	CURVE NO. (CN)	10-YR, 24-HR PRECIP. (in)	PEAK INFLOW (cfs)	RUNOFF VOLUME (ac-ft)
4.70	2.3	179	76	2.35	586	251.3

NOTE: 1. RUNOFF VOLUMES AND PEAK DISCHARGES WERE COMPUTED BY THE RAINFALL/RUNOFF PROGRAM "HEC-HMS" USING THE SCS TYPE II DISTRIBUTION.



SECTION A-A'

SCALE: 1" = 20'



SECTION B-B'

SCALE: 1" = 20'

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY

1101 SUGARVIEW DR. STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
06/15	ROUND 1 COMMENTS
10/15	ROUND 2 COMMENTS

EXHIBIT MP.5-2 TFN 6 2/025 RECD OCT 23, 2015 SHEET 3 OF 4

HIDDEN WATER CREEK YEAR 2 DIVERSION

Drawn By: DCJ
Checked By: JGB
Date: 7/2/14

FILE: EX_5-2_HWC_DIV_R2.dwg

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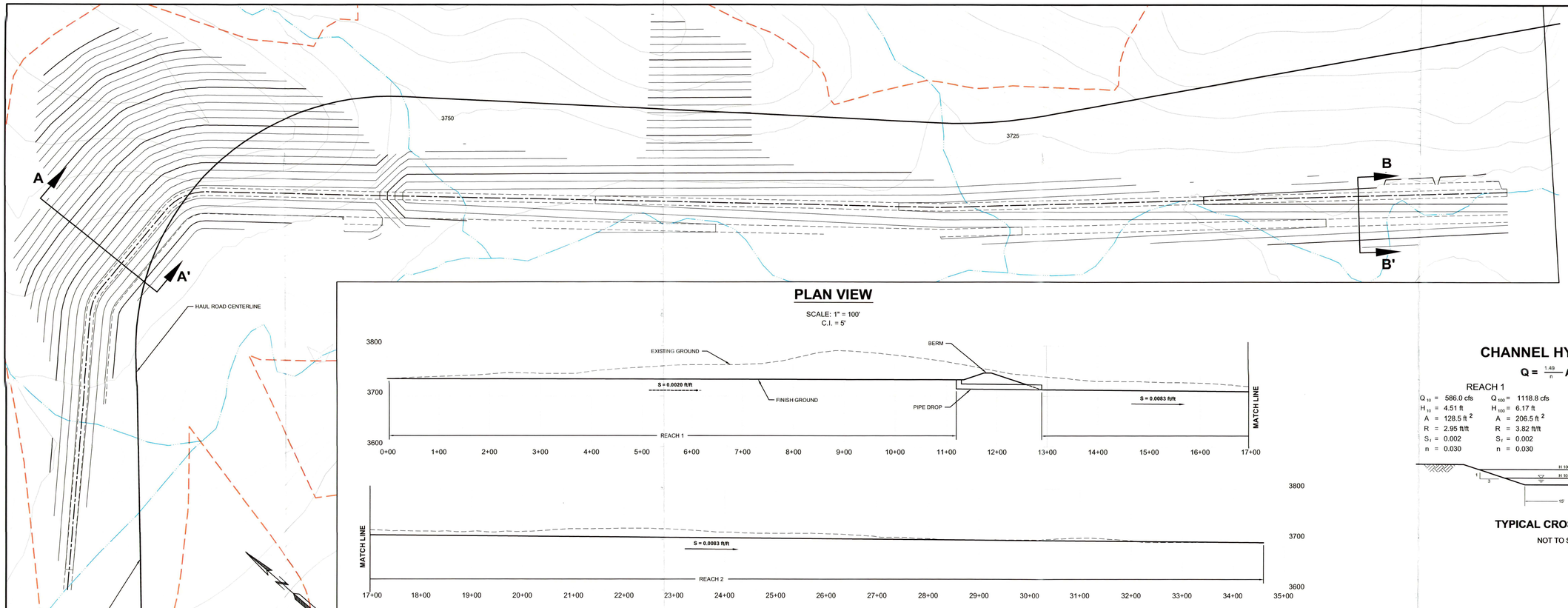


PLAN VIEW

SCALE: 1" = 100'
C.I. = 5'

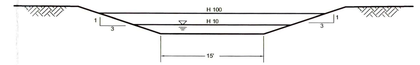
DIVERSION PROFILE

SCALE: 1" = 100'

CHANNEL HYDRAULICS

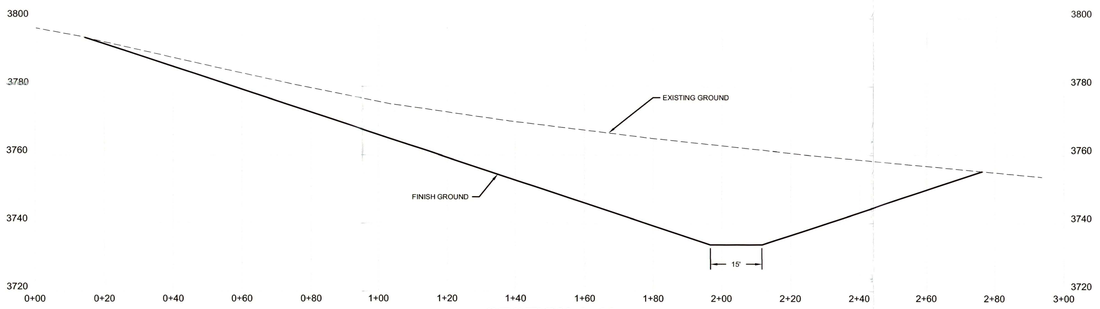
$$Q = \frac{1.49}{n} A R^{2/3} \sqrt{S_f}$$

REACH 1				REACH 2			
Q_{10} =	586.0 cfs	Q_{100} =	1118.8 cfs	Q_{10} =	586.0 cfs	Q_{100} =	1118.8 cfs
H_{10} =	4.51 ft	H_{100} =	6.17 ft	H_{10} =	3.14 ft	H_{100} =	4.36 ft
A =	128.5 ft^2	A =	206.5 ft^2	A =	76.75 ft^2	A =	122.56 ft^2
R =	2.95 ft/ft	R =	3.82 ft/ft	R =	2.20 ft/ft	R =	2.88 ft/ft
S_f =	0.002	S_f =	0.002	S_f =	0.0083	S_f =	0.0083
n =	0.030	n =	0.030	n =	0.030	n =	0.030



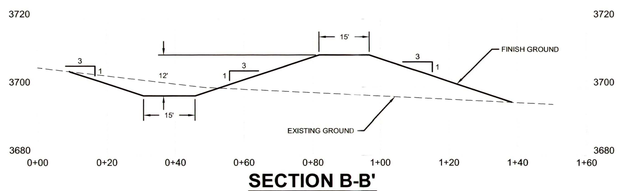
TYPICAL CROSS SECTION

NOT TO SCALE



SECTION A-A'

SCALE: 1" = 20'



SECTION B-B'

SCALE: 1" = 20'

HYDROLOGIC DESIGN STORM CALCULATIONS [1]

DRAINAGE BASIN PARAMETERS				10-YR, 24-HR STORM			100-YR, 24-HR STORM		
DRAINAGE AREA (sq-mi)	WATERCOURSE LENGTH (mi)	ELEVATION DIFFERENCE (ft)	CURVE NO. (CN)	10-YR, 24-HR PRECIP. (in)	PEAK INFLOW (cfs)	RUNOFF VOLUME (ac-ft)	100-YR, 24-HR PRECIP. (in)	PEAK INFLOW (cfs)	RUNOFF VOLUME (ac-ft)
4.70	2.3	179	76	2.35	586	251.3	3.57	1118.8	474.8

NOTE: 1. RUNOFF VOLUMES AND PEAK DISCHARGES WERE COMPUTED BY THE RAINFALL/RUNOFF PROGRAM "HEC-HMS" USING THE SCS TYPE II DISTRIBUTION.

LEGEND

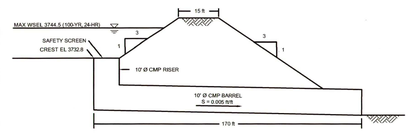
- AFFECTED AREA BOUNDARY
- DISTURBANCE BOUNDARY

DIVERSION DROP HYDRAULICS

DISCHARGE GOVERNED BY ORIFICE FLOW CONDITIONS

$$Q = CA(2gH)^{1/2}$$

$Q_{100,24}$ =	1118.8 cfs
g =	32.2
C =	0.52
A =	78.54 ft
H =	11.65 ft



DIVERSION DROP SCHEMATIC PROFILE

NOT TO SCALE

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY

1101 SUGARVIEW DR. STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
06/15	ROUND 1 COMMENTS
10/15	ROUND 2 COMMENTS

EXHIBIT MP.5-2 TFN 6 2/025 SHEET 4 OF 4
RECD OCT 23, 2015

HIDDEN WATER CREEK YEAR 3 DIVERSION

Drawn By: DCJ
Checked By: JGB
Date: 7/2/14

FILE: EX_5-2_HWC_DIV_R2.dwg

WWC ENGINEERING
www.wwcengineering.com

R.85 W. R.84 W.

T. 57 N.

HIDDEN WATER CREEK

SLATER CREEK

WELL CLUSTER 578510-CRN 578510-MST

UPPER 10 STOCK RESERVOIR

HALL RESERVOIR

WELL CLUSTER 578511-CRN 578511-MST

WELL CLUSTER 578512-CRN 578512-MST

EGERSKI BROS #1 STOCK RESERVOIR

578512-AL

SM578512-SW-1

WELCH #4 STOCK RESERVOIR

WELL CLUSTER 578513-CRN 578513-MST

578513-AL

LEGERSKI #1 STOCK RESERVOIR

BLACK MOUNTAIN NO. 1 STOCK RESERVOIR

PERMANENT IMPOUNDMENT #1 RESERVOIR

578418-AL

WELL CLUSTER 578418-CRN 578418-MST

SM578418-SW-1

578524-AL

USGS 06299980

578420-AL

SM578409-SW-1

WELL CLUSTER 578408-MST 578408-CRN

WELL CLUSTER 578409-MST 578409-MST-OB 578409-CRN 578409-CRN-OB 578409-MST-UB

WELL CLUSTER 578417-MST 578417-CRN

SM578415-SW-1

578415-AL

578415-CRN-MST

BIG HORN NO. 2 RESERVOIR

BIG HORN NO. 14 RESERVOIR

USGS 06305700

578433-AL-1

578434-AL-1

578434-AL-2

R.85 W. R.84 W.

Drawing Coordinates: WY83ECF

LEGEND

- BROOK MINE PERMIT BOUNDARY
- BIG HORN COAL PERMIT BOUNDARY (PERMIT NO. 213-T7)
- TAYLOR QUARRY PERMIT BOUNDARY (PERMIT NO. SP-757)
- 578409-MST-UB — UNDERBURDEN MONITOR WELL
- 578415-CRN-MST — COAL MONITOR WELL
- 578418-AL — ALLUVIAL MONITOR WELL
- 578524-AL — ALLUVIAL MONITOR WELL (PROPOSED)
- SM578418-SW-1 — SURFACE WATER MONITORING LOCATION

N

0 500 1,000 1,500 2,000
GRAPHIC SCALE (FEET)

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGARVIEW DR, STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
06/15	ROUND 1 COMMENTS
10/15	ROUND 2 COMMENTS
12/15	ROUND 3 COMMENTS

EXHIBIT MP.7-1

TFN 6 2/025
RECD DEC 18, 2015

OPERATIONAL SURFACE WATER AND GROUNDWATER MONITORING PROGRAM

Drawn By: CJG
Checked By: JGB
Date: 7/8/14

WWC ENGINEERING
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FILE: EX_7-1_WATER_MONITORING_R3.dwg

K:\Sheridan\RAMACO\131139\ACAD_WIRE\ECDWGS_MINE_PLAN_RESPONSE_REV_7\1_WATER_MONITORING_R3.dwg 12/2/2015 11:28:41 AM dave johnson

R.85 W. R.84 W.

T. 58 N.
T. 57 N.

R.85 W. R.84 W.

T. 58 N.
T. 57 N.

TR-10
TR-9B
TR-11
TR-12
TR-9A
TR-8
TR-7/SM-1
TR-6
TR-5
TR-4
TR-3B
TR-3A
TR-2
TR-1

BIGHORN MINE
CONABLE PROSPECT MINE
MASTERS MINE
KLEENBURN COAL TIPPLE MINE
RIVERSIDE MINE
BLACK MOUNTAIN MINE
ACME NUMBER THREE MINE
CARNEY MINE NUMBER FORTY-FOUR
ACME NUMBER ONE MINE
ACME NUMBER TWO MINE
ACME NUMBER FORTY-TWO MINE
BIGHORN MINE
BIG HORN NUMBER ONE MINE
ZOWADA PIT AND PLACHET PIT MINE
NEW ACME MINE
TONGUE RIVER STONE COMPANY MINE
MODEL MINE
HOTCHKISS NUMBER TWO MINE
WELCH MINE
WELCH STRIP MINE
GUERNSEY STONE QUARRY
KOOI NUMBER FORTY-SIX MINE
OLD MONARCH MINE
MONARCH NUMBER FIVE MINE
BUFFALO STRIP MINE
NEW MONARCH MINE
DIETZ NUMBER ONE MINE
DIETZ NUMBER FIVE AND EIGHT MINE
DIETZ MINE

Drawing Coordinates: WY83ECF

LEGEND

- BROOK MINE PERMIT BOUNDARY
- BIG HORN COAL PERMIT BOUNDARY (PERMIT NO. 213-T7)
- TAYLOR QUARRY PERMIT BOUNDARY (PERMIT NO. SP-757)
- MINED OUT UNDERGROUND 500' BUFFER
- DIETZ MINE — HISTORIC MINE LOCATION
- HISTORIC UNDERGROUND MINE
- HISTORIC SURFACE MINE
- BROOK MINE SURFACE MINING AND TRENCHES
- BROOK MINE HIGHWALL MINING

N

0 500 1,000 1,500 2,000
GRAPHIC SCALE (FEET)

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGARVIEW DR, STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
06/15	ROUND 1 COMMENTS
10/15	ROUND 2 COMMENTS
12/15	ROUND 3 COMMENTS

EXHIBIT MP.15-1

TFN 6 2/025
RECD DEC 18, 2015

HISTORIC UNDERGROUND MINES IN THE VICINITY OF THE BROOK MINE

Drawn By: CIG
Checked By: JGB
Date: 10/30/14

WWC ENGINEERING
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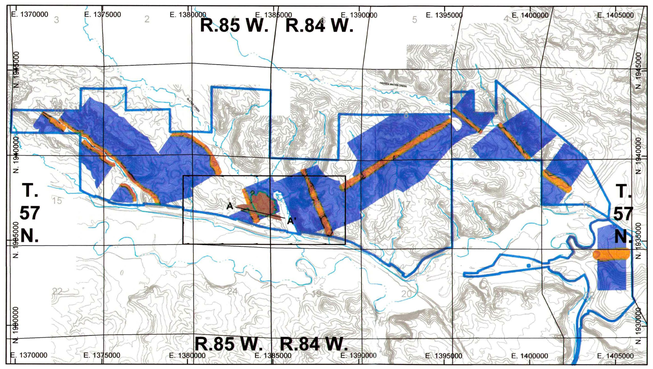
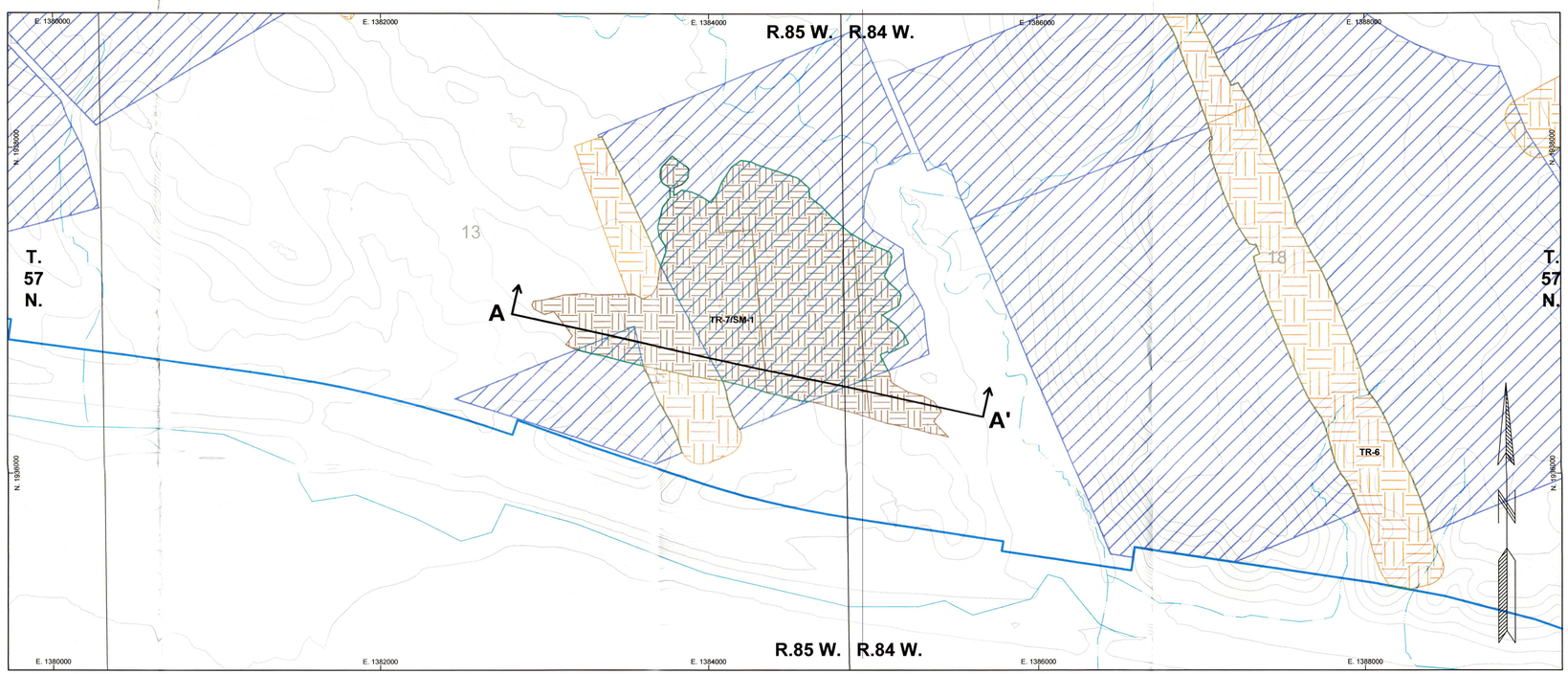
FILE: EX_15-1_HIS_MINE_R3.dwg



LOCATION VIEW

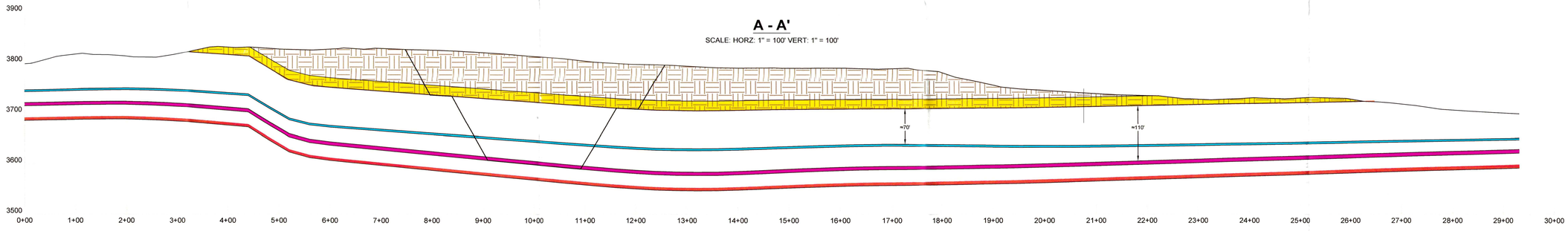
SCALE: 1" = 4000'
C.I. = 5'



Drawing Coordinates: WY83ECF

PLAN VIEW

SCALE: 1" = 400'
C.I. = 5'



LEGEND

- BROOK MINE PERMIT BOUNDARY
- HIGHWALL MINE TRENCH PROFILE
- SURFACE MINE TARGETING MONARCH COAL SEAM
- HIGHWALL MINER PANELS
- HIGHWALL MINE TRENCH
- MONARCH COAL SEAM
- UPPER CARNEY COAL SEAM
- LOWER CARNEY COAL SEAM
- MASTERS COAL SEAM

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY

1101 SUGARVIEW DR, STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
06/15	ROUND 1 COMMENTS
10/15	ROUND 2 COMMENTS
12/15	ROUND 3 COMMENTS

EXHIBIT MP.15-2

TFN 6 2'025
RECD DEC 18, 2015

SURFACE MINING OPERATIONS OCCURING OVER HIGHWALL MINING

Drawn By: CIG
Checked By: JGB
Date: 10/17/14

WWC ENGINEERING
www.wwcengineering.com

FILE: EX_15-2_SURFMINING_OVER_HWM_R3.dwg

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R. 85 W. R. 84 W.

T. 58 N.

T. 57 N.

C-French Springs

C-Ash Creek

C-Slater Creek

R. 85 W. R. 84 W.

T. 58 N.

T. 57 N.

E. 1360000 E. 1370000 E. 1380000 E. 1390000 E. 1400000 E. 1410000 E. 1420000

N. 1950000 N. 1940000 N. 1930000 N. 1920000

LEGEND

- BROOK MINE PERMIT BOUNDARY
- 2-MILE DISTURBANCE BUFFER BOUNDARY
- DISTURBANCE BOUNDARY
- AFFECTED AREA BOUNDARY
- SAGE-GROUSE LEK

0 1,000 2,000 3,000 4,000

GRAPHIC SCALE (FEET)
C.I. = 20'

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY

1101 SUGARVIEW DR, STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
06/15	ROUND 1 COMMENTS
10/15	ROUND 2 COMMENTS

EXHIBIT MP.16-1

TFN 6 2/025
RECD OCT 23, 2015

2 MILE BUFFER WITH SAGE GROUSE LEKS

Drawn By: DCJ
Checked By: JGB
Date: 11/13/14

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FILE: EX_16-1_GROUSE_LEKS_R2.dwg

K:\Shared\RAMACO\131104\CAD_WYSE\CDD\GIS_MINE_PLAN_RESPONSE_2\EX_16-1_GROUSE_LEKS_R2.dwg 10/21/2015 10:07:29 AM rod vanding

ADDENDUM MP-1

ADDENDUM MP-1

Alternative Sediment Control Measures

TFN 6 2/025
RECD NOV 14, 2014

DEQ 12-149

TABLE OF CONTENTS

MP-1.1 Introduction.....MP-1-3
MP-1.1.1 Surface Roughening.....MP-1-4
MP-1.1.2 Diversion Ditches.....MP-1-4
MP-1.1.3 Check Dams.....MP-1-5
MP-1.1.4 Silt Fence.....MP-1-6
MP-1.1.5 Straw Wattles.....MP-1-6
MP-1.1.6 Earthen Berms.....MP-1-7
MP-1.1.7 Sediment Traps.....MP-1-8
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MP-1.2 Inspection and Maintenance.....MP-1-10
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TFN 6 2/025
RECD NOV 14, 2014

DEQ 12-150

MP-1.1 INTRODUCTION

The use of Alternative Sediment Control Measures (ASCMs) will generally be limited to providing short-term sediment control for small areas not exceeding thirty (30) acres of total drainage. Prior to construction of any ASCM structure, the following materials will be provided to WDEQ:

- A map showing the location of the proposed ASCM structure(s), and identifying the drainage area for each ASCM structure. The map will have complete legend information;
- The type of each ASCM structure;
- The expected duration of use for each ASCM structure; and
- An estimate of the 10-year, 24-hour runoff volume and peak discharge rate for each ASCM structure which has a drainage area greater than five (5) acres. The estimate will identify the calculation methodology and input parameters.

It is understood that WDEQ will issue a letter of concurrence based upon receipt and review of the above information. Due to the variety of methods available that qualify as ASCMs and to ensure the use of the most appropriate method for a given location and design life, the types of ASCMs utilized for sediment control will be determined on a site-specific basis.

An objective of alternative sediment control will be to minimize the transport of sediment concentrations in excess of natural contributions from lands disturbed by mining. To accomplish this objective, ASCMs will be located proximal to source areas. ASCMs reduce sediment by slowing concentrated flow and allowing suspended matter to settle, by filtering out sediment, or by reducing erosion and facilitating entrapment at the source. In most cases, the most effective ASCM will be the one which employs a combination of these functions. Topsoil in the vicinity of ASCM locations will either be salvaged if the potential for degradation is significant, or will be protected in-situ by minimizing the extent of disturbance during construction and operation. One of the major objectives and benefits of the use of ASCMs is reduced surface disturbance. Whenever possible, ASCMs will be installed in

TFN 6 2/025
RECD NOV 14,2014

DEQ 12-151

easily accessible areas so that disturbance due to the required inspections and maintenance will be minimized.

Addendum MP-1 Exhibit 1 provides typical plans and visual representations for the various types of ASCMs that may be utilized to control sediment from areas disturbed by mining. The different types of ASCMs are necessary to allow flexibility in choosing the most appropriate method for a given condition. Each of these methods is effective when used under appropriate conditions. The types of ASCMs and their appropriate uses are discussed in the following subsections.

MP-1.1.1 Surface Roughening

Hard-packed disturbed land is not conducive to absorbing runoff. As a result, runoff will flow off the surface at an uninhibited velocity, and can cause scouring and erosion. Surface roughening breaks up the ground surface and makes it more receptive to absorbing precipitation. Surface roughening utilizes mechanical ripping, disking, tracking, or scarification. This technique increases the effective surface area of the ground, facilitates absorption, and creates benches and furrows perpendicular to the flow path that slow runoff velocity. Therefore, furrows and small terraces should follow along the contours of the grade. The degree or aggressiveness of surface roughening will correspond to the steepness of the slope and the soil type.

MP-1.1.2 Diversion Ditches

Diversion ditches can be constructed to capture run-on and divert flows around project areas. The ditches serve as conveyance structures depending upon the nature of the run-on. Run-on from disturbed areas will be conveyed to retention structures for sediment treatment prior to discharge. Run-on from undisturbed areas can be discharged directly to undisturbed areas downstream of the project areas.

TFN 6 2/025
RECD NOV 14, 2014

DEQ 12-152

When diversions are constructed, the ditch should have rounded or flat bottoms to avoid concentration of the flow at the bottom of the channel. Concentration in such a manner can lead to cutting.

Diversion ditches may be constructed in conjunction with an earthen berm. The addition of a compacted earthen berm on the downgradient side of the ditch will increase the capacity of the ditch, and prevent it from being overwhelmed or bypassed.

MP-1.1.3 Check Dams

Ditches, channels, and swales used to convey flow can be impacted by erosive velocities. Flows that are allowed to run unchecked through conveyance structures can rapidly erode the structure if it is not stabilized with vegetation or erosion control matting. Check dams can be installed to provide erosion control.

A check dam's function in a conveyance structure is to slow the flow velocity and prevent erosion. Check dams slow the velocity of the flow by causing the flow to pass through or over the feature. The cross section of the conveyance structure is also important. As discussed in the section on diversion ditches, the ditch bottom should be flat or rounded to promote unconcentrated laminar flow.

Check dams can be constructed or prefabricated. Silt fencing and other ASCMs that do not function in concentrated flows cannot be used as check dams. Features that have a tendency to pond large volumes of water without passing the flow will also be avoided.

To install check dams, the feature be buried below grade to prevent undermining. The check dams will be appropriately spaced to prevent flows from regaining erosive velocity. The check dam ends will be keyed into the adjoining grade to prevent bypass around the ends.

Rock check dams will intercept and slow flows. When properly installed, rock check dams will allow flow through and over the feature without bypass or

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undermining. Straw bales do not function well as check dams because flows do not readily penetrate the bales, creating ponding and hydraulic pressure due to head. The pressure will force water under the bales which leads to undermining.

MP-1.1.4 Silt Fence

Silt fencing performs as a barrier that intercepts sediment-laden runoff and impounds it until it infiltrates, evaporates, or weeps through the fabric. Silt fence is not designed or intended to function as an effective filter because very little runoff will actually discharge through the fabric.

Silt fencing has limitations that will be evaluated before installation. Understanding the limitations will determine if it is the appropriate ASCM for the site conditions. Silt fencing does not function in concentrated flow; manage large drainage areas by itself; perform if it is not installed along the grade contours; or work well if it is installed at the toe of a slope.

Silt fencing will be used for limited drainage basins typically no larger than a quarter-acre of disturbance discharging to 100 linear feet of fencing (if silt fencing is the only ASCM implemented to manage the area). Silt fencing performs best when used in conjunction with other ASCMs. If sited and installed correctly, silt fence will perform well as a sediment barrier and to pond storm water; but it should not be used as a diversion or installed running up and down a grade.

MP-1.1.5 Straw Wattles

Straw wattles can function as effective sediment barriers and perimeter control for small drainage areas. Wattles will pond runoff like silt fencing, but wattles will not filter runoff. During manufacture, wattles are commonly packed tight enough that flows cannot penetrate the wattle.

The low profile of straw wattles places limitations on the field applications. The most appropriate applications for straw wattles are:

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- Smaller drainage areas with sheet flows
- Areas with flatter grades
- In conjunction with other ASCMs

Installation procedures require wattles to be:

- Installed along the contour
- Trenched below grade and backfilled
- Firmly secured down
- Hooked up at the ends
- Adequately overlapped at joints

The correct installation of straw wattles will also include proper diameter selection. A common failure for straw wattles is due to undermining. This is the reason for trenching wattles below grade, and backfilling and compacting soil on the upgradient side. Stakes to secure the wattles will be driven through the straw wattle opposed to being driven along the side.

MP-1.1.6 Earthen Berms

Earthen berms (or dikes) are grading techniques that function as barriers. Similar to silt fencing, earthen berms will intercept and pond runoff. However, unlike silt fencing which will weep, an earthen berm will not discharge in such a way. If an earthen berm discharges, it is likely not installed correctly. If water discharges through or under the berm, it is not compacted correctly. If it discharges around the feature, it has not been turned up at the ends to prevent bypass. If it discharges over the berm, the drainage area is too large, or the height has not been correctly selected. If water overtops the berm, it can lead to embankment failure and loss of the earthen berm.

Earthen berms can be used in conjunction with ditches to aid in function of the ditch.

For proper construction of an earthen berm:

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- Fill material should be built in lifts to ensure proper compaction
- The berm should be of uniform height, except for the ends which should be turned up to prevent runoff from bypassing the berm
- The berm should be along the contour to facilitate ponding through interception of flow
- The base should be at least twice the width as the berm is tall

MP-1.1.7 Sediment Traps

Sediment traps can be used to manage water quality, as well as quantity, for small drainage areas. Functioning as sediment removal ASCMs, traps will impound runoff from disturbed areas and allow particles to settle out.

The design and installation of sediment traps will include calculations for sizing, which is determined by drainage area. In addition to potential runoff volume, additional sediment trap volume must be accounted for to allow sediment accumulation. A sediment trap also needs to be located to avoid interfering with operations.

Planning will consider the manner in which the sediment trap will be discharged. The trap will discharge at a designed, designated point, and the discharge point should not impact work. Sediment traps without a discharge point are vulnerable to embankment and pond failure. Embankments will have an outlet, or spillway, designed to facilitate non-erosive discharge. The discharge location may be armored to prevent scouring and damage to the embankment during discharge.

MP-1.1.8 Sediment Basins

Sediment basins are larger versions of sediment traps, and are intended for greater drainage areas. In addition to being larger, sediment basins typically have a perforated riser pipe that functions as the primary discharge point.

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MP-1.1.9 Erosion Seeding

Vegetation is considered the most powerful deterrent to surface erosion. Erosion seeding is the immediate seeding of freshly exposed slopes that are steeper than a 3H:1V grade. Seeding is executed manually without mulch or fertilizer application, but the seed is stabilized using equipment tracking. Seeding will be conducted using approved seed mixtures.

MP-1.1.10 Erosion Control Blankets

Erosion control blankets offer cover and moisture retention for newly seeded areas. If cover is not provided to new seeding, the seed beds will be vulnerable to wind and surface erosion. Moisture retention in the erosion control blankets promotes germination.

Erosion control blankets are routinely seeded for applications that require more resilient and longer-term protection than can be expected from other mechanically-installed applications (such as straw or hydro-mulch).

A wide range of styles, composition, and thicknesses are available. In order to determine the correct grade of blanket, the following site conditions/characteristics must be evaluated:

- Soil type
- Slope steepness and length
- Seed type, and number of year to yield establish growth
- Season; projected precipitation or irrigation
- Sheet flow application, or concentrated flow

Correct installation will include:

- Soil preparation
- Good soil contact
- Proper staking/pinning
- Overlapping

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- Anchor slot
- Correct Orientation

Erosion control blankets must be installed running in the direction of the flow, and adequately secured down. Good soil preparation, prior to placement, will prevent tenting or voids under the blanket.

MP-1.2 INSPECTION AND MAINTENANCE

Maintenance of ASCMs will be performed at a frequency appropriate for the type of ASCM utilized. ASCMs will be inspected at the beginning and end of each runoff season (March 1 through November 1) and following significant runoff events (events larger than 1.5 inches). Inspections will be conducted by qualified mine personnel familiar with sediment control requirements. All ASCMs will be inspected at least quarterly during the runoff season to ensure proper function and capacity.

Repairs to ASCMs will be initiated promptly following any inspection where problems are noted. Sediment accumulation will be removed when it reaches as much as 50% of the ASCM height. The 50% accumulation level will be determined visually when sediment reaches the top of appropriately placed markers. Filter fabric will be replaced at least every three years.

All repairs and sediment removal operations will be conducted in dry conditions and in such a manner as to minimize environmental damage to the surrounding area.

A written log documenting the performance and results of periodic inspections will be kept up to date and retained at the Brook Mine for review by WDEQ. The log will also contain a written record of maintenance procedures undertaken at each site.

MP-1.3 ASCM REMOVAL AND SITE RECLAMATION

Following the successful reclamation of the contributing drainage area and approval by WDEQ, each ASCM will be removed and the site will be

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reclaimed. The site reclamation work will be performed according to the reclamation procedures outlined in the Reclamation Plan, and in accordance with WDEQ regulations. The reclamation procedures will be performed by hand or with light equipment to reduce surface damage to the surrounding area. In cases where the environmental benefits of leaving the ASCM in place outweigh the disturbances associated with its removal, a formal request will be made to WDEQ to leave the ASCM as a part of the reclaimed surface.

MP-1.4 ASCMS FOR LARGE AREAS

In some situations, ASCMs may be the preferred sediment control method even when the area to be controlled is larger than 30 acres. In such cases, a proposal will be submitted to WDEQ/LQD that provides the information requested in WDEQ/LQD Guideline No. 15. A computer model will be used as the design tool, and the design will be based on predicted sediment loads or yields from the particular area of disturbance. The proposal submitted to WDEQ/LQD for each ASCM larger than 30 acres will include the following information:

1. A description of the area to be controlled.
2. A description of the ASCM design procedure.
3. A map of the ASCMs on a mining sequence overlay.
4. Specifications and schematic diagrams of each ASCM.
5. Pertinent drainage basin and channel designs for reclaimed areas.
6. A maintenance and inspection plan.
7. A monitoring plan and description of degradation analysis.

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ECD NOV 14, 2014

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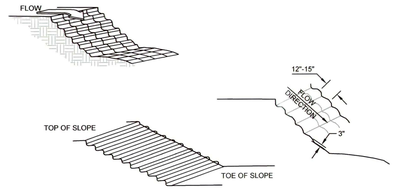
MP-1.5 REFERENCES

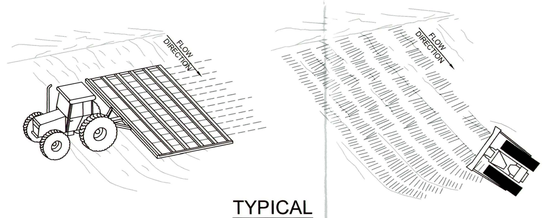
Montana Department of Environmental Quality. (n.d.). *Storm Water Management During Construction: Field Guide for Best Management Practices.* Montana Department of Environmental Quality. Retrieved 2014

Wyoming Department of Environmental Quality/Land Quality Division (WDEQ/LQD). (2004, January). *Guideline Number 15: Alternative Sediment Control Measures.* Retrieved 2014, from http://deq.state.wy.us/lqd/guidelns/Guide15=01-2004.pdf

TFN 6 2/025
RECD NOV 14,2014

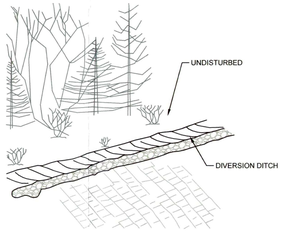


NOTE:
SURFACE ROUGHENING CREATES BENCHES AND FURROWS ALONG THE GRADE CONTOURS. PROMOTING ABSORPTION. WHILE TRAPPING RUN-OFF AND SEDIMENT.

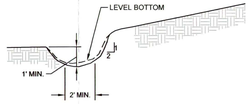


TYPICAL SURFACE ROUGHENING

NTS



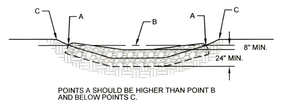
PERSPECTIVE



CROSS SECTION

TYPICAL DIVERSION DITCH

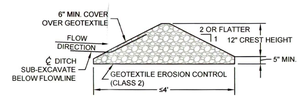
NTS



POINTS A SHOULD BE HIGHER THAN POINT B AND BELOW POINTS C.

TYPICAL SECTION VIEW

SECTION VIEW ALONG DITCH FLOWLINE

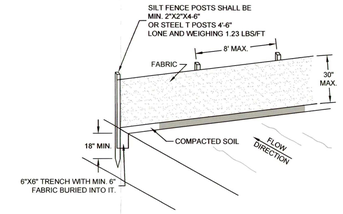


SECTION DETAIL

NOTES:
1. RIPRAP SIZE D_{50} - 6" OR AS SHOWN ON THE PLANS.
2. THE ENDS OF THE RIPRAP CHECK DAM SHALL BE A MINIMUM OF 6" HIGHER THAN CENTER OF THE CHECK DAM.
3. THE LENGTH "L" BETWEEN CHECK DAMS IS SUCH THAT THE CHANGE IN ELEVATION BETWEEN THE TOE OF ANY CHECK DAM AND SUBSEQUENT DOWNSTREAM CHECK DAM IS NO GREATER THAN 2%.

TYPICAL CHECK DAMS

NTS



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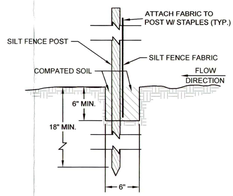
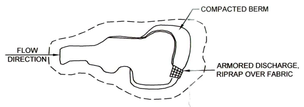


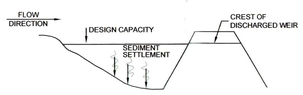
CROSS SECTION

TYPICAL SILT FENCE

NTS



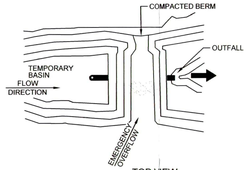
TOP VIEW



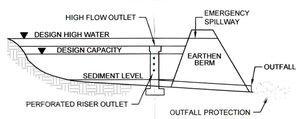
CROSS SECTION

TYPICAL SEDIMENT TRAPS

NTS



TOP VIEW



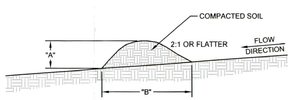
A-A CROSS SECTION

TYPICAL SEDIMENT BASINS

NTS

TYPICAL EROSION SEEDING

NTS



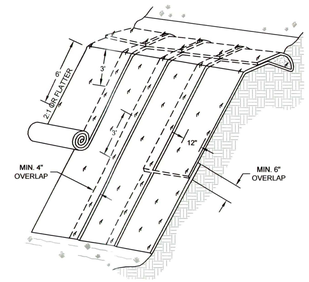
"B" = 2X"A" (MIN)

TEMPORARY BERM

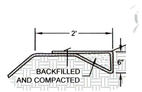
NOTES:
1. BASE WIDTH WILL BE DETERMINED BY HEIGHT. HEIGHT WILL BE DETERMINED BY SIZE OF DRAINAGE AREA.
2. BERMS WILL FUNCTION TO INTERCEPT FLOWS AND IMPOUND THEM.
3. BERMS WILL BE USED FOR LIMITED DRAINAGE AREAS, NOT TO EXCEED 1/4 ACRE FOR EVERY 100 LINEAR FEET OF BERM.

TYPICAL EARTHEN BERM

NTS



PERSPECTIVE

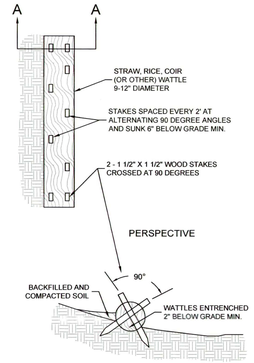


CROSS SECTION

NOTE:
1. SLOPE SURFACE SHALL BE FREE OF ROCKS, CLODS, STICKS AND GRASS. MATS/BLANKETS SHALL HAVE GOOD SOIL CONTACT.
2. APPLY PERMANENT SEEDING BEFORE PLACING BLANKETS.
3. LAY BLANKETS LOOSELY AND STAKE OR STAPLE TO MAINTAIN DIRECT CONTACT WITH THE SOIL. DO NOT STRETCH.

TYPICAL EROSION CONTROL BLANKET

NTS



PERSPECTIVE

A-A CROSS SECTION

TYPICAL STRAW WATTLE

NTS

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY

1101 SUGARVIEW DR. STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description

ADDENDUM MP-1
EXHIBIT 1

TFN 6 2/025
RECD NOV 14, 2014

TYPICAL ALTERNATIVE SEDIMENT CONTROL MEASURES

Drawn By:	DCJ
Checked By:	JGB
Date:	6-6-13

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FILE: EX_MP-1_ASCM.DWG

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ADDENDUM MP-2

ADDENDUM MP-2

Hydrologic Control Designs

TFN 6 2/025
RECD OCT 23, 2015

DEQ 12-163

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Exhibit 6 SP-6 Sediment Pond (2 Sheets)

Exhibit 7 SP-7 Sediment Pond

Exhibit 8 FC-1 Flood Control Impoundment

Exhibit 9 FC-2 Flood Control Impoundment

Exhibit 10 FC-3 Flood Control Impoundment

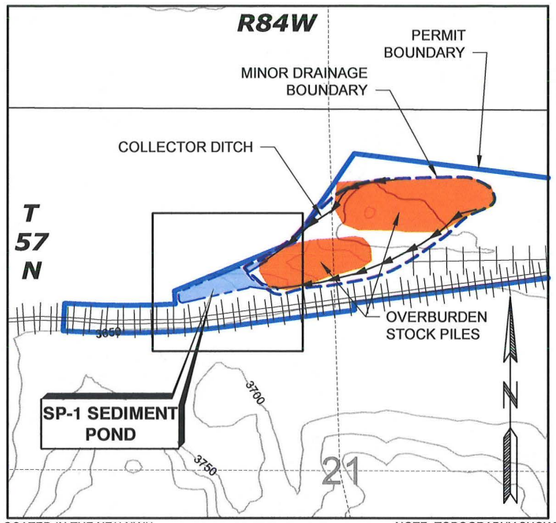
Exhibit 11 FC-4 Flood Control Impoundment

Exhibit 12 Typical Facilities Reservoir

Exhibit 13 SP-8 Sediment Pond (2 Sheets)

TFN 6 2/025
RECD DEC 18, 2015

DEQ 12-164



LOCATED IN THE NE/4 NW/4 AND SE/4 NW/4 OF SECTION 21, T57N, R84W

LOCATION VIEW

SCALE: 1" = 1000'
C.I. = 10'

NOTE: TOPOGRAPHY SHOWN USES NAD 83 WYOMING EAST CENTRAL COORDINATE SYSTEM

HYDROLOGIC DESIGN STORM CALCULATIONS FOR SP-1

DRAINAGE BASIN PARAMETERS					10-YR, 24-HR STORM		
DRAINAGE AREA (sq-mi)	WATERCOURSE LENGTH (mi)	ELEVATION DIFFERENCE (ft)	CURVE NO. (CN)	INFILTRATION LOSS (iph)	10-YR, 24-HR PRECIP. (in)	PEAK INFLOW (cfs)	RUNOFF VOLUME (ac-ft)
0.03	0.41	78	90	0.00	2.35	33.08	2.24

NOTE: RUNOFF VOLUMES AND PEAK INFLOWS WERE COMPUTED BY THE RAINFALL/RUNOFF PROGRAM "TRIHYDRO" USING THE SCS TYPE II DISTRIBUTION.

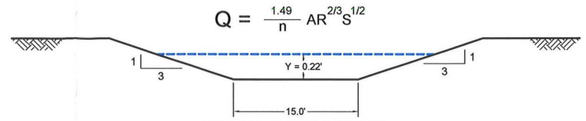
SEDIMENT YIELD CALCULATIONS

SOURCE AREA (ac)	RAINFALL FACTOR (R)	SOIL ERODIBILITY (K)	TOPOGRAPHIC FACTOR (LS)	COVER MANAGEMENT (C)	SUPPORT PRACTICE (P)	SOIL [1] LOSS (t/ac/yr)	DELIVERY [2] RATIO (%)	THREE-YEAR SEDIMENT YIELD (ac-ft)
20.20	30.00	0.50	22.0	1	1	329.6	57.4	6.6

NOTE:
1. SEDIMENT CAPACITY WAS DETERMINED BY THE APPLICATION OF THE UNIVERSAL SOIL LOSS EQUATION (USLE) TO SEDIMENT SOURCE AREA(S). FOR THESE CALCULATIONS SEDIMENT DENSITY WAS ASSUMED TO EQUAL 80 lb/cu ft.
2. SEDIMENT DELIVERY RATIO TAKEN FROM "SEDIMENT SOURCE AREAS, DELIVERY RATIOS, AND INFLUENCING MORPHOLOGICAL FACTORS." ROEHL 1961.

TRAPEZOIDAL INLET CHANNEL HYDRAULICS

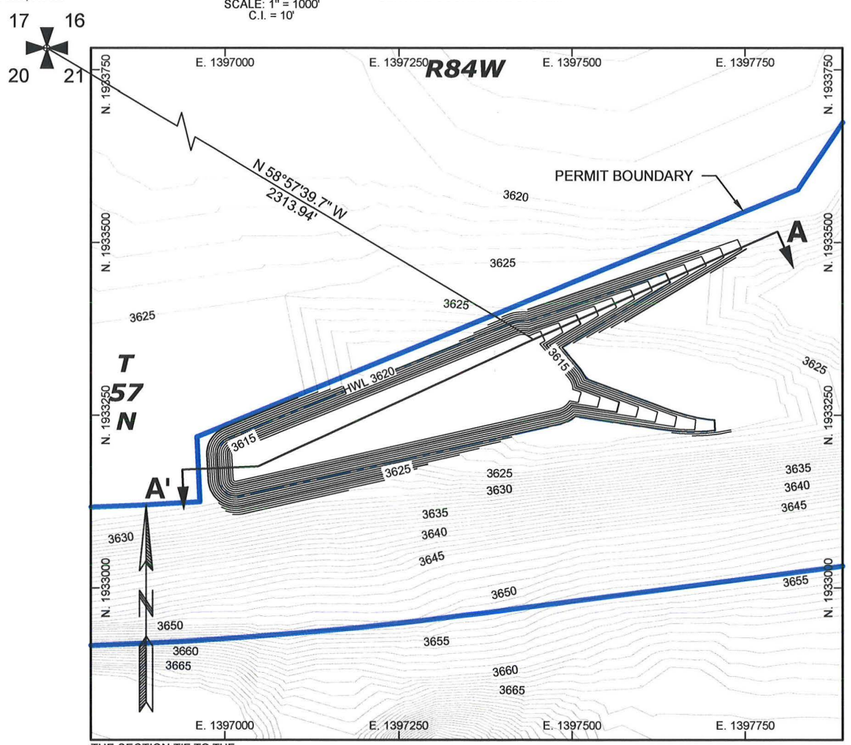
$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$



TYPICAL CROSS SECTION
NOT TO SCALE

Q = 17.00 cfs	A = 3.45 ft^2
n = 0.020	P = 16.39 ft
S = 0.035 ft/ft	R = 0.21 ft
b = 15.0 ft	V = 4.92 fps
	Y = 0.22 ft

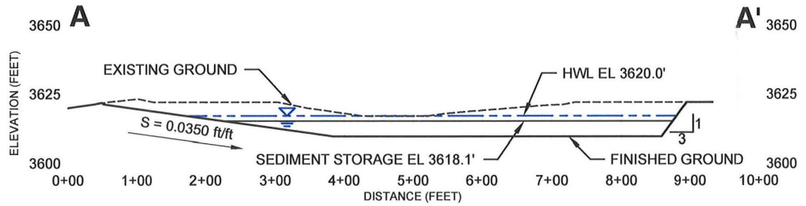
NOTE: CROSS SECTION IS TYPICAL FOR BOTH INLETS.



THE SECTION TIE TO THE SP-1 POND IS LOCATED AT LAT:45.916752, LON:-101.640951

PLAN VIEW

SCALE: 1" = 200'
C.I. = 1'



CROSS SECTION A-A'

SCALE: HORIZ 1"=200' VERT 1"=50'

NOTE: INLET SLOPE IS TYPICAL FOR BOTH INLETS.

AREA CAPACITY TABLE

ELEVATION (ft)	AREA (ac)	AVG. AREA (ac)	CAPACITY (ac-ft) INCR.	CAPACITY (ac-ft) ACCUM.	
3613.0	0.94			0.00	
		0.99	0.99		
3614.0	1.04			0.99	
		1.10	1.10		
3615.0	1.15			2.09	
		1.21	1.21		
3616.0	1.27			3.30	
		1.33	1.33		
3617.0	1.39			4.63	
		1.46	1.46		
3618.0	1.53			6.09	
		1.54	0.15		
3618.1	1.54			6.59	
		1.61	1.45		
3619.0	1.67			7.69	
		1.75	1.75		
3620.0	1.82			9.44	

INACTIVE CAPACITY 6.6 ac-ft

ACTIVE CAPACITY 2.84 ac-ft

INDUSTRIAL POLLUTION CONTROL (SEDIMENT STORAGE) 6.6 ac-ft

INDUSTRIAL POLLUTION CONTROL (DUST ABATEMENT) 2.84 ac-ft

TOTAL AVAILABLE CAPACITY = 9.44 ac-ft

NOTE:
1. POND IS ENTIRELY INCISED. NO SPILLWAY HYDRAULICS ARE PROVIDED.
2. TOTAL AVAILABLE RUNOFF STORAGE EXCEEDS RUNOFF VOLUME.
3. THE ACTIVE CAPACITY WILL BE PUMP EVACUATED.

CERTIFICATE OF ENGINEER

I, Jeffrey G. Barron, hereby certify that this drawing was prepared by myself or by engineers under my direct supervision and that it correctly represents the conditions described in the accompanying application which is designed to meet the requirements of the Wyoming Environmental Quality Act and its accompanying regulations.

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY

1101 SUGARVIEW DR. STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description

ADDENDUM MP-2
EXHIBIT 1

TFN 6 2/025
RECD OCT 23, 2015

SP-1 SEDIMENT POND

Drawn By:	CIG
Checked By:	JGB
Date:	9/25/2015

FILE: EX_1-7_12.dwg

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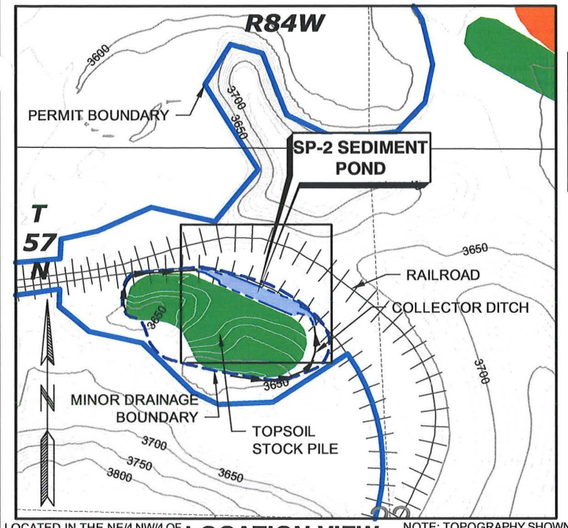
www.wwcengineering.com

K:\Sheridan\RAMACO\13139\ACAD_WY83EC\DWGS_MINE_PLAN_RESPONSE_2\ADD_MP-2\EX_1-7_12.dwg 10/1/2015 8:57:12 AM rod ventling

DEQ 12-165



LOCATED IN THE NE/4 NW/4 OF SECTION 22, T57N, R84W

LOCATION VIEW

SCALE: 1" = 1000'
C.I. = 10'

NOTE: TOPOGRAPHY SHOWN USES NAD 83 WYOMING EAST CENTRAL COORDINATE SYSTEM

HYDROLOGIC DESIGN STORM CALCULATIONS FOR SP-2

DRAINAGE BASIN PARAMETERS					10-YR, 24-HR STORM		
DRAINAGE AREA (sq-mi)	WATERCOURSE LENGTH (mi)	ELEVATION DIFFERENCE (ft)	CURVE NO. (CN)	INFILTRATION LOSS (iph)	10-YR, 24-HR PRECIP. (in)	PEAK INFLOW (cfs)	RUNOFF VOLUME (ac-ft)
0.03	0.36	95	90	0.00	2.35	34.81	2.24

NOTE: RUNOFF VOLUMES AND PEAK INFLOWS WERE COMPUTED BY THE RAINFALL/RUNOFF PROGRAM "TRIHYDRO" USING THE SCS TYPE II DISTRIBUTION.

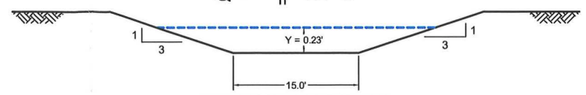
SEDIMENT YIELD CALCULATIONS

SOURCE AREA (ac)	RAINFALL FACTOR (R)	SOIL ERODIBILITY (K)	TOPOGRAPHIC FACTOR (LS)	COVER MANAGEMENT (C)	SUPPORT PRACTICE (P)	SOIL [1] LOSS (t/ac/yr)	DELIVERY [2] RATIO (%)	THREE-YEAR SEDIMENT YIELD (ac-ft)
16.25	30.00	0.50	18.9	1	1	284.1	60.1	4.8

NOTE:
1. SEDIMENT CAPACITY WAS DETERMINED BY THE APPLICATION OF THE UNIVERSAL SOIL LOSS EQUATION (USLE) TO SEDIMENT SOURCE AREA(S). FOR THESE CALCULATIONS SEDIMENT DENSITY WAS ASSUMED TO EQUAL 80 lb/cu ft.
2. SEDIMENT DELIVERY RATIO TAKEN FROM "SEDIMENT SOURCE AREAS, DELIVERY RATIOS, AND INFLUENCING MORPHOLOGICAL FACTORS." ROEHL 1961.

TRAPEZOIDAL INLET CHANNEL HYDRAULICS

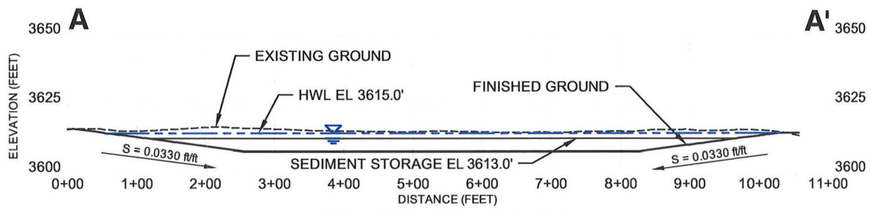
$$Q = \frac{1.49}{n} AR^{2/3}S^{1/2}$$



TYPICAL CROSS SECTION
NOT TO SCALE

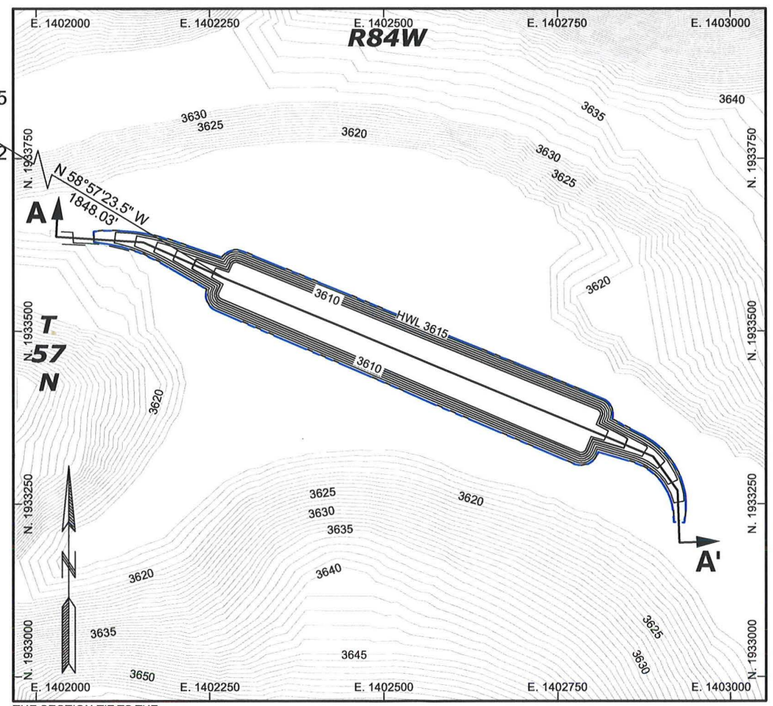
Q = 18.00 cfs	A = 3.64 ft^2
n = 0.020	P = 16.47 ft
S = 0.033 ft/ft	R = 0.22 ft
b = 15.0 ft	V = 4.94 fps
	Y = 0.23 ft

NOTE: CROSS SECTION IS TYPICAL FOR BOTH INLETS.



CROSS SECTION A-A'

SCALE: HORIZ 1"=200' VERT 1"=50'



THE SECTION TIE TO THE SP-2 POND IS LOCATED AT LAT:45.916757, LON:-101.621979

PLAN VIEW

SCALE: 1" = 200'
C.I. = 1'

AREA CAPACITY TABLE

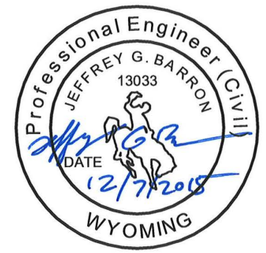
ELEVATION (ft)	AREA (ac)	AVG. AREA (ac)	CAPACITY (ac-ft) INCR.	CAPACITY (ac-ft) ACCUM.	
3609.0	0.84			0.00	
		0.90	0.90		
3610.0	0.95			0.90	
		1.01	1.01		
3611.0	1.07			1.91	
		1.14	1.14		
3612.0	1.20			3.05	
		1.27	1.27		
3613.0	1.34			4.86	
		1.42	1.42		
3614.0	1.49			5.74	
		1.57	1.57		
3615.0	1.64			7.32	

INACTIVE CAPACITY 4.8 ac-ft — INDUSTRIAL POLLUTION CONTROL (SEDIMENT STORAGE) 4.8 ac-ft

ACTIVE CAPACITY 2.52 ac-ft — INDUSTRIAL POLLUTION CONTROL (DUST ABATEMENT) 2.52 ac-ft

TOTAL AVAILABLE CAPACITY = 7.32 ac-ft

NOTE:
1. POND IS ENTIRELY INCISED. NO SPILLWAY HYDRAULICS ARE PROVIDED.
2. TOTAL AVAILABLE RUNOFF STORAGE EXCEEDS RUNOFF VOLUME.
3. THE ACTIVE CAPACITY WILL BE PUMP EVACUATED.



CERTIFICATE OF ENGINEER

I, Jeffrey G. Barron, hereby certify that this drawing was prepared by myself or by engineers under my direct supervision and that it correctly represents the conditions described in the accompanying application which is designed to meet the requirements of the Wyoming Environmental Quality Act and its accompanying regulations.

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGAR VIEW DR., STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
12/15	ROUND 3 COMMENTS

ADDENDUM MP-2
EXHIBIT 2

SP-2 SEDIMENT POND

TFN 6 2/025
RECD DEC 18, 2015

Drawn By: CIG
Checked By: JGB
Date: 9/25/2015

FILE: EX_1-7_12_R3.dwg

WWC ENGINEERING
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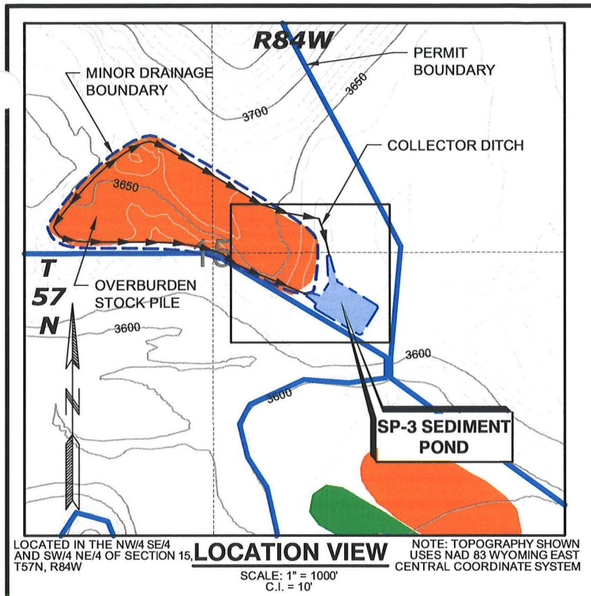
K:\Sheridan\RAMACO\13139\ACAD_WY83EC\DWGS_MINE_PLAN_RESPONSE_3\ADD_MP-2\EX_1-7_12_R3.dwg 12/7/2015 3:21:33 PM condia gonzales

DEQ 12-166



LOCATED IN THE NW/4 SE/4 AND SW/4 NE/4 OF SECTION 15, T57N, R84W

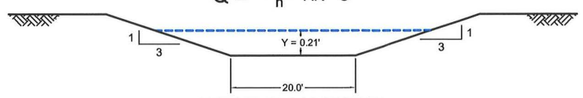
LOCATION VIEW

SCALE: 1" = 1000'
C.I. = 10'

NOTE: TOPOGRAPHY SHOWN USES NAD 83 WYOMING EAST CENTRAL COORDINATE SYSTEM

TRAPEZOIDAL INLET A-A' CHANNEL HYDRAULICS

$$Q = \frac{1.49}{n} AR^{2/3}S^{1/2}$$

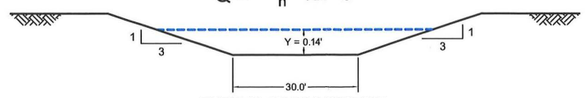


TYPICAL CROSS SECTION
NOT TO SCALE

Q = 21.00 cfs	A = 4.28 ft^2
n = 0.020	P = 21.31 ft
S = 0.037 ft/ft	R = 0.20 ft
b = 20.0 ft	V = 4.90 fps
	Y = 0.21 ft

TRAPEZOIDAL INLET B-B' CHANNEL HYDRAULICS

$$Q = \frac{1.49}{n} AR^{2/3}S^{1/2}$$



TYPICAL CROSS SECTION
NOT TO SCALE

Q = 21.00 cfs	A = 4.19 ft^2
n = 0.020	P = 30.87 ft
S = 0.065 ft/ft	R = 0.14 ft
b = 30.0 ft	V = 5.01 fps
	Y = 0.14 ft

NOTE: SEE SHEET 2 FOR INLET A-A' AND B-B' PLAN VIEW.

HYDROLOGIC DESIGN STORM CALCULATIONS FOR SP-3

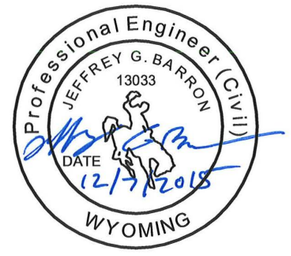
DRAINAGE BASIN PARAMETERS					10-YR, 24-HR STORM		
DRAINAGE AREA (sq-mi)	WATERCOURSE LENGTH (mi)	ELEVATION DIFFERENCE (ft)	CURVE NO. (CN)	INFILTRATION LOSS (iph)	10-YR, 24-HR PRECIP. (in)	PEAK INFLOW (cfs)	RUNOFF VOLUME (ac-ft)
0.04	0.56	105	90	0.00	2.35	40.84	2.98

NOTE: RUNOFF VOLUMES AND PEAK INFLOWS WERE COMPUTED BY THE RAINFALL/RUNOFF PROGRAM "TRIHYDRO" USING THE SCS TYPE II DISTRIBUTION.

SEDIMENT YIELD CALCULATIONS

SOURCE AREA (ac)	RAINFALL FACTOR (R)	SOIL ERODIBILITY (K)	TOPOGRAPHIC FACTOR (LS)	COVER MANAGEMENT (C)	SUPPORT PRACTICE (P)	SOIL [1] LOSS (t/ac/yr)	DELIVERY [2] RATIO (%)	THREE-YEAR SEDIMENT YIELD (ac-ft)
27.16	30.00	0.50	30.5	1	1	457.9	53.9	11.5

NOTE:
1. SEDIMENT CAPACITY WAS DETERMINED BY THE APPLICATION OF THE UNIVERSAL SOIL LOSS EQUATION (USLE) TO SEDIMENT SOURCE AREA(S). FOR THESE CALCULATIONS SEDIMENT DENSITY WAS ASSUMED TO EQUAL 80 lb/cu ft.
2. SEDIMENT DELIVERY RATIO TAKEN FROM "SEDIMENT SOURCE AREAS, DELIVERY RATIOS, AND INFLUENCING MORPHOLOGICAL FACTORS." ROEHL 1961.



CERTIFICATE OF ENGINEER

I, Jeffrey G. Barron, hereby certify that this drawing was prepared by myself or by engineers under my direct supervision and that it correctly represents the conditions described in the accompanying application which is designed to meet the requirements of the Wyoming Environmental Quality Act and its accompanying regulations.

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGARVIEW DR. STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
12/15	ROUND 3 COMMENTS

ADDENDUM MP-2
EXHIBIT 3
SHEET 1 OF 2

SP-3 SEDIMENT POND

TFN 6 2/025
RECD DEC 18, 2015

Drawn By: CIG
Checked By: JGB
Date: 9/25/2015
FILE: EX_1-7_12_R3.dwg

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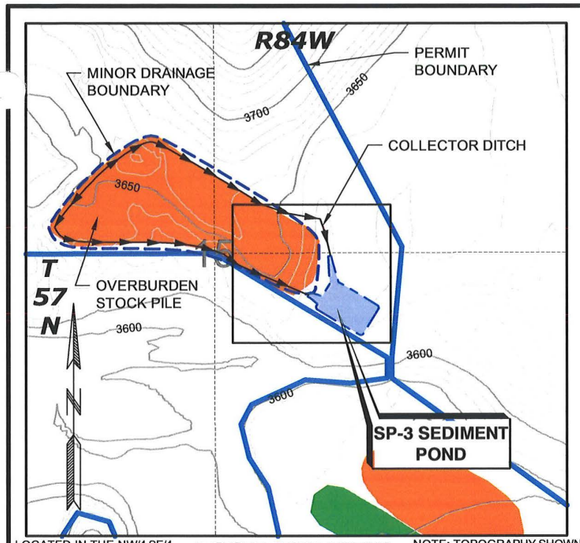
K:\Sheridan\RAMACO\13139\ACAD_WY83EC\DWGS_MINE_PLAN_RESPONSE_3\ADD_MP-2\EX_1-7_12_R3.dwg 12/7/2015 3:21:49 PM condia gonzales

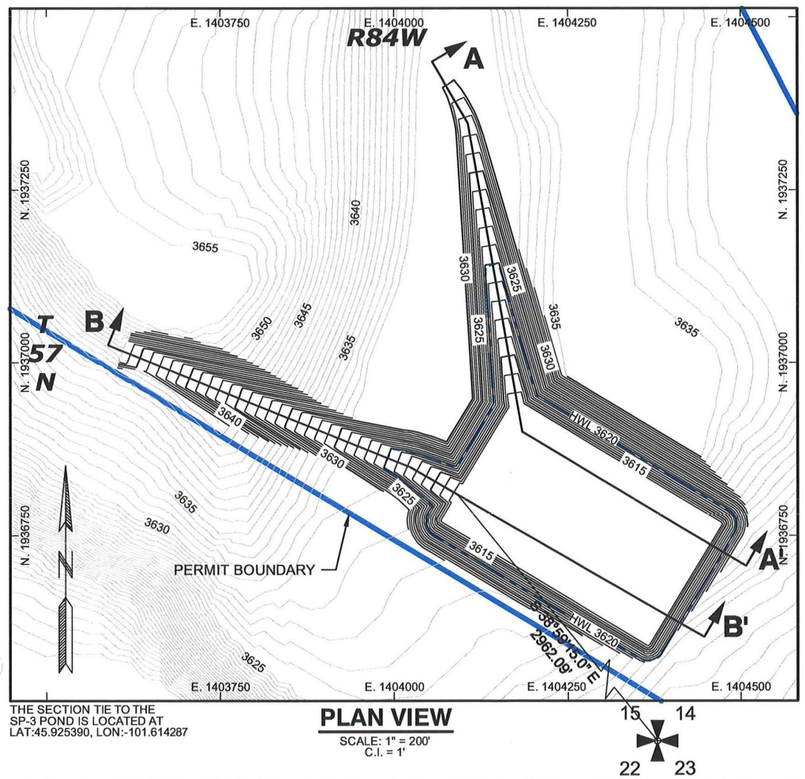


LOCATED IN THE NW/4 SE/4 AND SW/4 NE/4 OF SECTION 15, T57N, R84W

LOCATION VIEW

SCALE: 1" = 1000'
C.I. = 10'

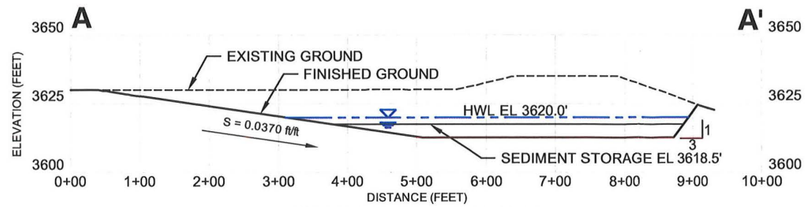
NOTE: TOPOGRAPHY SHOWN USES NAD 83 WYOMING EAST CENTRAL COORDINATE SYSTEM



THE SECTION TIE TO THE SP-3 POND IS LOCATED AT LAT:45.925390, LON:-101.614287

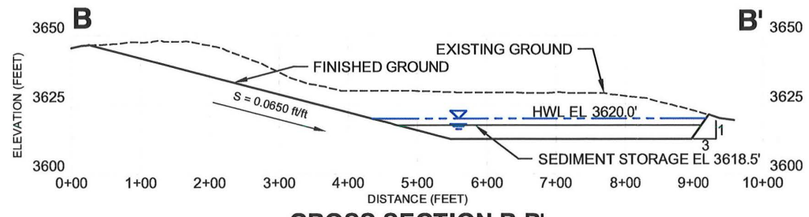
PLAN VIEW

SCALE: 1" = 200'
C.I. = 1'



CROSS SECTION A-A'

SCALE: HORIZ 1"=200' VERT 1"=50'



CROSS SECTION B-B'

SCALE: HORIZ 1"=200' VERT 1"=50'

AREA CAPACITY TABLE

ELEVATION (ft)	AREA (ac)	AVG. AREA (ac)	CAPACITY (ac-ft) INCR.	CAPACITY (ac-ft) ACCUM.	
3613.0	1.68			0.00	
		1.74	1.74		
3614.0	1.79			1.74	
		1.84	1.84		
3615.0	1.89			3.58	
		1.95	1.95		
3616.0	2.01			5.53	INDUSTRIAL POLLUTION CONTROL (SEDIMENT STORAGE) 11.5 ac-ft
		2.07	2.07		
3617.0	2.12			7.60	
		2.19	2.19		
3618.0	2.25			9.79	
		2.28	1.14		
3618.5	2.31			11.42	
		2.35	1.18		
3619.0	2.38			12.11	INDUSTRIAL POLLUTION CONTROL (DUST ABATEMENT) 3.06 ac-ft
		2.45	2.45		
3620.0	2.51			14.56	

INACTIVE CAPACITY 11.5 ac-ft

ACTIVE CAPACITY 3.06 ac-ft

TOTAL AVAILABLE CAPACITY = 14.56 ac-ft

NOTE: 1. POND IS ENTIRELY INCISED. NO SPILLWAY HYDRAULICS ARE PROVIDED.
2. TOTAL AVAILABLE RUNOFF STORAGE EXCEEDS RUNOFF VOLUME.
3. THE ACTIVE CAPACITY WILL BE PUMP EVACUATED.

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGAR VIEW DR. STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
12/15	ROUND 3 COMMENTS

ADDENDUM MP-2
EXHIBIT 3

SHEET 2 OF 2

SP-3 SEDIMENT POND

TFN 6 2/025
RECD DEC 18, 2015

Drawn By: CIG
Checked By: JGB
Date: 9/25/2015

FILE: EX_1-7_12_R3.dwg

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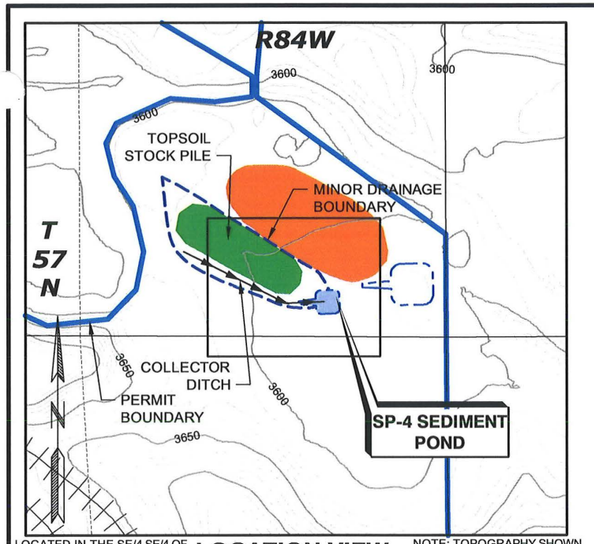
K:\Sheridan\RAMACO\13139\ACAD_WY83EC\DWGS_MINE_PLAN_RESPONSE_3\ADD_MP-2\EX_1-7_12_R3.dwg 12/7/2015 3:22:00 PM condia gonzales



LOCATED IN THE SE/4 SE/4 OF SECTION 15, T57N, R84W

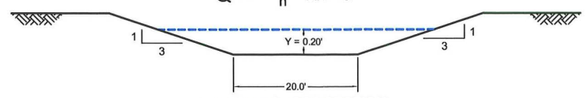
LOCATION VIEW

SCALE: 1" = 1000'
C.I. = 10'

NOTE: TOPOGRAPHY SHOWN USES NAD 83 WYOMING EAST CENTRAL COORDINATE SYSTEM

TRAPEZOIDAL INLET A-A' CHANNEL HYDRAULICS

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$



TYPICAL CROSS SECTION
NOT TO SCALE

Q = 20.00 cfs	A = 4.06 ft^2
n = 0.020	P = 21.25 ft
S = 0.040 ft/ft	R = 0.19 ft
b = 20.0 ft	V = 4.92 fps
	Y = 0.20 ft

NOTE: SEE SHEET 2 FOR INLET A-A' PLAN VIEW.

HYDROLOGIC DESIGN STORM CALCULATIONS FOR SP-4

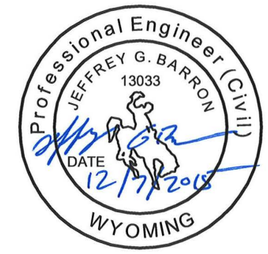
DRAINAGE BASIN PARAMETERS					10-YR, 24-HR STORM		
DRAINAGE AREA (sq-mi)	WATERCOURSE LENGTH (mi)	ELEVATION DIFFERENCE (ft)	CURVE NO. (CN)	INFILTRATION LOSS (iph)	10-YR, 24-HR PRECIP. (in)	PEAK INFLOW (cfs)	RUNOFF VOLUME (ac-ft)
0.02	0.34	15	90	0.00	2.35	19.23	1.49

NOTE: RUNOFF VOLUMES AND PEAK INFLOWS WERE COMPUTED BY THE RAINFALL/RUNOFF PROGRAM "TRIHYDRO" USING THE SCS TYPE II DISTRIBUTION.

SEDIMENT YIELD CALCULATIONS

SOURCE AREA (ac)	RAINFALL FACTOR (R)	SOIL ERODIBILITY (K)	TOPOGRAPHIC FACTOR (LS)	COVER MANAGEMENT (C)	SUPPORT PRACTICE (P)	SOIL [1] LOSS (t/ac/yr)	DELIVERY [2] RATIO (%)	THREE-YEAR SEDIMENT YIELD (ac-ft)
11.82	30.00	0.50	6.9	1	1	104.1	64.3	1.4

NOTE:
1. SEDIMENT CAPACITY WAS DETERMINED BY THE APPLICATION OF THE UNIVERSAL SOIL LOSS EQUATION (USLE) TO SEDIMENT SOURCE AREA(S). FOR THESE CALCULATIONS SEDIMENT DENSITY WAS ASSUMED TO EQUAL 80 lb/cu ft.
2. SEDIMENT DELIVERY RATIO TAKEN FROM "SEDIMENT SOURCE AREAS, DELIVERY RATIOS, AND INFLUENCING MORPHOLOGICAL FACTORS." ROEHL 1961.



CERTIFICATE OF ENGINEER

I, Jeffrey G. Barron, hereby certify that this drawing was prepared by myself or by engineers under my direct supervision and that it correctly represents the conditions described in the accompanying application which is designed to meet the requirements of the Wyoming Environmental Quality Act and its accompanying regulations.

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGARVIEW DR. STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
12/15	ROUND 3 COMMENTS

ADDENDUM MP-2
EXHIBIT 4
SHEET 1 OF 2

SP-4 SEDIMENT POND

TFN 6 2/025
RECD DEC 18, 2015

Drawn By: CIG
Checked By: JGB
Date: 12/7/2015

FILE: EX_1-7_12_R3.dwg

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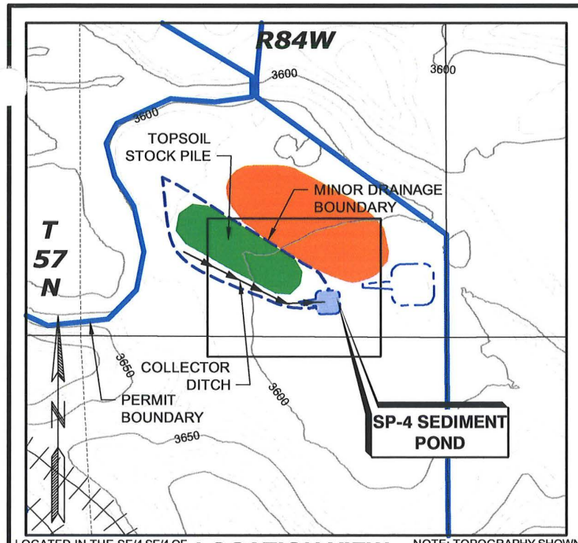
DEQ 12-169

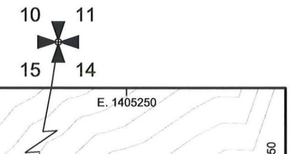


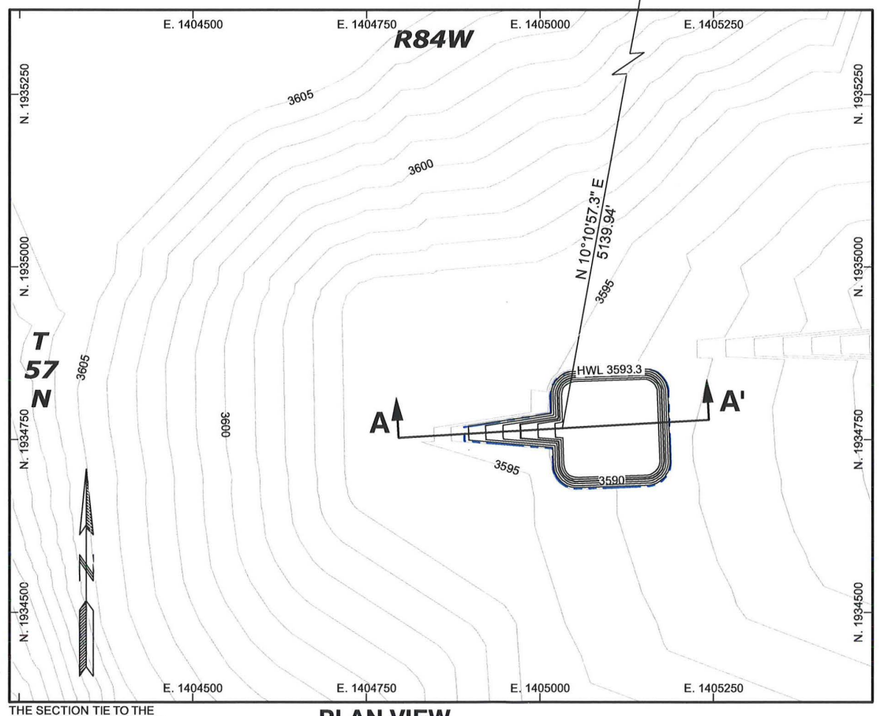
LOCATED IN THE SE/4 SE/4 OF SECTION 15, T57N, R84W

LOCATION VIEW

SCALE: 1" = 1000'
C.I. = 10'

NOTE: TOPOGRAPHY SHOWN USES NAD 83 WYOMING EAST CENTRAL COORDINATE SYSTEM

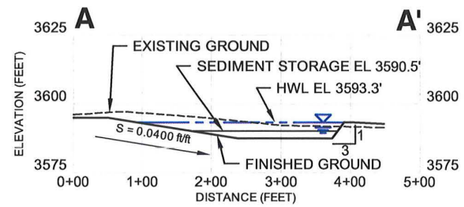




THE SECTION TIE TO THE SP-4 POND IS LOCATED AT LAT:45.919678, LON:-101.610948

PLAN VIEW

SCALE: 1" = 200'
C.I. = 1'



CROSS SECTION A-A'

SCALE: HORIZ 1"=200' VERT 1"=50'

AREA CAPACITY TABLE

ELEVATION (ft)	AREA (ac)	AVG. AREA (ac)	CAPACITY (ac-ft) INCR.	CAPACITY (ac-ft) ACCUM.
3588.0	0.44			0.00
3589.0	0.49	0.47	0.47	0.47
3590.0	0.54	0.52	0.52	0.99
3590.5	0.57	0.56	0.28	1.27
3591.0	0.60	0.59	0.30	1.57
3592.0	0.66	0.63	0.63	2.20
3593.0	0.72	0.69	0.69	2.89
3593.3	0.74	0.73	0.19	3.08

INACTIVE CAPACITY 1.4 ac-ft

ACTIVE CAPACITY 1.68 ac-ft

INDUSTRIAL POLLUTION CONTROL (SEDIMENT STORAGE) 1.4 ac-ft

INDUSTRIAL POLLUTION CONTROL (DUST ABATEMENT) 1.68 ac-ft

TOTAL AVAILABLE CAPACITY = 3.08 ac-ft

NOTE: 1. POND IS ENTIRELY INCISED. NO SPILLWAY HYDRAULICS ARE PROVIDED.
2. TOTAL AVAILABLE RUNOFF STORAGE EXCEEDS RUNOFF VOLUME.
3. THE ACTIVE CAPACITY WILL BE PUMP EVACUATED.

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY

1101 SUGAR VIEW DR. STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
12/15	ROUND 3 COMMENTS

ADDENDUM MP-2
EXHIBIT 4

SP-4 SEDIMENT POND

TFN 6 2/025
RECD DEC 18, 2015

Drawn By: CIG
Checked By: JGB
Date: 12/7/2015

FILE: EX_1-7_12_R3.dwg

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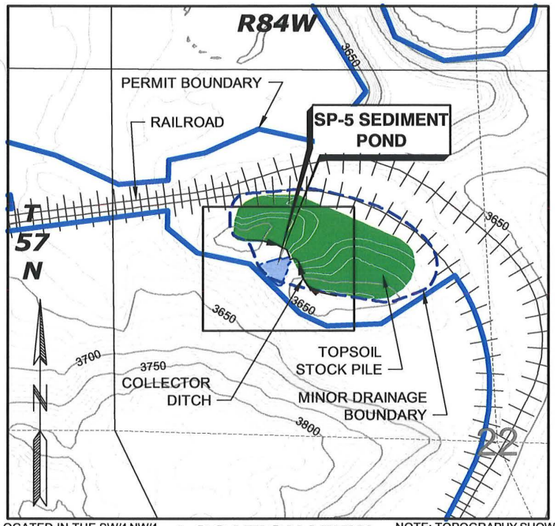
K:\Sheridan\RAMACO\13139\ACAD_WY83EC\DWGS_MINE_PLAN_RESPONSE_3\ADD_MP-2\EX_1-7_12_R3.dwg 12/7/2015 3:22:25 PM condia gonzales



LOCATED IN THE SW/4 NW/4 OF SECTION 22, T57N, R84W

LOCATION VIEW

SCALE: 1" = 1000'
C.I. = 10'

NOTE: TOPOGRAPHY SHOWN USES NAD 83 WYOMING EAST CENTRAL COORDINATE SYSTEM

HYDROLOGIC DESIGN STORM CALCULATIONS FOR SP-5

DRAINAGE BASIN PARAMETERS					10-YR, 24-HR STORM		
DRAINAGE AREA (sq-mi)	WATERCOURSE LENGTH (mi)	ELEVATION DIFFERENCE (ft)	CURVE NO. (CN)	INFILTRATION LOSS (iph)	10-YR, 24-HR PRECIP. (in)	PEAK INFLOW (cfs)	RUNOFF VOLUME (ac-ft)
0.01	0.08	105	90	0.00	2.35	12.48	0.75

NOTE: RUNOFF VOLUMES AND PEAK INFLOWS WERE COMPUTED BY THE RAINFALL/RUNOFF PROGRAM "TRIHYDRO" USING THE SCS TYPE II DISTRIBUTION.

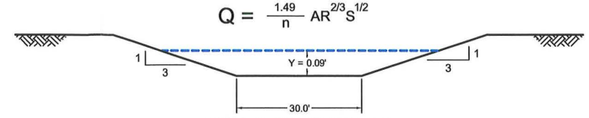
SEDIMENT YIELD CALCULATIONS

SOURCE AREA (ac)	RAINFALL FACTOR (R)	SOIL ERODIBILITY (K)	TOPOGRAPHIC FACTOR (LS)	COVER MANAGEMENT (C)	SUPPORT PRACTICE (P)	SOIL [1] LOSS (t/ac/yr)	DELIVERY [2] RATIO (%)	THREE-YEAR SEDIMENT YIELD (ac-ft)
4.26	30.00	0.50	27.3	1	1	409.8	79.9	2.4

NOTE:
1. SEDIMENT CAPACITY WAS DETERMINED BY THE APPLICATION OF THE UNIVERSAL SOIL LOSS EQUATION (USLE) TO SEDIMENT SOURCE AREA(S). FOR THESE CALCULATIONS SEDIMENT DENSITY WAS ASSUMED TO EQUAL 80 lb/cu ft.
2. SEDIMENT DELIVERY RATIO TAKEN FROM "SEDIMENT SOURCE AREAS, DELIVERY RATIOS, AND INFLUENCING MORPHOLOGICAL FACTORS." ROEHL 1961.

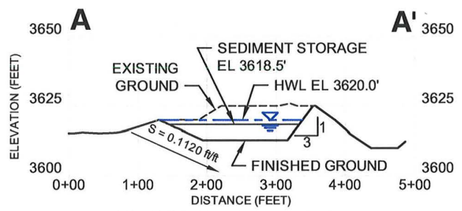
TRAPEZOIDAL INLET CHANNEL HYDRAULICS

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$



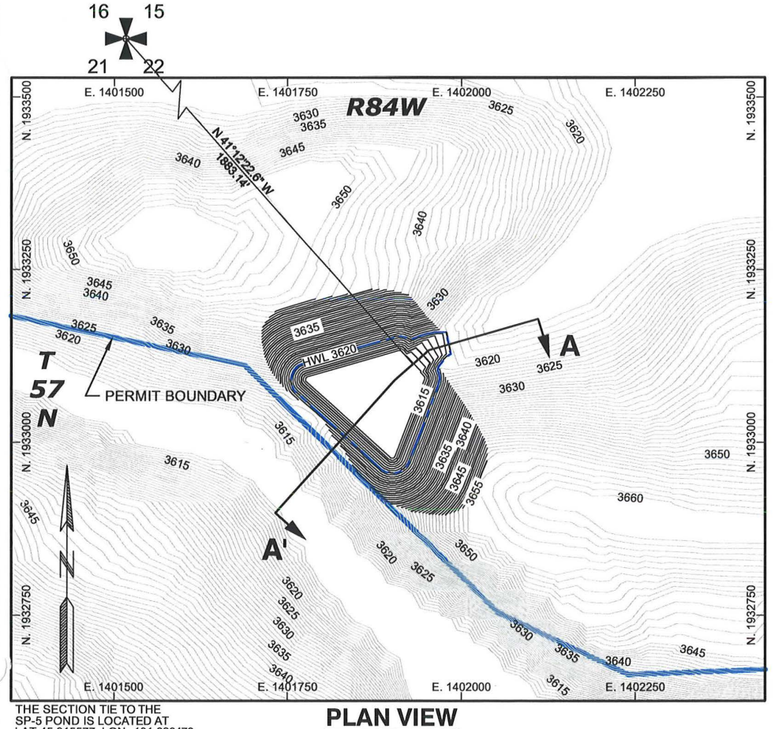
TYPICAL CROSS SECTION
NOT TO SCALE

Q = 12.50 cfs	A = 2.60 ft^2
n = 0.020	P = 30.54 ft
S = 0.112 ft/ft	R = 0.08 ft
b = 30.0 ft	V = 4.82 fps
	Y = 0.09 ft



CROSS SECTION A-A'

SCALE: HORIZ 1"=200' VERT 1"=50'



THE SECTION TIE TO THE SP-5 POND IS LOCATED AT LAT:45.915577, LON:-101.623476

PLAN VIEW

SCALE: 1" = 200'
C.I. = 1'

AREA CAPACITY TABLE

ELEVATION (ft)	AREA (ac)	AVG. AREA (ac)	CAPACITY (ac-ft) INCR.	CAPACITY (ac-ft) ACCUM.	
3613.0	0.32			0.00	
		0.34	0.34		
3614.0	0.36			0.34	
		0.38	0.38		
3615.0	0.40			0.72	INDUSTRIAL POLLUTION CONTROL (SEDIMENT STORAGE) 2.4 ac-ft
		0.42	0.42		
3616.0	0.44			1.14	
		0.47	0.47		
3617.0	0.49			1.61	
		0.51	0.51		
3618.0	0.53			2.12	
		0.55	0.27		
3618.5	0.56			2.39	
		0.57	0.29		
3619.0	0.58			2.68	
		0.61	0.61		
3620.0	0.63			3.29	

INACTIVE CAPACITY 2.4 ac-ft

ACTIVE CAPACITY 0.89 ac-ft

INDUSTRIAL POLLUTION CONTROL (DUST ABATEMENT) 0.89 ac-ft

TOTAL AVAILABLE CAPACITY = 3.29 ac-ft

NOTE:
1. POND IS ENTIRELY INCISED. NO SPILLWAY HYDRAULICS ARE PROVIDED.
2. TOTAL AVAILABLE RUNOFF STORAGE EXCEEDS RUNOFF VOLUME.
3. THE ACTIVE CAPACITY WILL BE PUMP EVACUATED.

Professional Engineer (Civil)
JEFFREY G. BARRON
13033
DATE 12/7/2015
WYOMING

CERTIFICATE OF ENGINEER

I, Jeffrey G. Barron, hereby certify that this drawing was prepared by myself or by engineers under my direct supervision and that it correctly represents the conditions described in the accompanying application which is designed to meet the requirements of the Wyoming Environmental Quality Act and its accompanying regulations.

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGARVIEW DR. STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
12/15	ROUND 3 COMMENTS

ADDENDUM MP-2
EXHIBIT 5

SP-5 SEDIMENT POND

TFN 6 2/025
RECD DEC 18, 2015

Drawn By: CIG
Checked By: JGB
Date: 9/25/2015

FILE: EX_1-7_12_R3.dwg

WWC ENGINEERING
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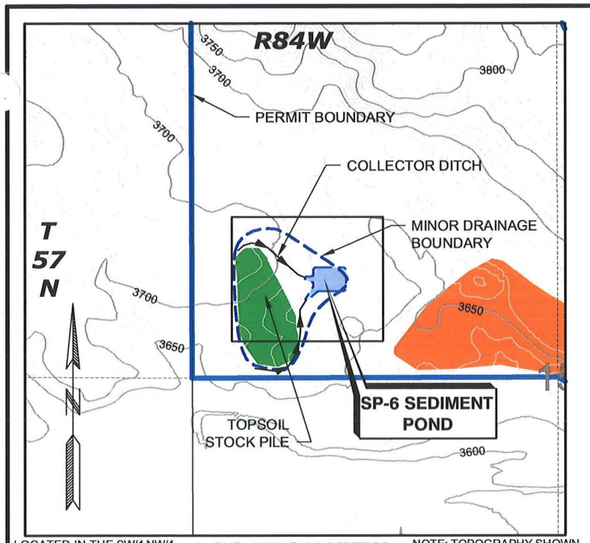
DEQ 12-171



LOCATED IN THE SW/4 NW/4 OF SECTION 15, T57N, R84W

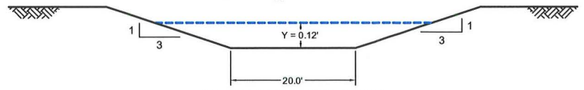
LOCATION VIEW

SCALE: 1" = 1000'
C.I. = 10'

NOTE: TOPOGRAPHY SHOWN USES NAD 83 WYOMING EAST CENTRAL COORDINATE SYSTEM

TRAPEZOIDAL INLET A-A' CHANNEL HYDRAULICS

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$$

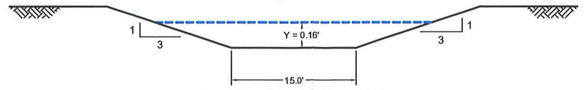


TYPICAL CROSS SECTION
NOT TO SCALE

Q = 12.00 cfs	A = 2.40 ft^2
n = 0.020	P = 20.75 ft
S = 0.08 ft/ft	R = 0.12 ft
b = 20.0 ft	V = 4.99 fps
	Y = 0.12 ft

TRAPEZOIDAL INLET B-B' CHANNEL HYDRAULICS

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$$



TYPICAL CROSS SECTION
NOT TO SCALE

Q = 12.00 cfs	A = 2.42 ft^2
n = 0.020	P = 15.99 ft
S = 0.055 ft/ft	R = 0.15 ft
b = 15.0 ft	V = 4.95 fps
	Y = 0.16 ft

NOTE: SEE SHEET 2 FOR INLET A-A' AND B-B' PLAN VIEW.

HYDROLOGIC DESIGN STORM CALCULATIONS FOR SP-6

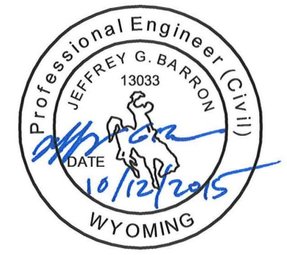
DRAINAGE BASIN PARAMETERS					10-YR, 24-HR STORM		
DRAINAGE AREA (sq-mi)	WATERCOURSE LENGTH (mi)	ELEVATION DIFFERENCE (ft)	CURVE NO. (CN)	INFILTRATION LOSS (iph)	10-YR, 24-HR PRECIP. (in)	PEAK INFLOW (cfs)	RUNOFF VOLUME (ac-ft)
0.02	0.28	70	90	0.00	2.35	23.68	1.49

NOTE: RUNOFF VOLUMES AND PEAK INFLOWS WERE COMPUTED BY THE RAINFALL/RUNOFF PROGRAM "TRIHYDRO" USING THE SCS TYPE II DISTRIBUTION.

SEDIMENT YIELD CALCULATIONS

SOURCE AREA (ac)	RAINFALL FACTOR (R)	SOIL ERODIBILITY (K)	TOPOGRAPHIC FACTOR (LS)	COVER MANAGEMENT (C)	SUPPORT PRACTICE (P)	SOIL [1] LOSS (t/ac/yr)	DELIVERY [2] RATIO (%)	THREE-YEAR SEDIMENT YIELD (ac-ft)
28.15	30.00	0.50	7.3	1	1	109.3	53.5	2.8

NOTE:
1. SEDIMENT CAPACITY WAS DETERMINED BY THE APPLICATION OF THE UNIVERSAL SOIL LOSS EQUATION (USLE) TO SEDIMENT SOURCE AREA(S). FOR THESE CALCULATIONS SEDIMENT DENSITY WAS ASSUMED TO EQUAL 80 lb/cu ft.
2. SEDIMENT DELIVERY RATIO TAKEN FROM "SEDIMENT SOURCE AREAS, DELIVERY RATIOS, AND INFLUENCING MORPHOLOGICAL FACTORS." ROEHL 1961.



CERTIFICATE OF ENGINEER

I, Jeffrey G. Barron, hereby certify that this drawing was prepared by myself or by engineers under my direct supervision and that it correctly represents the conditions described in the accompanying application which is designed to meet the requirements of the Wyoming Environmental Quality Act and its accompanying regulations.

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY

1101 SUGARVIEW DR, STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description

ADDENDUM MP-2
EXHIBIT 6 **SHEET 1 OF 2**

SP-6 SEDIMENT POND

TFN 6 2/025
RECD OCT 23, 2015

Drawn By: CIG
Checked By: JGB
Date: 9/25/2015

FILE: EX_1-7_12.dwg

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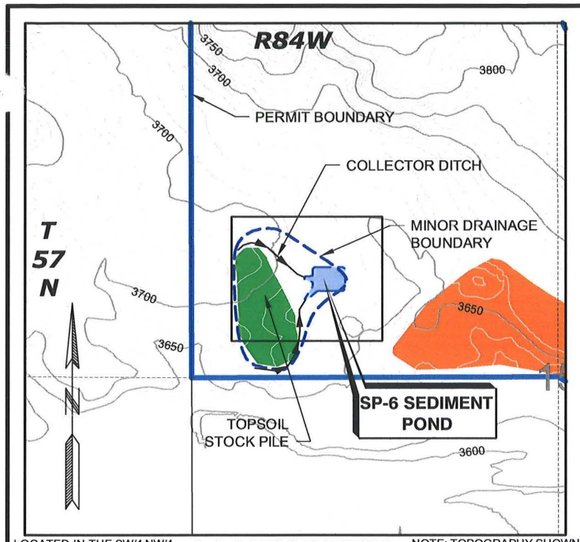
DEQ 12-172



LOCATED IN THE SW/4 NW/4 OF SECTION 15, T57N, R84W

LOCATION VIEW

SCALE: 1" = 1000'
C.I. = 10'

NOTE: TOPOGRAPHY SHOWN USES NAD 83 WYOMING EAST CENTRAL COORDINATE SYSTEM

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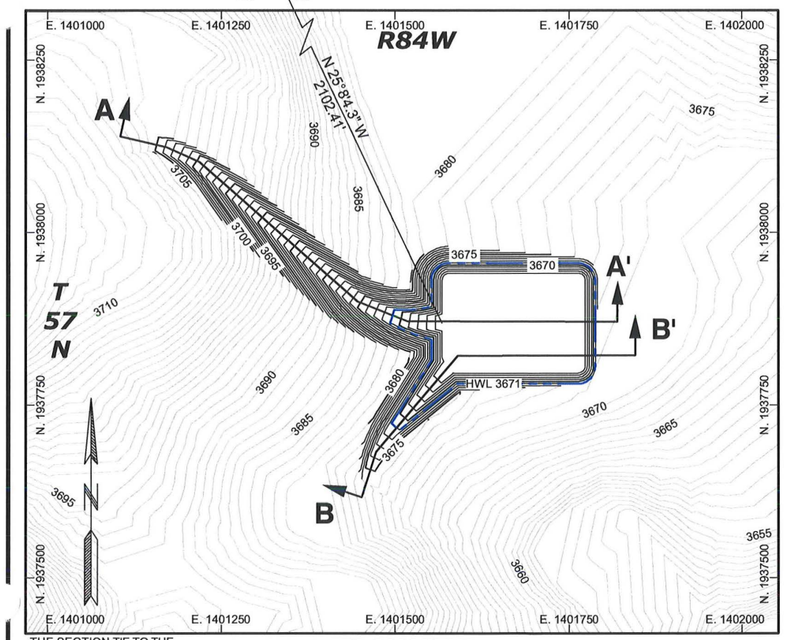
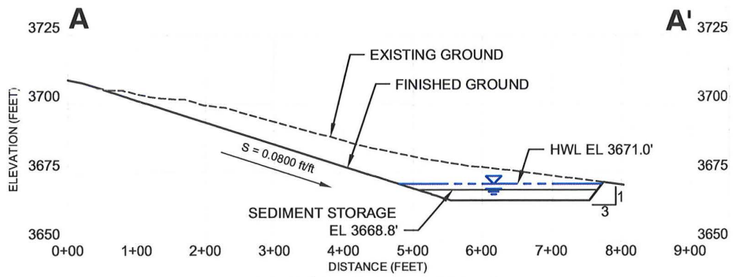


THE SECTION TIE TO THE SP-6 POND IS LOCATED AT LAT:45.928592, LON:-101.623994

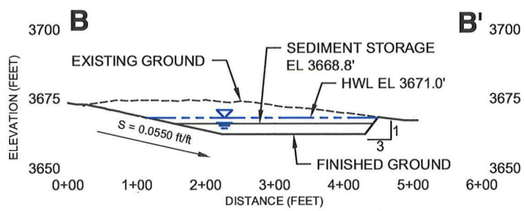
PLAN VIEW

SCALE: 1" = 200'
C.I. = 1'



CROSS SECTION A-A'

SCALE: HORIZ 1"=200' VERT 1"=50'



CROSS SECTION B-B'

SCALE: HORIZ 1"=200' VERT 1"=50'

AREA CAPACITY TABLE

ELEVATION (ft)	AREA (ac)	AVG. AREA (ac)	CAPACITY (ac-ft) INCR.	CAPACITY (ac-ft) ACCUM.	
3666.0	0.69			0.00	
		0.72	0.72		
3667.0	0.75			0.72	
		0.79	0.79		
3668.0	0.82			1.51	
		0.85	0.68		
3668.8	0.87			2.77	
		0.88	0.18		
3669.0	0.89			2.95	
		0.93	0.93		
3670.0	0.96			3.86	
		1.00	1.00		
3671.0	1.04			4.30	

INACTIVE CAPACITY 2.8 ac-ft — INDUSTRIAL POLLUTION CONTROL (SEDIMENT STORAGE) 2.8 ac-ft

ACTIVE CAPACITY 1.5 ac-ft — INDUSTRIAL POLLUTION CONTROL (DUST ABATEMENT) 1.5 ac-ft

TOTAL AVAILABLE CAPACITY = 4.30 ac-ft

NOTE: 1. POND IS ENTIRELY INCISED. NO SPILLWAY HYDRAULICS ARE PROVIDED.
2. TOTAL AVAILABLE RUNOFF STORAGE EXCEEDS RUNOFF VOLUME.
3. THE ACTIVE CAPACITY WILL BE PUMP EVACUATED.

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY

1101 SUGARVIEW DR, STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description

ADDENDUM MP-2
EXHIBIT 6

SHEET 2 OF 2

SP-6 SEDIMENT POND

TFN 6 2/025
RECD OCT 23, 2015

Drawn By:	CIG
Checked By:	JGB
Date:	9/25/2015

FILE: EX_1-7_12.dwg

WWC ENGINEERING
www.wwcengineering.com

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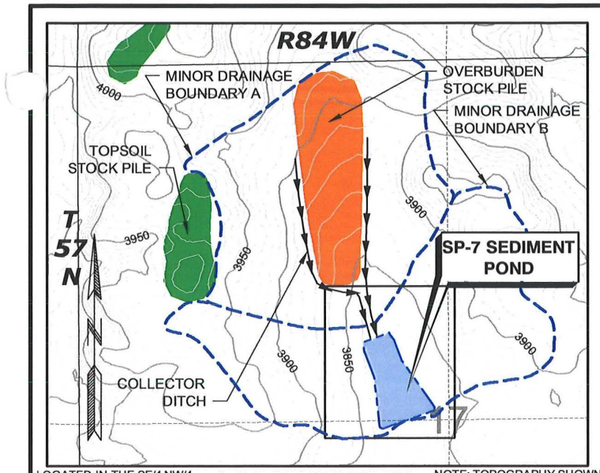
DEQ 12-173

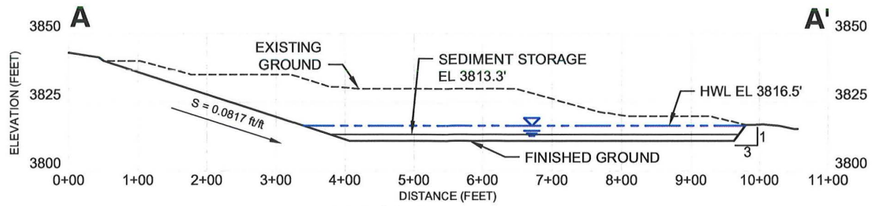


LOCATED IN THE SE/4 NW/4 AND NE/4 SW/4 OF SECTION 17, T57N, R84W

LOCATION VIEW

SCALE: 1" = 1000'
C.I. = 10'

NOTE: TOPOGRAPHY SHOWN USES NAD 83 WYOMING EAST CENTRAL COORDINATE SYSTEM

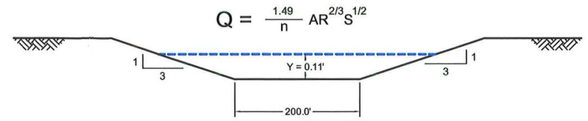


CROSS SECTION A-A'

SCALE: HORIZ 1"=200' VERT 1"=50'

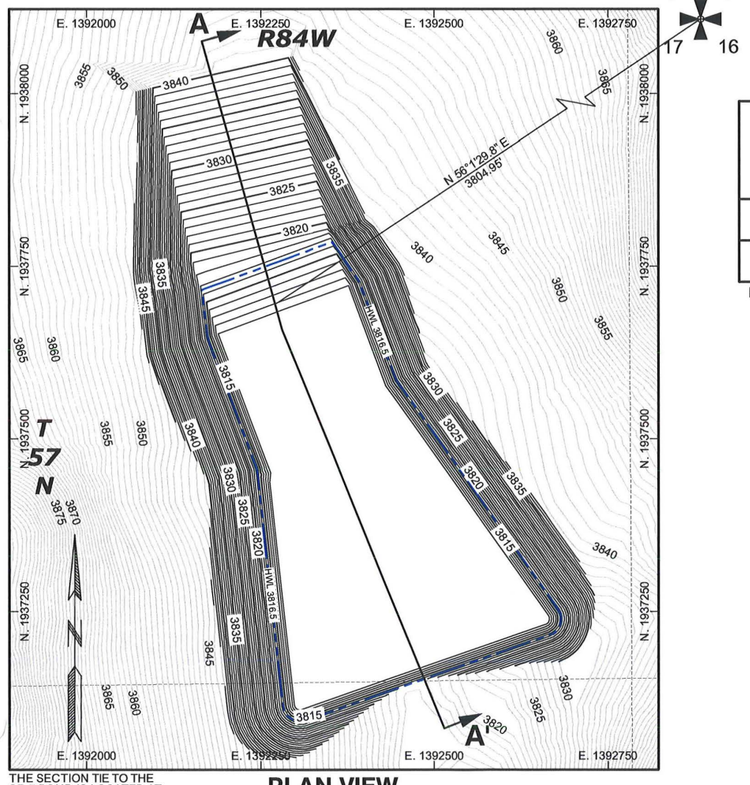
TRAPEZOIDAL INLET CHANNEL HYDRAULICS

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$$



TYPICAL CROSS SECTION
NOT TO SCALE

Q = 114.50 cfs	A = 22.92 ft^2
n = 0.020	P = 200.72 ft
S = 0.0817 ft/ft	R = 0.11 ft
b = 200.0 ft	V = 5.00 fps
	Y = 0.11 ft



THE SECTION TIE TO THE SP-7 POND IS LOCATED AT LAT:45.929247, LON:-101.660483

PLAN VIEW

SCALE: 1" = 200'
C.I. = 1'

SEDIMENT YIELD CALCULATIONS

DRAINAGE BOUNDARY	SOURCE AREA (ac)	RAINFALL FACTOR (R)	SOIL ERODIBILITY (K)	TOPOGRAPHIC FACTOR (LS)	COVER MANAGEMENT (C)	SUPPORT PRACTICE (P)	SOIL [1] LOSS (t/ac/yr)	DELIVERY [2] RATIO (%)	THREE-YEAR SEDIMENT YIELD (ac-ft)
A	61.52	30.00	0.29	17.1	1	1	150.2	45.3	7.2
B	53.76	30.00	0.19	2.7	1	1	14.8	46.6	0.6

NOTE:
1. SEDIMENT CAPACITY WAS DETERMINED BY THE APPLICATION OF THE UNIVERSAL SOIL LOSS EQUATION (USLE) TO SEDIMENT SOURCE AREA(S). FOR THESE CALCULATIONS SEDIMENT DENSITY WAS ASSUMED TO EQUAL 80 lb/cu ft.
2. SEDIMENT DELIVERY RATIO TAKEN FROM "SEDIMENT SOURCE AREAS, DELIVERY RATIOS, AND INFLUENCING MORPHOLOGICAL FACTORS." ROEHL 1961.

HYDROLOGIC DESIGN STORM CALCULATIONS FOR SP-7

DRAINAGE BASIN PARAMETERS						10-YR, 24-HR STORM		
DRAINAGE BASIN	DRAINAGE AREA (sq-mi)	WATERCOURSE LENGTH (mi)	ELEVATION DIFFERENCE (ft)	CURVE NO. (CN)	INFILTRATION LOSS (iph)	10-YR, 24-HR PRECIP. (in)	PEAK INFLOW (cfs)	RUNOFF VOLUME (ac-ft)
A	0.10	0.43	132	90	0.00	2.35	114.25	7.46
B	0.08	0.39	130	90	0.00	2.35	93.30	5.96

NOTE: RUNOFF VOLUMES AND PEAK INFLOWS WERE COMPUTED BY THE RAINFALL/RUNOFF PROGRAM "TRIHYDRO" USING THE SCS TYPE I DISTRIBUTION.

AREA CAPACITY TABLE

	ELEVATION (ft)	AREA (ac)	AVG. AREA (ac)	CAPACITY (ac-ft) INCR.	CAPACITY (ac-ft) ACCUM.	
INACTIVE CAPACITY 7.8 ac-ft	3811.0	3.39			0.00	
	3812.0	3.55	3.47	3.47	3.47	INDUSTRIAL POLLUTION CONTROL (SEDIMENT STORAGE) 7.8 ac-ft
	3813.0	3.71	3.63	3.63	7.10	
	3813.3	3.76	3.74	1.12	7.88	
ACTIVE CAPACITY 13.47 ac-ft	3814.0	3.88	3.82	2.67	10.89	
	3815.0	4.05	3.97	3.97	14.86	INDUSTRIAL POLLUTION CONTROL (DUST ABATEMENT) 13.47 ac-ft
	3816.0	4.22	4.14	4.14	19.00	
	3816.5	4.31	4.27	2.26	21.27	
TOTAL AVAILABLE CAPACITY = 21.27 ac-ft						

NOTE:
1. POND IS ENTIRELY INCISED. NO SPILLWAY HYDRAULICS ARE PROVIDED.
2. TOTAL AVAILABLE RUNOFF STORAGE EXCEEDS RUNOFF VOLUME.
3. THE ACTIVE CAPACITY WILL BE PUMP EVACUATED.

Professional Engineer (Civil) JEFFREY G. BARRON 13033 DATE 10/12/2015 WYOMING

CERTIFICATE OF ENGINEER

I, Jeffrey G. Barron, hereby certify that this drawing was prepared by myself or by engineers under my direct supervision and that it correctly represents the conditions described in the accompanying application which is designed to meet the requirements of the Wyoming Environmental Quality Act and its accompanying regulations.

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGARVIEW DR, STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description

ADDENDUM MP-2
EXHIBIT 7

SP-7 SEDIMENT POND

TFN 6 2/025
RECD OCT 23, 2015

Drawn By: CIG
Checked By: JGB
Date: 9/25/2015
FILE: EX_1-7_12.dwg

WWC ENGINEERING
www.wwcengineering.com

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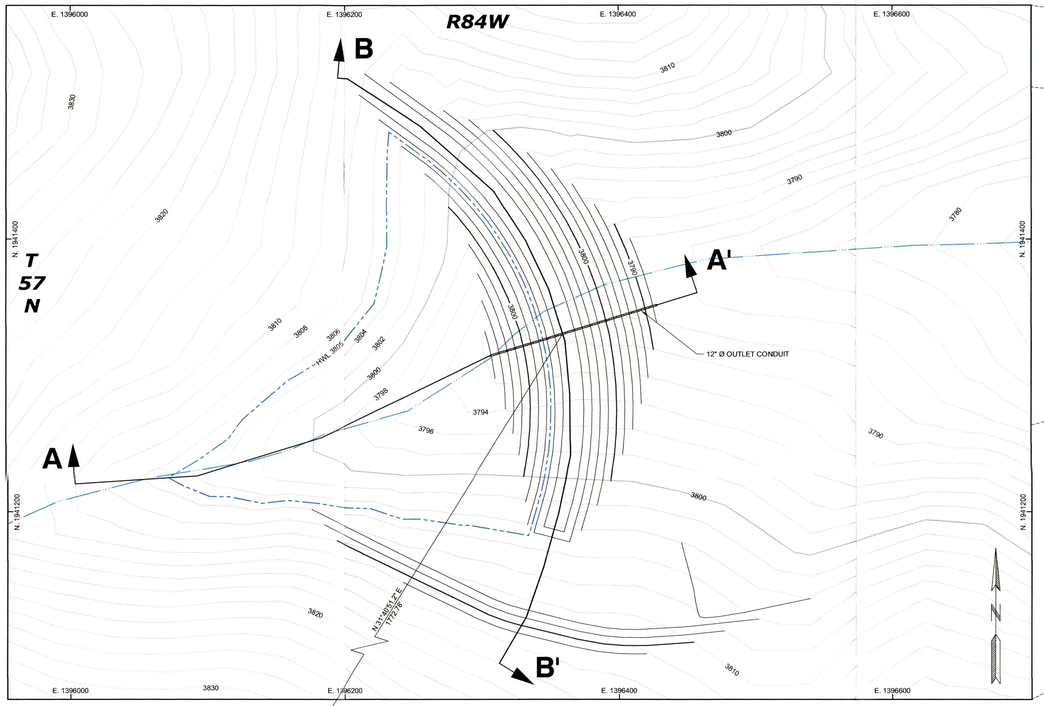
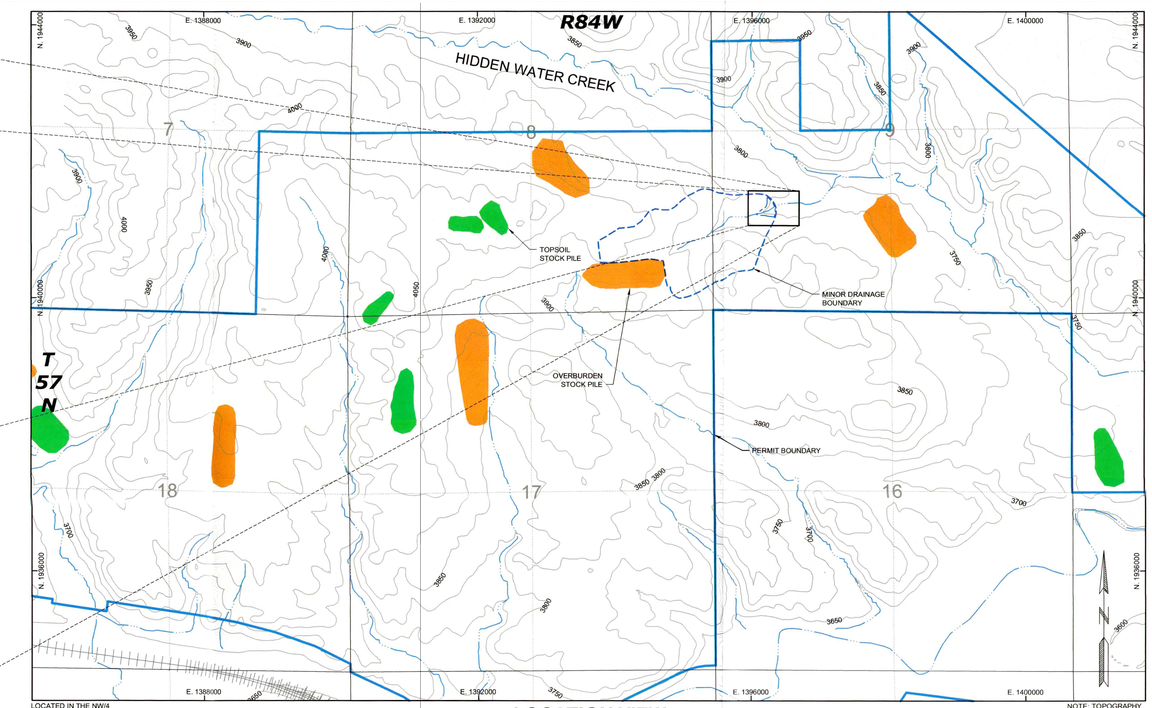
DEQ 12-174



PLAN VIEW
SCALE: 1" = 50'
C.I. = 2'

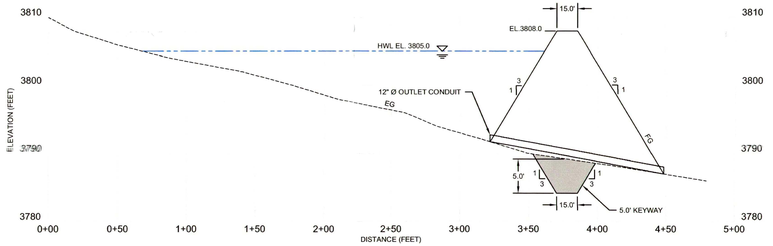
THE SECTION TIE TO THE IMPOUNDMENT IS LOCATED AT LAT:45.93870, LON:101.84362



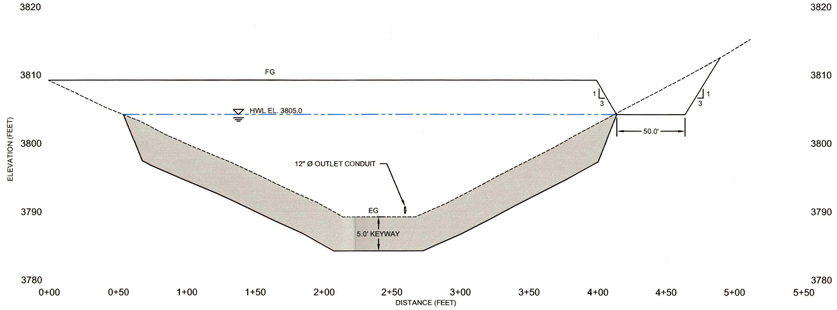
LOCATED IN THE NW/4 SW/4 OF SECTION 9, T57N, R84W

LOCATION VIEW
SCALE: 1" = 1000'
C.I. = 10'

NOTE: TOPOGRAPHY SHOWN USES NAD 83 WYOMING EAST CENTRAL COORDINATE SYSTEM



CROSS SECTION A-A'
SCALE: HORIZ 1" = 50' VERT 1" = 10'



CROSS SECTION B-B'
SCALE: HORIZ 1" = 50' VERT 1" = 10'

HYDROLOGIC DESIGN STORM CALCULATIONS

DRAINAGE BASIN PARAMETERS					10-YR, 24-HR STORM			25-YR, 6-HR STORM		
DRAINAGE AREA (sq-mi)	WATERCOURSE LENGTH (mi)	ELEVATION DIFFERENCE (ft)	CURVE NO. (CN)	INFILTRATION LOSS (iph)	10-YR, 24-HR PRECIP. (in)	PEAK INFLOW (cfs)	RUNOFF VOLUME (ac-ft)	25-YR, 6-HR PRECIP. (in)	PEAK INFLOW (cfs)	RUNOFF VOLUME (ac-ft)
0.09	0.57	180	76	0.00	2.35	39.17	2.91	1.95	36.70	1.86

NOTE: RUNOFF VOLUMES AND PEAK INFLOWS WERE COMPUTED BY THE RAINFALL/RUNOFF PROGRAM "TRIHYDRO" USING THE SCS TYPE II DISTRIBUTION.

EMERGENCY SPILLWAY HYDRAULICS

CONTROL SECTION

$$Q = CLH^{3/2}$$

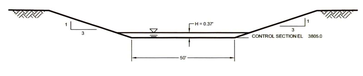
$Q_{25\text{-}6}$ = 36.70 cfs
C = 3.2
L = 50 ft
$H = \left(\frac{Q_{25\text{-}6}}{C}\right)^{2/3} = \left(\frac{36.70\ cfs}{3.2 \times 50\ ft}\right)^{2/3}$
H = 0.37 ft

TRANSPORT SECTION

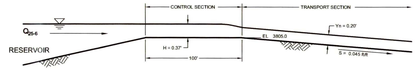
$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

Q = 36.70 cfs
n = 0.030
S = 0.045 ft/ft
Z = 3H:1V
b = 50 ft
A = 10.22 ft²
WP = 51.28 ft
R = 0.20 ft
V = 3.59 fps
Yn = 0.20 ft

NOTE: EMBANKMENT AND EMERGENCY SPILLWAY SLOPES WILL BE PROTECTED FROM EROSION BY PLANTING WITH WDEQ/LQD APPROVED GRASS MIXTURE.



EMERGENCY SPILLWAY CROSS SECTION
NOT TO SCALE



EMERGENCY SPILLWAY PROFILE
NOT TO SCALE

AREA CAPACITY TABLE

ELEVATION (ft)	AREA (ac)	AVG. AREA (ac)	CAPACITY (ac-ft) INCR.	CAPACITY (ac-ft) ACCUM.
3792.0	0.00			0.00
		0.03	0.06	
3794.0	0.05			0.06
		0.09	0.18	
3796.0	0.13			0.24
		0.19	0.38	
3798.0	0.24			0.62
		0.32	0.64	
3800.0	0.39			1.26
		0.49	0.98	
3802.0	0.58			2.24
		0.69	1.38	
3804.0	0.79			3.62
		0.85	0.85	
3805.0	0.91			4.47

ACTIVE CAPACITY 4.47 ac-ft

INDUSTRIAL POLLUTION CONTROL (DUST ABATEMENT) 4.47 ac-ft

NOTE: THE FLOOD CONTROL IMPOUNDMENT HAS BEEN SIZED TO ENTIRELY CONTAIN THE 10-YR, 24-HR DESIGN STORM RUNOFF VOLUME.

CERTIFICATE OF ENGINEER

I, Jeffrey G. Barron, hereby certify that this drawing was prepared by myself or by engineers under my direct supervision and that it correctly represents the conditions described in the accompanying application which is designed to meet the requirements of the Wyoming Environmental Quality Act and its accompanying regulations.

Professional Engineer (Civil) JEFFREY G. BARRON 13033 WYOMING
DATE EXP. 10/31/2015

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGARVIEW DR, STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
10/15	ROUND 2 COMMENTS

ADDENDUM MP-2
EXHIBIT 8

TFN 6 2/025
RECD OCT 23, 2015

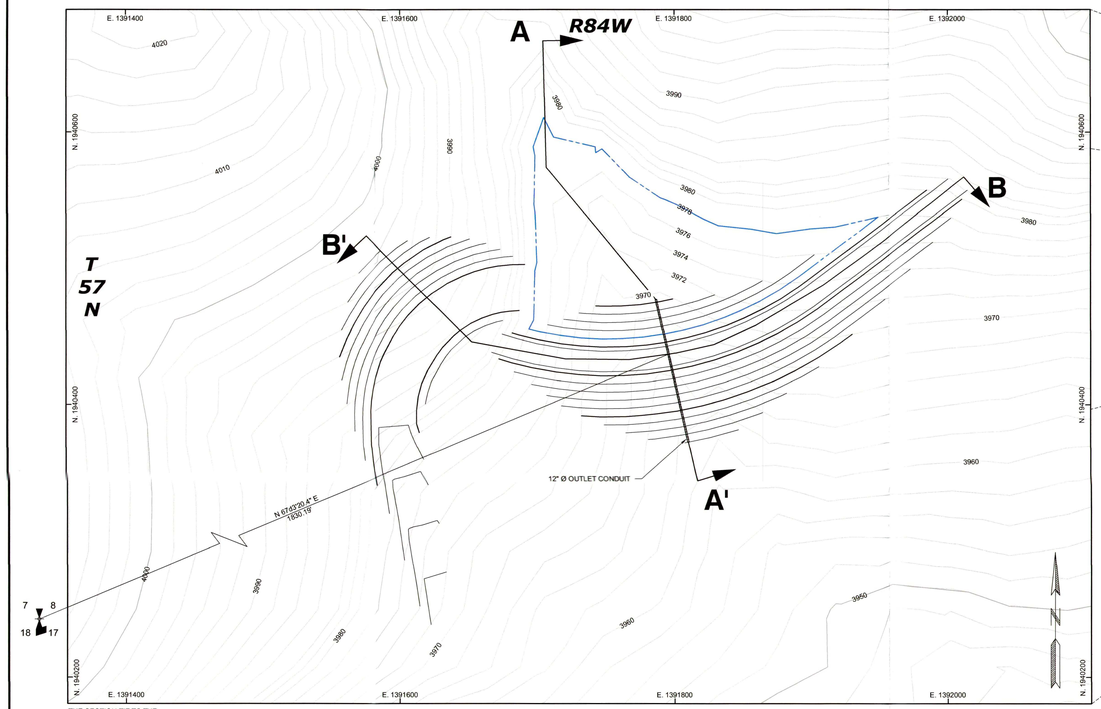
FC-1 FLOOD CONTROL IMPOUNDMENT

Drawn By: DCJ
Checked By: JGB
Date: 9-18-15

FILE: EX_8-11_R2.dwg

WWC ENGINEERING
www.wwcengineering.com

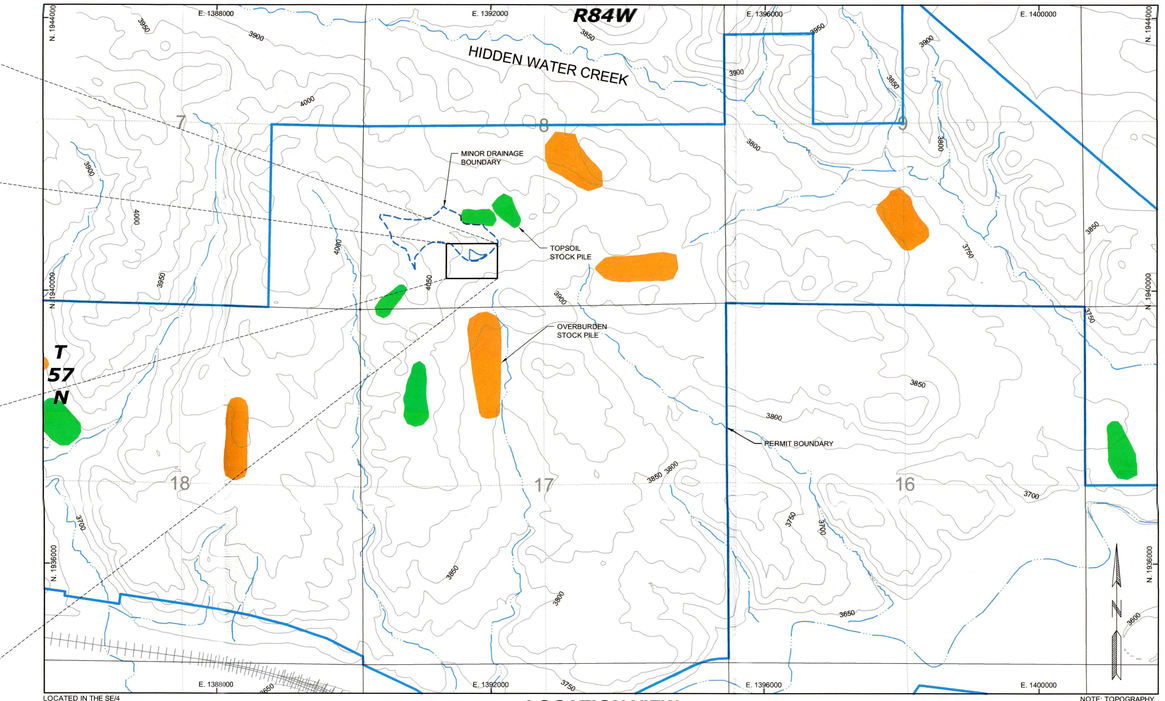
K:\Sheridan\RAMACO\13103\ACAD_WY83EC\DWGS_MINE_PLAN_RESPONSE_2\ADD_MP-2\EX_8-11_R2.dwg 10/12/15 8:49:58 AM rod.wilding



THE SECTION TIE TO THE IMPOUNDMENT IS LOCATED AT LAT:45.93870, LON:101.64382

PLAN VIEW

SCALE: 1" = 50'
C.I. = 2'

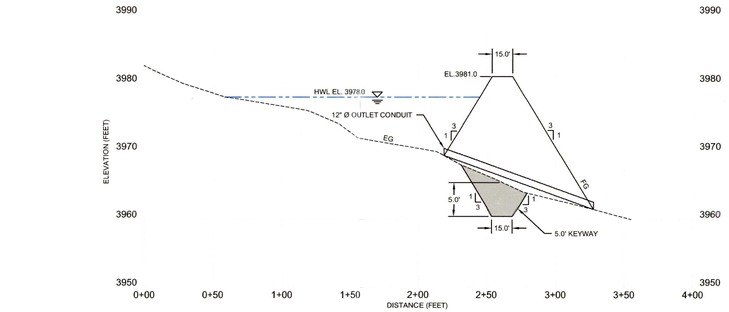


LOCATED IN THE SE/4 SW/4 OF SECTION 8, T57N, R84W

LOCATION VIEW

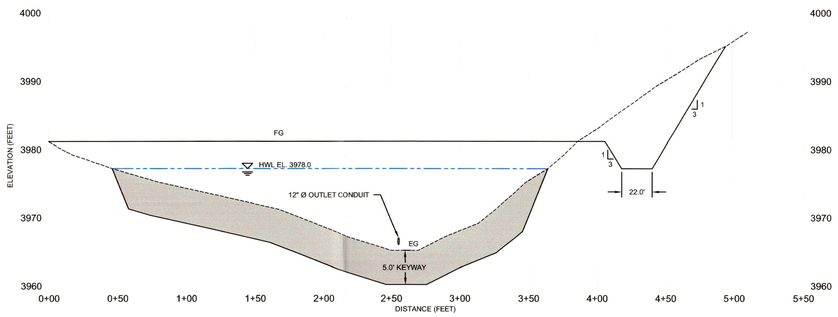
SCALE: 1" = 1000'
C.I. = 10'

NOTE: TOPOGRAPHY SHOWN USES NAD 83 WYOMING EAST CENTRAL COORDINATE SYSTEM



CROSS SECTION A-A'

SCALE: HORIZ 1" = 50' VERT 1" = 10'



CROSS SECTION B-B'

SCALE: HORIZ 1" = 50' VERT 1" = 10'

HYDROLOGIC DESIGN STORM CALCULATIONS

DRAINAGE BASIN PARAMETERS					10-YR, 24-HR STORM			25-YR, 6-HR STORM		
DRAINAGE AREA (sq-mi)	WATERCOURSE LENGTH (mi)	ELEVATION DIFFERENCE (ft)	CURVE NO. (CN)	INFILTRATION LOSS (iph)	10-YR, 24-HR PRECIP. (in)	PEAK INFLOW (cfs)	RUNOFF VOLUME (ac-ft)	25-YR, 6-HR PRECIP. (in)	PEAK INFLOW (cfs)	RUNOFF VOLUME (ac-ft)
0.03	0.35	110	73	0.00	2.35	11.32	0.78	1.95	10.25	0.48

NOTE: RUNOFF VOLUMES AND PEAK INFLOWS WERE COMPUTED BY THE RAINFALL/RUNOFF PROGRAM "TRIHYDRO" USING THE SCS TYPE II DISTRIBUTION.

EMERGENCY SPILLWAY HYDRAULICS

CONTROL SECTION

$$Q = CLH^{3/2}$$

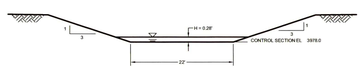
$Q_{25.6}$ = 10.25 cfs
C = 3.2
L = 22 ft
$H = \frac{(Q/L)^{2/3}}{C^{2/3}} = \left(\frac{10.25\ cfs}{3.2 \times 22\ ft}\right)^{2/3}$
H = 0.28 ft

TRANSPORT SECTION

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$$

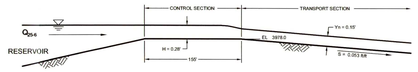
Q = 10.25 cfs
n = 0.030
S = 0.053 ft/ft
Z = 3H:1V
b = 22 ft
A = 3.28 ft^2
WP = 22.93 ft
R = 0.14 ft
V = 3.12 fps
Yn = 0.15 ft

NOTE: EMBANKMENT AND EMERGENCY SPILLWAY SLOPES WILL BE PROTECTED FROM EROSION BY PLANTING WITH WDEQ/LQD APPROVED GRASS MIXTURE.



EMERGENCY SPILLWAY CROSS SECTION

NOT TO SCALE



EMERGENCY SPILLWAY PROFILE

NOT TO SCALE

AREA CAPACITY TABLE

ELEVATION (ft)	AREA (ac)	AVG. AREA (ac)	CAPACITY (ac-ft) INCR.	CAPACITY (ac-ft) ACCUM.
3970.0	0.01			0.00
		0.04	0.08	
3972.0	0.07			0.08
		0.12	0.24	
3974.0	0.16			0.32
		0.22	0.44	
3976.0	0.28			0.76
		0.37	0.74	
3978.0	0.45			1.50

ACTIVE CAPACITY 1.50 ac-ft

INDUSTRIAL POLLUTION CONTROL DUST ABATEMENT) 1.50 ac-ft

NOTE: THE FLOOD CONTROL IMPOUNDMENT HAS BEEN SIZED TO ENTIRELY CONTAIN THE 10-YR, 24-HR DESIGN STORM RUNOFF VOLUME.

CERTIFICATE OF ENGINEER

I, Jeffrey G. Barron, hereby certify that this drawing was prepared by myself or by engineers under my direct supervision and that it correctly represents the conditions described in the accompanying application which is designed to meet the requirements of the Wyoming Environmental Quality Act and its accompanying regulations.

Professional Engineer (Civil) JEFFREY G. BARRON 13033 STATE OF WYOMING
DATE 10/12/2015

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGARVIEW DR, STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
10/15	ROUND 2 COMMENTS

ADDENDUM MP-2
EXHIBIT 9

TFN 6 2/025
RECD OCT 23, 2015

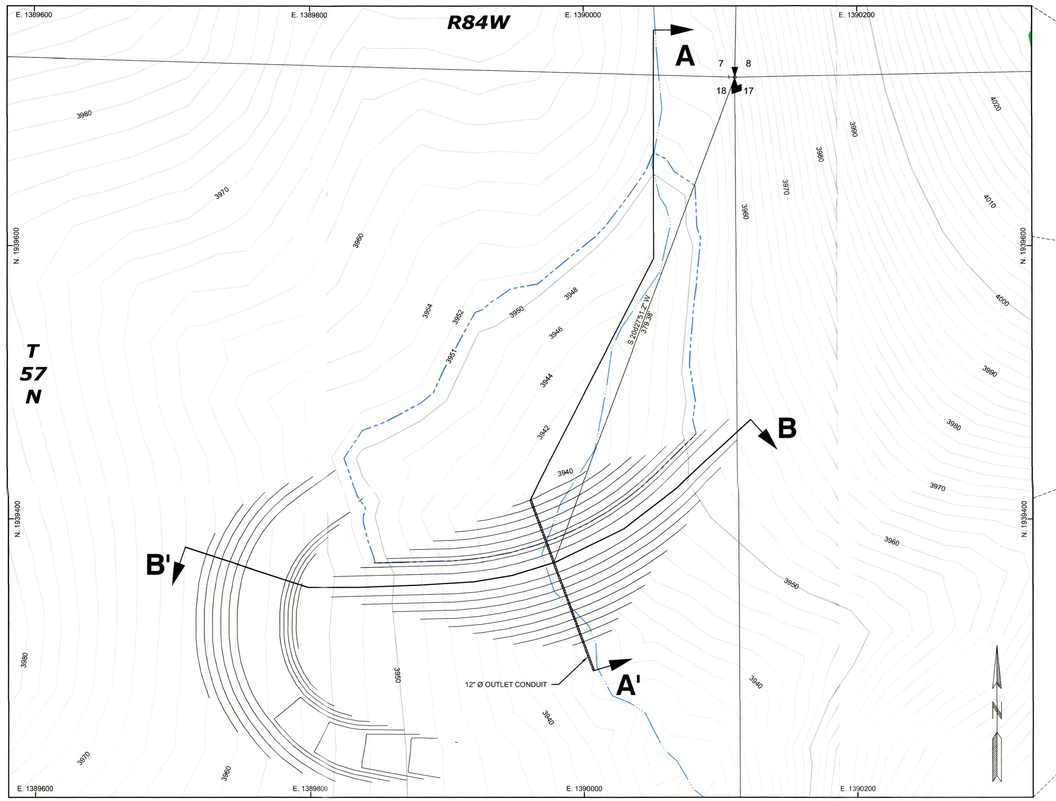
FC-2 FLOOD CONTROL IMPOUNDMENT

Drawn By: DCJ
Checked By: JGB
Date: 9-18-15

WWC ENGINEERING
www.wwcengineering.com

FILE: EX_8-11_R2.dwg

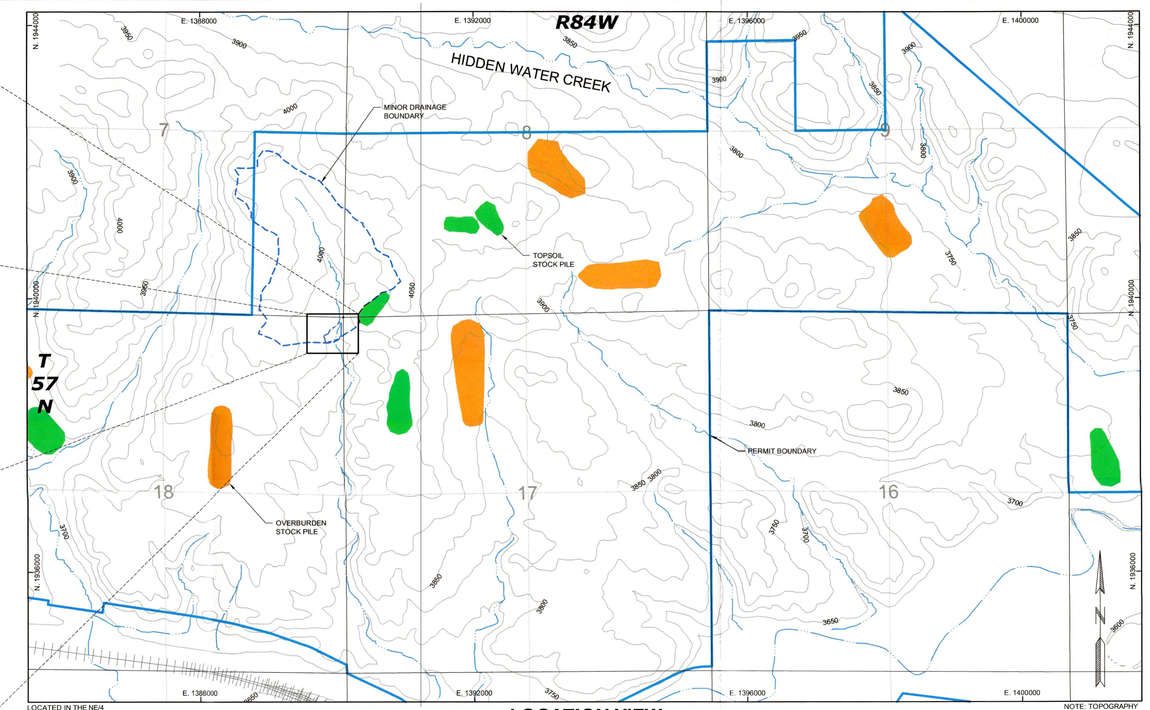
R:\Sheridan\RAMACO\31315\ACAD_MYFILES\CIVIL\DWGS_MINE_PLAN_RESPONSE_2\ADD_MP-2\EX_8-11_R2.dwg 10/12/2015 8:50:51 AM mdi overlay



THE SECTION TIE TO THE IMPOUNDMENT IS LOCATED AT LAT:45.93410, LON:101.66920

PLAN VIEW

SCALE: 1" = 50'
C.I. = 2'



LOCATED IN THE NE/4 NE/4 OF SECTION 18, T57N, R84W

LOCATION VIEW

SCALE: 1" = 1000'
C.I. = 10'

NOTE: TOPOGRAPHY SHOWN USES NAD 83 WYOMING EAST CENTRAL COORDINATE SYSTEM

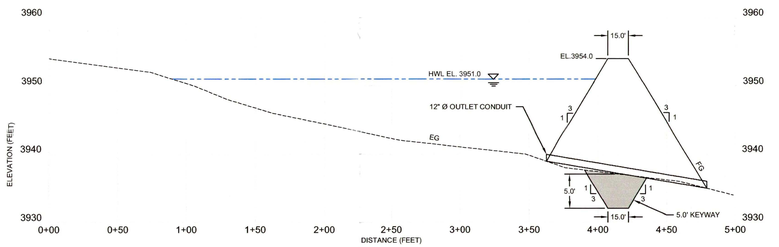
AREA CAPACITY TABLE

ELEVATION (ft)	AREA (ac)	AVG. AREA (ac)	CAPACITY (ac-ft) INCR.	CAPACITY (ac-ft) ACCUM.
3940.0	0.01			0.00
		0.06	0.12	
3942.0	0.11			0.12
		0.18	0.36	
3944.0	0.24			0.48
		0.33	0.66	
3946.0	0.41			1.14
		0.51	1.02	
3948.0	0.61			2.16
		0.73	1.46	
3950.0	0.85			3.62
		0.92	0.92	
3951.0	0.99			4.54

ACTIVE CAPACITY 4.54 ac-ft

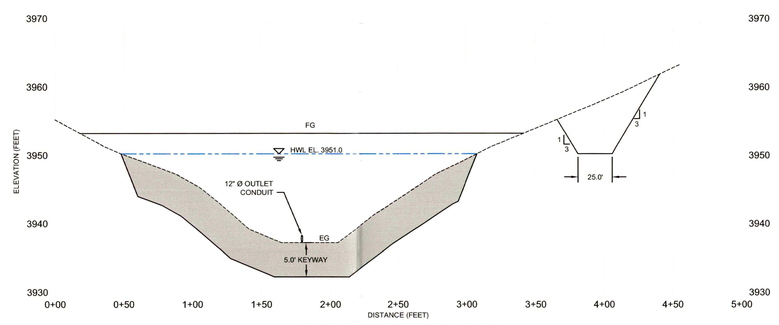
INDUSTRIAL POLLUTION CONTROL (DUST ABATEMENT) 4.54 ac-ft

NOTE: THE FLOOD CONTROL IMPOUNDMENT HAS BEEN SIZED TO ENTIRELY CONTAIN THE 10-YR, 24-HR DESIGN STORM RUNOFF VOLUME.



CROSS SECTION A-A'

SCALE: HORIZ 1" = 50' VERT 1" = 10'



CROSS SECTION B-B'

SCALE: HORIZ 1" = 50' VERT 1" = 10'

HYDROLOGIC DESIGN STORM CALCULATIONS

DRAINAGE BASIN PARAMETERS					10-YR, 24-HR STORM			25-YR, 6-HR STORM		
DRAINAGE AREA (sq-mi)	WATERCOURSE LENGTH (mi)	ELEVATION DIFFERENCE (ft)	CURVE NO. (CN)	INFILTRATION LOSS (iph)	10-YR, 24-HR PRECIP. (in)	PEAK INFLOW (cfs)	RUNOFF VOLUME (ac-ft)	25-YR, 6-HR PRECIP. (in)	PEAK INFLOW (cfs)	RUNOFF VOLUME (ac-ft)
0.14	0.67	180	72	0.00	2.35	36.27	3.38	1.95	30.11	2.03

NOTE: RUNOFF VOLUMES AND PEAK INFLOWS WERE COMPUTED BY THE RAINFALL/RUNOFF PROGRAM "TR8HYDRO" USING THE SCS TYPE II DISTRIBUTION.

EMERGENCY SPILLWAY HYDRAULICS

CONTROL SECTION

$$Q = CLH^{3/2}$$

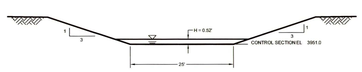
$Q_{25\text{-}6}$ = 30.11 cfs
C = 3.2
L = 25 ft
$H = \frac{(Q)^{2/3}}{(C)(L)} = \left(\frac{30.11\ cfs}{3.2 \times 25\ ft}\right)^{2/3}$
H = 0.52 ft

TRANSPORT SECTION

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$$

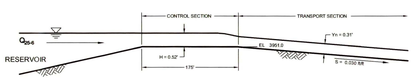
Q = 30.11 cfs
n = 0.030
S = 0.030 ft/ft
Z = 3H:1V
b = 25 ft
A = 7.94 ft^2
WP = 26.94 ft
R = 0.29 ft
V = 3.79 fps
Yn = 0.31 ft

NOTE: EMBANKMENT AND EMERGENCY SPILLWAY SLOPES WILL BE PROTECTED FROM EROSION BY PLANTING WITH WDEQ/LQD APPROVED GRASS MIXTURE.



EMERGENCY SPILLWAY CROSS SECTION

NOT TO SCALE



EMERGENCY SPILLWAY PROFILE

NOT TO SCALE

CERTIFICATE OF ENGINEER

I, Jeffrey G. Barron, hereby certify that this drawing was prepared by myself or by engineers under my direct supervision and that it correctly represents the conditions described in the accompanying application which is designed to meet the requirements of the Wyoming Environmental Quality Act and its accompanying regulations.

Professional Engineer (Civil) JEFFREY G. BARRON 13033 REGISTERED DATE 10/12/2015 WYOMING

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGARVIEW DR, STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
10/15	ROUND 2 COMMENTS

ADDENDUM MP-2
EXHIBIT 10

TFN 6 2/025
RECD OCT 23, 2015

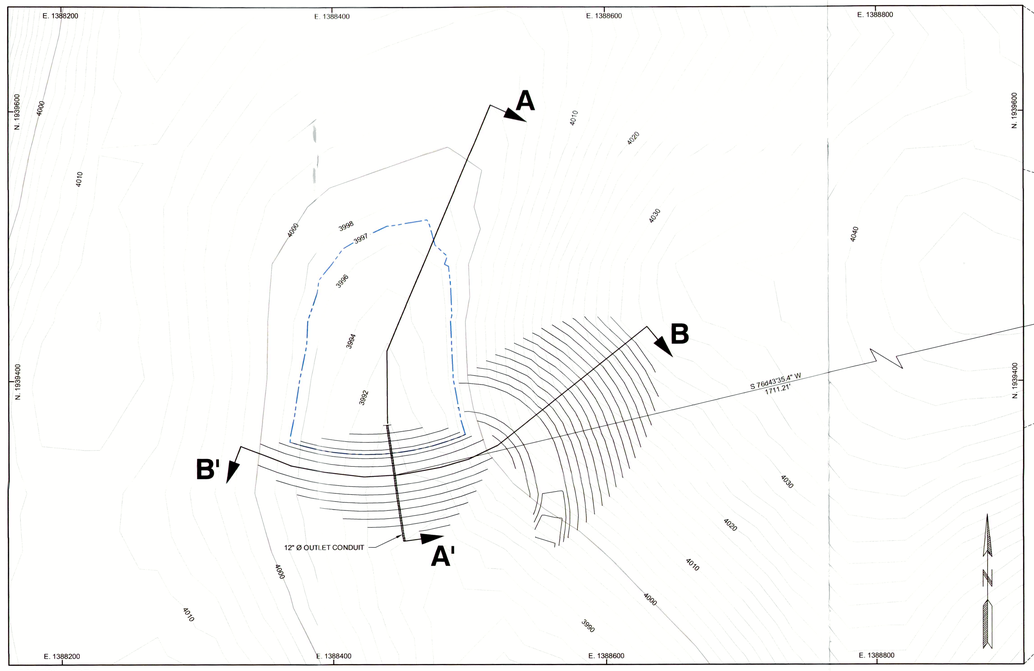
FC-3 FLOOD CONTROL IMPOUNDMENT

Drawn By: DCJ
Checked By: JGB
Date: 9-18-15

WWC ENGINEERING
www.wwcengineering.com

FILE: EX 8-11_R2.dwg

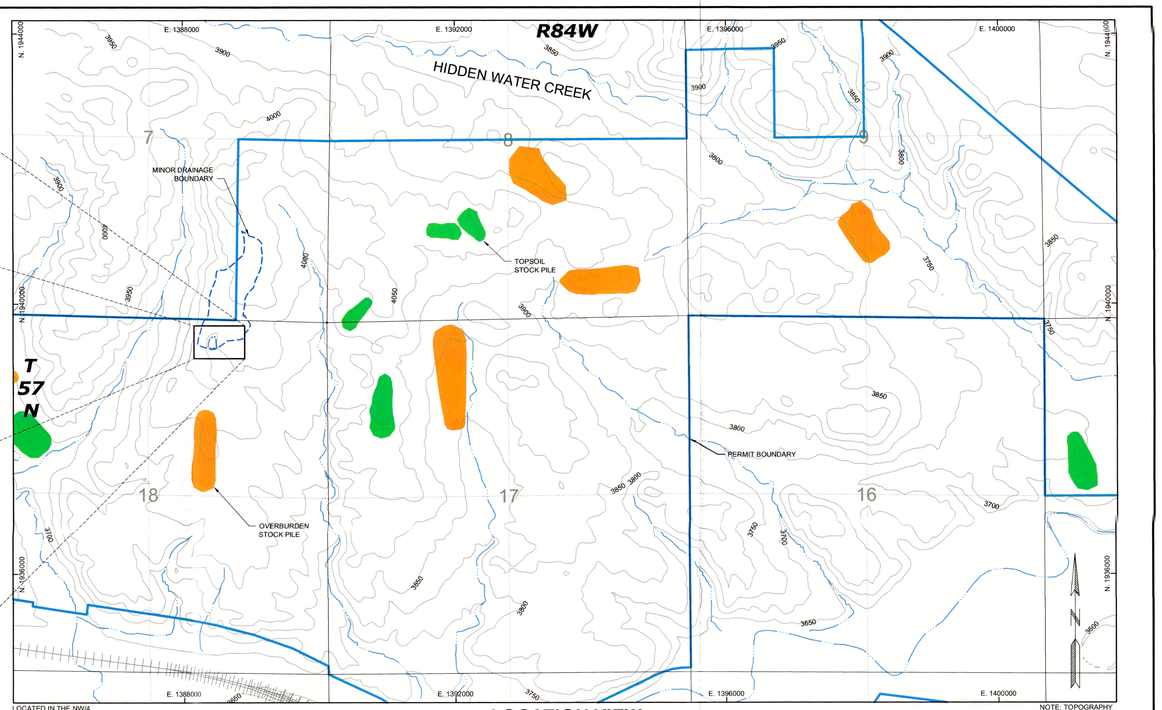
K:\Sheridan\RAMACO\1131\RACAD_WY\SEC\DWGS_MINE_PLAN_RESPONSE_2\ADD_MP-2\EX_8-11_R2.dwg 10/13/2015 8:51:23 AM rod.rehling



THE SECTION TIE TO THE IMPOUNDMENT IS LOCATED AT LAT:45.93418, LON:101.67522

PLAN VIEW

SCALE: 1" = 50'
C.I. = 2'

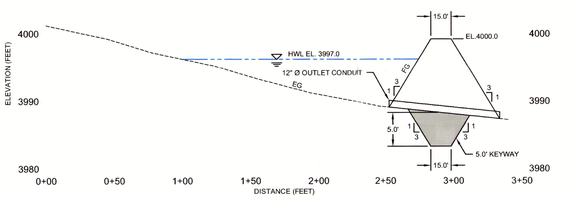


LOCATED IN THE NW/4 NE/4 OF SECTION 18, T57N, R84W

LOCATION VIEW

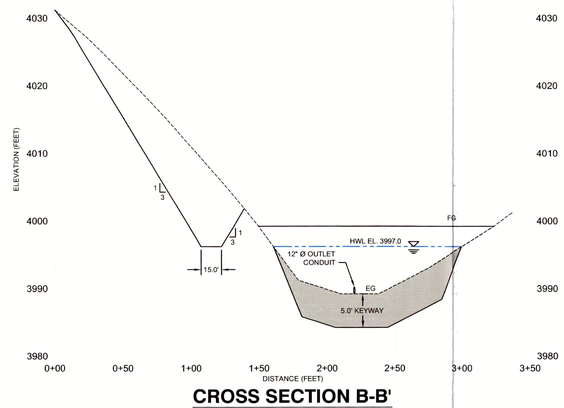
SCALE: 1" = 1000'
C.I. = 10'

NOTE: TOPOGRAPHY SHOWN USES NAD 83 WYOMING EAST CENTRAL COORDINATE SYSTEM



CROSS SECTION A-A'

SCALE: HORIZ 1" = 50' VERT 1" = 10'



CROSS SECTION B-B'

SCALE: HORIZ 1" = 50' VERT 1" = 10'

HYDROLOGIC DESIGN STORM CALCULATIONS

DRAINAGE BASIN PARAMETERS					10-YR, 24-HR STORM			25-YR, 6-HR STORM		
DRAINAGE AREA (sq-mi)	WATERCOURSE LENGTH (mi)	ELEVATION DIFFERENCE (ft)	CURVE NO. (CN)	INFILTRATION LOSS (iph)	10-YR, 24-HR PRECIP. (in)	PEAK INFLOW (cfs)	RUNOFF VOLUME (ac-ft)	25-YR, 6-HR PRECIP. (in)	PEAK INFLOW (cfs)	RUNOFF VOLUME (ac-ft)
0.03	0.48	120	72	0.00	2.35	8.74	0.72	1.95	7.42	0.43

NOTE: RUNOFF VOLUMES AND PEAK INFLOWS WERE COMPUTED BY THE RAINFALL/RUNOFF PROGRAM "TRIHYDRO" USING THE SCS TYPE II DISTRIBUTION.

EMERGENCY SPILLWAY HYDRAULICS

CONTROL SECTION

$$Q = CLH^{3/2}$$

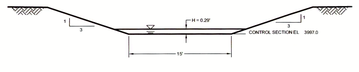
$Q_{25\text{-}6}$ = 7.42 cfs
C = 3.2
L = 15 ft
$H = \left(\frac{Q}{CL}\right)^{2/3} = \left(\frac{7.42\ cfs}{3.2 \times 15\ ft}\right)^{2/3}$
H = 0.29 ft

TRANSPORT SECTION

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$$

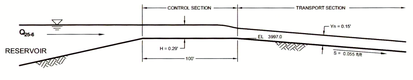
Q = 7.42 cfs
n = 0.030
S = 0.055 ft/ft
Z = 3H:1V
b = 15 ft
A = 2.32 ft²
WP = 15.95 ft
R = 0.15 ft
V = 3.20 fps
Yn = 0.15 ft

NOTE: EMBANKMENT AND EMERGENCY SPILLWAY SLOPES WILL BE PROTECTED FROM EROSION BY PLANTING WITH WDEQ/LQD APPROVED GRASS MIXTURE.



EMERGENCY SPILLWAY CROSS SECTION

NOT TO SCALE



EMERGENCY SPILLWAY PROFILE

NOT TO SCALE

AREA CAPACITY TABLE

ELEVATION (ft)	AREA (ac)	AVG. AREA (ac)	CAPACITY (ac-ft) INCR.	CAPACITY (ac-ft) ACCUM.
3990.0	0.00			0.00
		0.02	0.04	
3992.0	0.04			0.04
		0.10	0.20	
3994.0	0.15			0.24
		0.23	0.46	
3996.0	0.31			0.70
		0.35	0.35	
3997.0	0.39			1.05

ACTIVE CAPACITY: 1.05 ac-ft

INDUSTRIAL POLLUTION CONTROL (DUST ABATEMENT) 1.05 ac-ft

NOTE: THE FLOOD CONTROL IMPOUNDMENT HAS BEEN SIZED TO ENTIRELY CONTAIN THE 10-YR, 24-HR DESIGN STORM RUNOFF VOLUME.

CERTIFICATE OF ENGINEER

I, Jeffrey G. Barron, hereby certify that this drawing was prepared by myself or by engineers under my direct supervision and that it correctly represents the conditions described in the accompanying application which is designed to meet the requirements of the Wyoming Environmental Quality Act and its accompanying regulations.

Professional Engineer (Civil) JEFFREY G. BARRON 13033 DATE 10/22/15 WYOMING

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGARVIEW DR, STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
10/15	ROUND 2 COMMENTS

ADDENDUM MP-2
EXHIBIT 11

TFN 6 2/025
RECD OCT 23, 2015

FC-4 FLOOD CONTROL IMPOUNDMENT

Drawn By: DCJ
Checked By: JGB
Date: 9-18-15

FILE: EX_8-11_R2.dwg

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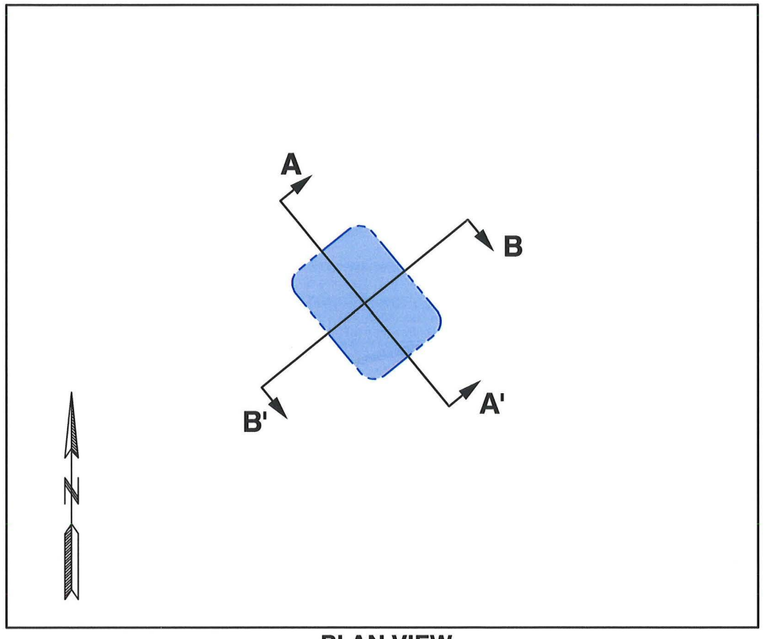

PLAN VIEW

SCALE: 1" = 200'
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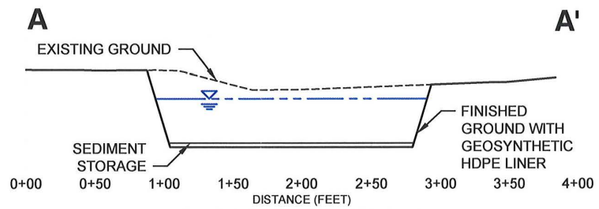
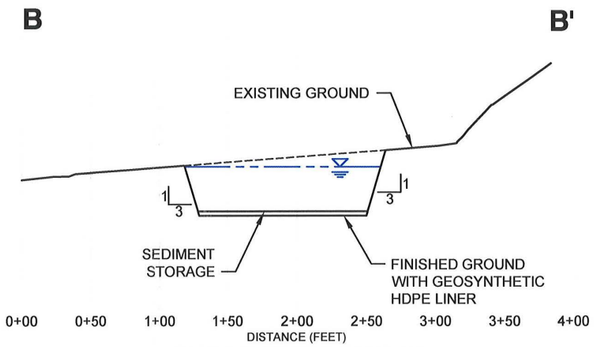


CROSS SECTION A-A'

SCALE: HORIZ 1"=200' VERT 1"=10'



CROSS SECTION B-B'

SCALE: HORIZ 1"=200' VERT 1"=10'

NOTE: THE FACILITIES RESERVOIR WILL BE SIZED APPROPRIATELY TO STORE WASH WATER VOLUME, RUNOFF VOLUME AND SEDIMENT LOADING FROM THE CONTRIBUTING DRAINAGE AREA.

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TYPICAL FACILITIES RESERVOIR

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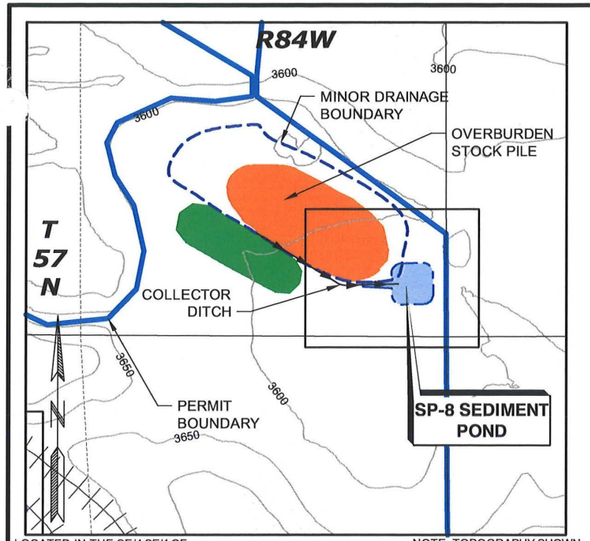


LOCATED IN THE SE/4 SE/4 OF SECTION 15, T57N, R84W

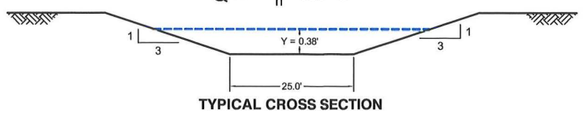
LOCATION VIEW

SCALE: 1" = 1000'
C.I. = 10'

NOTE: TOPOGRAPHY SHOWN USES NAD 83 WYOMING EAST CENTRAL COORDINATE SYSTEM

TRAPEZOIDAL INLET CHANNEL HYDRAULICS

$$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$$



TYPICAL CROSS SECTION
NOT TO SCALE

Q = 37.25 cfs	A = 9.93 ft^2
n = 0.020	P = 27.40 ft
S = 0.030 ft/ft	R = 0.36 ft
b = 25.0 ft	V = 3.75 fps
	Y = 0.38 ft

NOTE: SEE SHEET 2 FOR INLET A-A' PLAN VIEW.

HYDROLOGIC DESIGN STORM CALCULATIONS FOR SP-8

DRAINAGE BASIN PARAMETERS					10-YR, 24-HR STORM		
DRAINAGE AREA (sq-mi)	WATERCOURSE LENGTH (mi)	ELEVATION DIFFERENCE (ft)	CURVE NO. (CN)	INFILTRATION LOSS (iph)	10-YR, 24-HR PRECIP. (in)	PEAK INFLOW (cfs)	RUNOFF VOLUME (ac-ft)
0.04	0.40	20	90	0.00	2.35	37.25	2.98

NOTE: RUNOFF VOLUMES AND PEAK INFLOWS WERE COMPUTED BY THE RAINFALL/RUNOFF PROGRAM "TRIHYDRO" USING THE SCS TYPE II DISTRIBUTION.

SEDIMENT YIELD CALCULATIONS

SOURCE AREA (ac)	RAINFALL FACTOR (R)	SOIL ERODIBILITY (K)	TOPOGRAPHIC FACTOR (LS)	COVER MANAGEMENT (C)	SUPPORT PRACTICE (P)	SOIL [1] LOSS (t/ac/yr)	DELIVERY [2] RATIO (%)	THREE-YEAR SEDIMENT YIELD (ac-ft)
25.88	30.00	0.50	17.4	1	1	261.1	54.4	6.3

NOTE: 1. SEDIMENT CAPACITY WAS DETERMINED BY THE APPLICATION OF THE UNIVERSAL SOIL LOSS EQUATION (USLE) TO SEDIMENT SOURCE AREA(S). FOR THESE CALCULATIONS SEDIMENT DENSITY WAS ASSUMED TO EQUAL 80 lb/cu ft.
2. SEDIMENT DELIVERY RATIO TAKEN FROM "SEDIMENT SOURCE AREAS, DELIVERY RATIOS, AND INFLUENCING MORPHOLOGICAL FACTORS." ROEHL 1961.

CERTIFICATE OF ENGINEER

I, Jeffrey G. Barron, hereby certify that this drawing was prepared by myself or by engineers under my direct supervision and that it correctly represents the conditions described in the accompanying application which is designed to meet the requirements of the Wyoming Environmental Quality Act and its accompanying regulations.

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EXHIBIT 13 **SHEET 1 OF 2**

SP-8 SEDIMENT POND

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Date: 12/7/2015

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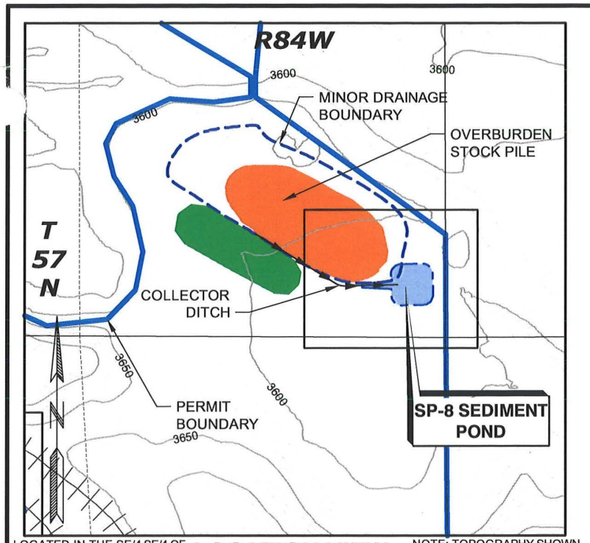
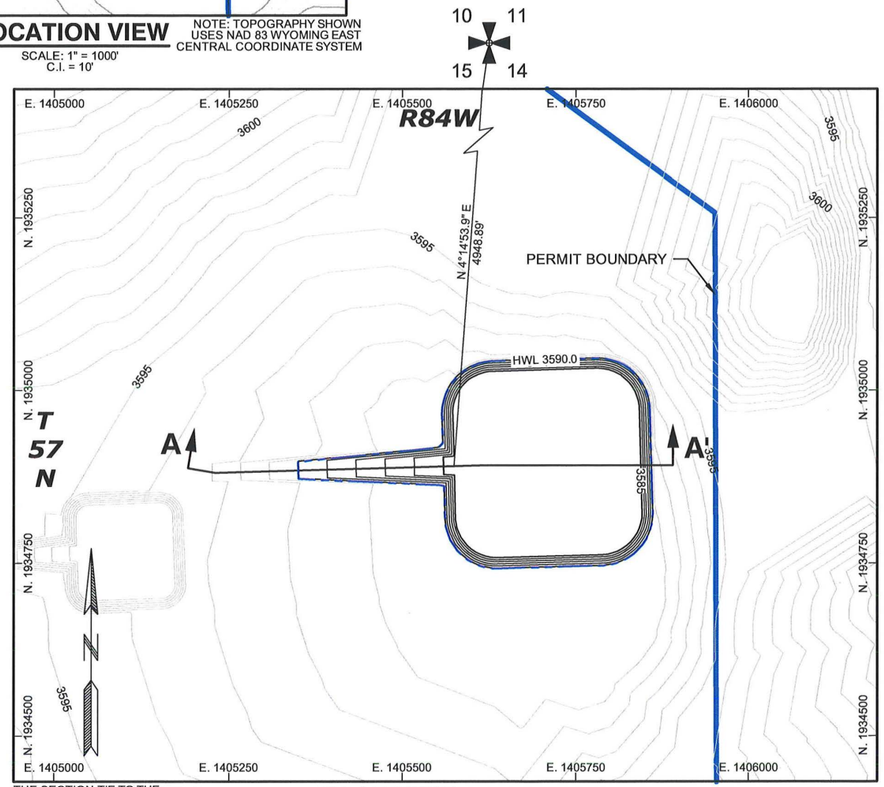


LOCATED IN THE SE/4 SE/4 OF SECTION 15, T57N, R84W

LOCATION VIEW

SCALE: 1" = 1000'
C.I. = 10'

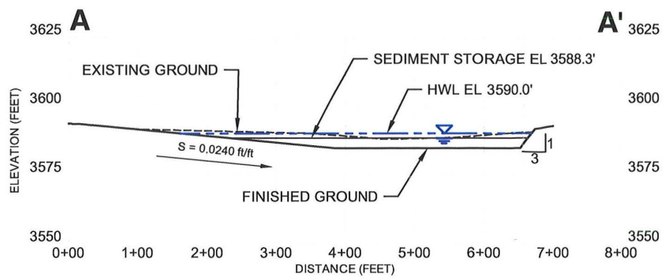
NOTE: TOPOGRAPHY SHOWN USES NAD 83 WYOMING EAST CENTRAL COORDINATE SYSTEM



THE SECTION TIE TO THE SP-8 POND IS LOCATED AT LAT:45.919950, LON:-101.608800

PLAN VIEW

SCALE: 1" = 200'
C.I. = 1'



CROSS SECTION A-A'

SCALE: HORIZ 1"=200' VERT 1"=50'

AREA CAPACITY TABLE

ELEVATION (ft)	AREA (ac)	AVG. AREA (ac)	CAPACITY (ac-ft) INCR.	CAPACITY (ac-ft) ACCUM.	
3585.0	1.61			0.00	
		1.66	1.66		
3586.0	1.70			1.66	INDUSTRIAL POLLUTION CONTROL (SEDIMENT STORAGE) 6.3 ac-ft
		1.75	1.75		
3587.0	1.80			3.41	
		1.86	1.86		
3588.0	1.91			5.27	
		1.93	0.58		
3588.3	1.94			5.85	
		1.98	1.39		
3589.0	2.02			7.24	
		2.09	2.09		
3590.0	2.15			9.33	

INACTIVE CAPACITY 6.3 ac-ft

ACTIVE CAPACITY 3.03 ac-ft

INDUSTRIAL POLLUTION CONTROL (DUST ABATEMENT) 3.03 ac-ft

TOTAL AVAILABLE CAPACITY = 9.33 ac-ft

NOTE: 1. POND IS ENTIRELY INCISED. NO SPILLWAY HYDRAULICS ARE PROVIDED.
2. TOTAL AVAILABLE RUNOFF STORAGE EXCEEDS RUNOFF VOLUME.
3. THE ACTIVE CAPACITY WILL BE PUMP EVACUATED.

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SHEET 2 OF 2

SP-8 SEDIMENT POND

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ADDENDUM MP-3

ADDENDUM MP-3

Groundwater Model

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DEQ 12-183

EXECUTIVE SUMMARY
GROUDWATER MODELING OF POTENTIAL IMPACTS ASSOCIATED WITH THE BROOK MINE PROJECT

This executive summary is intended to orient the reader to the groundwater model developed in support of the Brook Mine Project. Enough detail is provided within this summary to generally describe the model development and results. However, as the name implies, this is a summary and the interested reader is referred to the whole report for specific details related to the modeling effort.

BACKGROUND

RAMACO, LLC (RAMACO) plans to develop the Brook Mine (the Project) in north-central Sheridan County approximately 8 miles northwest of Sheridan, Wyoming. RAMACO contracted WWC Engineering to develop a groundwater model to analyze the potential direct, indirect, and cumulative hydrological effects of the Project on a regional basis with the following primary goals:

1. Identify potential impact (if any) to adjacent water rights.
2. Estimate long-term impacts from mining operations.

The coals to be mined are found in the upper-most member of the Paleocene age Fort Union Formation known as the Tongue River Member. The Tongue River is underlain conformably by the Lebo and Tullock Members of the Fort Union Formation which represent the bottom of the groundwater model.

GROUNDWATER USE

Private wells completed within the region provide water for stock and domestic uses. Since most of the private wells are not completed in the coals proposed for mining, impacts to domestic users within the area are expected to be low.

MODEL CONSTRUCTION

The numerical groundwater model utilizes the USGS modular finite-difference groundwater model MODFLOW (Macdonald and Harbaugh 1988) and the pre/post processor Groundwater Vistas Version 6 (Rumbaugh and

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Rumbaugh 2011). The model is constructed with variable grid spacing generally parallel to the geologic dip of the formations of interest. The model consists of six layers which include coal and over/interburden layers described in Section 4.1.

HYDRAULIC PARAMETERS

Hydraulic parameters used in the groundwater model include hydraulic conductivity, storage, recharge, and porosity. Values for these parameters were determined by onsite investigations, literature sources and adjustments to meet model calibration. Hydraulic conductivity for the Carney and Masters coals were 0.31 and 0.54 ft/day, respectively. Interburden hydraulic conductivities were 0.004 ft/day in the horizontal direction and 0.00035 ft/day in the vertical direction. The overburden was assigned horizontal hydraulic conductivity ranging from 0.1 to 0.025 ft/day and vertical hydraulic conductivities from 0.1 to 0.00025 ft/day.

WATER BUDGET AND BOUNDARY CONDITIONS

Water flows in and out of the model domain by three primary mechanisms: 1) Water flows within confined aquifers downgradient to the south and east and laterally from adjacent aquifers across general head boundaries along the perimeter of the model domain, 2) water within unconfined/perched aquifers recharges into or drains out of the model at seam outcrops, and 3) water moves into and out of the model where it intersects the Tongue River through the river boundary cells. Water availability in areas stratigraphically higher than the Tongue River or Slater Creek alluvium/colluvium is intermittent and generally accounted for using either recharge or drain boundary cells.

CALIBRATION

During the calibration process, hydraulic property values were adjusted until the modeled heads closely fit measured values from the coal monitor well

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network in a steady-state model. Data from the steady-state simulation was then imported into the transient model for operational simulation and recovery.

OPERATION SIMULATION

The calibrated model was used to simulate the impacts of mine progression within the Brook Mine Area. A pattern of drains associated with yearly mine progression came on sequentially during the year each panel was slated for mining. All drains were left in place for a period of two years to simulate mining operations, and were then shut in. Drawdowns were then calculated for the entire region on 5-year increments through the life of the mine.

IMPACTS

To assess the impacts on water levels for all users within the region, water levels were monitored during the mining simulation at the locations of wells completed within specific aquifers, and along the Tongue River. The maximum modeled drawdown within one existing domestic well was 25.8 feet. However, the maximum drawdown observed at most wells was less than 2 feet with almost no drawdown predicted at many wells. The maximum estimated drawdown due to mining at additional targets along the Tongue River alluvium is less than 0.5 feet.

RECOVERY SIMULATION

Recovery was observed at 5-, 10-, 20-, and 50-year periods after cessation of mining operations. Initial recovery from mining impacts is relatively rapid and follows an exponential curve. Recovery to within 10 feet of the pre-mine potentiometric surface is expected to occur for the majority of the Project within 20 years. Recovery rates within the Project Area may also increase as the depressed surface from coal bed methane (CBM) development rebounds. Therefore, model estimates are likely conservative.

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CONCLUSIONS

As a result of the modeling effort:

1. Mining impacts to water availability for all users in the area are expected to occur as follows:

    a. Estimated impacts within the Tongue River alluvium will be minor and in most places not measurable.

    b. Maximum loss of available head to private wells in the area is estimated at 25.8 feet for one well and most wells will see no measurable impacts.

2. Recovery of residual impacts from mine dewatering is estimated to occur to within 90% of pre-mine static water elevations for the majority of the Project Area within 20 years. This rate may be accelerated if CBM production within the area completely ceases in the coming years.

Coal seams of interest largely outcrop into ephemeral drainages and often are dry or only partially saturated. For this reason, impacts from dewatering for mine progression are minimized. In addition, CBM operations in the vicinity have significantly dewatered the coal seams. The true magnitude of CBM dewatering is not known, but on the east side of the model domain total water level decreases are estimated to be on the order of a hundred to several hundred feet. Existing and ongoing CBM development impacts to water levels in the coals are significantly greater than the predicted impacts from RAMACO's proposed mining operations.

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1.0 INTRODUCTION

RAMACO, LLC (RAMACO) plans to develop coal resources via both open pit and highwall/auger mining methods from the Brook Mine (the Project), which is located on privately owned surface approximately six miles northwest of Sheridan, Wyoming, as depicted on Figure 1.0-1.

RAMACO contracted WWC Engineering to analyze the potential direct, indirect and cumulative hydrological effects of the Project. As part of the analysis, a numerical groundwater flow model was developed to estimate the groundwater impacts resulting from the Project. This report describes the numerical groundwater model which has been prepared as part of the Permit to Mine application for the Wyoming Department of Environmental Quality, (WDEQ) which is hereafter referred to as the Permit.

This report presents the model conceptualization, documentation and results for the numerical model used to estimate impacts to the groundwater flow system resulting from the Brook Mine development. The numerical groundwater model presented herein utilizes the United States Geological Survey (USGS) modular finite-difference groundwater model, MODFLOW (MacDonald and Harbaugh, 1988) and the pre/post processor Groundwater Vistas (Environmental Simulations, Version 6). The Brook Mine groundwater model was designed specifically to determine groundwater impacts as a result of dewatering necessary for mine progression. The model grid extends several miles outside the Brook Mine permit boundary to minimize effects from boundary conditions. Exploration data within the Project Area to date provides a limited understanding of the coal location, continuity and hydrology. This model was therefore constructed to provide a general understanding of regional groundwater impacts.

Following standard practice, simplifying assumptions were made in order to construct the model. Hydrogeological information was limited to a few observation points, monitor wells installed in the fall of 2013 by RAMACO, and

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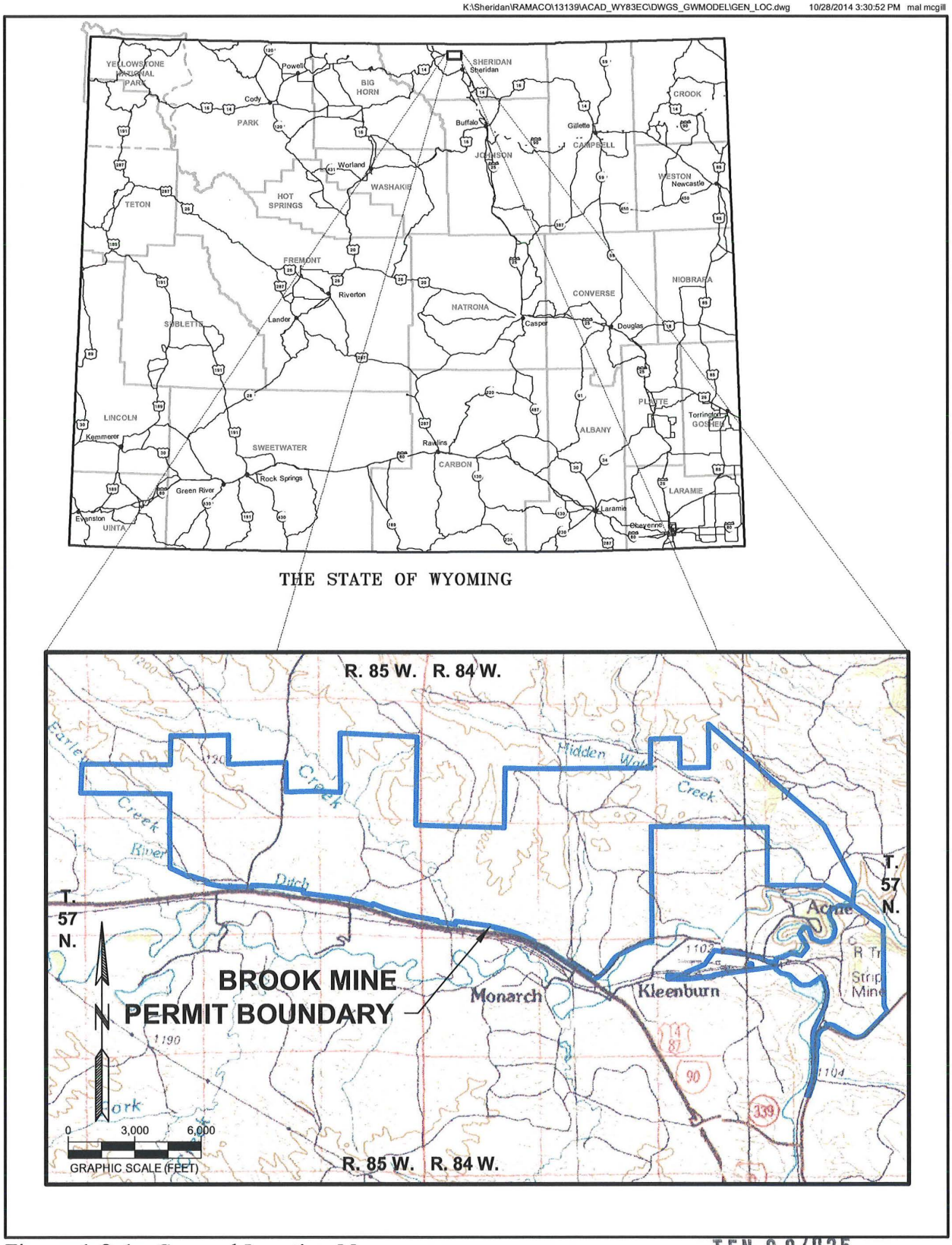

Figure 1.0-1. General Location Map.

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pumping tests performed on several of these wells, as well as data from several private wells from the State Engineers Office (SEO) database.

2.0 CONCEPTUAL MODEL

2.1 Hydrogeologic Setting

Brook Mine is located near the western edge of the Powder River structural and topographic basin that occupies portions of northeastern Wyoming and southern Montana. The basin is a broad asymmetric syncline defined by the Black Hills on the east, the Casper Arch, Laramie Mountains, and the Hartville uplift on the south, the Bighorn Mountains on the west, and the Miles City arch in Montana to the north. The axis of the syncline is west of the center of the basin. Flanking dips are gentle on the eastern limb (two to three degrees) but dip more steeply on the western limb. Faulting occurs in many localities within the basin, especially along the basin margins in association with folding. Vertical displacements can be several hundred feet. Faulting is more common on the western limb of the syncline than on the eastern limb.

The coals to be mined are found in the upper-most member of the Paleocene age Fort Union Formation known as the Tongue River Member. The Tongue River Member is underlain conformably by the Lebo and Tullock Members of the Fort Union, which in turn is conformably underlain by the Lance Formation (Hell Creek Formation) of Upper Cretaceous age. The Lebo Member is largely a lacustrine mudstone interval approximately 1,200 feet thick. With a very small percentage of sand or permeable aquifer material, as demonstrated by deep oilfield geophysical logs in the area, it is considered a lower confining unit for the system (WOGCC, 2014). A generic regional stratigraphic column in the Project Area is provided as Figure 2.1-1 and the bedrock geology for the Project Area is depicted on Figure 2.1-2.

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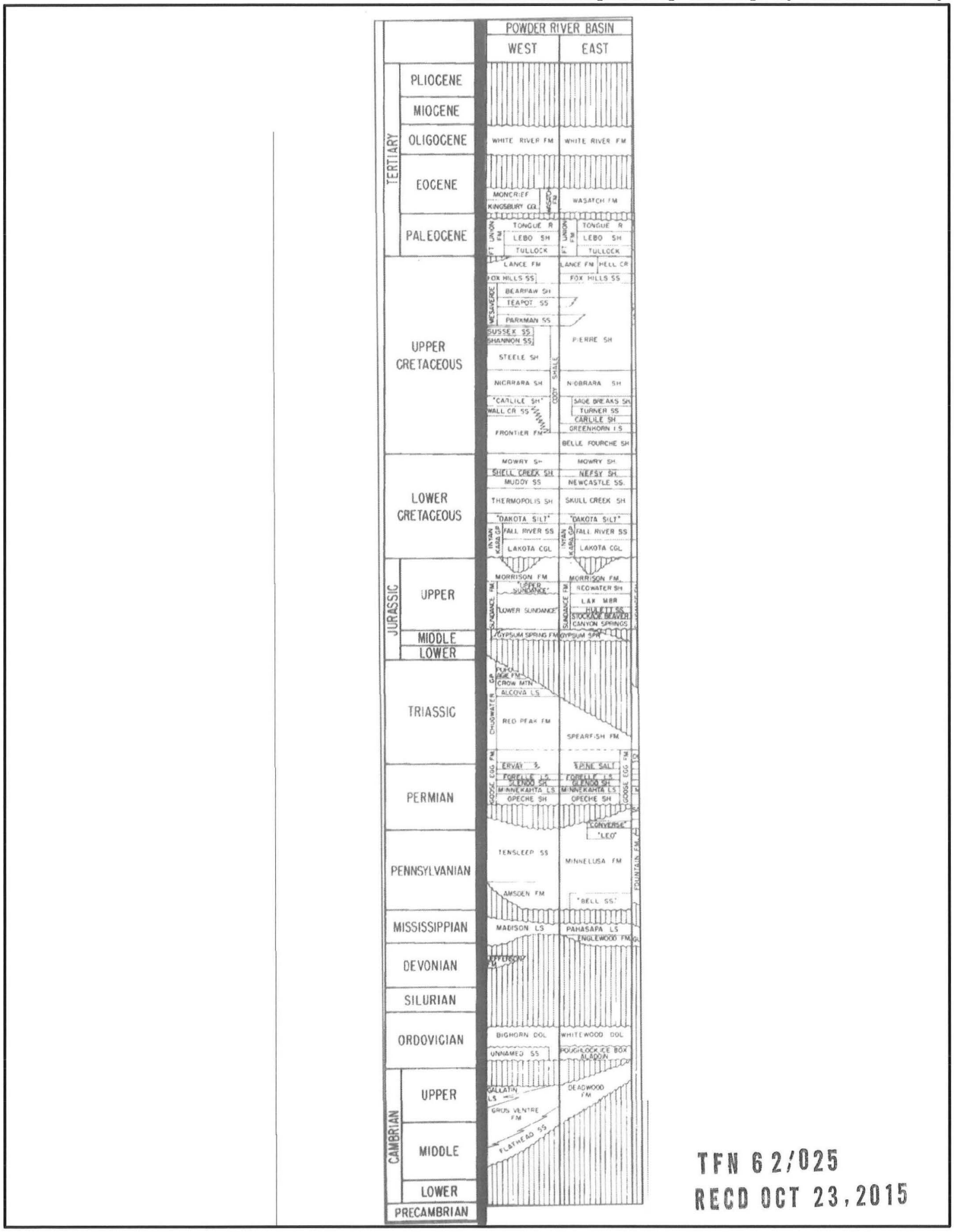

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Figure 2.1-1. Regional Stratigraphic Column. Modified from WGA Guidebook for 28th Annual Field Conference (1976)

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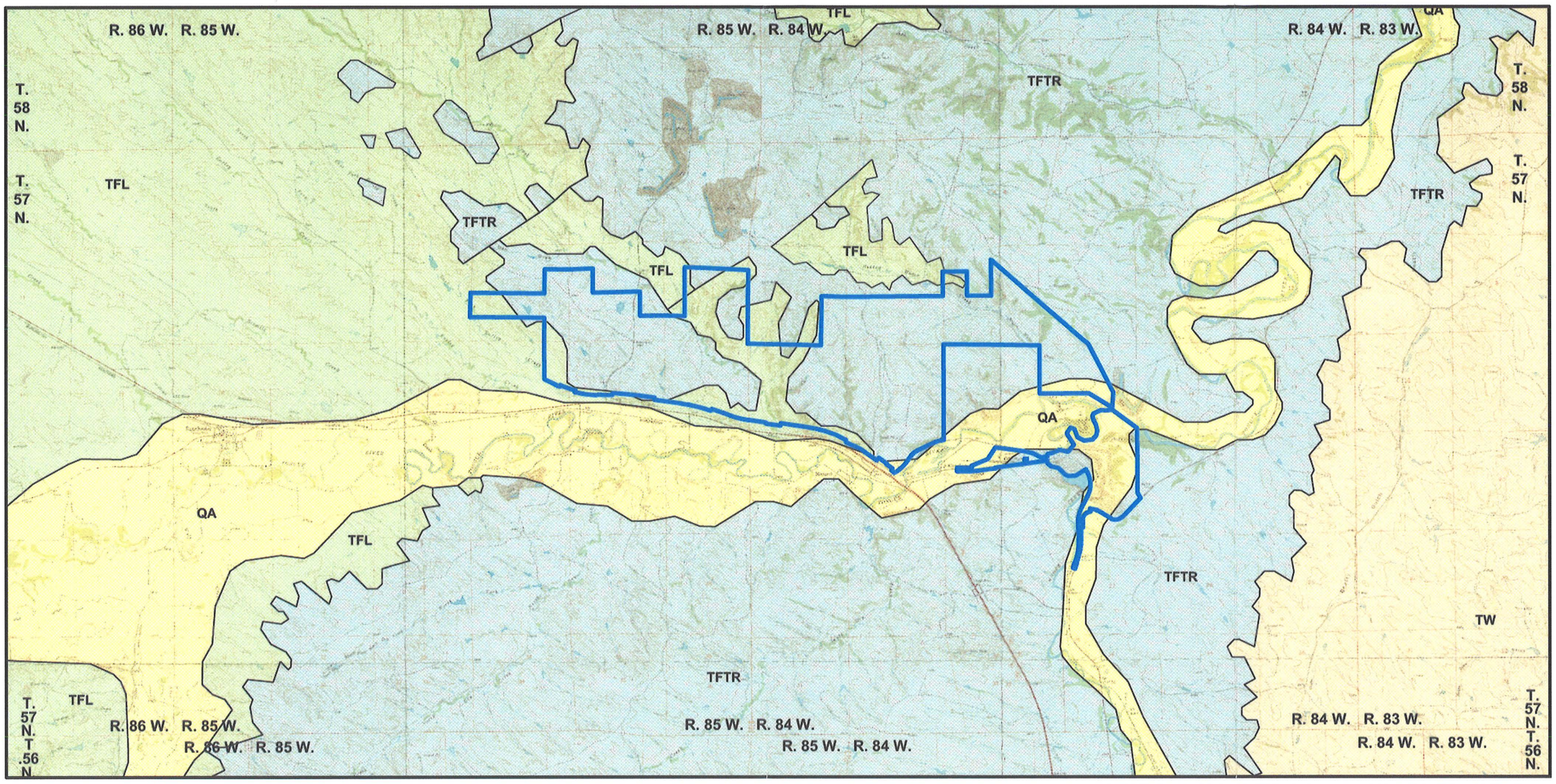

LEGEND

- BROOK MINE PERMIT BOUNDARY
- QA — ALLUVIUM AND COLLUVIUM
- TFL — FORT UNION FORMATION: LEBO MEMBER
- TFTR — FORT UNION FORMATION: TONGUE RIVER MEMBER
- TW — WASATCH FORMATION

N

0 3,000 6,000

GRAPHIC SCALE (FEET)

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY

1101 SUGARVIEW DR STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description

FIGURE 2.1-2

RAMACO PROJECT AREA
BEDROCK GEOLOGY

TFN 6 2/025

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Drawn By: MBM
Checked By: JGB
Date: 7/18/14

FILE: GEOLOGY.dwg

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2.2 Hydrostratigraphic Units

For the purpose of this modeling study, the primary units of interest are the Carney and Masters coal seams of the Fort Union Formation's Tongue River Member which represent the most continuous water-bearing intervals. The overburden and interburden are composed predominately of grey clay/mudstone. Based on hydrostatic water elevation differences between the Carney and Masters as measured from monitor wells installed in support of Appendix D6 of the permit, these intervals are assumed to be aquitards of very low hydraulic conductivity, and were modeled as such as described in Section 2.5-1.

Other aquifer materials, such as clean sandstone as desired for developing groundwater resources, are relatively scarce and generally thin and discontinuous in the area as demonstrated on the geologic cross sections in Appendix D5 of the Permit. Because the sandstone aquifers are very localized and not regionally extensive, these marginal water bearing lenses within the overburden and interburden have been merged with the regional clay/mudstone matrix and were not individually identified for the purposes of this evaluation.

Underlying the minable sequence are the Lebo and Tullock Members of the Fort Union formation which consists of approximately 2,000 feet of clay/mudstones, as described in Appendix D5 of the Permit, and essentially form an impermeable barrier beneath the Masters Coal.

2.3 Groundwater Flow System

The groundwater system for the Brook Mine Project Area is relatively complex due to the fact that the coal aquifers have been dissected by erosion and broken and displaced by a series of northeast-southwest en-echelon normal faults in the area. The dip of the strata in the Project Area is generally east-southeast into the Powder River Basin and the groundwater flow direction is believed to follow this trend regionally, although some local variations may

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be present as demonstrated on the pre-mine potentiometric surfaces depicted in Figures 2.3-1 and 2.3-2.

Recharge for the coal aquifers stratigraphically higher than the Tongue River/Slater Creek system occurs in areas of coal seam outcrops, saturated historic mine pits which are in hydrologic communication with the coal seams, or in areas where the coal is adjacent to the high infiltration zones created by scoria and clinker residuum. However, due to extensive out/sub-cropping and faulting of the Carney coal seam, it is hypothesized that a substantial portion of the water recharging from the northwest drains to the surficial/alluvial system rather than contributing to the recharge of the regional coal aquifer system. Therefore, these intervals are largely unconfined or even dry. Hydrostatic water levels in the coal monitoring well network installed for groundwater characterization (provided in Appendix D6), support this conclusion by demonstrating that the coal seams are, in many instances, only partially saturated. Where the coal seams lie below or in communication with the Tongue River or Slater Creek alluvium, they are assumed to be more extensively saturated and may receive recharge from the overlying alluvium. Recent water withdrawals from the aquifer system for coal bed methane (CBM) production are believed to have impacted water levels in the coal seams. CBM operations have been ongoing east of the project area for over 15 years and have significantly lowered the water levels in the coals. However, there is very limited data available to help quantify the impacts.

Appendix D6 of Big Horn Coal's Permit states, "Extensive exploratory drilling has verified that these coal seams cannot be classified as aquifers where they lie stratigraphically higher in elevation than the Tongue River... and are not subject to recharge from the river." (D6 Big Horn Coal Permit). Although the Big Horn Coal Permit is referring to coal seams above the Carney (Dietz, Monarch, etc.) the same conclusion can be made of the Brook Mine Project Area where the majority of the coal seams of interest also lie stratigraphically higher than the Tongue River. Additionally, pumping tests conducted on the Carney and Masters Seams suggest that these stratigraphic

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R.85 W. R.84 W.

T. 57 N.

T. 57 N.

R.85 W. R.84 W.

LEGEND

- BROOK MINE PERMIT BOUNDARY
- POTENTIOMETRIC CONTOUR
- POTENTIOMETRIC CONTOUR (INFERRED)
- FAULT LOCATION - APPROXIMATE (D / U)
- FAULT LOCATION - INFERRED
- FAULT LOCATION - CONCEALED
- APPROXIMATE CARNEY OUTCROP LINE
- EDGE OF SATURATION ZONE OF COAL SEAM
- 578417-CRN 3795.59 — CARNEY SEAM MONITOR WELL WITH OBSERVED WATER LEVEL

N

0 1,500 3,000 4,500 6,000

GRAPHIC SCALE (FEET)

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGARVIEW DR STE. 201
SHERIDAN, WY 82801

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Date	Description

FIGURE 2.3-1

CARNEY SEAM PRE-MINE POTENTIOMETRY

Drawn By: MBM
Checked By: SMR
Date: 7/18/14

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FILE: POT_CARNEY_PRE.dwg

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RECD OCT 23, 2015

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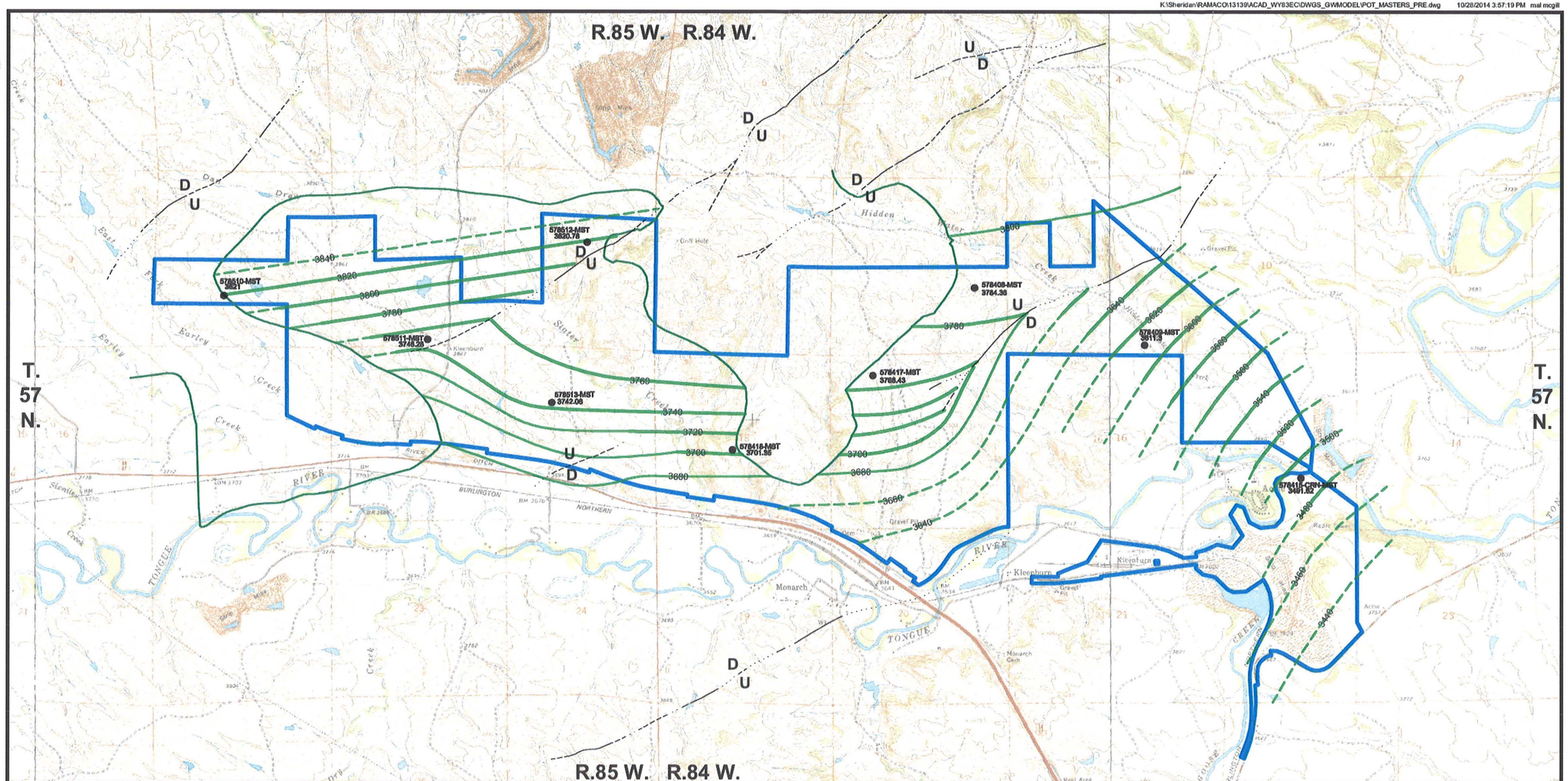

LEGEND

- BROOK MINE PERMIT BOUNDARY
- POTENTIOMETRIC CONTOUR
- POTENTIOMETRIC CONTOUR (INFERRED)
- FAULT LOCATION - APPROXIMATE (D / U)
- FAULT LOCATION - INFERRED
- FAULT LOCATION - CONCEALED
- EDGE OF SATURATION ZONE OF COAL SEAM
- 578417-CRN 3705.59 — CARNEY SEAM MONITOR WELL WITH OBSERVED WATER LEVEL

N

0 1,500 3,000 4,500 6,000

GRAPHIC SCALE (FEET)

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGARVIEW DR STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description

FIGURE 2.3-2

MASTERS SEAM
PRE-MINE POTENTIOMETRY

Drawn By: MBM
Checked By: SMR
Date: 7/18/14

FILE: POT_MASTERS_PRE.dwg

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October 2015

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intervals are of low permeability and yields from these intervals will generally be low.

The stratum located above the coal seams of interest is generally claystone with low permeability, as discussed in Section 2.2. Therefore, interaction of groundwater between these units and the Tongue River or Goose Creek is very limited. Within the model domain, the Tongue River alluvium does have large deciduous trees and other vegetation immediately adjacent to the river. Conceptually, evapotranspiration from the vegetation along the Tongue River would indicate that through the model domain the Tongue River is a losing stream. Throughout most of the model domain where the Tongue River is present, there are overburden strata with low permeability between the Tongue River alluvium and the coal seams which hydrologically isolate the Tongue River from both the Masters and the Carney coal seams. Since Goose Creek is located in the eastern portion of the model domain where the coal is significantly below the alluvium and the clay intervals are even thicker, the Goose Creek alluvium is also hydrologically separated from the Masters and Carney coals. The Goose Creek alluvium would likely experience similar losses to evapotranspiration that would be observed in the Tongue River alluvium.

A review of the Wyoming SEO database, which is included in Appendix B of the Adjudication portion of the permit, indicates that there are not very many wells permitted for stock or domestic use within the Brook Mine Permit Boundary. However, several stock and domestic wells are located immediately outside, generally to the south and east, of the Brook Mine Permit Boundary. Most of the stock and domestic wells within or immediately adjacent to the permit boundary are completed in formations below the Masters coal since the Masters coal and the geologic strata overlying it are not particularly robust water bearing intervals. Shallow stock and domestic wells are also completed within the Tongue River alluvium in many places adjacent to the Brook Mine Permit Boundary. Most of the wells within the model domain are stock or domestic wells with intermittent pumping and not completed in geologic strata with a direct hydrological connection to the Carney or Masters coal. Therefore,

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they are relatively inconsequential to the groundwater system modeled in this report because the relatively low pumpage rates experienced at the wells do not significantly impact the groundwater system. Along the far eastern edge of the model domain there are a number of CBM production wells that, based on available data available from the SEO database, likely have a direct hydrological connection to the Carney and Masters coal seams. Pumping from the CBM wells has significantly affected water levels in the coals along the eastern edge of the model domain. As is discussed later in this report, boundary conditions were used to simulate impacts from the CBM wells.

Potentiometric data for the coal seams of interest were obtained from several sources including the monitor well network installed in the fall of 2013 within the Lower Carney and Masters Seams, SEO, and Wyoming Oil and Gas Conservation (WOGCC) databases. Data collected from the SEO and WOGCC databases included well completion locations, intervals, and initial estimated water surface elevations for stock, domestic and CBM wells that may have had completions across the aquifers of interest. However, because many of the private wells in the area may have had completions across multiple aquifers or were constructed prior to CBM development, the static water levels provided in the SEO and WOGCC records do not fit well with the potentiometric surface generated from RAMACO's monitor well network. As necessary, these wells were omitted from use in creation of the initial potentiometric surfaces. The initial potentiometric surfaces and tabulations of the wells used in the creation of the Carney and Master coal seam potentiometry are provided in Figures 2.3-1, 2.3-2, and Appendix D6 of RAMACO's Permit to Mine.

2.4 Hydrogeologic Boundaries

The hydrologic boundaries within the model include both internal and external boundaries. The model boundaries vary from layer to layer and are described in more detail in the following sub-sections.

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2.4.1 External Boundaries

The primary physical groundwater flow boundary is the lacustrine claystone/mudstone of the Lebo Member which underlies the target coal seams and serves as a hydrologic barrier to groundwater movement vertically between the Tongue River Member and underlying strata east of its outcrop on the northwest portion of the model domain. This boundary has been used as the no-flow boundary at the model's base as well as in the northwest corner of the model domain.

Outcrops of both the Carney and Masters Seams west of the Project Area provide a natural boundary for the groundwater system. Conceptually, these outcrops provide either recharge to the coal or drainage from the coal depending on the topography; these zones were addressed in several ways. Where these outcrops intersected the ground surface, boundary conditions/hydrologic properties including drains or recharge zones were assigned to the corresponding cells. This allowed water to move into or out of the model at the coal faces. Areas of the model domain where coal or over/interburden layers had been removed by erosion were removed from the simulation using no-flow cells.

Along the north and western edges of the model there are series of faults. Faulting within the permit area was mapped by B.E. Barnum on the USGS Monarch Quadrangle. As noted in Section D5.3.2 of Appendix D5, Barnum indicates fault displacements on the order of 50 feet within the permit area. Lithologic logs provided in Addendum D5-2 demonstrate that the dominating lithology in the column is claystone and coal thicknesses are less than 20 feet. This offset geology from faulting results in a claystone hanging or footwall adjacent the coal aquifer and therefore discontinuity of the aquifer and an assumed hydrologic flow boundary. As presented in Appendix D6, within the northeastern portion of the Brook Mine permit area there are two monitor well clusters that straddle both sides of a fault (578408 and 578409). Since water level measurements taken in the Carney and Masters wells on either side of the fault are significantly different, they demonstrate that the fault is a hydraulic

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barrier. Additionally, the average groundwater quality of some wells compared across faults further supports faulting as a no flow boundary. Water quality types inferred from Figure D6.2-1 in Appendix D6 present the differences between wells. In the Carney seam on the upside of the fault, well 578408-CRN indicates a magnesium sulfate water type. Conversely, on the down side of the fault, 578409-CRN indicates a water type of sodium sulfate. Also, 578408-CRN indicates much higher iron concentrations compared to concentrations obtained from 578409-CRN. In the Masters Seam on the upside of the fault, 578408-MST indicates a magnesium sulfate water type, while on the downside of the fault, 578409-MST indicates a sodium bicarbonate water type. Iron concentrations also differ greatly between the two wells. The faults are significant in lateral extent and form natural no flow boundaries. These faults are modeled as either faults or no flow boundaries depending on their locations. No physical boundaries are believed to exist to the south and east of the model, and in these areas the aquifers of interest are confined with water flowing generally to the east into the basin. The groundwater flow into the basin was simulated using general head boundaries. General head boundaries along the south and east edges of the model domain have been placed as far from the area of interest as reasonable by limitations of model size to eliminate potential boundary effects from the modeling software.

2.4.2 Internal Boundaries

The primary internal boundaries within the Project Area are horizontal flow barrier (HFB) boundaries provided by displacement from sealing faults. A series of northeast-southwest trending normal faults have dissected the coal seams of interest into a series of isolated tabular intervals causing disruption and complexity to the hydrogeologic setting, as depicted on the pre-mine potentiometric surfaces provided in Figures 2.3-1 and 2.3-2.

Additionally, the Tongue River provides a boundary through a portion of the overburden (Layer 1) and in several other layers where the river crosses

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outcrop zones. The river boundary condition in the model was used to approximate conditions of the Tongue River.

2.5 Hydraulic Properties

Hydraulic properties needed to characterize each aquifer or confining unit include hydraulic conductivity, storage coefficient (for confined aquifers), specific yield (for unconfined aquifers), and recharge. Available information for each of these properties is described within the following sections.

2.5.1 Hydraulic Conductivity

Hydraulic conductivity is one of the most critical hydraulic parameters driving groundwater flow. Within the Carney and Masters coal seams, hydraulic conductivities were measured by pump tests within the Project Area. No site-specific hydraulic conductivity information is available for the alluvial areas and over/interburden layers, and published literature was relied on for model inputs. Stratification and lithification often create anisotropic tendencies in sedimentary deposits, and vertical hydraulic conductivities are typically lower than horizontal hydraulic conductivities. Therefore, following standard practice, the vertical hydraulic conductivity for each of the coal layers was assumed to be one order of magnitude smaller than the horizontal hydraulic conductivity. The over/interburden vertical to horizontal hydraulic conductivity ratio was determined during model calibration. Hydraulic conductivity values utilized for each model layer are provided in Section 4.2.1.

2.5.1.1 Alluvial Aquifers

As described in Section 2.3, where the alluvial/colluvial deposits are immediately adjacent to the coal outcrops water may enter into or leave the respective coal seams from the alluvium. The hydraulic conductivity of the alluvial/colluvial materials can vary significantly. Within the Tongue River alluvium, Bighorn Coal reported in Addendum D6-1 of their permit application to DEQ, hydraulic conductivities ranging from 150 to 750 feet/day. Lower

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hydraulic conductivities would be expected outside of the main Tongue River alluvium where the particle size is smaller and permeability is reduced.

2.5.1.2 Over/Interburden

The Fort Union Formation's Tongue River Member is composed of alternating sandstone, siltstone, claystone and coal intervals. As noted during exploration drilling within the Project Area, the Tongue River Member is largely composed of claystone with thin discontinuous sand and siltstone lenses. Hydraulic conductivities of the Tongue River Member, which make up interburden and overburden layers, are estimated to range between 0.1 and 0.001 feet/day or less (Metesh, 2002).

2.5.1.3 Carney – The Upper Coal Seam of Interest

The Carney seam averages 16 feet thick on the east portion of Project Area and is generally, although not exclusively, confined. This seam splits into the Upper and Lower Carney members nearly parallel to the strike of the formations. Based on a multi-well pumping test conducted by WWC Engineering in November 2013, the hydraulic conductivity of this seam was measured at 0.31 feet/day near the eastern side of the Project.

2.5.1.4 Masters – Lower-Most Coal Seam of Interest

This seam averages 6 feet thick within the Project Area and is generally, although not exclusively, confined. The hydraulic conductivity of this seam, based on a multi-well pumping test conducted by WWC Engineering near the eastern side of the Project in November of 2013, is estimated at 0.54 feet/day. No other measured hydraulic conductivity values are available for the Masters Coal.

2.5.1.5 Fort Union Formation, Lebo Shale

The Lebo Shale of the Fort Union Formation is a substantial (1,200') interval composed predominately of dark shale with interbedded carbonaceous shale, siltstone and thin local coals (Slagle et al., 1985). The Lebo Shale has

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very low permeability; is devoid of substantial water bearing strata; and represents the base of the model.

Surficial geology is composed of bedrock outcrops, alluvium and scoria, and clinker deposits. There is substantial alluvial fill within the model domain mapped along the Tongue River and Goose Creek drainages. Where the alluvium occurs, it forms a surficial aquifer. Although site-specific measurements are not available, these aquifers are assumed to have a higher hydraulic conductivity than the underlying strata. Where the alluvium is in contact with bedrock aquifers, it may provide a source of recharge. Scoria deposits affect the larger groundwater system due to increased infiltration rates on surface exposures, which subsequently increases recharge from precipitation. However, due to a substantially higher horizontal hydraulic conductivity within the scoria aquifer than the underlying strata, it is hypothesized that much of the infiltrating water runs down the geologic dip at the scoria/bedrock contact and seeps out of the groundwater system. A small percentage is expected to infiltrate into the larger groundwater system where the scoria is in contact with coal or sand aquifer units.

2.5.2 Storage Coefficients and Porosity

An average storativity and specific yield were assumed to be uniformly distributed in each layer. For confined aquifers, changes in storage are calculated using specific storage (Ss). Ss is calculated by dividing the storativity by the aquifer thickness. For unconfined aquifers, specific yield (Sy) is used to calculate changes in storage. All six layers within the model have portions that are unconfined.

Storativity values determined by the pumping tests for the Carney and Masters coal sequences were 3.64×10^{-4} and 2.49×10^{-4} (unitless), respectively, which were then divided by aquifer thickness to obtain Ss prior to input in the model software. Storage values were increased in regions of historic underground mining where the aquifer is largely an open room. Aquifer parameters for the under and interburden zones were not measured through

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pumping tests for the Brook Mine Project. As such, an initial value of Ss for the claystone confining layers was estimated based on textbook values using Equation 2.5-1 from Freeze and Cherry (1979) as follows:

Equation 2.5-1.

$Ss=\rho g*(\alpha+\varphi*\beta)$

Where:
ρ=density of water (1000 kg/m^3)
g=acceleration of gravity (9.8 m/s^2)
α=aquifer compressibility ($1.5x10^{-11}$ to $1.5x10^{-9}$ N/m^2 elastic compressibility of shale, Carmichael 1986)
φ=porosity (27% from exploration log analysis)
β=compressibility of water ($4.6x10^{-10}$ N/m^2)

The resulting calculated value of Ss used in the model for the overburden and interburden claystone/shale intervals was $2.7x10^{-6}$ ft^{-1}.

Porosity values for coals are generally lower than clastic sediments. Without project-specific coal core analyses, porosity of coal layers within the model were assigned a value of 10% based on literature values (Zou, 2013). Similarly, no project-specific measurements of over/interburden porosity were available. However, porosity calculations from bulk density logs obtained during coal exploration yields an average claystone porosity of 27% based on the relationship between typical matrix and formation fluid densities and measured bulk density (assuming a formation matrix density of 2.65 g/cc and a formation water density of 1.0 g/cc).

2.6 Water Budget

As discussed previously, water generally enters the model from the north and west as precipitation infiltration along the recharge zones. With no unnatural stresses on the system, water infiltrating along these outcrops moves down the geologic dip to the south and east and either recharges the larger aquifer system or encounters a down-gradient outcrop and returns to the surface water system. Water also enters the system where the Tongue River and Slater Creek cross seam outcrops which are also on the west and northwest edges of the model domain.

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Water leaves the model domain by three primary mechanisms: 1) Water flux of confined aquifers downgradient to the south and east and across general head boundaries along the perimeter of the model domain, 2) water within unconfined/perched aquifers drains from outcrops into the surface water system as seeps or springs (drain cells), and 3) water leaves the model in the Tongue River in the river boundary cells. Water is also removed by CBM production wells which were simulated with general head boundaries, and by dewatering for mine progression which was simulated for the Brook Mine.

Evidence of seeps from outcrops can be seen in Color Infrared Imagery (CIR), which is included in the permit as Exhibit D11.1-1. The areas of seepage are manifested on the CIR imagery as areas with more vegetation. Evapotranspiration from the vegetation growing along the seep removes all the water before it emanates from the formation into the drainage. Therefore, no measurements of the seepage rate at the outcrops are available.

The largest anthropogenic sink in the region in recent years has been due to coalbed methane development which reduced the head on the eastern edge of the Project to approximately the top of the target coal seam. This creates unnaturally low boundary conditions on the edges of the model and allows water to drain quickly from the stratigraphically higher areas of the model with limited recharge sources. Due to a lack of sufficient data prior to CBM development in the Project Area, it was not possible to accurately determine the impacts CBM development has had on the regional aquifer system, the pre-CBM potentiometric surface and the rate at which the system will recharge from CBM drawdowns. Therefore to be conservative, the post-CBM (2014) potentiometric surface was considered the static water elevation for the model. The Post CBM (2014) potentiometric surface is likely one hundred to several hundred feet lower than the naturally occurring water level would have been prior to CBM development.

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2.6.1 Recharge

Recharge within the coal aquifers is expected to be a twofold process with recharge entering the aquifers from the outcrop as well as flowing laterally into the coals from aquifers adjacent to the model domain. The primary source of surficial recharge is at coal outcrops and subcrops under alluvial fill where it is in hydrologic communication with the alluvial aquifer. Recharge from direct precipitation is expected to occur only where the coal outcrops at the surface. Since precipitation rates are low and evapotranspiration is relatively high (with respect to precipitation), precipitation infiltration is expected to be minimal in the Project. Recharge values used in the model are provided in Section 4.2.3.

Recharge to the surficial aquifers is expected to primarily be driven by the Tongue River, Goose Creek and Slater Creek surface water bodies. Recharge from precipitation is difficult to measure. The ratio between run-off, evapotranspiration and infiltration varies by topography, vegetation, soils and climatic conditions. Significant variability of these parameters near the recharge zones for the Brook Mine Model domain create further difficulty in determining actual rates of recharge into the groundwater system. Therefore, recharge values were initially set at expected regional values and then adjusted, within reasonable ranges, during model calibration.

Lateral recharge into the model is provided by the general head boundaries around the perimeter of the model domain. The volume of recharge entering the model laterally from horizontally adjacent aquifers is minimal because CBM development has significantly decreased water levels in the coal aquifers.

2.6.2 Drains

As described in further detail in Section 4.3, in areas of down-dip coal outcrops, drain cells were placed in the model to simulate seeps from the outcrops. These drains allow water to leave the groundwater system. Any seepage from the coal outcrops leaves the system by evapotranspiration before it reaches the surface. During field investigations no flowing water was

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observed at the seeps and it was not possible to obtain field measurements of drain flux; therefore drain characteristics were estimated and adjusted to achieve model calibration.

2.6.3 Rivers

River cells from MODFLOW's river boundary condition package were placed in the model to simulate the Tongue River. These river cells were assigned approximate characteristics of the Tongue River to provide both a source and a sink for the groundwater system depending on the head of the adjacent model cells. These rivers provide a source of recharge in areas where they cross the coal seam outcrops. Groundwater Vistas applies the river cells across the entire thickness of the layer that the river cells are inserted into. The thickness of Layer 1 along the eastern edge of the model domain is several hundred feet thick, while the Goose Creek and Tongue River alluvium are estimated to be between 15 and 30 feet thick based on the thickness of alluvial wells constructed by Big Horn Coal in the area. Therefore, river boundary cells were not placed in the eastern side of the model domain because the model would have allowed river cells in these areas to recharge the underlying coal aquifers even though there is no hydrologic connection between the coals and the river. However, there is an intermediary region where the actual level of the river is some 30-70 feet higher than the coals. At these locations, the river boundary cells were put into the model to conservatively show the impacts to the river. However, the alluvium in these areas is likely thinner than 40-70 feet. As a result, the model allows the river to directly contribute water to the coals below and the model is expected to overestimate the impacts to the Tongue River in these locations.

3.0 COMPUTER CODES

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3.1 Software

The numerical groundwater model utilizes the USGS modular finite-difference groundwater model MODFLOW (Macdonald and Harbaugh 1988)

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and the pre/post processor Groundwater Vistas Version 6.80 Build 1 (Environmental Solutions, Version 6). Groundwater Vistas and MODFLOW2000 are well recognized within the groundwater modeling community and are widely utilized and accepted by both industry and regulatory agencies.

3.2 MODFLOW Input Files

Nine MODFLOW packages were used to develop the Brook Mine groundwater model. The packages include:

- Basic – Basic Package containing starting heads, constant heads, and some options
- Block Centered Flow – BCF, contains aquifer property data and grid spacings
- Output Control – Determines what model results to print and save to files during simulation
- Solver – PCG2 was utilized to solve the partial differential equations in MODFLOW
- Drain – Drain boundary conditions package
- River – River boundary conditions package
- General Head – General head boundary conditions
- Horizontal Flow Barrier – HFB, sealing fault boundary conditions
- Recharge – provides recharge to the model.

In addition to the MODFLOW packages listed above, several packages specific to MODFLOW2000 were also used. They include the LFB and DIS packages.

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3.3 Limitations and Assumptions

As with any modeling software there are a number of limitations and assumptions built into the code. MacDonald and Harbaugh (1988) describe limitations and assumptions within the MODFLOW code in detail. Rumbaugh and Rumbaugh (2011) also detail the limitations and assumptions built into

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Groundwater Vistas. Many of the assumptions and limitations within the modeling software are the result of inaccuracies inherent in modeling a natural system and are generally similar for all modeling software. Limitations and assumptions specific to this modeling effort are primarily due to the complexity of the hydrogeologic system and a lack of data on physical and hydraulic characteristics of the aquifers and confining units being modeled, as described in detail within this report.

4.0 MODEL CONSTRUCTION

4.1 Model Domain

The model grid is oriented north to south and is generally aligned parallel to the strike and major coal seams within the model domain. The grid encompasses approximately 38,711 acres. The model is constructed with variable grid spacing ranging from a minimum of 125 x 125 feet within the permit area to 500 x 500 feet at the model boundaries consisting of 164 rows and 325 columns. The maximum increase in size between adjacent cells is limited to less than 1.5 times in order to eliminate numerical errors (Anderson and Woessner 1992). The model grid is depicted in Figure 4.1-1. The model domain was sized to minimize edge effects created by artificial boundary conditions on the south and east boundaries of the domain.

The model consists of six layers which are conceptually shown on Figure 4.1-2 and described as follows:

- Layer 1 – Represents the coal overburden. This layer generally overlies the entire model domain and is composed of mud/claystone, coal, argillaceous sand/siltstones, and residuum from coal burn (clinker and scoria). Although some lateral permeability is provided by overlying coal intervals, Layer 1 is generally modeled with low vertical permeability due to interbedded mud/claystones and leakance. Therefore, Layer 1 is not considered a substantial recharge source to the underlying aquifers except in the Tongue River and Slater Creek alluvium where it was assigned a higher hydraulic conductivity to simulate alluvium. The modeled thickness of Layer 1 varies from 0 feet up to approximately 1,100 feet.

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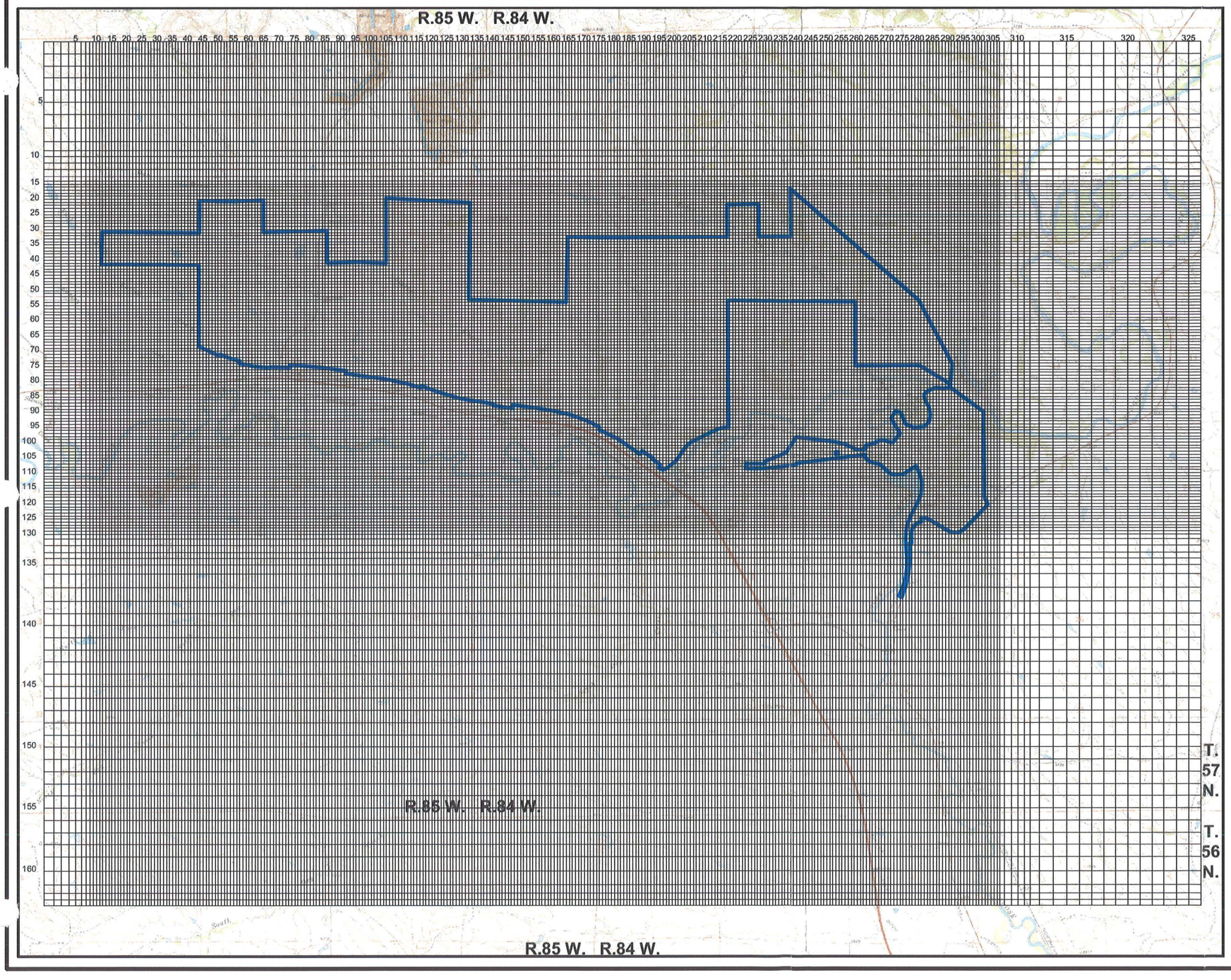

LEGEND

- BROOK MINE PERMIT BOUNDARY
- MODEL GRID

N

0 2,000 4,000 6,000 8,000
GRAPHIC SCALE (FEET)

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGARVIEW DR STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description

FIGURE 4.1-1

GROUNDWATER MODEL GRID

Drawn By: MBM
Checked By: SMR
Date: 7/9/2015

FILE: GWMODEL_GRID_R1.dwg

WWC ENGINEERING
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Figure 4.1-2. Conceptual Groundwater Model Layers.

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- Layer 2 – Upper Carney Coal seam. This layer is isolated in the western portion of the model domain due to a split of the seam but in the eastern portion of the model the coal seams coalesce. This seam represents a primary target for mining operations. The modeled thickness of Layer ranges from 2 to 7 feet throughout the model domain.

- Layer 3 – Carney Interburden. Represents a claystone parting separating the Upper and Lower Carney Seams. This interval is generally of low to very low permeability and is present in the western portion of the Project Area. The modeled thickness of Layer 3 varies from 4 to 15 feet throughout the active portion of the model domain.

- Layer 4 – Lower Carney Coal seam. Represents the lower half of the Carney coal seam. This layer coalesces with the upper half of the Carney seam on the eastern portion of the Project Area. This seam is a primary target for mining operations. Layer 4 was modeled with a constant thickness of 8 feet throughout the model domain.

- Layer 5 – Carney/Masters interburden. Represents a confining unit between the Carney and Masters Seams. This layer is predominantly composed of claystone, with a modeled thickness from 4 feet to 69 feet within the model domain.

- Layer 6 – Masters Coal seam. Bottom-most minable coal sequence in the Project area. This layer is underlain by the substantial clay and mudstones of the Lebo Shale. This seam represents a primary and secondary target for mining operations and has a constant thickness of 6 feet within the model domain.

The clay and mudstones in the Lebo Shale essentially serve as an impermeable flow barrier beneath the Masters Coal. In Groundwater Vistas, the bottom of the model is treated as an impermeable boundary. As such, the model approach accurately simulates real world conditions.

Layer top and bottom elevations used for volumetric coal estimates were provided by Cardno MM&A and used in the model. Minor adjustments were made to these surfaces based on new data provided by additional exploration drilling completed after the resource estimates were completed. Figure 4.1-3 depicts actual cross sections cut through the model domain.

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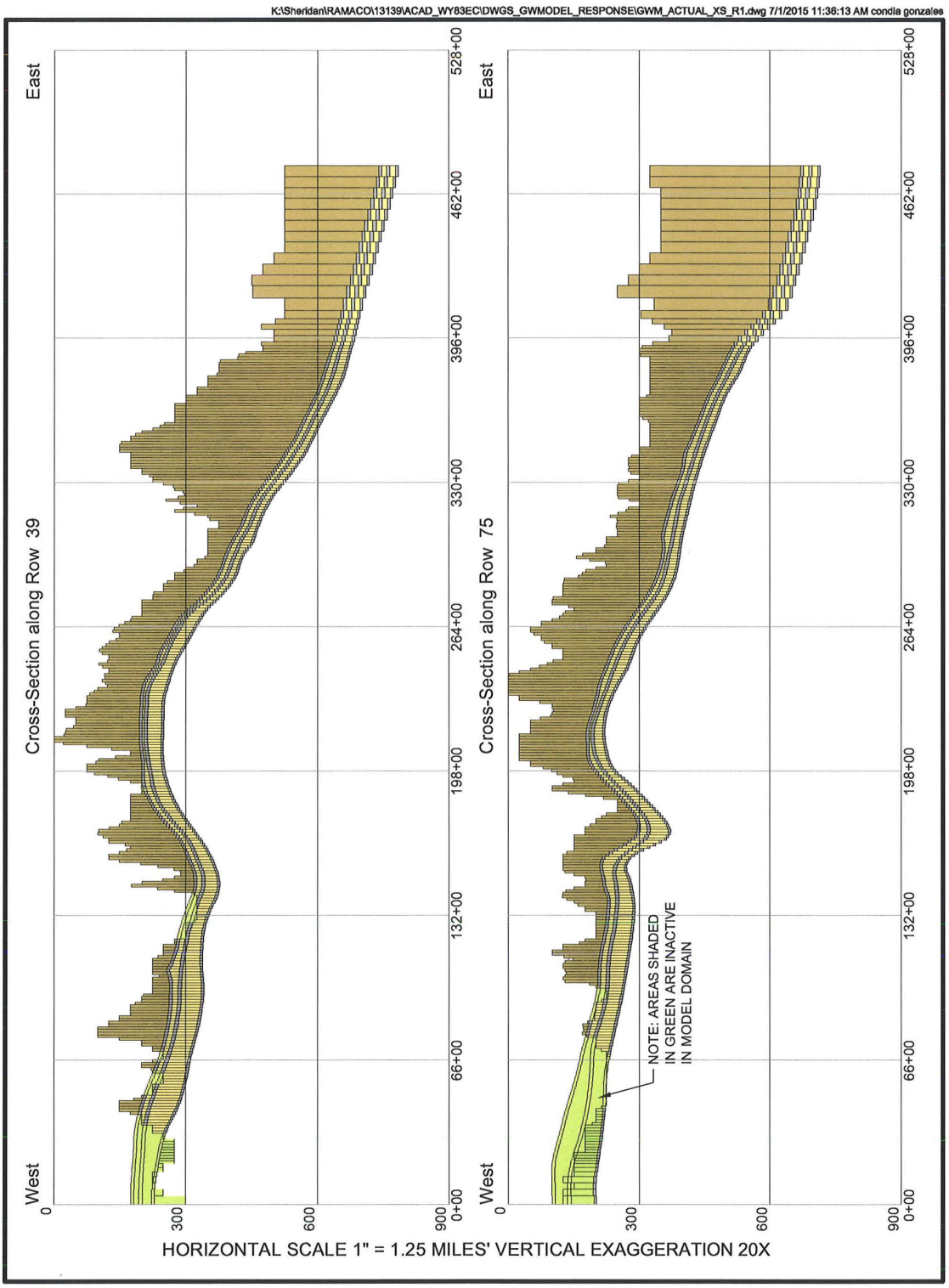

Figure 4.1-3. Actual East West Cross Sections From Ground Water Model

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4.2 Hydraulic Parameters

Hydraulic properties needed to characterize each aquifer or confining unit include: hydraulic conductivity, storage coefficient (for confined aquifers), specific yield (for unconfined aquifers), and recharge. Available information for each of these properties was determined for the Carney and Masters coal seams by a multi-well pumping test performed at the 578409 monitoring well cluster. Given the lack of additional hydrologic data within the Brook Mine Permit Area, these values provided the best available data for model inputs and were assigned to the coal sequences across the entire model domain.

4.2.1 Hydraulic Conductivity

As noted in Section 2.5.1, Carney and Masters hydraulic conductivity values were measured during pumping tests. Hydraulic conductivity values for the intervening confining units have not been measured and were determined by utilizing typical literature values that were further adjusted during model calibration. Hydraulic conductivity values used for the modeling effort are provided in Table 4.2-1. As shown on Table 4.2-1, Layer 3, which represents the Carney interburden, has two dominant hydraulic properties. Within the western portion of the model domain where low permeability interburden separates the upper and lower Carney a low hydraulic conductivity was assigned to the layer. Within the eastern portion of the model, the upper and lower Carney coalesce and the hydraulic conductivity assigned to Layer 3 was the same as the Carney Coal. This adjustment in hydraulic conductivity allows the model to realistically model the coalescence of the upper and lower Carney seams. To minimize error associated with abrupt hydraulic conductivity changes, the Carney split modeled by Layer 3 was bounded by several bands of decreasing hydraulic conductivity to provide a smooth transition between the coal and non-coal interval. As noted in Section 2.3, there are small areas within the model domain where the coal is in indirect contact with Tongue River alluvium or Slater Creek Colluvium. At these locations, a higher hydraulic conductivity was assigned to Layer 1. Figure 4.2-1 depicts where the

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Table 4.2-1. Hydraulic Conductivity Summary

Layer	Aquifer Unit	Hydraulic Conductivity Values (ft/day)	
		Horizontal	Vertical
1	Overburden	0.1-0.025	0.1 – 0.00025
2	Upper Carney	0.31	0.031
3	Carney Interburden	0.004/0.31	0.00035/0.031
4	Lower Carney	0.31	0.031
5	Carney/Masters Interburden	0.004	0.00035
6	Masters	0.54	0.054

hydraulic conductivity in Layer 1 has been adjusted to mimic alluvial/colluvial deposits. The actual hydraulic conductivity values assigned to the alluvial areas were decreased (from typical expected alluvial values) for the purposes of this model because in most of the areas far from the Tongue River, the alluvium is very thin while Layer 1 is modeled in some of these areas significantly thicker than the alluvium. The lower calibrated hydraulic conductivity values allowed the model to move water from the alluvium into the underlying layers without flooding them with water from the river boundary.

4.2.2 Recharge

The initial recharge rates utilized in the model were estimated based on values developed by Carter and Driscoll (2001) in a study conducted on the eastern side of the Powder River basin and the Black Hills area. In their study, Carter and Driscoll reported recharge rates varying from 0.04 inches per year to 2.93 inches per year within the eastern periphery of the Powder River Basin and the Black Hills. The 2.93 inch per year recharge rate was reported within the Madison limestone formation outcrops in the Black Hills, while the lower range of recharge rates were estimated for areas in the eastern periphery of the Powder River Basin where the precipitation and soil types are similar in nature to the Brook Mine permit area. Based on a starting value of 0.04 inches per year, the recharge rates applied to the project area were adjusted as necessary during model calibration. Several areas within the model were assigned higher recharge rates including: areas of coal outcrops and alluvial subcrops which

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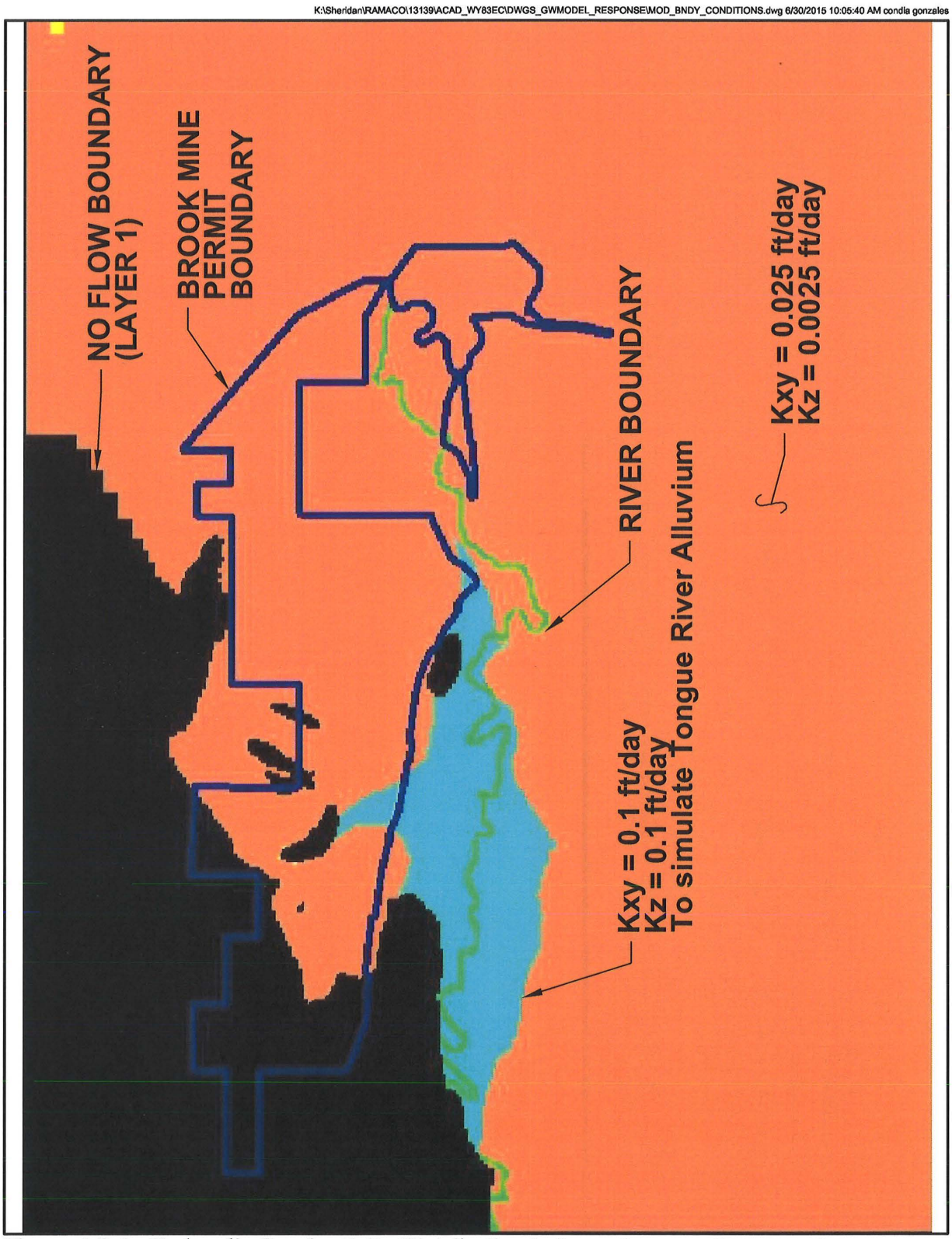

Figure 4.2-1. Hydraulic Conductivity Distribution in Layer 1.

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are stratigraphically higher than the main body of the coal; some areas with a scoria and clinker residuum at surface may allow rapid infiltration; and in areas of substantial shallow alluvium. The recharge rate throughout Layer 1 is much lower than the range of recharges developed by Carter and Driscoll. This is reasonable because much of Layer 1 has no hydrologic connection to the underlying coal seams. The evapotranspiration package was not utilized in the model. Therefore, in areas were evapotranspiration will reduce the amount of recharge, the recharge value was adjusted downward to account for evapotranspiration losses. Recharge values used in the model for each of these specific recharge zones are provided in Table 4.2-2.

Table 4.2-2. Recharge Summary

Layer	Recharge Zone	Recharge Rate ($ft/day/ft^2$)	Recharge Rate (in/yr)
1	Base Recharge – Top of Layer 1	$1.2x10^{-7}$	0.0005
1	Scoria residuum at surface	$8.0x10^{-5}$	0.35
2, 3 and 4	Carney outcrops	$1.4x10^{-4} – 2.0x10^{-4}$	0.61 – 0.88
6	Masters outcrops	$4.5x10^{-5}$	0.20

Recharge is applied within the modeling software by applying the recharge to the highest active layer. At specific formation outcrops, overlying strata have been removed by erosion and therefore are not active within the model. This allows the recharge to be applied to the correct model layer. Figure 4.2-2 depicts the spatial distribution of recharge within the model domain. Along the north and the west sides of the model, there is a good portion of the model domain where the upper layers have eroded away. These areas of erosion were accounted for using no flow cells. As shown in the figures in Section 4.4, the no flow cells in the top layer are the largest in areal extent while each underlying layer has a slightly decreased areal extent of no flow cells. In this case, the no flow cell distribution was adjusted to match the outcrop of each layer. The software applies the recharge to the highest active layer. This was advantageous in the model because it is an effective way to apply recharge to an outcropping layer which is under another layer present in the model, but is eroded away in actuality. Because CBM operations have

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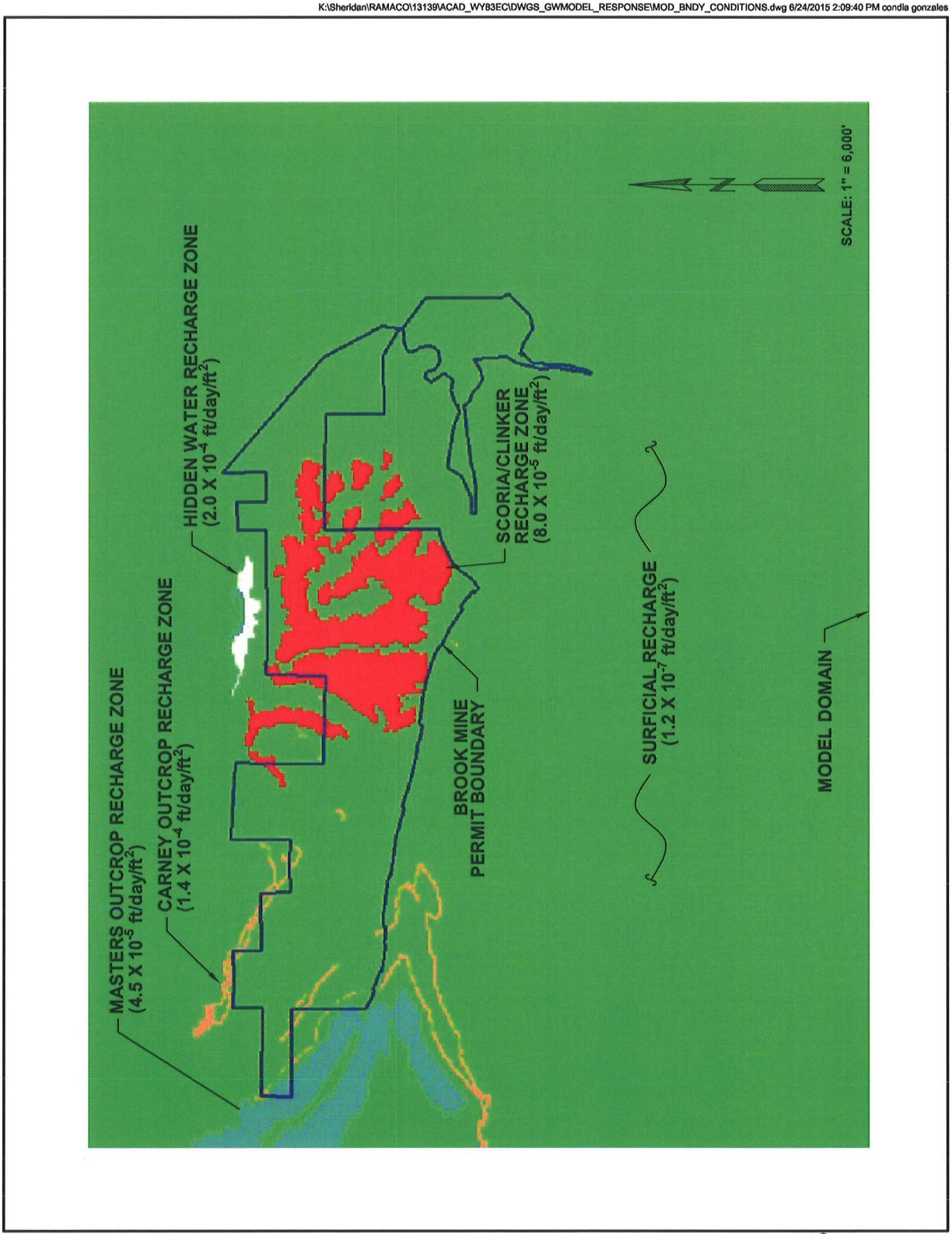

Figure 4.2-2. Spatial Distribution of Recharge Zones.

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generally removed most of the water from the coal seams, there are some locations within the model domain where dry cells during the modeling have caused cells in layer 1 to go dry and the recharge is applied to the next active layer below. While this could be problematic if a high recharge rate were assigned to the model cells, generally throughout the model domain the recharge rate is very low. Therefore, this results in a very minor amount of water coming into the model and did not significantly affect the model calibration.

4.2.3 Storage Coefficients and Porosity

As described in Section 2.5.2, estimated storage coefficients (Ss and Sy) and porosity were developed for each layer based on measured data and/or research on similar materials. MODFLOW2000 utilizes specific storage (Ss) rather than a storage coefficient. As such, all storage coefficients were converted to Ss prior to input in the model by dividing by the average layer thickness. Each layer was assigned a unique specific storage, specific yield and porosity value which did not vary spatially except for in areas of historic mining where the values were raised to account for increased storage created by existing mining operations. Storage coefficient values used for each layer in the modeling effort are summarized in Table 4.2-3 below. MODFLOW does not utilize porosity as part of its flow calculations, however, estimated porosity values for each layer are also included in Table 4.2-3 for future use if alternative analyses are conducted that do utilize porosity.

4.3 Sinks

Water leaves the model domain by three primary mechanisms: 1) Water flows within confined aquifers downgradient to the south and east and across general head boundaries along the perimeter of the model domain, 2) water within unconfined/perched aquifers drains from outcrops into the surface water system through drain cells, and 3) water leaves the model in the Tongue River in the river boundary cells. Water is also removed by CBM production wells and by dewatering for mine progression; however CBM impacts to the

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Table 4.2-3. Summary of Specific Storage and Porosity Values by Layer

Layer	Aquifer Unit	Model Storage Coefficient Values (1/ft)		Model Porosity Values (%)
		Specific Storage	Specific Yield	
1	Overburden	$2.7x10^{-6}$	0.2	27
2	Upper Carney Coal	$3.64x10^{-5}$	0.075	10
3	Carney Interburden	$2.7x10^{-6}$	0.2	27
4	Lower Carney	$3.64x10^{-5}$	0.075	10
5	Carney/Masters Interburden	$2.7x10^{-6}$	0.2	27
6	Masters Coal	$4.2x10^{-5}$	0.075	10
2/4	Carney – Historic Mining	$3.64x10^{-5}$	0.8	80

groundwater system were ignored and operational stresses were modeled transiently as described in more detail later in this report.

General head boundary conditions were used to simulate the natural gradient and thus simulate water leaving the model within the confined layers.

The general head boundary conditions are described in more detail within Section 4.4.

To model seeps from the Carney Coal, the surface topography and coal structure contours were overlaid and drains were placed at the intersection of the two surfaces along the downgradient outcrops allowing water moving along the formational contacts to seep from the simulated groundwater system.

River cells were placed to simulate the Tongue River along the western portion of the model domain where the Tongue River alluvium could potentially be in contact with the coals. As described in Section 2.6.3, the river cells allow water to both enter and leave the groundwater system depending on the head of the adjacent model cells.

4.4 Boundary Conditions

The boundary conditions within the model vary slightly from layer to layer. For each layer the boundary conditions are summarized below:

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4.4.1 Layer 1

The boundary conditions include, no-flow cells in the northwest portion of the model where the formation outcrops or does not contribute to the greater groundwater system. River boundary cells are also placed along the Tongue River and drainage where Tongue River alluvium may be in contact with the Carney Coal. The boundary conditions within Layer 1 are shown on Figure 4.4-1. No faults were simulated within Layer 1. Because Layer 1 is not composed of aquifer material and because the hanging and footwalls are composed of strata with similar hydraulic properties, displacement due to faulting does not substantially change the flow through the aquitard, and placing horizontal flow barriers in the model in Layer 1 was not necessary.

4.4.2 Layers 2, 4 and 6

The boundary conditions within the coal layers are similar and consist of drain, general head, and no-flow boundaries. Internal horizontal flow barriers were used to simulate faults and breaks in the aquifer continuity. Horizontal flow barriers require two input parameters in Groundwater Vistas including wall thickness and hydraulic conductivity. The input parameter used in the model for wall thickness was 10 feet and a hydraulic conductivity of 1.0×10^{-5} ft/day was used. The horizontal flow barrier parameters as applied will essentially limit all but a very minor amount of flow across the barrier. A spatial summary of the location of these boundary conditions is shown on Figure 4.4-2.

4.4.3 Layer 3

The boundary conditions in Layer 3 include river boundary cells where the river is in contact with the Layer 3 outcrop, drains, general head boundaries east of the Carney split line, horizontal flow barriers and no-flow

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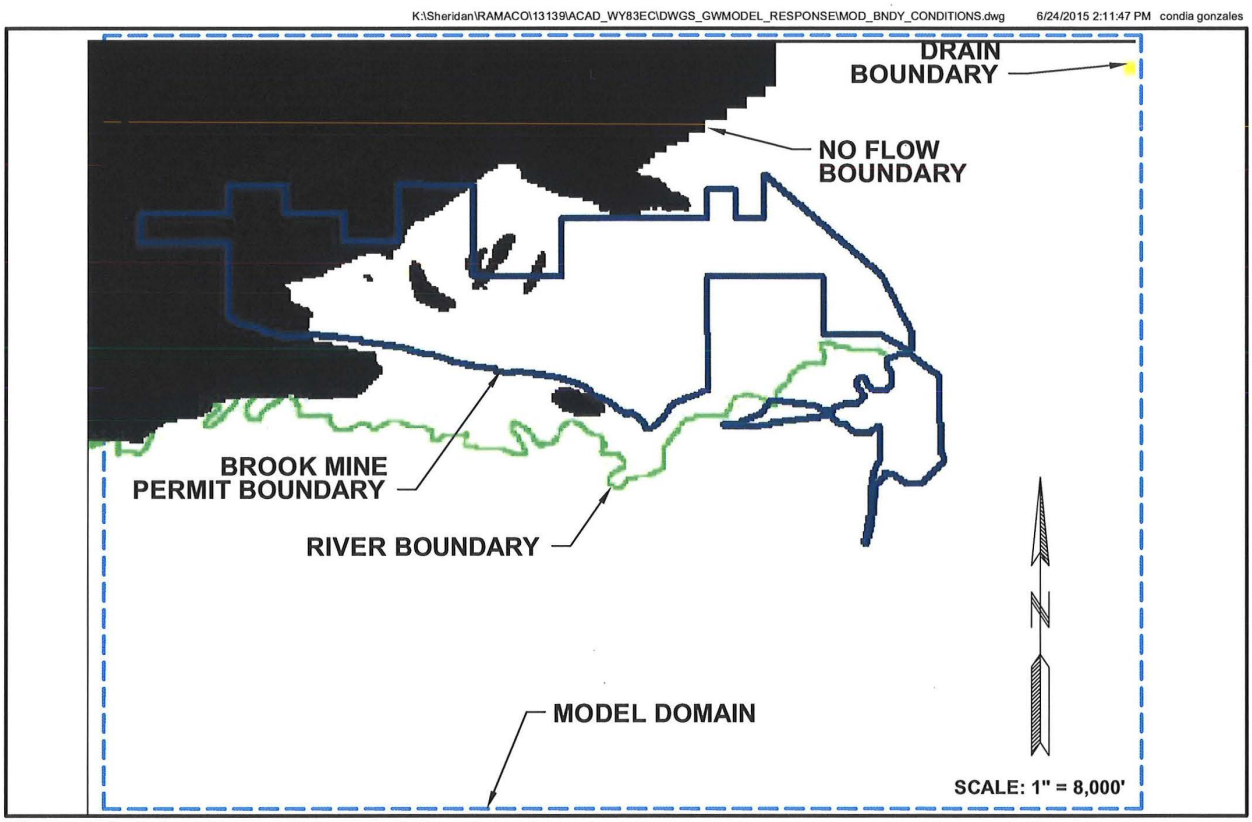

Figure 4.4-1. Layer 1 Boundary Conditions.

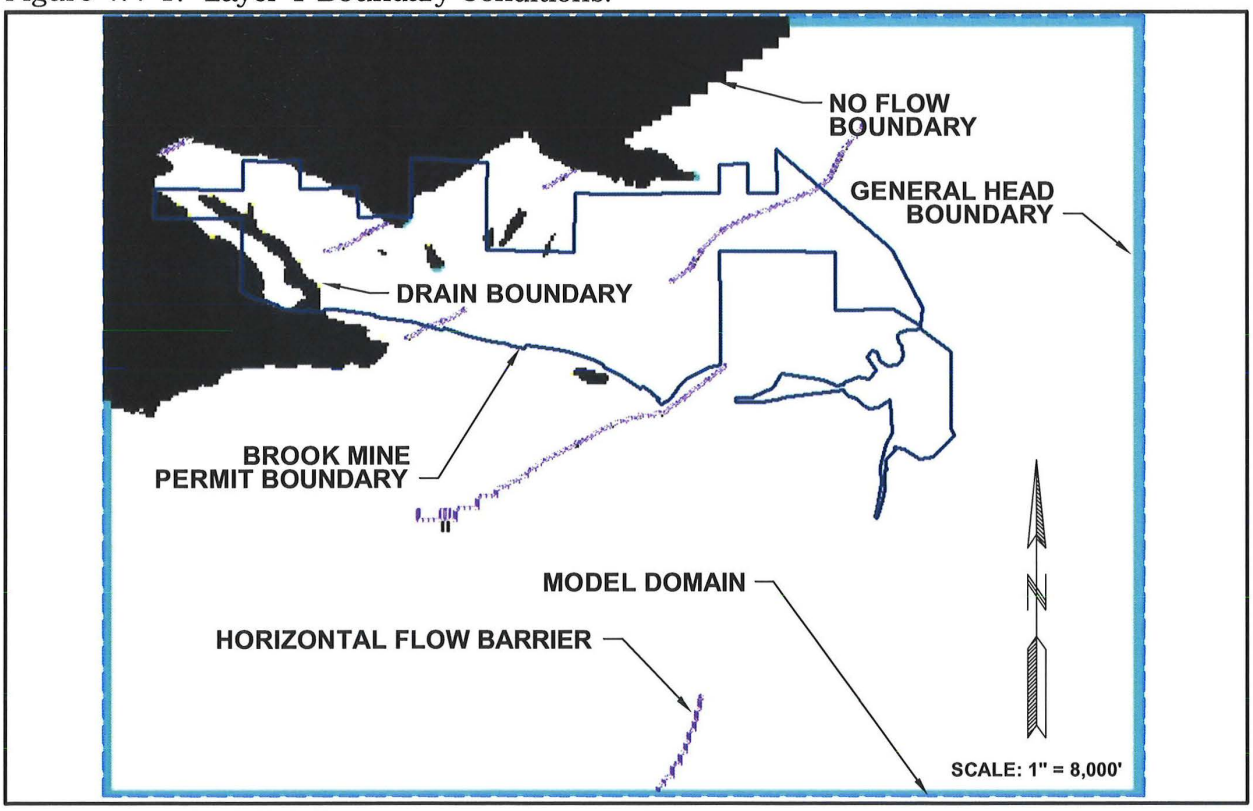

Figure 4.4-2. Layer 2, 4 and 6 Boundary Conditions.

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boundaries, which are all depicted on Figure 4.4-3. The horizontal flow barriers were assigned the same properties in Layer 3 as Layers 2, 4, and 6.

4.4.4 Layer 5

The boundary conditions in Layer 5 include drains, several river boundary cells where the river is in contact with the Layer 5 outcrop, horizontal flow barriers and no-flow boundaries, which are all depicted on Figure 4.4.4. The horizontal flow barriers were assigned the same properties in Layer 5 as Layers 2, 4, and 6.

4.5 Calibration Targets and Goals

Important features that are available to calibrate the groundwater model include outcrop boundaries, seep/spring locations, estimated recharge rates and static water elevations in coal monitor wells. The goals of model calibration and verification were to adjust these hydraulic parameters as necessary to match observed and computed water elevations within the model domain. A calibrated pre-mine model provides the basis for mining impact analysis.

4.6 Numerical Parameters

The PCG2 solver within MODFLOW was utilized as the solver package. The maximum number of outer iterations was set at 100, and the maximum number of inner iterations was set at 50. Due to a model that begins with a large number of partially saturated and dry cells, model instability was a problem. Therefore, head change criterion for convergence and other default numerical parameters were relaxed to allow MODFLOW to converge on a repeatable solution. By relaxing the requirements for convergence, additional numerical error is introduced into the model. Because of this, the simulated mass balance was reviewed after each model run to ensure that the simulation was valid. Mass balance residual error for the model was not allowed to exceed 1.0% during the steady-state calibration run. Mass balance comparisons are described in detail in Section 4.10.

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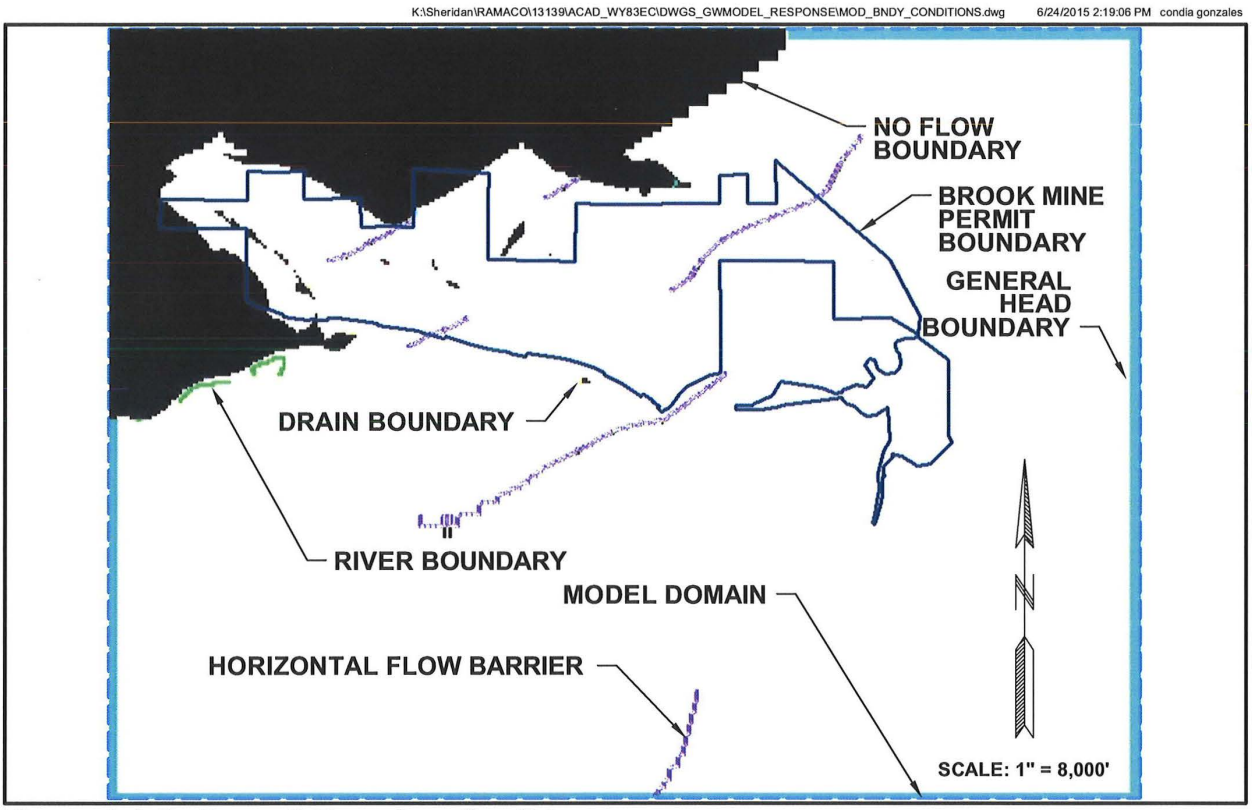

Figure 4.4-3. Layer 3 Boundary Conditions.

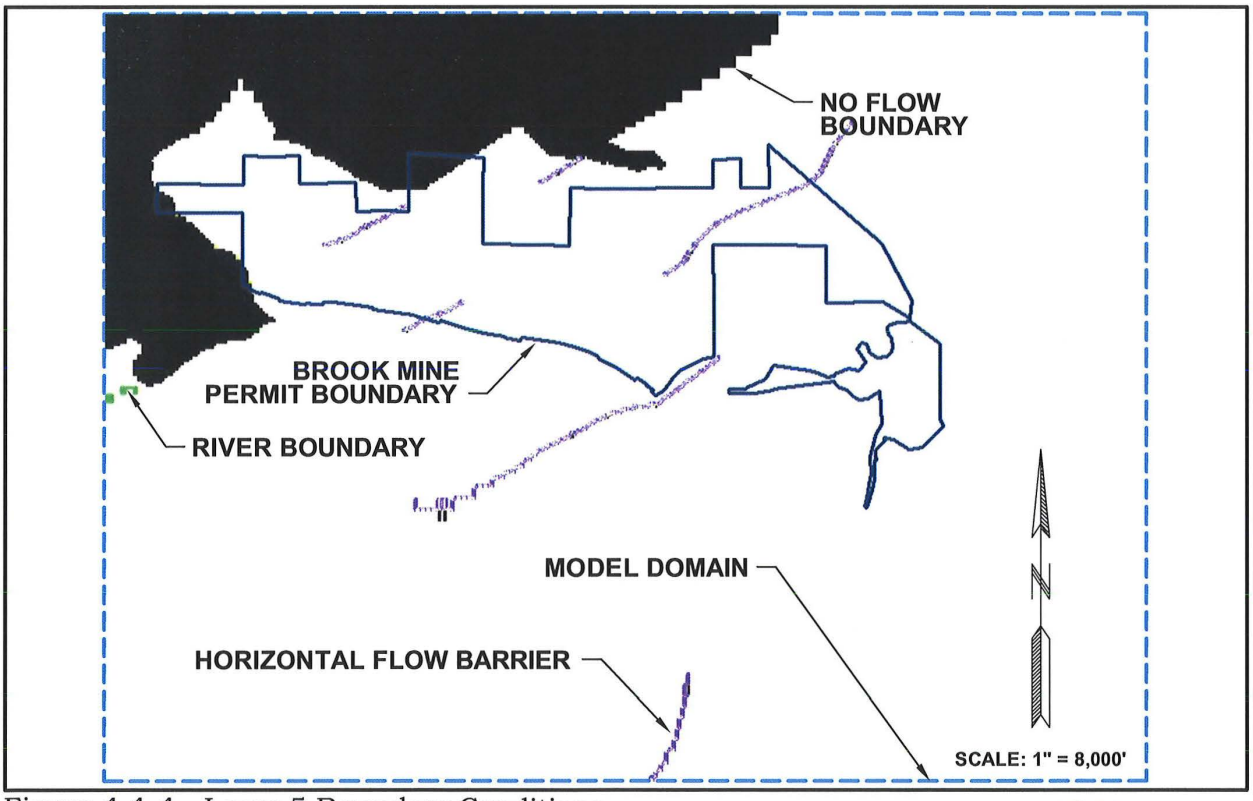

Figure 4.4-4. Layer 5 Boundary Conditions.

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4.7 Calibration and Verification

4.7.1 Calibration Approach

The calibration approach was an iterative process continuously moving towards a more refined model. The first step was to construct a working model with the proper number of layers representing the geology within the Project Area. The first model was a relatively simple steady-state model utilizing homogeneous hydraulic properties in each layer. A structured sensitivity approach was then used adjust these hydraulic parameters. This method takes specified parameters and makes several model runs while changing the parameter over a specified range. Upon a review of the calibration statistics and mass balance from each model run, the parameter that best optimizes the model results is chosen and the model is updated. This process was repeated until an optimized, steady-state calibration was achieved.

As the current, post-CBM potentiometric surface is considered the static water level for the model domain for the purposes of the modeling effort, water levels from the coal monitor well network were then inserted into the model as steady-state head targets. The hydraulic parameters were adjusted during each subsequent steady-state simulation to approximate these head values as nearly as possible. Due to local geologic complexity and hydrologic heterogeneity, model calibration was based on regional reduction of residual error between modeled and actual water level data. This calibrated potentiometric surface was then imported into a transient model for determining impacts resulting from mine dewatering.

CBM operations are designed to dewater the coal seams in order to remove the gas from the coal, therefore, the post CBM assumption used in the model meant that the water levels in the coal near CBM wells were set at very low levels which caused some of the cells in the model to go dry in the steady state model. In other words, the model demonstrated that the CBM operations were successful in accomplishing their intended goal. Unfortunately, MODFLOW does not handle dry cells very well. When cells go dry, the program

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treats them as no flow areas and this significantly impacts the way the model moves water around and through the cells. MODFLOW does allow for rewetting of cells and this option was turned on. However, the wetting option in MODFLOW is not very robust and usually does not work well. The dry cells cause model instability and make calibration more difficult because one cell going dry may cascade into multiple cells going dry. As a result, small changes in the model parameters may result in significant changes in the modeled results simply because of dry cells. As noted later, some of the model predicted impacts have resulted from dry cells rather than impacts from mining. Nevertheless, even considering the challenges that CBM dewatering has provided the calibration is considered reasonable.

4.7.2 Verification/Calibration Results

The resulting hydraulic parameters yielded an acceptable fit between the modeled potentiometric surface and the target wells within the coal seams of interest. Table 4.7-1 summarizes the calibration targets as well as the calculated residuals and statistics from the calibrated model. Figure 4.7-1 depicts a graph of the observed vs. computed target values during calibration. Although assuming heterogeneous hydraulic conductivity may have resulted in a slightly better fit, the solution would be non-unique due to a lack of measured hydraulic conductivity data and constant hydraulic conductivities were assumed across the Project Area. Due to a system of thin aquifers with similar sources and sinks and homogenous hydraulic conductivities, the head values of the steady-state model were similar in the separate coal layers as noted in Table 4.7-1. This suggests that the hydraulic conductivity values used to simulate the interburden between the coals is higher in the model than they are in the natural system.

In addition to the calibration targets, interactions between the coal aquifers and the Tongue River were also reviewed during the calibration process. As described in Section 2.3, the Carney coal is largely dry to the north and west of its subcrop into the Tongue River alluvium and becomes saturated

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Table 4.7-1. Summary of Model Calibration Results

Well Name	Layer	Easting	Northing	MP Elevation (ft amsl)	Water Elev. (ft. BMP)	Observed (ft. amsl)	Computed (ft. amsl)	Residual (ft)
578510-CRN-1	4	1371807.2	1941542.1	3965.4	DRY	DRY	DRY	NA
578510-MST-1	6	1371823.0	1941558.1	3964.4	146.1	3821	3827.8	-6.9
578511-CRN-1	4	1377926.5	1940246.5	3896.1	119.6	3776.5	3786.6	-10.1
578511-MST-1	6	1377944.7	1940243.6	3896.4	150.1	3746.3	3787.3	-41.0
578513-CRN-1	4	1381665.6	1938329.3	3850.0	117.1 (DRY)	3742	3728.8	13.2
578513-MST-1	6	1381680.6	1938341.4	3850.6	108.54	3742.1	3728.9	13.2
578418-CRN-1	4	1387102.2	1936927.8	3884.5	146.6	3737.9	3714.8	23.1
578418-MST-1	6	1387130.9	1936922.9	3885.8	184.5 (DRY)	3731.4 (DRY)	3715.9	15.5
578417-CRN-1	4	1391364	1939152	3929.1	133.3	3795.6	3786.8	8.8
578417-MST-1	6	1391382	1939175	3928.7	160.5	3768.4	3778.6	-10.2
578408-CRN-1	4	1394416	1941810	3890.0	87.7	3802.6	3784.6	18.0
578408-MST-1	6	1394423	1941802	3890.5	105.9	3784.4	3782.8	1.6
578409-CRN-1	4	1399549.2	1940097.5	3712.7	90.7	3622	3602.0	20
578409-MST-1	6	1399559.3	1940087.6	3712.4	101.1	3611.3	3598.9	12.4
578415-CRN/MST	4 - 6	1404291.8	1936077.6	3614.3	122.7	3491.6	3494.7	-3.1

Residual Mean	3.63	Min. Residual	-41.0
Absolute Residual Mean	13.13	Max. Residual	23.1
Residual Std. Deviation	15.96	Number of Observations	14
Sum of Squares	4,020.3	Range in Observations	384.1
RMS Error	16.37		

BMP = below measuring point

at an elevation just above where it subcrops beneath the Tongue River alluvium. Therefore, it is likely that the Carney coal would lose water to the Tongue River alluvium. The potentiometric surface in the Masters coal is roughly the same as the potentiometric surface of the Tongue River where the Masters coal subcrops beneath it. A review of the steady state groundwater model shows that where the river boundary cells are immediately above the Masters coal, the net effect is that the river boundary cells input approximately 3.2 gpm into the model. Conversely, near the upper and lower Carney coal/Tongue River outcrops, the river cells remove roughly 0.16 gpm from the model. Since the coal outcrops occur beneath the Tongue River, verification of these flows cannot be made in the field, but conceptually they do seem reasonable.

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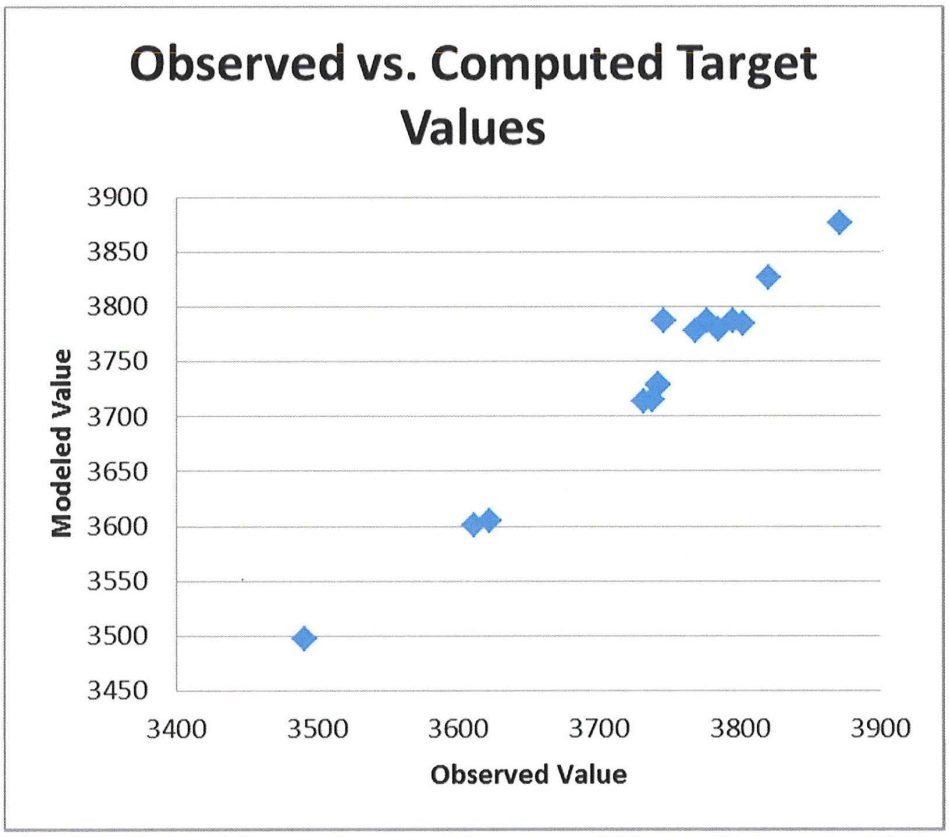

Figure 4.7-1. Observed versus Computed Target Values for Model Calibration

Some error may be introduced due to the fact that the river boundary cells extend to the bottom of the layer in which they are placed. The river boundary cells were placed in Layer 1 to the confluence of Goose Creek and the Tongue River, which extends east of the area where the Carney coal is likely in communication with the Tongue River alluvium. The river boundary cells extend to the bottom of the layer and provide a conduit for the river to recharge the Carney coal even though the river is likely physically separated from the coal by multiple zones of low permeability shales. The model predicted recharge in this area from the Tongue River to both Layers 1 and 2 is approximately 8 gpm. Because the modeled contact area between the river boundary cells and the Carney Coal is likely larger than the actual contact area, the 8 gpm model estimated recharge is conservatively high and actual recharge from the Tongue River to the Carney Coal may be lower. In total, the model conservatively estimates that up to 11.2 gpm would be discharged from the river to the groundwater system.

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Model calibrated pre-mine potentiometric surfaces are provided for the Upper and Lower Carney and Masters Seams in Figures 4.7-2, 4.7-3 and 4.7-4.

4.8 Sensitivity Analysis

In order to assess which input parameters are most critical to the model results, a sensitivity analysis was performed on the calibrated model to determine which parameters impacted calibration the most. The details and results from the sensitivity analysis for each parameter are presented in the following sections.

4.8.1 Model Sensitivity to CBM Recharge Rate

The rate at which groundwater impacts from CBM development will recover is largely unknown because at this time the future of CBM in the region is unknown. According to WOGCC records, many of the CBM wells are currently shut in and some are in the process of being abandoned. However, a number of wells are still showing water production. Economic conditions will likely impact future CBM development. However, because the assumed "static" potentiometry used for the model effort is a snapshot of a transient system, model recharge from the surrounding aquifer will likely increase as the regional aquifer levels increase post-CBM. However, the impacts and recovery periods estimated within the model are believed to be conservative because they assume water levels are maintained at current (post-CBM) levels and if CBM production ceases, recovery rates will likely be higher than estimated in the model. Therefore, no specific sensitivity analyses were performed to evaluate how CBM operations will impact the model results.

4.8.2 Model Sensitivity to Hydraulic Conductivity

To evaluate the model's sensitivity to horizontal and vertical hydraulic conductivity, each aquifer layer's hydraulic conductivities were adjusted both up and down one order of magnitude. The horizontal values were adjusted independently from the vertical values. The sensitivity results are provided in Tables 4.8-1 and 4.8-2.

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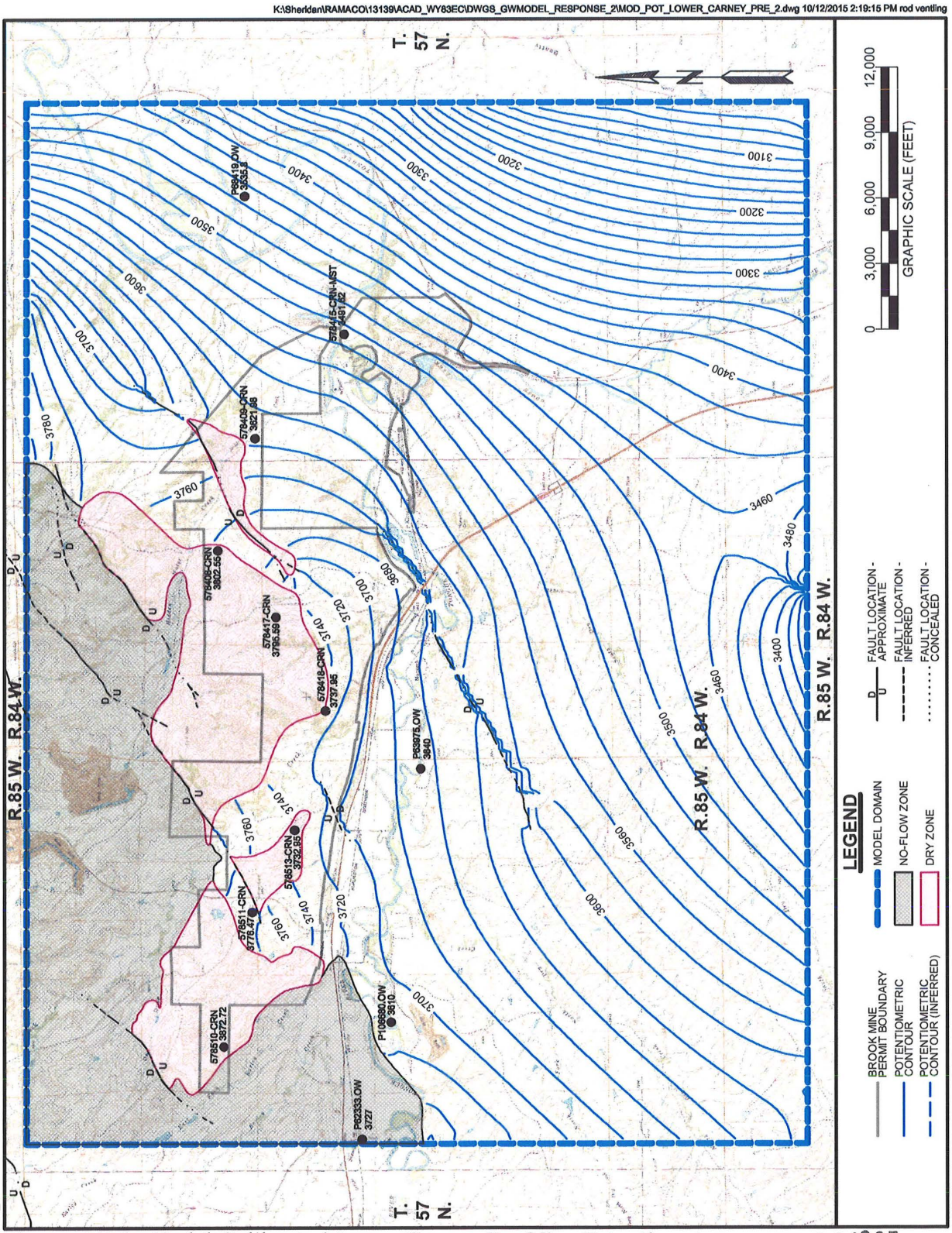

Figure 4.7-2. Model Calibrated Lower Carney Pre-Mine Potentiometry.

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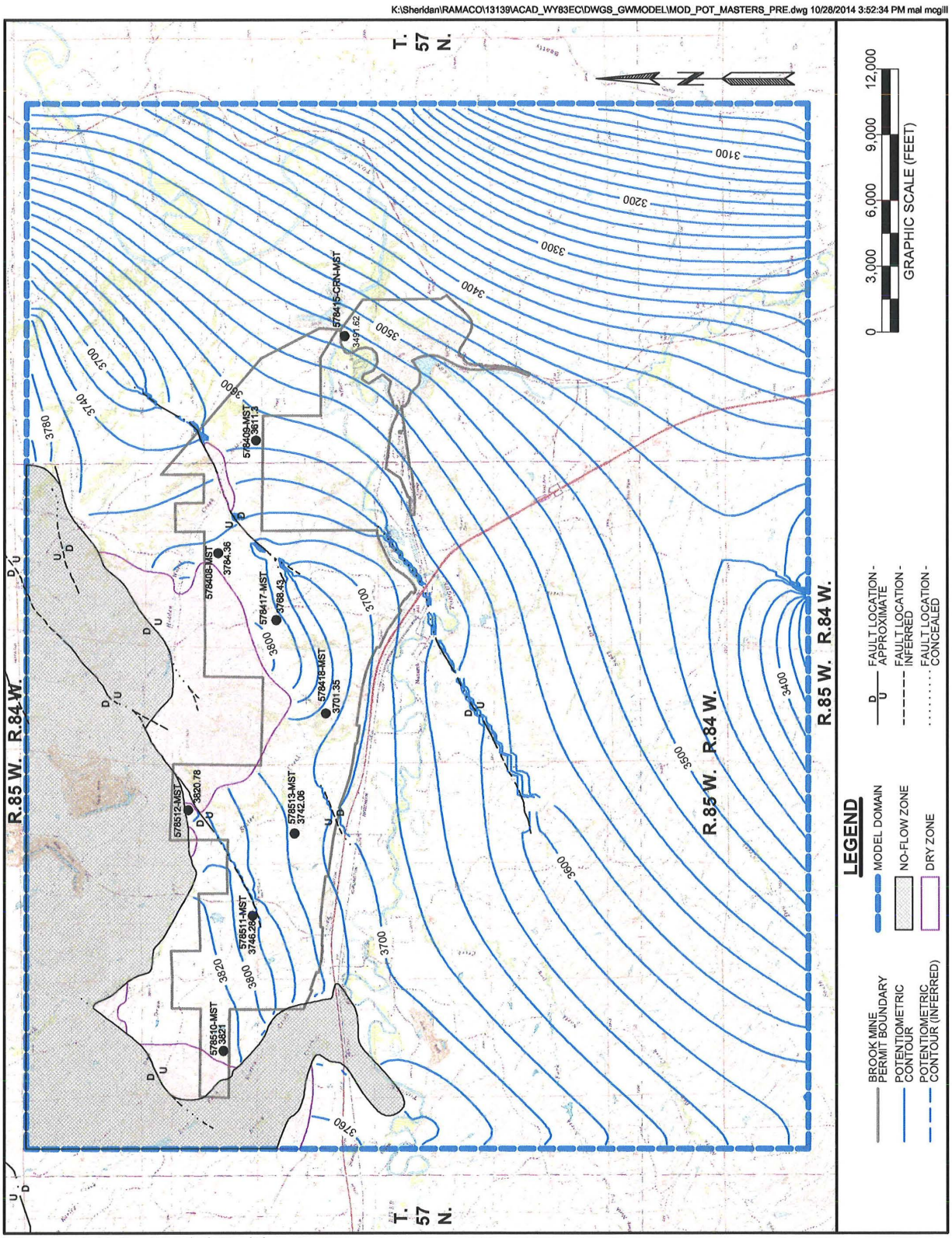

Figure 4.7-3. Model Calibrated Masters Pre-Mine Potentiometry.

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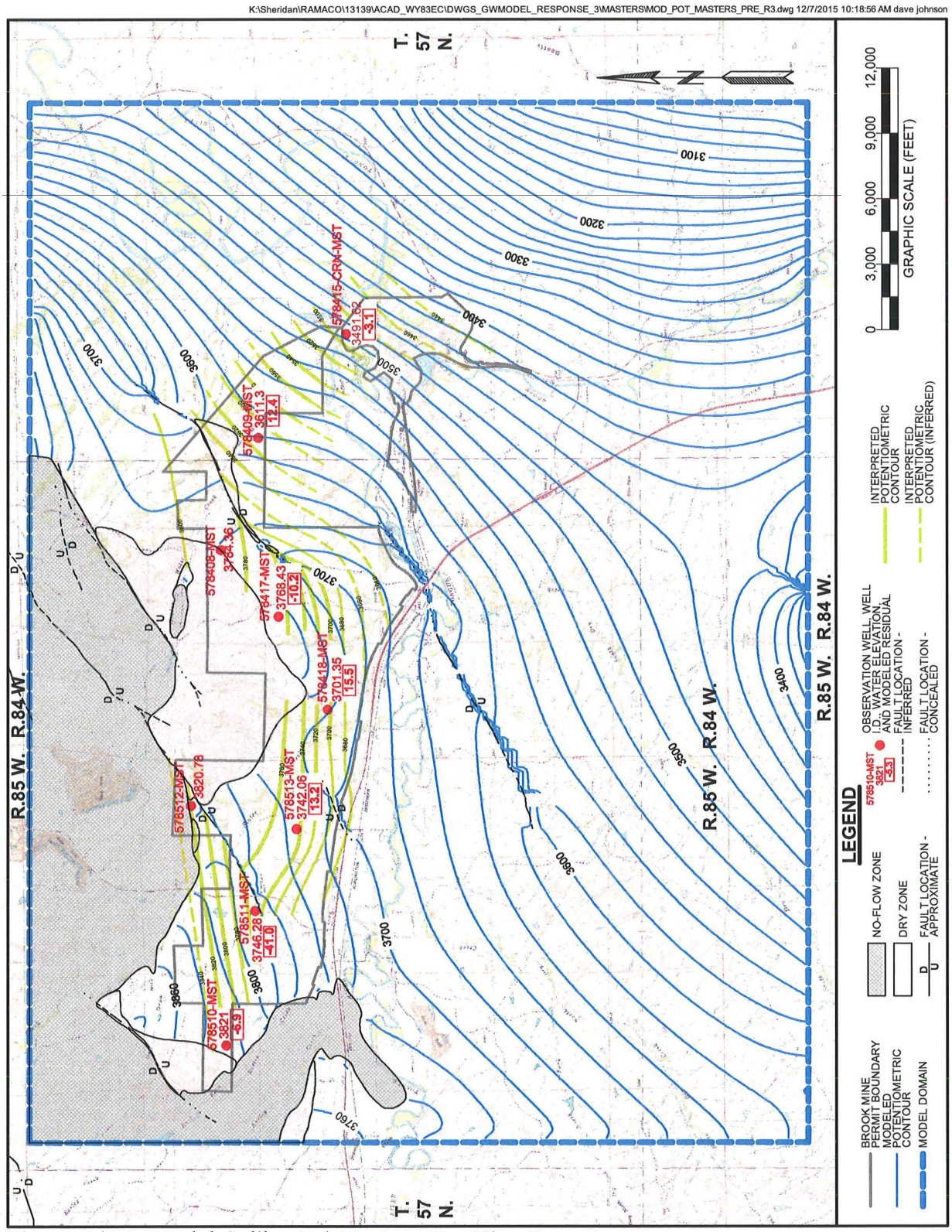

Figure 4.7-4. Model Calibrated Masters Pre-Mine Potentiometry.

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As shown on Tables 4.8-1 and 4.8-2, the coal model layers are relatively sensitive to slight adjustments of hydraulic conductivity, and model calibration may have been increased through additional spatial adjustment. However, as previously discussed due to the scarcity of available hydrologic information, coal hydraulic conductivities were held constant and homogenous throughout the model domain. As presented in Tables 4.8-1 and 4.8-2, adjusting the interburden hydraulic conductivities up by a factor of 10 often results in model instability. Generally, the model was less sensitive to changes in hydraulic conductivity in the interburden than the coal. The results of this sensitivity analyses demonstrate that hydraulic conductivity is a relatively sensitive parameter.

Table 4.8-1. Horizontal Hydraulic Conductivity Sensitivity Results

Run	Multiplier	Horizontal Hydraulic Conductivity Sensitivity			
		Kxy (ft/day)	Sum of Square Residuals	Residual Mean	Residual Std. Dev.
Layer 1					
1	0.1	0.0025	4,770	2.1	17.7
2	1	0.025	4,020	3.6	16.0
3	10	0.25	7,410	10.1	19.8
Layer 2 and 4					
1	0.1	0.031	19,300	-16.6	31.8
2	1	0.31	4,020	3.6	16.0
3	10	3.1	*	*	*
Layer 3 and 5					
1	0.1	0.0004	4,090	3.2	16.2
2	1	0.004	4,020	3.6	16.0
3	10	0.04	*	*	*
Layer 6					
1	0.1	0.054	79,200	-30.6	66.2
2	1	0.54	4,020	3.6	16.0
3	10	5.4	*	*	*

* Model did not successfully compute at this value.

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4.8.3 Model Sensitivity to Recharge Rate

Given difficulties associated with measuring recharge, it was adjusted as necessary to allow model calibration. Actual recharge rates are largely unknown and are likely variable from year to year and season to season. To

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Table 4.8-2. Vertical Hydraulic Conductivity Sensitivity Results

Run	Multiplier	Vertical Hydraulic Conductivity Sensitivity			
		Kz (ft/day)	Sum of Square Residuals	Residual Mean	Residual Std. Dev.
Layer 1					
1	0.1	0.000025	5,510	8.1	17.4
2	1	0.00025	4,020	3.6	16.0
3	10	0.0025	4,030	3.1	16.1
Layer 2 and 4					
1	0.1	0.0031	4,020	3.6	16.0
2	1	0.031	4,020	3.6	16.0
3	10	0.31	*	*	*
Layer 3 and 5					
1	0.1	0.000035	4,420	1.6	17.1
2	1	0.00035	4,020	3.6	16.0
3	10	0.0035	4,000	4.2	15.8
Layer 6					
1	0.1	0.0054	4,020	3.6	16.0
2	1	0.054	4,020	3.6	16.0
3	10	0.54	4,140	3.3	16.3

NA - Model did not successfully compute at this value.

assess the consequences of gross errors in the recharge rate a sensitivity analysis was performed. For the sensitivity analysis the recharge rate for all recharge zones in the model were adjusted up 10 percent and down 10 percent. The results of these adjustments are presented in Table 4.8-3. Fluctuations of recharge rates greater than those presented in Table 4.8-3 resulted in model instability.

Table 4.8-3. Recharge Rate Sensitivity Results

Run	Multiplier	Sum of Square Residuals	Residual Mean	Residual Std. Dev.
1	0.9	8,090	19.6	12.4
2	1	4,020	3.6	16.0
3	1.1	4,560	0.9	17.4

The results of the recharge rate sensitivity analysis and model instability from large-scale adjustments demonstrates the recharge rates as modeled are likely reasonable.

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4.8.4 Model Sensitivity to General Head Boundaries

Within layers 2, 4, 6 and portions of layer 3, general head boundaries (GHB) were placed around the model boundaries to allow water to move into and out of the model. Each GHB has a conductance term associated with it. The conductance term dictates how much water is released into or out of the model through the GHB over a given time period. To evaluate the impacts an increase or a decrease in the conductance assigned to the GHB would have on the model calibration, sensitivity analyses were performed assuming the conductance was increased and decreased by an order of magnitude. Table 4.8-4 presents the calculated sensitivity to GHB conductance. GHB conductance is a not a highly sensitive parameter as shown on Table 4.8-4, but the values used in the model appear to provide reasonable calibration.

Table 4.8-4. GHB Conductance Sensitivity Analysis

Run	Multiplier	Sum of Square Residuals	Residual Mean	Residual Std. Dev.
Parameter: GHB Conductance Zone: All Layer: 2, 4, 6 and portions of layer 3				
1	0.1	4,380	4.5	16.5
2	1	4,020	3.6	16.0
3	10	4,120	3.4	16.2

4.8.5 Model Sensitivity to Storage Coefficients and Porosity

Storage coefficient and specific yield dictate how much water can be removed from an aquifer per unit of drawdown. Specific yield is used in unconfined aquifers and specific storage is used in confined aquifers. Layer 1 is unconfined across the entire model domain while layers 2-6 have portions that are both confined and unconfined. A higher storage coefficient or specific yield corresponds to a greater amount of water in storage. A steady-state MODFLOW model does not utilize either storage coefficients or porosity in the model calculations. Therefore, no sensitivity analyses for storage coefficients or porosity were conducted.

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4.9 Operational Simulation

Mining is scheduled to occur over a 12-year period, with separate panels targeted for extraction each year. This mining progression begins on the east side of the Brook Mine Project Area and generally moves west over time. Transient drains were placed in the model to simulate dewatering and were modeled for two years in 6-month stress periods, to allow for excavation, mining and reclamation, after which they were turned off while the drains in subsequent panels were turned on. This process occurred for each successive mine panel until the entire resource was mined out. The simulated mine progression used in the modeling effort is provided in Figure 4.9-1. The Upper and Lower Carney Seams are the primary mining targets, and mining from these seams was modeled across the entire Project Area. However, current mine planning for the Masters seam mines only the three eastern-most mine blocks presented on Figure 4.9-1. Also, in December 2015 RAMACO adjusted the slot location approximately 630 feet to the north in the eastern most coal mining block (years 1 and 2). Since the footprint of the mining block did not substantially change, this small change is not expected to significantly change the observed drawdowns. As such, no specific changes were made to the model to address the minor changes made to the mine block in December 2015. Therefore, mining in the Masters seam was only simulated in these three northwest – southeast trending mine blocks on the eastern portion of the Project. Simulated groundwater drawdowns for each coal seam are depicted in 5-year intervals during mining in Figures 4.9-2 thru 4.9-10. As demonstrated in these figures, the simulated impacts are often limited by fault boundaries which provide flow barriers within the aquifer system.

The simulated impacts on water elevations within the private wells identified within the model domain are presented in Table 4.9-1. To determine which wells would potentially be impacted by mining operations, well completions were compared to modeled surfaces to estimate which formation the well was completed in. Wells thought to be completed in the Carney or Masters coals were included. The well list in Table 4.9-1 errs on the side of being over inclusive. Some of the wells are believed to be completed over multiple water bearing intervals but modeled impacts are reported as if they are only completed in the coal seams of interest. In addition, the well depths were determined based on the SEO water rights database and, in many cases, the well depth was left blank or is questionable. If there was a question as to

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R.85 W. R.84 W.

T. 57 N.

T. 57 N.

R.85 W. R.84 W.

PHASE I COAL MINING

1	YEAR 1	7	YEAR 7
2	YEAR 2	8	YEAR 8
3	YEAR 3	9	YEAR 9
4	YEAR 4	10	YEAR 10
5	YEAR 5	11	YEAR 11
6	YEAR 6	12	YEAR 12

LEGEND

BROOK MINE PERMIT BOUNDARY

NOTE:
YEAR 1 CORRESPONDS TO YEAR 2017.

0 1,500 3,000 4,500 6,000

GRAPHIC SCALE (FEET)

RAMACO

BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGAR VIEW DR. STE. 201
SHERIDAN, WY 82801

REVISIONS	
Date	Description
10/15	ROUND 2 COMMENTS
12/15	ROUND 3 COMMENTS

FIGURE 4.9-1

SIMULATED MINE PROGRESSION

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Drawn By: MBM
Checked By: SMR
Date: 10/14/14

FILE: MINE_SEQUENCE_3.dwg

WWC ENGINEERING
www.wwcengineering.com

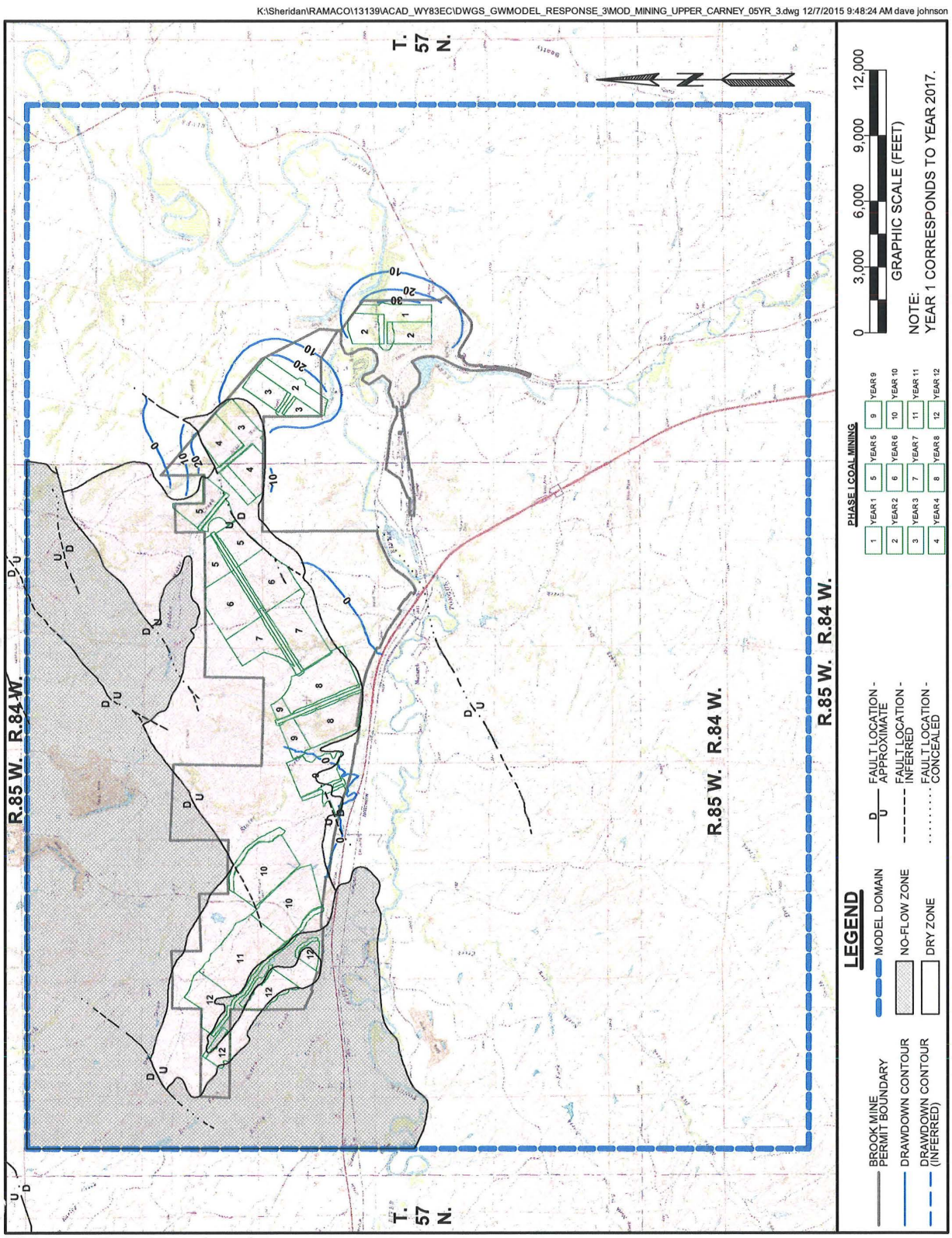

Figure 4.9-2. Simulated Impacts to Upper Carney Seam 5 Years After Mining Begins.

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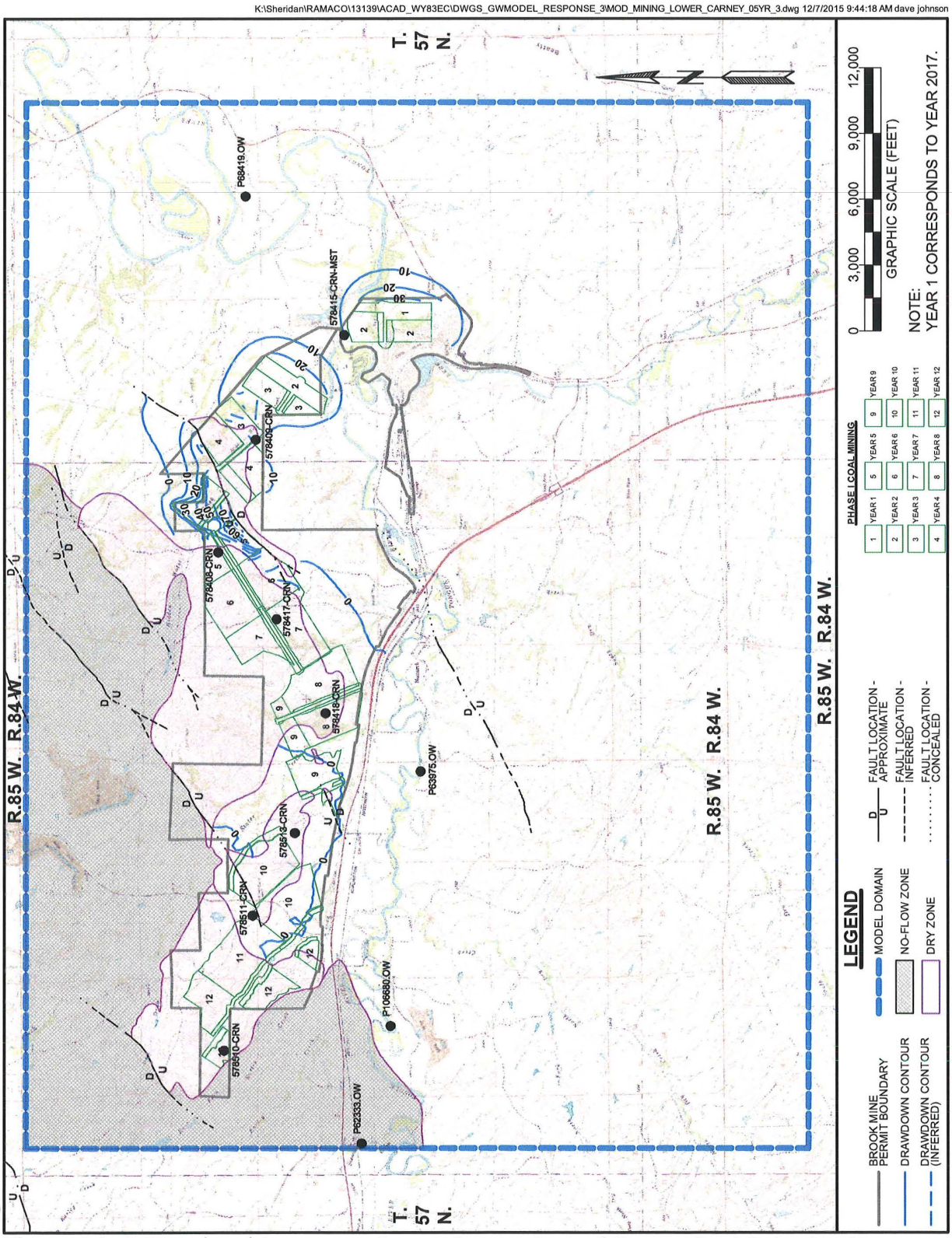

Figure 4.9-3. Simulated Impacts to Lower Carney Seam 5 Years After Mining Begins.

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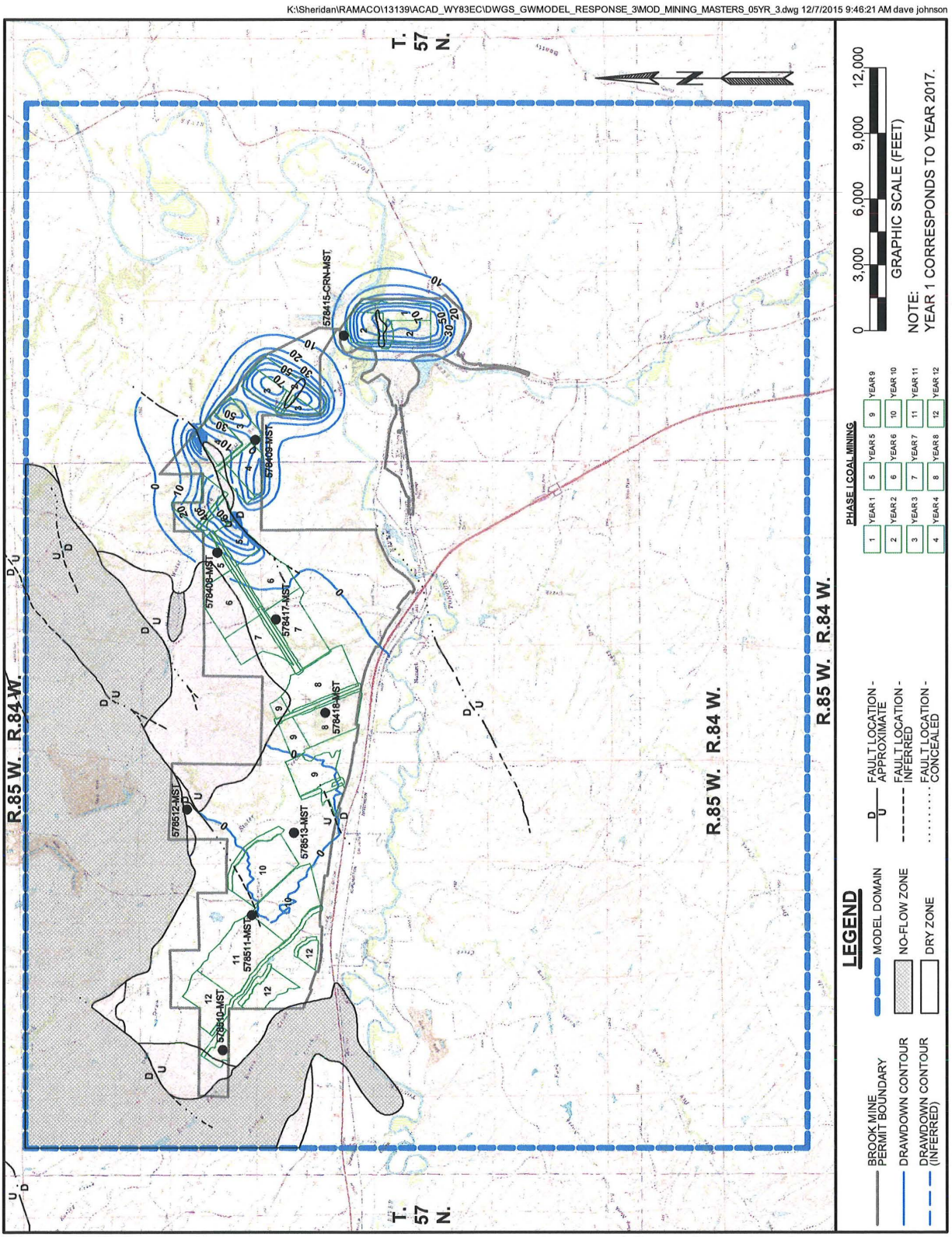

Figure 4.9-4. Simulated Impacts to Masters Seam 5 Years After Mining Begins.

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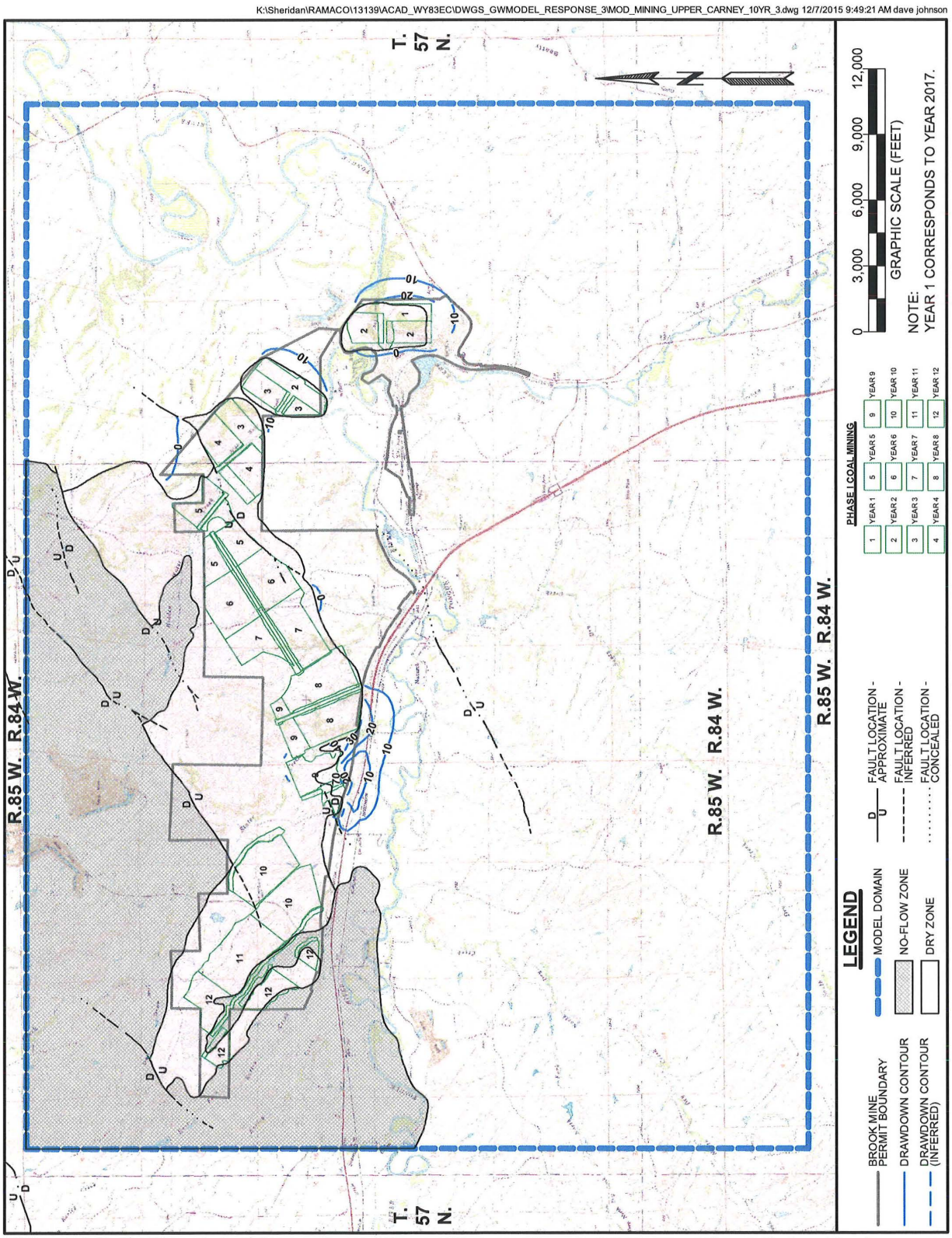

Figure 4.9-5. Simulated Impacts to Upper Carney Seam 10 Years After Mining Begins.

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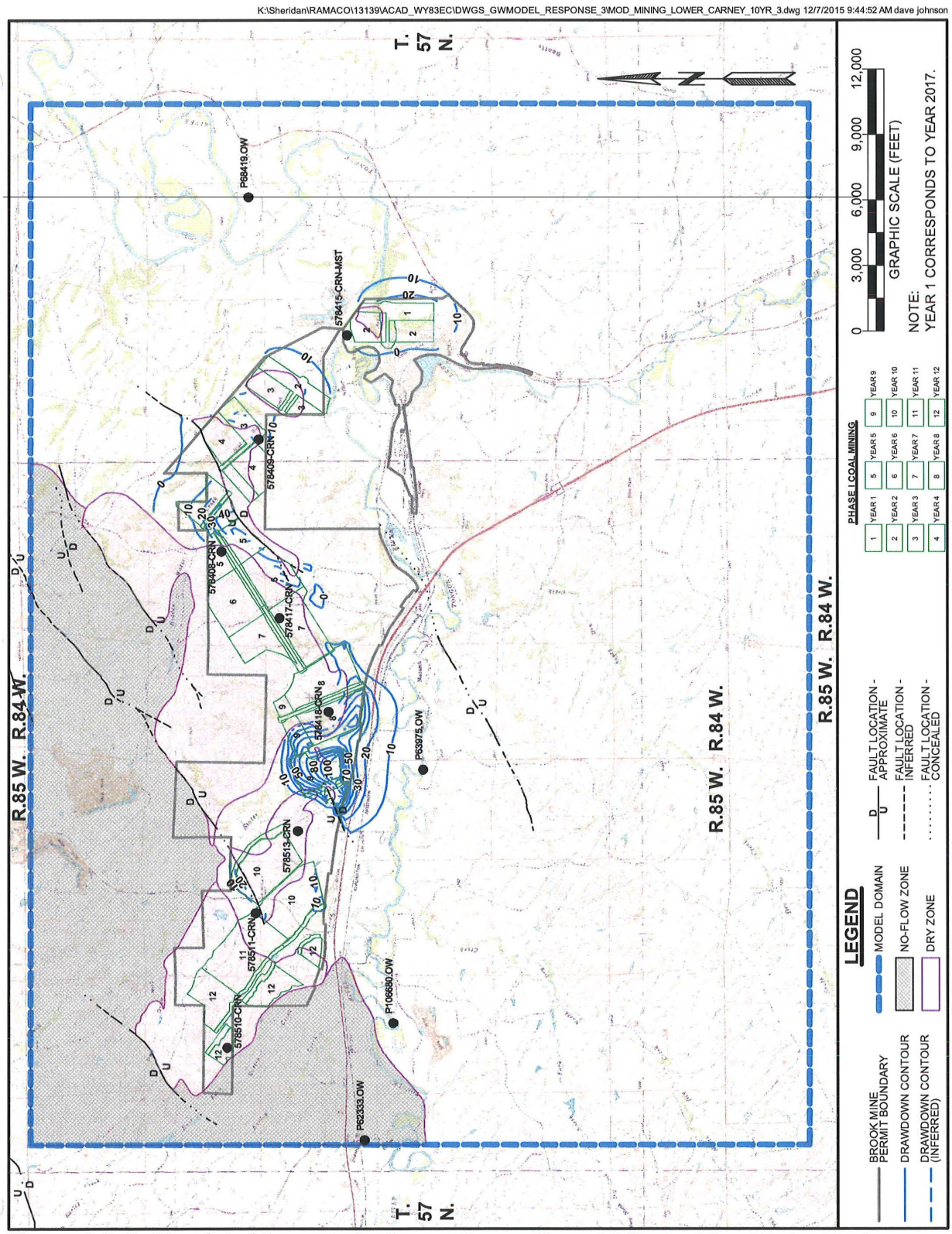

Figure 4.9-6. Simulated Impacts to Lower Carney Seam10 Years After Mining Begins.

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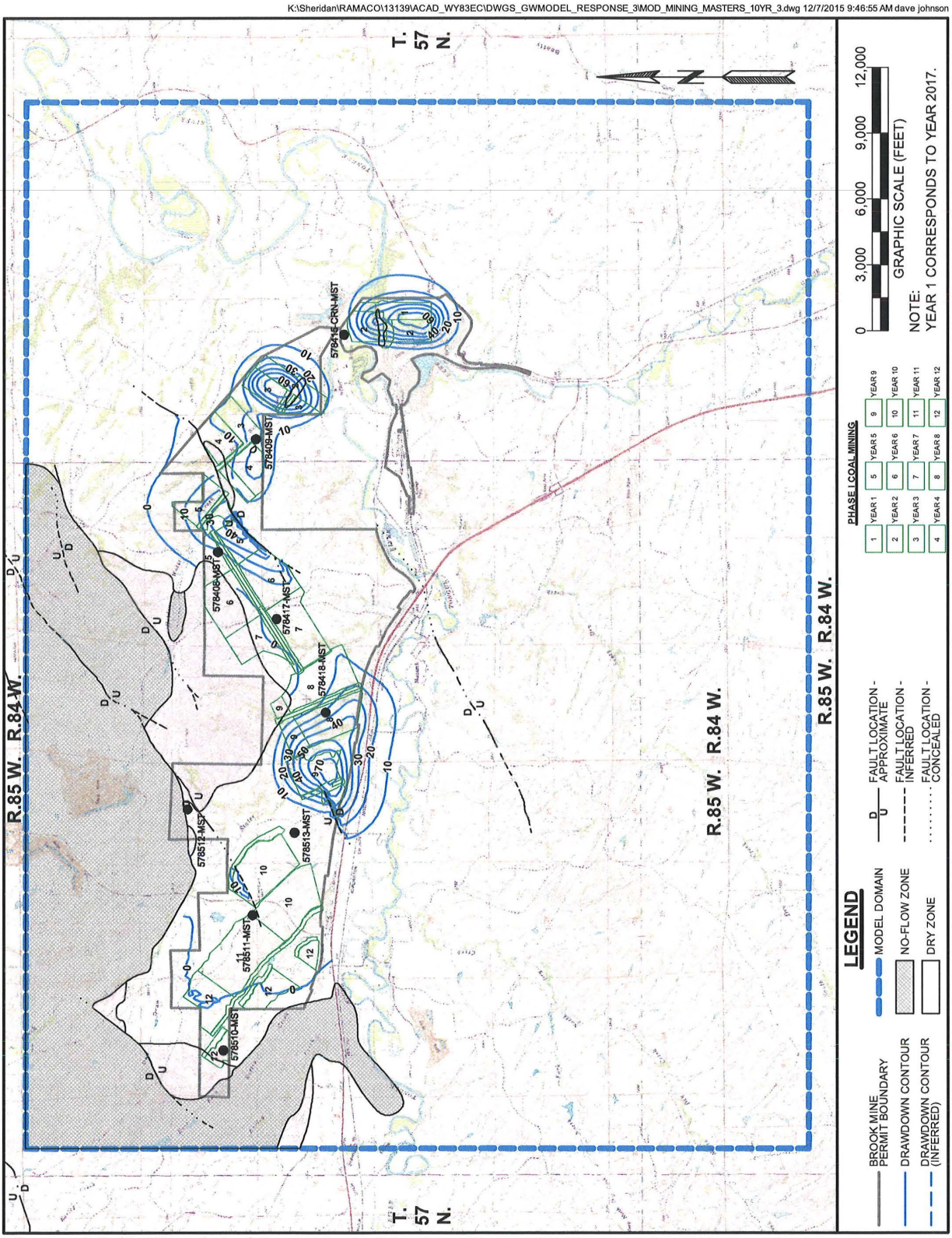

Figure 4.9-7. Simulated Impacts to Masters Seam 10 Years After Mining Begins.

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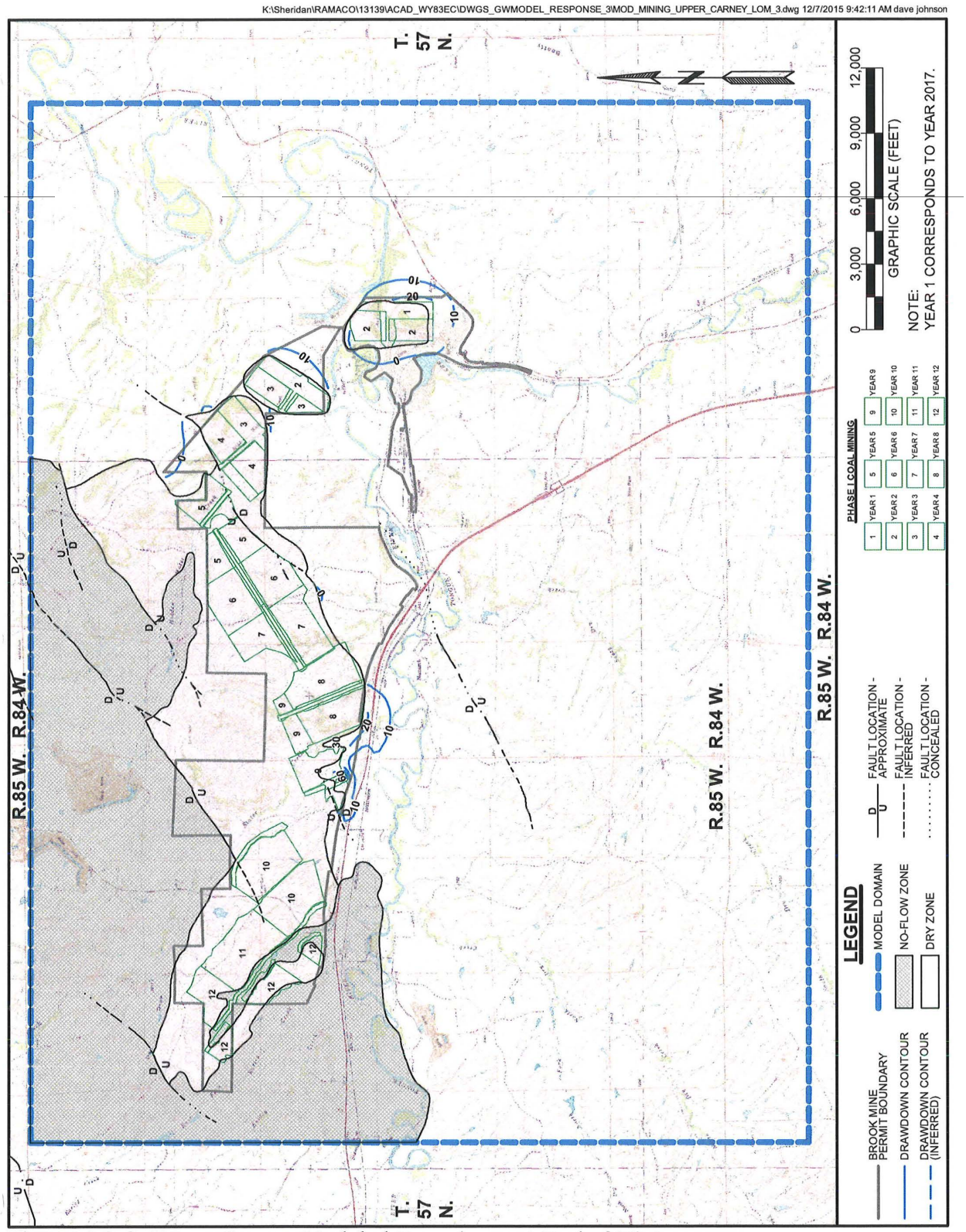

Figure 4.9-8. Upper Carney Modeled Drawdown at End of Mining.

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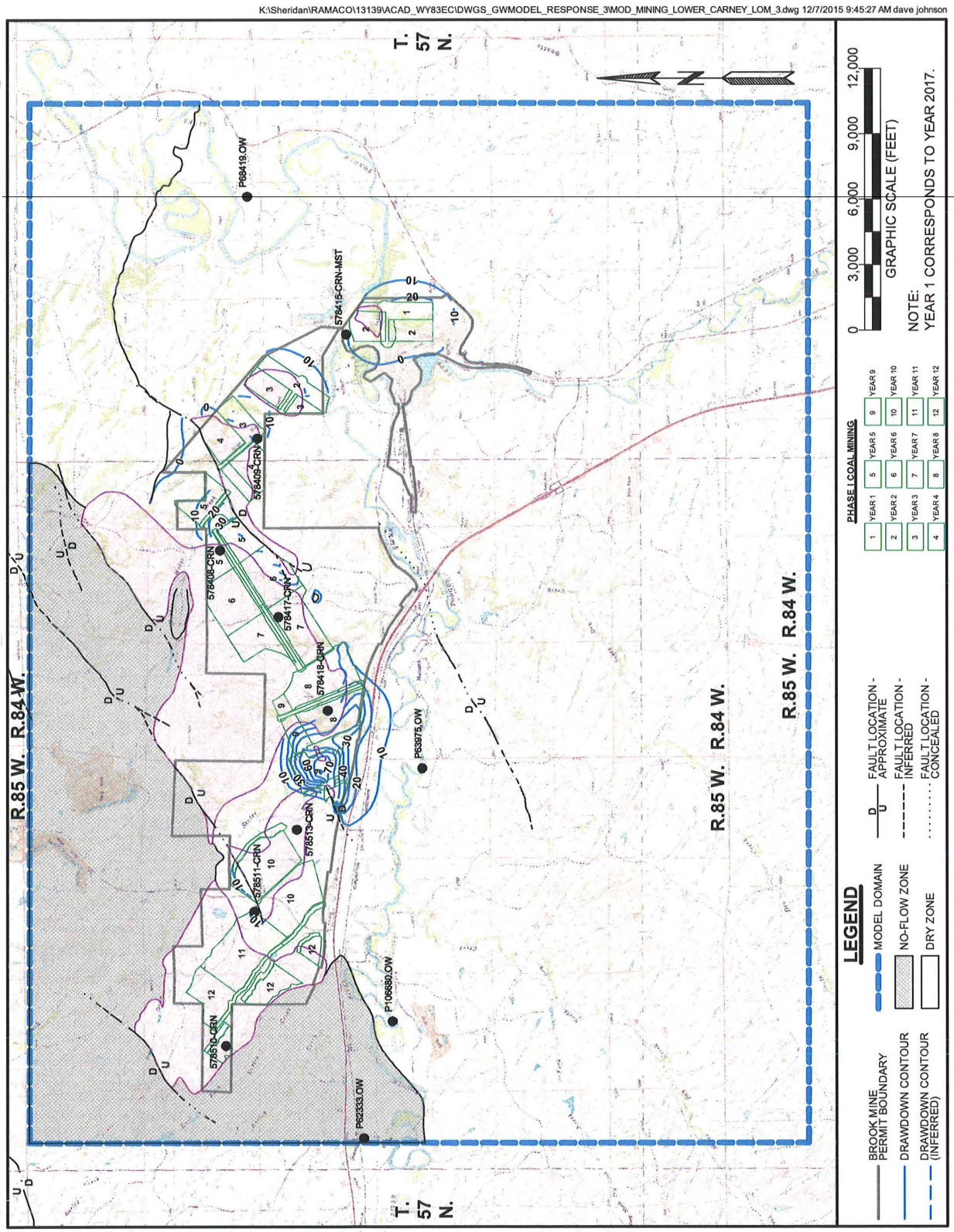

Figure 4.9-9. Lower Carney Modeled Drawdown at End of Mining.

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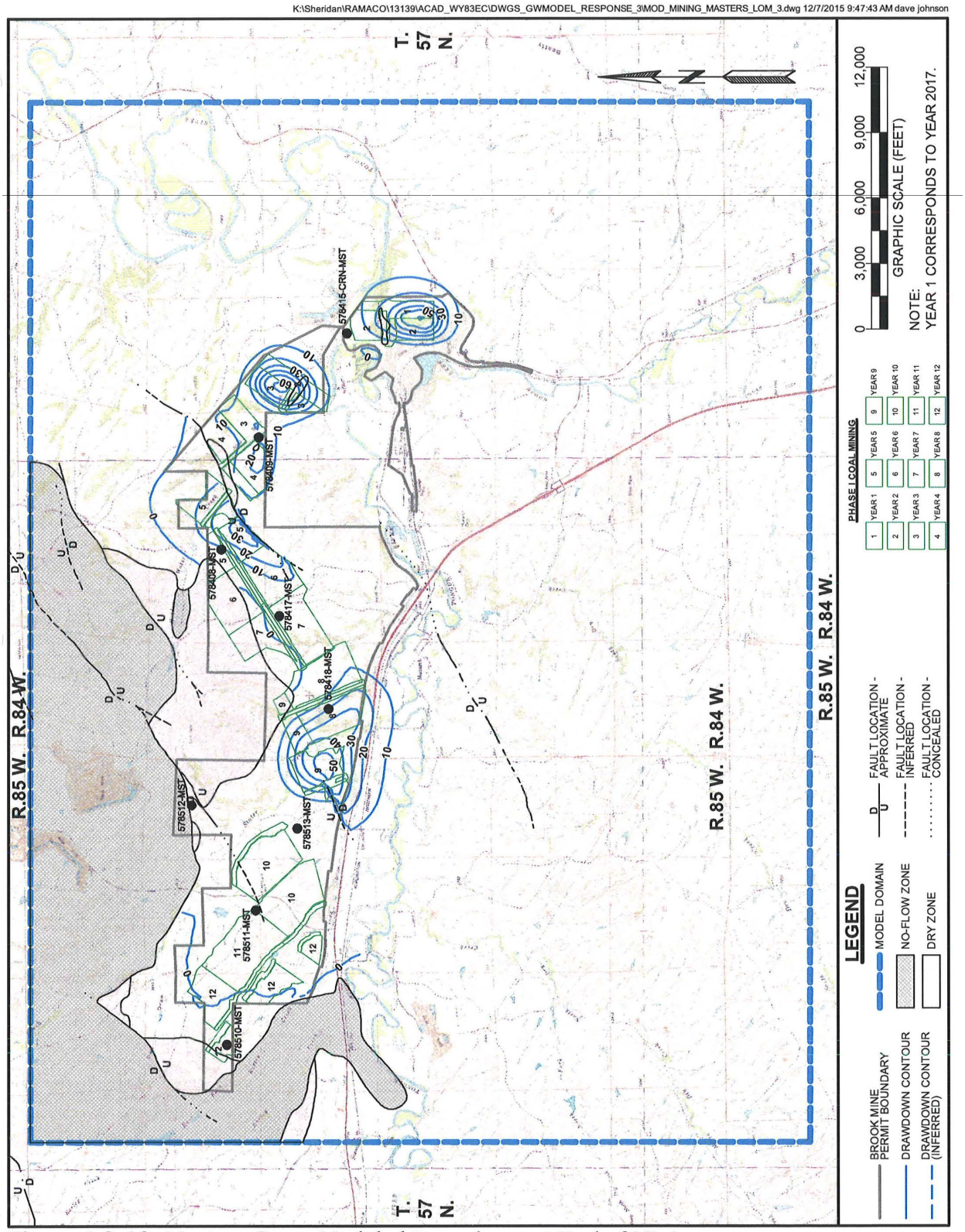

Figure 4.9-10. Masters Seam Modeled Drawdown at End of Mining.

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Table 4.9-1. Maximum Modeled Well Drawdowns during Mining

Well	Easting	Northing	Layer	Use	Screen Top	Screen Bottom	Total Depth	Max Drawdown (ft)
P33064W	1396036	1944411	4	Domestic Groundwater	113	174	180	7.4
P48251W	1400016	1943126	4	Stock	245	265	280	25.8
P98281W	1402650	1943144	4	Stock	270	290	290	1.9
P68201W	1386975	1932597	4	Domestic Groundwater	62	70	70	1.2
P92235W	1386975	1932597	4	Domestic Groundwater/Stock	75	85	90	1.2
P70103W	1392193	1931231	4	Domestic Groundwater/Stock	115	175	180	0.0
P30978W	1396145	1932548	4	Domestic Groundwater	90	230	230	0.0
P83047W	1398785	1933871	4	Misc.	120	180	260	0.1
P108644W	1396194	1931247	4	Domestic Groundwater	200	260	260	0.0
P183590W	1395413	1932693	4	Domestic Groundwater	120	140	160	0.0
P30986W	1402584	1924729	4	Domestic Groundwater	126	160	240	0.0
P35036W	1406568	1928720	4	Stock	100	340	340	0.4
P40563W	1406568	1928720	4	Domestic Groundwater/Stock	100	340	340	0.4
P69482W	1402546	1928746	4	Domestic Groundwater	221	242	263	0.0
P100555W	1402584	1924729	4	Domestic Groundwater	320	345	350	0.0
P139640W	1402584	1924729	4	Domestic Groundwater	396	416	416	0.0
P63648W	1401119	1924715	4	Domestic Groundwater	190	205	210	0.0
P65670W	1401119	1924715	4	Domestic Groundwater/Stock	185	215	220	0.0
P144442W	1371495	1941983	4	Domestic Groundwater/Stock	20	170	170	Mined Through
P119576W	1376790	1936691	4	Domestic Groundwater/Stock	20	60	60	1.5
P120822W	1376790	1936691	4	Domestic Groundwater/Stock	20	40	40	1.5
P36783W	1376864	1932728	4	Domestic Groundwater	143/196*	155/213*	360	0.1
P82129W	1379443	1934059	4	Domestic Groundwater/Stock	6	20	20	0.8
P91874W	1378135	1934052	4	Domestic Groundwater	6	22	22	0.5
P63975W	1384433	1932636	4	Domestic Groundwater	110	120	120	1.6
P71814W	1381990	1934024	4	Domestic Groundwater	90/115*	100/125*	140	2.2

* Wells are screened in multiple intervals

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whether a well was actually completed in the coal aquifer of interest, the well was assumed to be completed in the coals. Therefore, the well list may include wells that are not actually completed in the Carney or Masters coal. Because the completions of these wells are often across multiple zones which are sometimes difficult to distinguish based on SEO records, these impacts are assumed to occur as they would to a perfectly completed, interval specific monitor well.

Hydrographs from the wells in Table 4.9-1 are included in Appendix A. Many of the hydrographs in Appendix A seem to show long term drawdowns (albeit very minor) in the wells. It is important to understand that these drawdowns are likely due to model instability rather than real expected results. As noted in Section 4.9, CBM operations have already significantly dewatered the coals, and as a result, many of the cells in the model are dry. During mining simulations several additional cells go dry and do not rewet as expected after the mining stresses are removed.

To measure the impacts to the Tongue River alluvium, a series of targets were placed along in Layer 1 during the operational simulation as shown in Figure 4.9-11. The targets are simply areas where Groundwater Vistas records water levels and do not correspond with actual well locations. Hydrographs from these targets are included in Appendix A. As noted above, most of the drawdowns observed in the alluvial targets resulted from model instability. Due to the fact that several cells went dry and did not rewet, the water levels adjacent to the cells were permanently altered which resulted in the model over estimating the actual drawdown at the targets. The actual drawdown in the alluvial targets induced from mining is estimated to be less than 0.5 feet. Maximum impacts are expected to occur in areas where the overburden is thin (near coal seam subcrops) and are of short duration. Increased infiltration into the groundwater system and thereby stream flow losses from the Tongue River as a result of these impacts are therefore expected to be marginal.

During the mining simulations, pit inflows were estimated by comparing the volume of water leaving the model from the drains during mining with the

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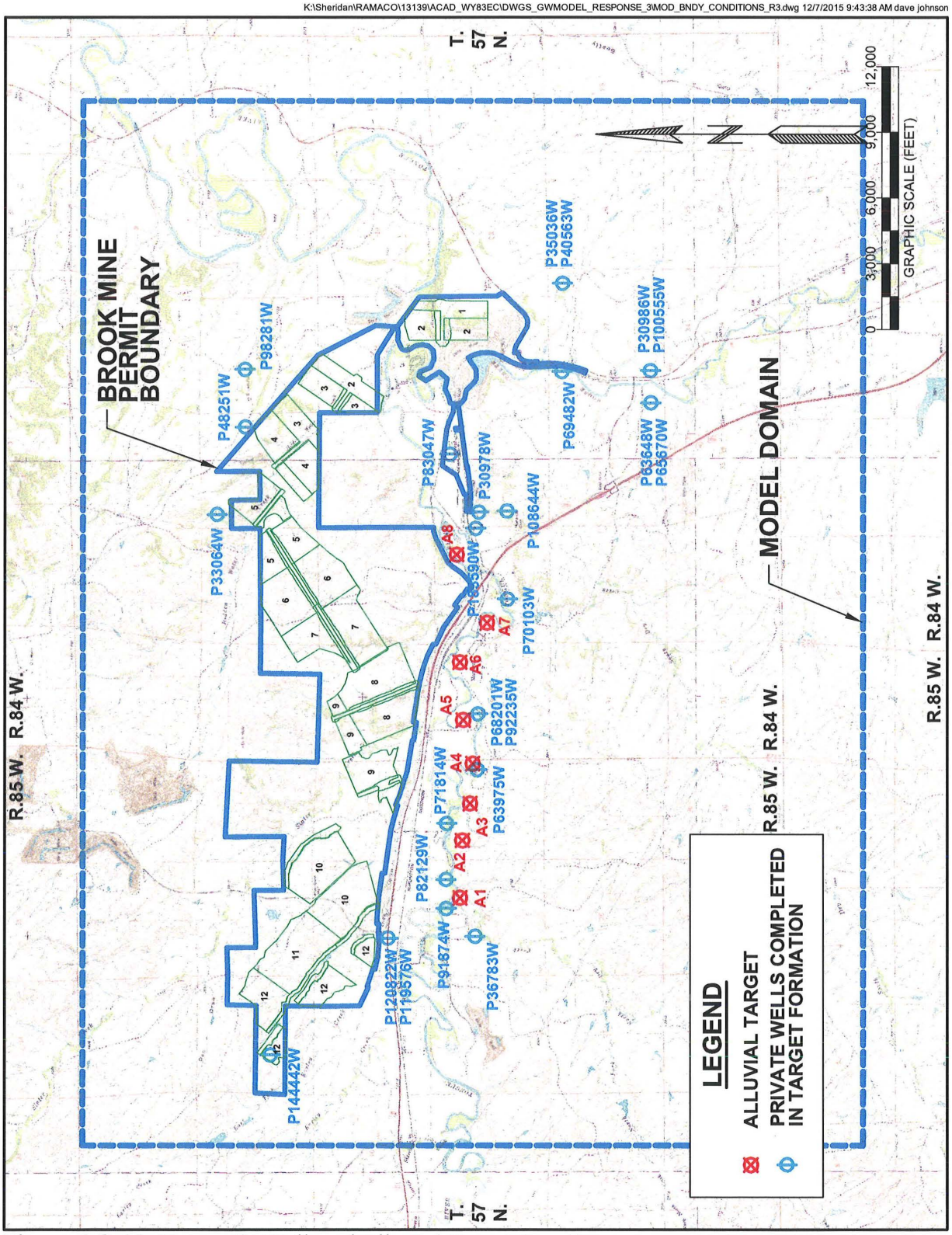

Figure 4.9-11. Domestic Well and Alluvial Target Locations.

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volume of water that was leaving the model. Table 4.9-2 depicts the total volume of water predicted to be discharged into the mine pits through the life of the mine. As shown on Table 4.9-2 maximum pit inflows of approximately 75 gpm are expected during the first year of mining. Predicted pit inflows in subsequent years will vary from approximately 100 gpm to 0.3 gpm. The pit inflows will vary depending on what portion of the mine is being actively mined. For example, the first year mining block is located in an area where the coals are fully saturated, so it is reasonable that the pit inflows would be higher for this year. Conversely, the eleventh and twelfth year mining blocks are located in an area where the coal seams are mostly dry, and in those years the pit inflows are significantly lower that during the first year of mining.

Table 4.9-2 Model Predicted Pit Inflows to the Brook Mine

Model Stress Period	**Year**	**Pit inflow* (gpm)**	**Model Stress Period**	**Year**	**Pit inflow* (gpm)**
1	0.5	Begin Mining	14	7	98.90
2	1	74.5	15	7.5	53.8
3	1.5	63.1	16	8	58.7
4	2	65.4	17	8.5	46.3
5	2.5	50.7	18	9	57.7
6	3	63.1	19	9.5	20.1
7	3.5	35.4	20	10	15.5
8	4	31.1	21	10.5	4.8
9	4.5	18.1	22	11	3.0
10	5	17.7	23	11.5	0.7
11	5.5	7.8	24	12	0.3
12	6	41.7	25	12.5	End Mining
13	6.5	49.5			

*Pit inflow is the inflow reported at the end of the stress period.

Model-generated end-of-mine potentiometric surfaces for the Upper and Lower Carney and Masters coal seams are provided in Figures 4.9-12, 4.9-13, and 4.9-14, respectively.

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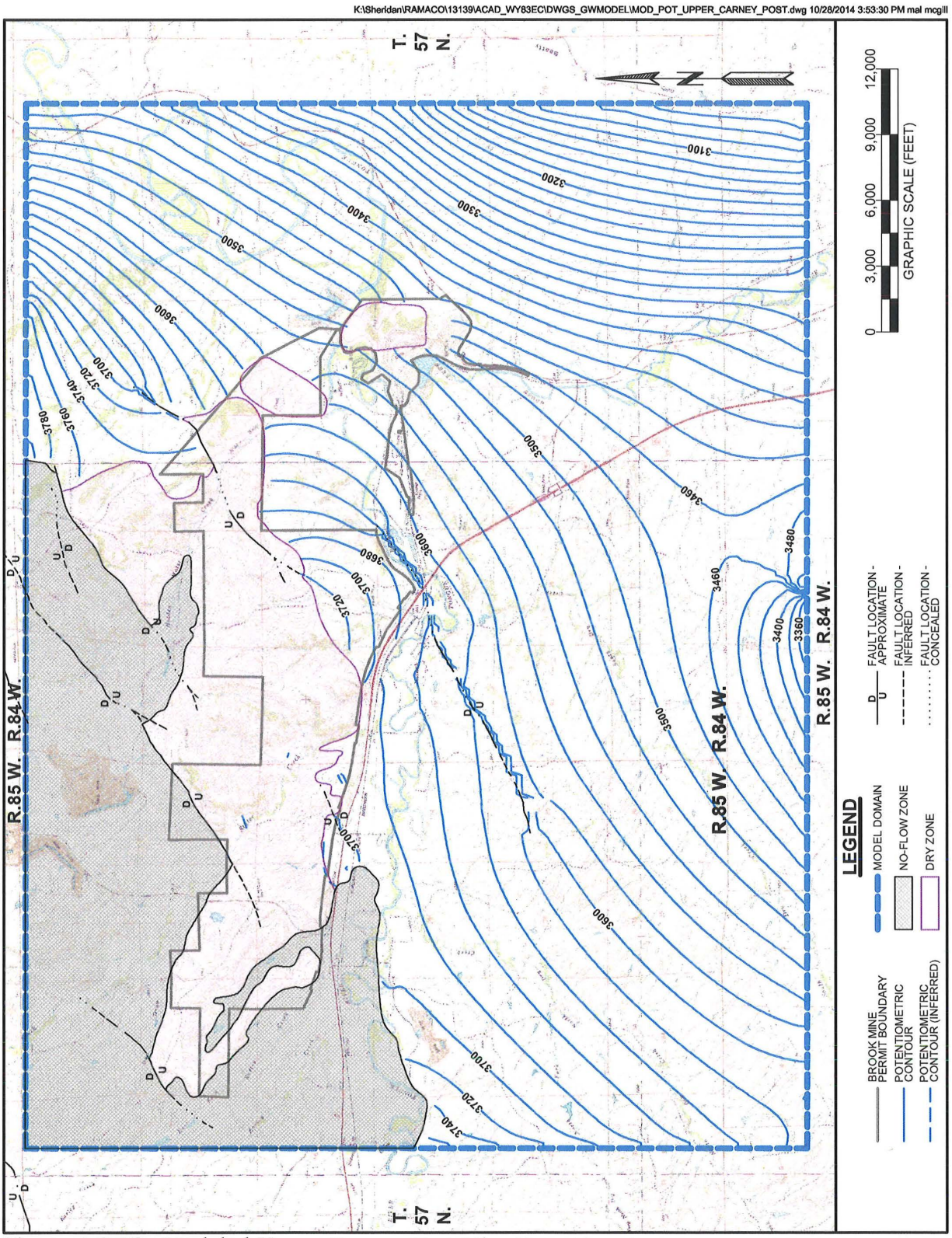

Figure 4.9-12. Modeled Upper Carney Post Mine Potentiometry.

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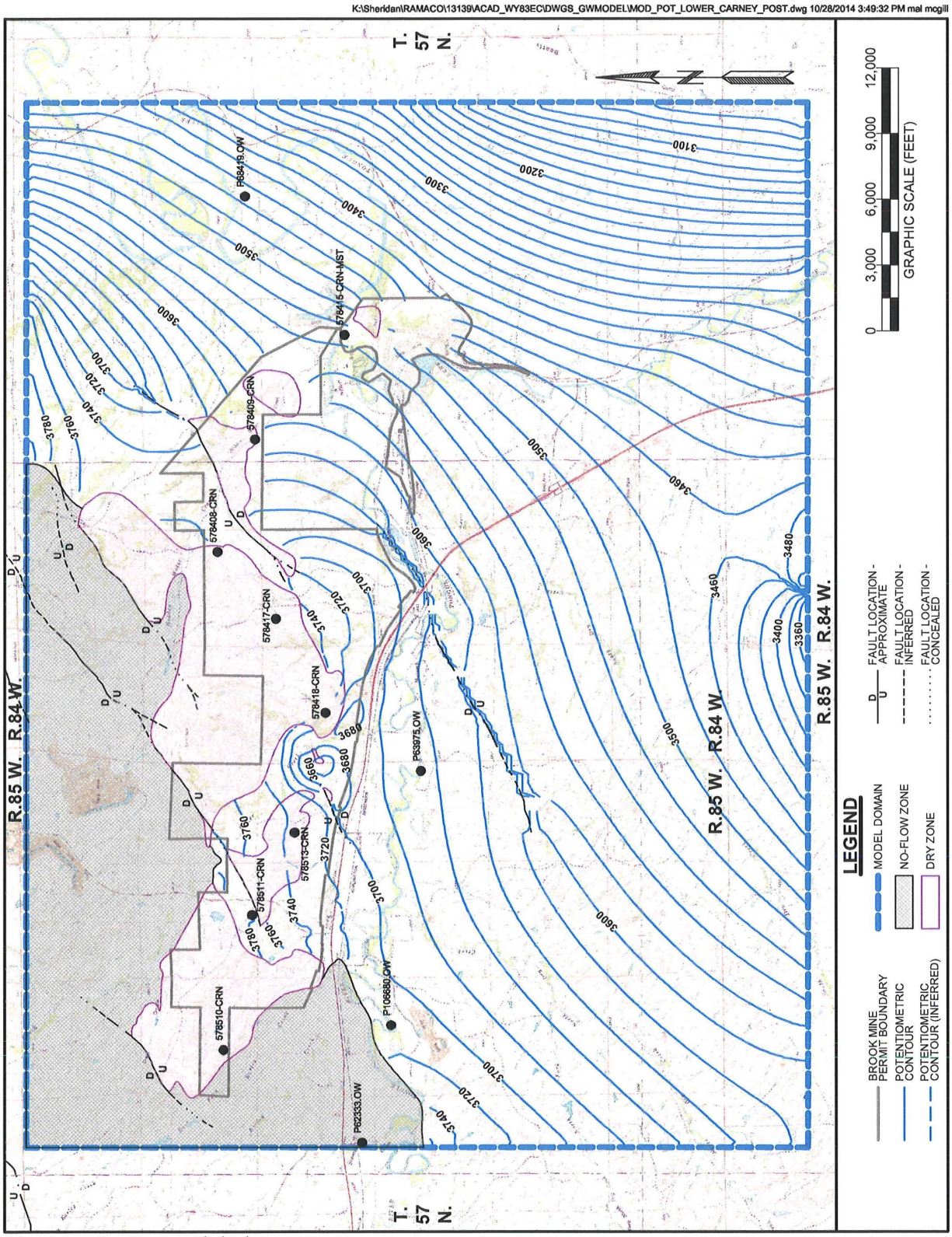

Figure 4.9-13. Modeled Lower Carney Post Mine Potentiometry.

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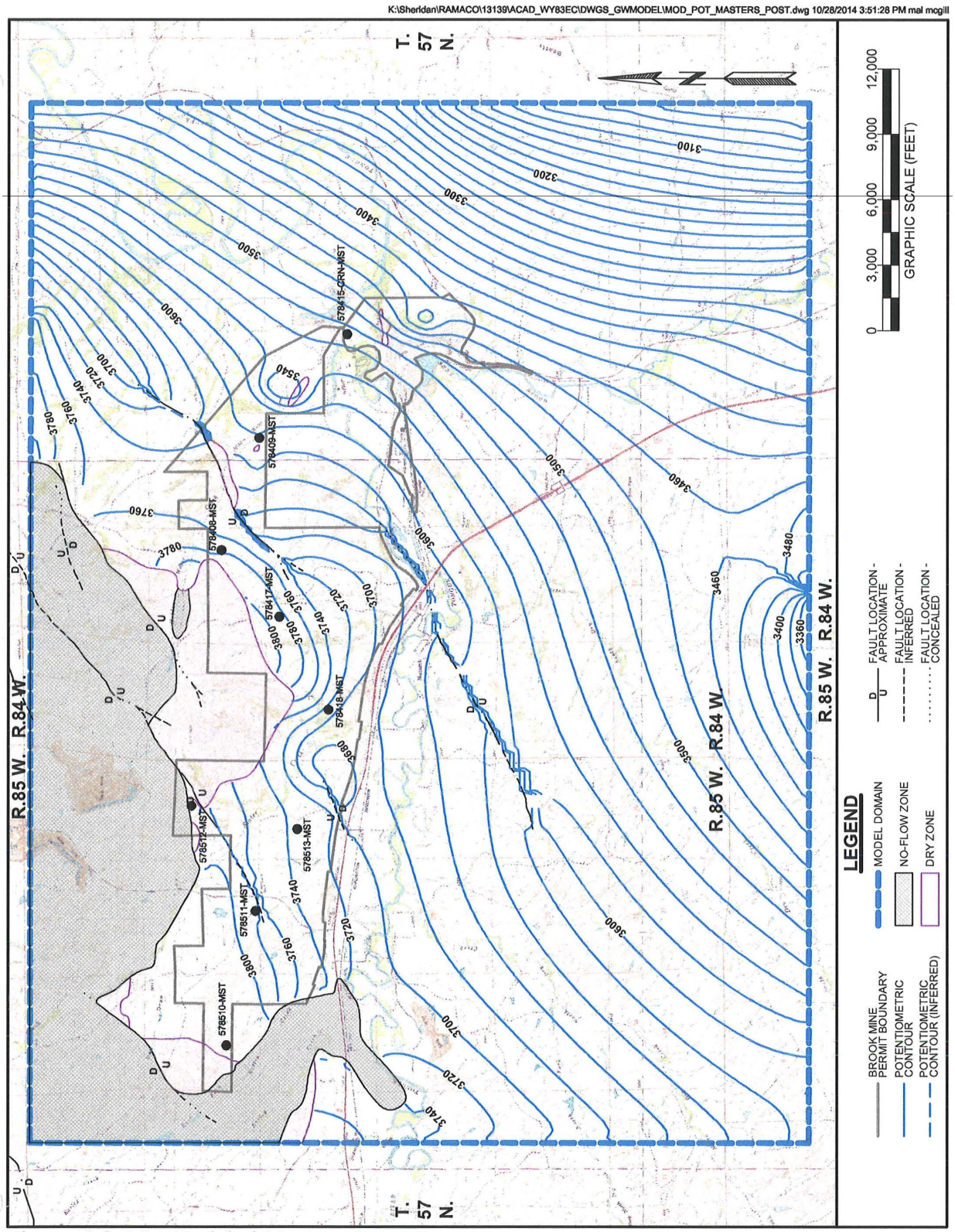

Figure 4.9-14. Modeled Masters Post Mine Potentiometry.

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4.10 Recovery

To simulate water-level recovery, the model was run for 5-, 10-, 20- and 50-year periods after the cessation of mining. The residual drawdowns during recovery are presented in Appendix B. Residual drawdowns presented in Appendix B are based from the model calibrated potentiometric surfaces generated from the monitor well network as described previously.

In general, the figures within Appendix A show that recovery to a residual drawdown of less than 10 feet from the pre-mine modeled potentiometric surface is expected to occur relatively quickly. Recovery to a residual drawdown of less than 10 feet generally occurs in the Upper Carney and the Lower Carney within 10 years and in the Masters within 20 years. Most of the recovery occurs within the first five to ten years as recovery versus time follows an exponential curve. Full recovery to pre-mine levels is largely dependent on the direction of CBM-development, which may vary based on the future value of natural gas. This is outside RAMACO's control and the recovery model conservatively assumes CBM development continues indefinitely.

In addition to evaluating the model predicted potentiometric surfaces such as those presented in Appendix B, the mass balance throughout the various stages of the model (pre-mine, mining, and recovery) was also evaluated. A comparison of the model predicted inflows and outflows through the modeled scenarios against conceptual estimates provides further verification on the adequacy of the model. Table 4.10-1 summarizes the model mass balance at each stage.

As shown in Table 4.10-1, the five main categories of inflows and outflows include 1) storage, 2) general head boundaries, 3) river boundaries, 4) drains, and 5) recharge. Following is discussion regarding model predicted inflows and outflows for each category:

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Table 4.10-1. Mass Balance Throughout Model Simulation

Period	**Premine (T1, S1) (Steady State)**		**5 Years into Mining (S11, T5)**		**End of Mining (S25, T5)**		**End of Recovery (S34, T5)**	
Source or Sink	Inflow (ft^3/d)	Outflow (ft^3/d)	Inflow (ft^3/d)	Outflow (ft^3/d)	Inflow (ft^3/d)	Outflow (ft^3/d)	Inflow (ft^3/d)	Outflow (ft^3/d)
Storage	-	-	12,864	11,173	10,082	9,977	1,501	1,604
General Heads	16,092	22,885	16,059	22,884	16,065	22,875	16,072	22,873
River	2,598	408	2,615	406	2,621	389	2,651	374
Drains	-	560	-	2,063	-	540	-	536
Recharge	5,168	-	5,168	-	5,168	-	5,161	-
Total	23,859	23,853	36,707	36,526	33,937	33,781	25,386	25,387

Note: Sx, Tx designation denotes stress period (S) and timestep from model.

1) Storage – During the steady-state model there is no inflow or outflow from storage, so storage does not change in the premine simulation. The model predicts that during active mining more water will come out of storage than will go into storage. Conceptually, this is reasonable since during mining, water from the coals would be draining into the mined out areas. There is a trend of water continuing to come out of storage even after mining ceases. Even though the volume of water coming out of storage is quite low, it is contrary to the conceptualization of the system to have water leaving storage after mining because at this point water should be going back into storage. This phenomenon is attributed to the fact that many of the cells in the model go dry during mining because CBM operations have significantly dewatered the coals and there is not much water available in storage. When the cells go dry, MODFLOW treats them as no flow areas and there can be a ripple effect that causes additional cells going dry. Since MODFLOW is not very efficient at rewetting dry cells when they should be resaturated, this ripple effect is probably still causing some cells around the no flow cells to go dry. Over an extended time, the model would be expected to come to a steady state condition where flow into and out of storage is equal.

2) General Head Boundaries – The amount of water going into and out of the model domain via the general head boundaries remains relatively consistent throughout the modeled operations. This is reasonable because the general head boundaries are a long distance from the mining area and would not be expected to be significantly impacted by mining. In addition, the total volume of outflows from the general head boundaries generally balances the inflows from other sources. This is conceptually correct.

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3) River Boundaries – The conceptual inflow and outflow from the coals to the Tongue River are discussed in detail in Section 4.7.2. Groundwater Vistas does apply the river boundary cells to the bottom of the layer in which they are inserted. The Tongue River boundary cells were inserted into the model up to the point where Goose Creek joins the Tongue River. At that location, the top of the Carney coal is estimated to be approximately 100 feet below the surface. Since the alluvium is generally much thinner in this area and there is actually a large amount of low permeability strata between the Tongue River alluvium and the coal, the model likely overestimates the contribution of the river boundary cells to the model because the river boundary cells provide a direct connection (in the model) between the river and the coals where there is not a physical connection. This conservatively over estimates how much water discharges from the river boundary cells to the model.

4) Drains – One drain was placed into Layer 1 in the northeast side of the model domain to allow water to drain from the model where the Tongue River crosses the domain boundary. This represents the amount of water in Layer 1 lost to the surface water system. The total discharge from this drain during steady state conditions is 560 ft^3/day (2.9 gpm). While no physical measurements were (or can be) made to verify this amount, conceptually it is reasonable. The strata along the Tongue River likely does discharge a small amount of water to the river where it cuts through the numerous perched sand lenses that become saturated from natural recharge. There is no evidence of large groundwater discharges to the Tongue River in this area so it makes sense that a small discharge to the river (rather than a large discharge) would be observed in the model. During mining, drains were added to the model to remove water from the mine pits. Table 4.10-1 indicates that during mining, discharges from the drains do increase as expected. After mining is complete, discharges from the drains return approximately to premining levels, which is conceptually correct.

5) The recharge amount used in the model stays relatively the same throughout the simulations, which is expected since changes in the stage of mining are not expected to affect recharge. Total recharge across the model area is approximately 27 gpm. The recharge is reasonable based on available data.

Limitations of the modeling software have decreased the confidence in the recovery simulation. These limitations include: difficulty re-wetting cells dried out by mine progression and the inability to model hydraulic parameters transiently.

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As expected, portions of the cells within the proposed mine panels dried out during operational simulation, especially in the Upper Carney. When recovery commenced, the model did not allow water to re-enter into many of these cells. This phenomenon is a potential modeling concern as it alters the groundwater flow because a dry cell is treated as a no flow area. It also potentially reduces the amount of water necessary to bring the potentiometric surface back to pre-mine levels as there is less matrix volume to re-saturate, thereby decreasing the estimated recovery period. MODFLOW has a package for allowing cells to resaturate; however, it was generally not effective. Minor drawdowns are observed throughout the recovery period in portions of the Carney and Masters Seams downgradient of the cells that dried out during the mining simulation. These "apparent" drawdowns are a result of modeling limitations rather than impacts from mine dewatering and should be disregarded. Additional error was introduced as the modeling software does not have the ability to model porosity transiently.

Within the areas where the highwall miner is used for mining, an open cavern will remain. Unless the mined out areas collapse, the backfill aquifer is essentially an open cavern with 100% porosity. During resaturation of the mined areas, the assigned storage coefficients remained the same as the original aquifer properties. As a result, the model may underestimate the time that it takes for the aquifer to resaturate where the mining methods have increased the porosity, and thereby, the resaturation volume. Inversely, in the slots mined with traditional open cut mining techniques, coal will be removed and replaced with overburden material. In these locations the backfilled material is expected to have poor aquifer characteristics because it will primarily be a mix of fine grained clay and silt with some sand. In these areas, the aquifer will be essentially removed. Again, the modeling software does not have the ability to transiently change aquifer properties and this effect was ignored during the modeling.

Figure 4.9-1 shows the areal extent of mining and Figures 4.7-2, 4.7-3, and 4.7-4 depict the areas that were modeled as dry within the Brook Mine

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permit area. A large percentage of the area that will be mined is dry prior to the initiation of mining. In addition, figures in Section 4 show that after mining, some of the areas go dry and do not rewet. In the areas where slots are excavated, this prediction is reasonable because the backfill will act as an aquitard with poor aquifer characteristics. A layer by layer review of the mined area at the end of mining was conducted to determine conceptually how ignoring the changes in the coal porosity and changes in backfill material may have impacted the model predictions. The following discussion summarizes this review of the mined area:

Upper Carney-With exception of a very small portion of mine block 9 (Figure 4.9-1), the entire Upper Carney coal is unsaturated. Therefore, there is no resaturation and no recovery. The model estimates are appropriate for the Upper Carney coal.

Lower Carney - Most of the mine blocks, as well as the open slots, are dry in the Lower Carney at the end of mining. Only mine blocks 1, 2, 5, 9, and 10 had substantial portions that were saturated. As a result, the potential error created by transient aquifer properties in model predicted resaturation rates to the underground mined coal blocks in the Lower Carney coal, if any, is expected to be very low. With the exception of the slots cut to mine blocks 5, 9, and 10, all of the slots cut to mine the Carney coal will also be dry; therefore, resaturation at those locations will not substantially impact model predictions. The slots cut for blocks 9 and 10 generally run parallel to the direction of water flow. If the coal in these locations is completely removed and replaced with an aquitard, the impact to the aquifer will be minimal because water will simply flow around the portion of the backfilled aquifer. The open pit slot cut adjacent to mine block 5 does run perpendicular to the direction that water is flowing and may change the groundwater flow patterns in this area. However, the location of the slot is near the groundwater divide caused by the fault just to the south. Therefore, this slot is not expected to substantially impact groundwater flows either.

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Masters - Most of the Masters coal mine blocks are saturated. Only blocks 4, 5, 6, and 7 have substantial areas that are not saturated. In the mine blocks where underground mining techniques are employed, the model may underestimate the time it takes for resaturation to occur because the storage coefficient is not updated to account for the increased porosity of the mined out block. However, this resaturation time will be balanced out by the fact that there will be no aquifer replaced in the open cuts to resaturate, and thus these areas would not resaturate as the model predicts. With the exception of the open cut for mine block 5, all of the open cuts are oriented so that they will have minimal impacts on the natural flow gradients, or are located within or adjacent to dry areas. As previously noted, the open cut near mine block 5 is located adjacent the drainage divide so it will not significantly change the water flow within the aquifer.

Due to the fact that much of the mined area is dry, the actual area mined that is below the water table is relatively small, and that the open cuts are oriented such that they have minimal impacts to groundwater flow, the recovery analysis performed by the model is reasonable. Also, as noted, the areas where underground mining is employed and the model overestimates the rate at which the aquifer is resaturated are counterbalanced by the areas of open cuts where the aquifer will not be replaced and the model underestimates the time it takes for the strata to resaturate.

The model may overestimate impacts from CBM operations. The pre-mine static water level assumes that CBM continues to depress the potentiometric surface indefinitely. Therefore, when, and if, CBM production ceases, additional water will be available to the system, and may increase the recovery rates, subsequently offsetting the modeling errors discussed above. As noted in Section 2.6, there is limited data available regarding pre-CBM water levels in the CBM wells completed in the coals along the eastern edge of the model domain. However, the total impacts to the water level in the coal due to CBM water withdrawals are likely on the order of hundreds of feet. Therefore,

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the impacts to the water levels in the coal resulting from CBM operations are orders of magnitude larger than the expected impacts from mining.

4.11 Summary and Conclusions

The Brook Mine Groundwater Model was constructed primarily to predict the groundwater impacts of mine dewatering within the Project Area as required for the Permit to Mine application for the WDEQ. The data used to construct the groundwater model was compiled from monitor wells and exploration drilling conducted by RAMACO over the past two years, as well as WOGCC and SEO records of domestic and CBM wells in the area. Literature values were utilized as necessary to address site specific unknowns.

The Brook Mine Project is expected to decrease the heads within the coal seam aquifers, which in turn may increase the amount of water infiltrated to the coal aquifers where it subcrops under the Tongue River alluvial system and reduces water availability for private wells located near the Project Area. However, mining impacts to the Tongue River alluvium are predicted to be minimal. The only predicted impacts outside of the Brook Mine permit boundary would be observed at the existing water supply wells. The largest model predicted impact seen at any existing well outside of the Brook Mine permit boundary is 20 feet. This impact is estimated to be short lived (approximately 4 years). Model predicted drawdowns at the rest of the wells are less than 5 feet. At most of the wells, predicted drawdowns are less than 1 foot over the life of the mine.

Maximum expected impacts to the coal aquifer system occur in the mined panels where the aquifer matrix is essentially removed and no water saturation will exist post-mining. However, the recovery simulation demonstrates that these aquifers will generally reach 90 percent of their pre-mine water levels within 20 years. Due to CBM development, the current hydrogeologic system is not at equilibrium, but estimating the impact of CBM development on the aquifer system was outside the scope of this model. A post-CBM pre-mine static potentiometric surface was used for the modeling effort,

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which conservatively overestimates impacts if CBM development ceases. Existing and ongoing CBM development impacts to the water levels in the coals are significantly greater than the predicted impacts from RAMACO's proposed mining operations. In the event that CBM development ceases, this model conservatively over estimates the combined impacts that will occur from mining and CBM production.

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APPENDIX A

Simulated Water Level Hydrographs at Targets and Wells

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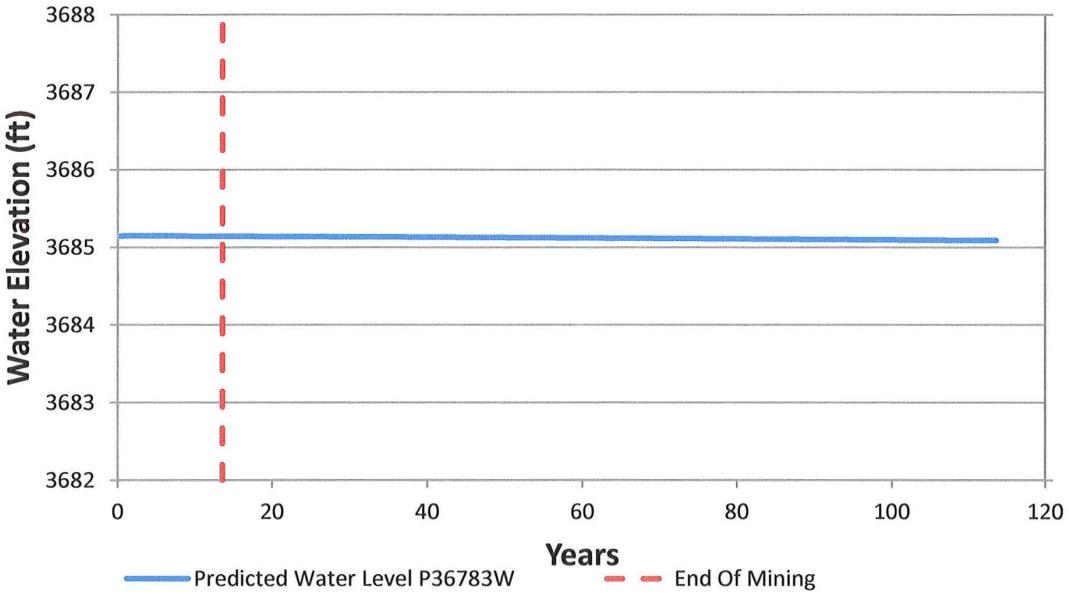
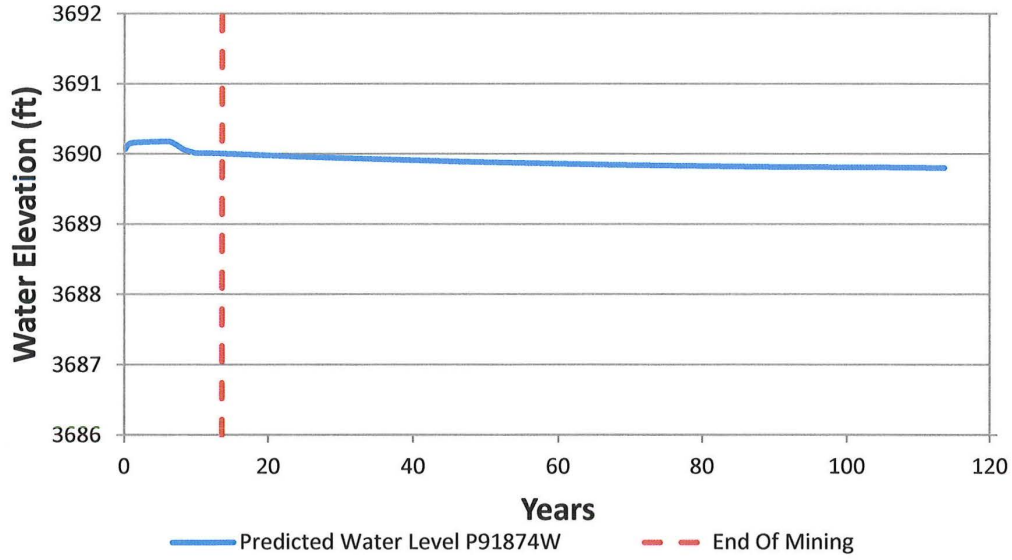
Model Predicted Hydrograph at Well P36783W



Model Predicted Hydrograph at Well P91874W



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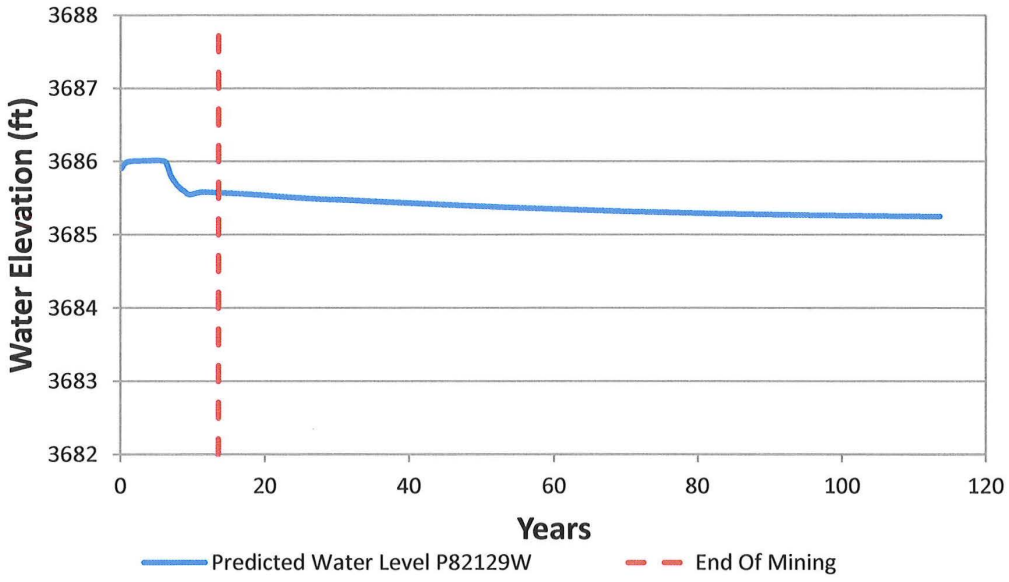
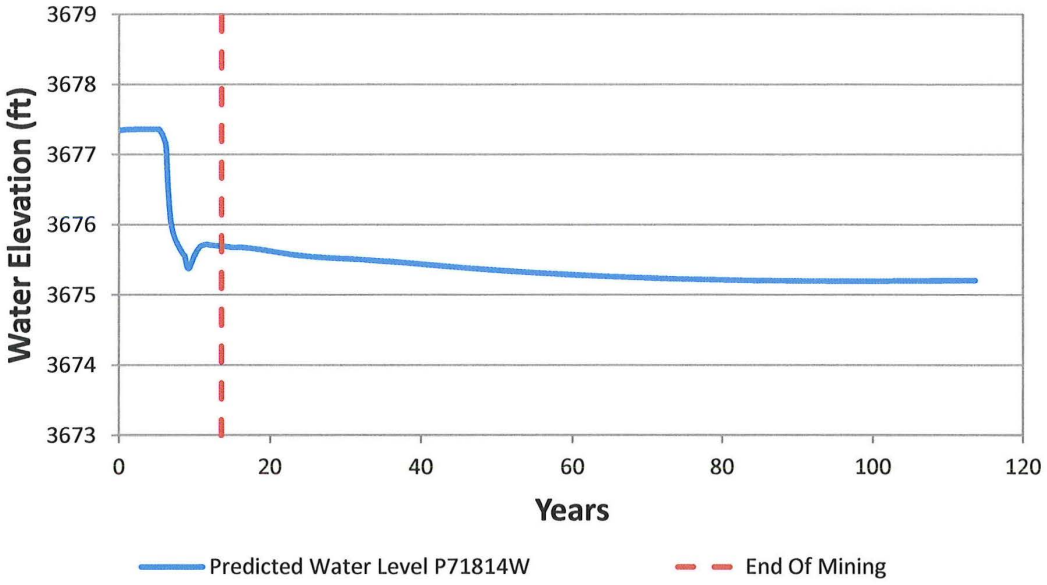
Model Predicted Hydrograph at Well P82129W



Model Predicted Hydrograph at Well P71814W



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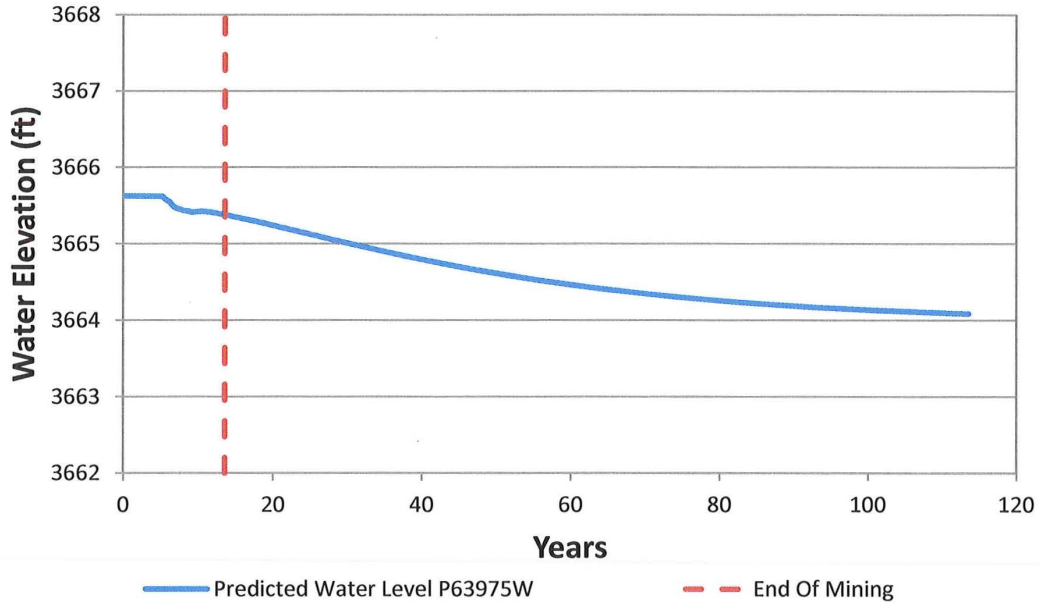
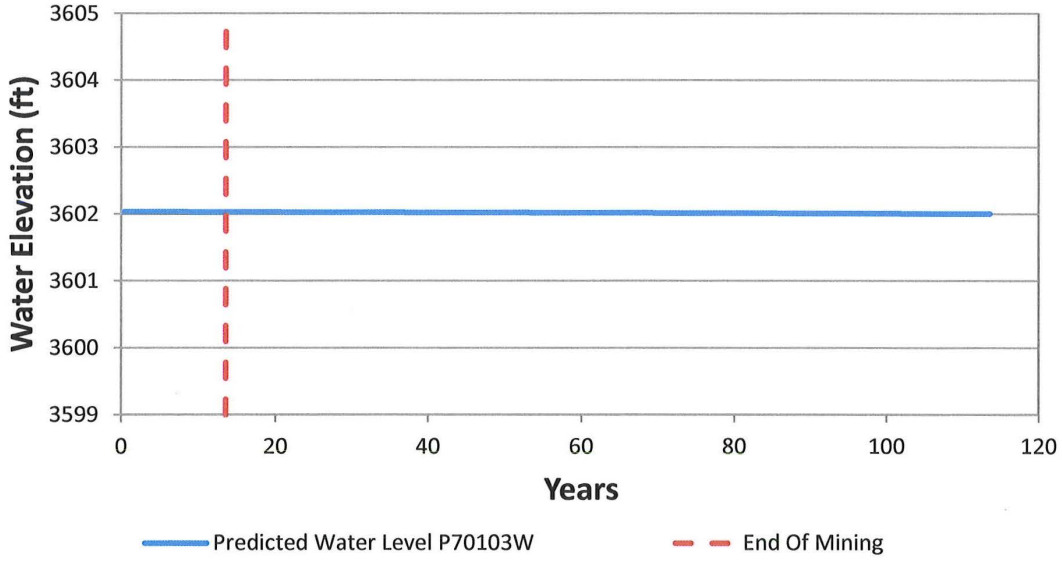
Model Predicted Hydrograph at Well P63975W



Model Predicted Hydrograph at Well P70103W



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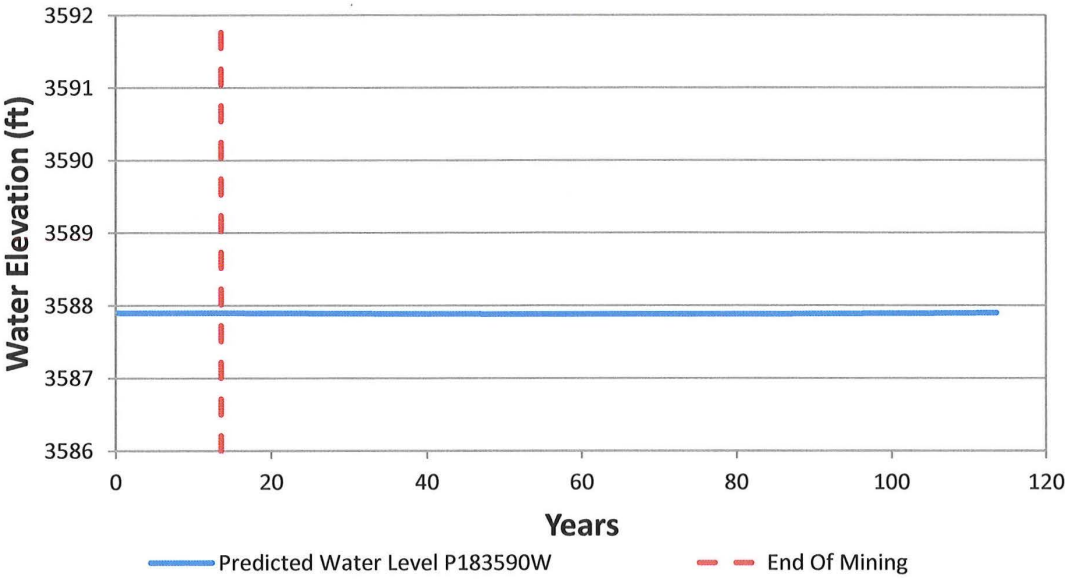
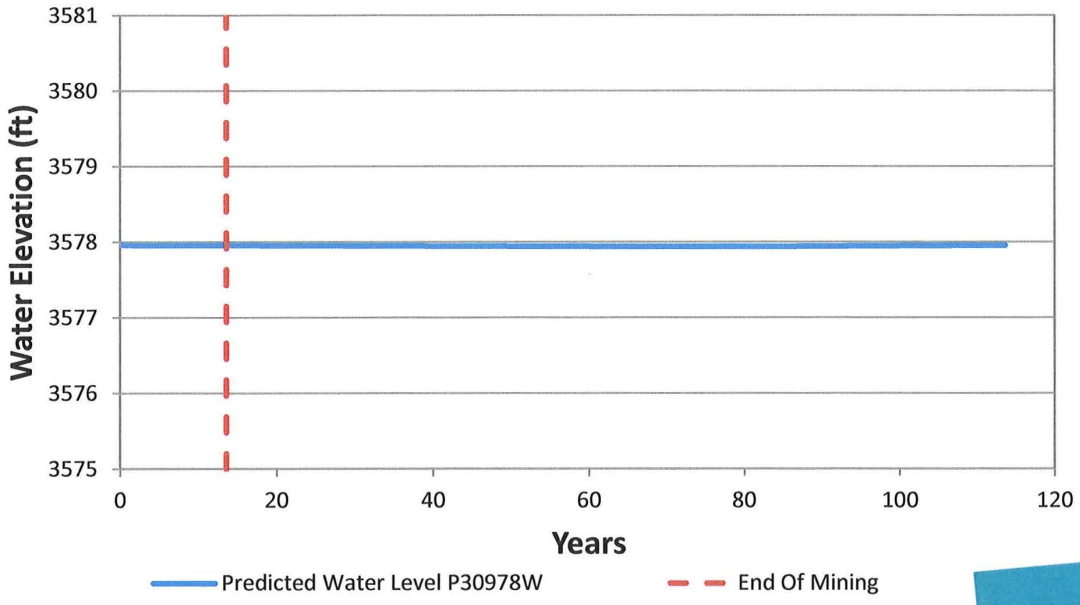
Model Predicted Hydrograph at Well P183590W



Model Predicted Hydrograph at Well P30978W



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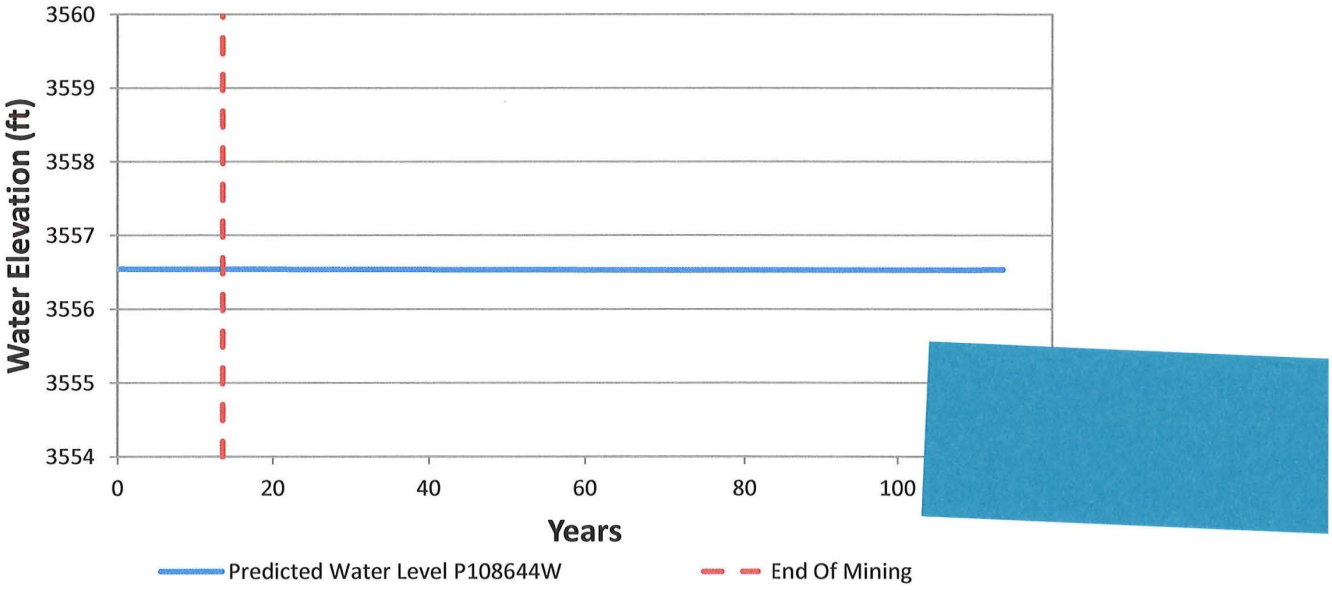
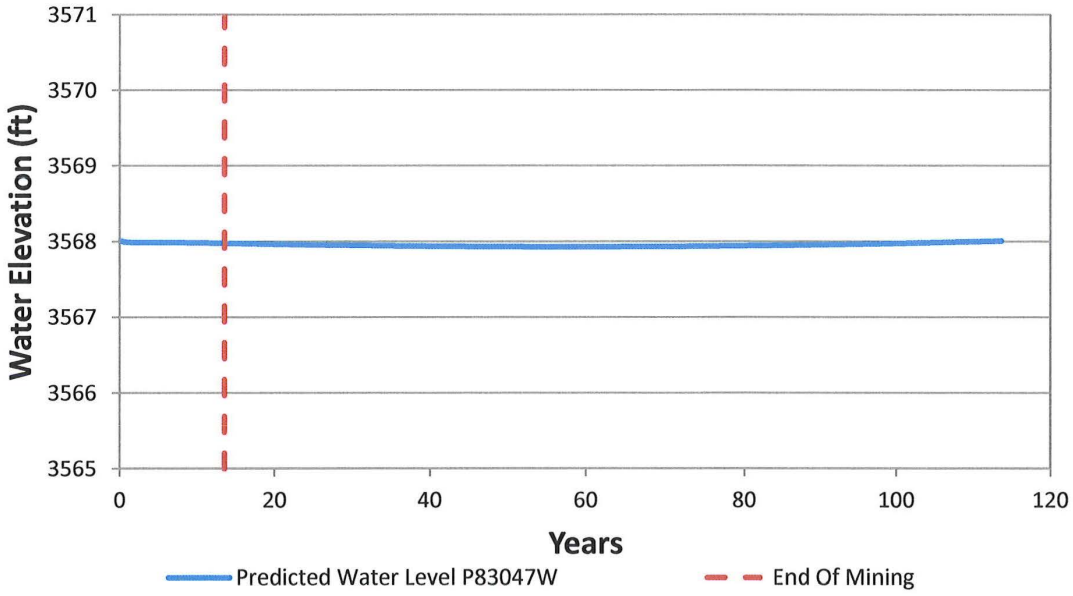
Model Predicted Hydrograph at Well P108644W



Model Predicted Hydrograph at Well P83047W



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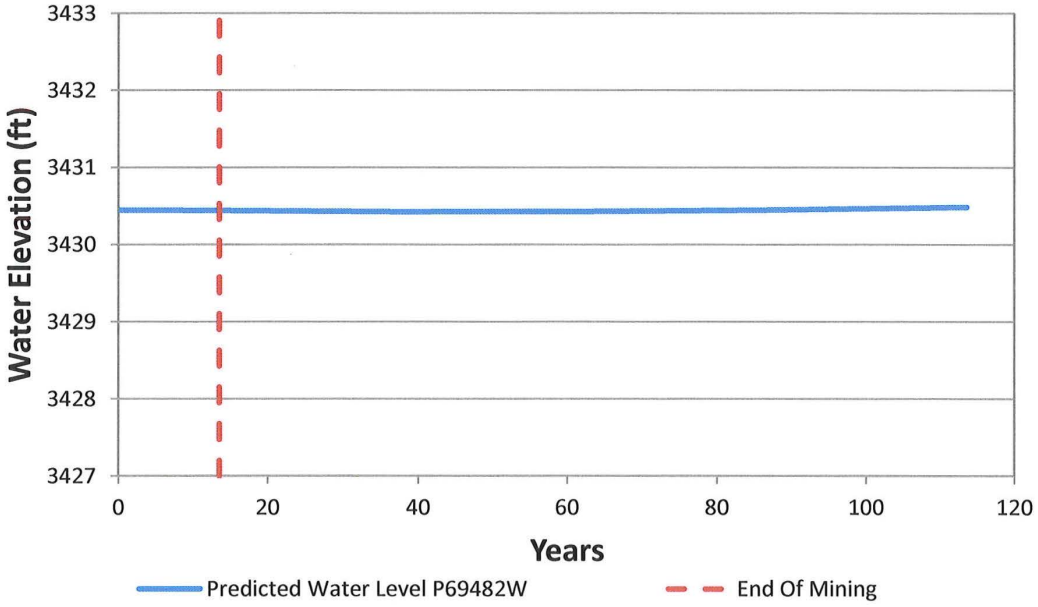
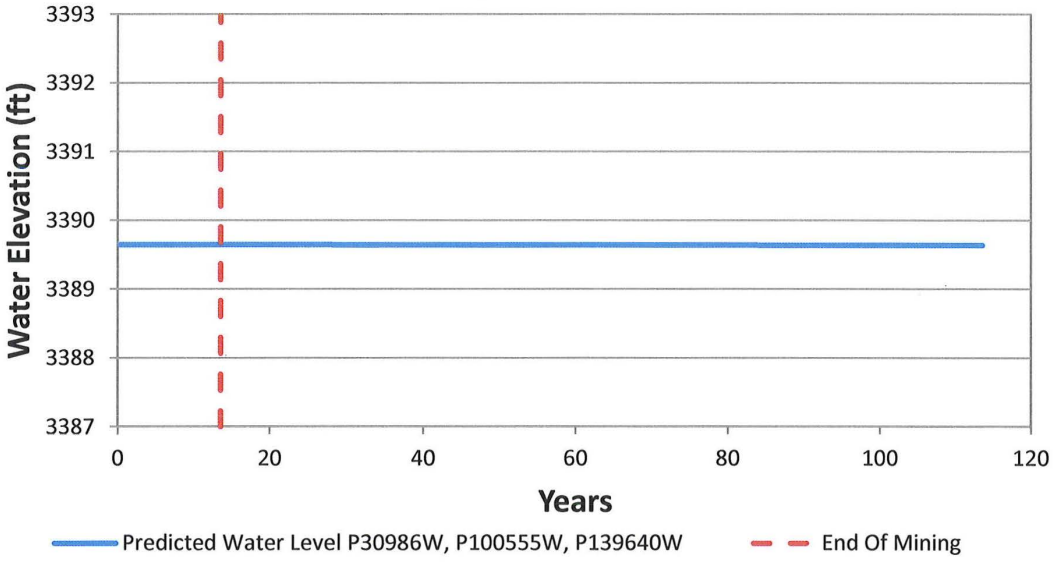
Model Predicted Hydrograph at Well P69482W



Model Predicted Hydrograph at Wells P30986W, P100555W, and P139640W



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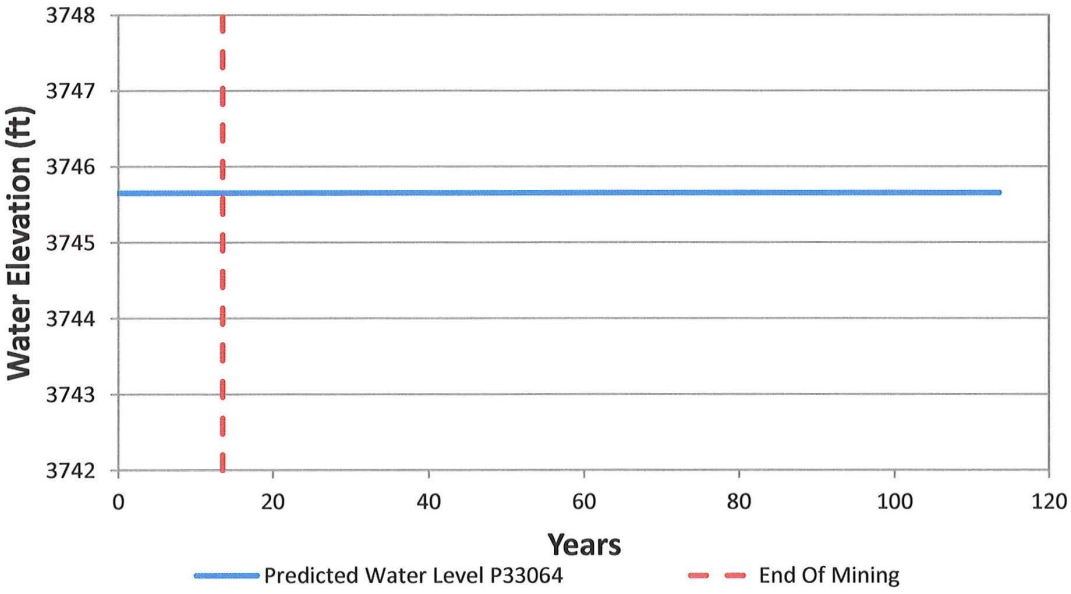
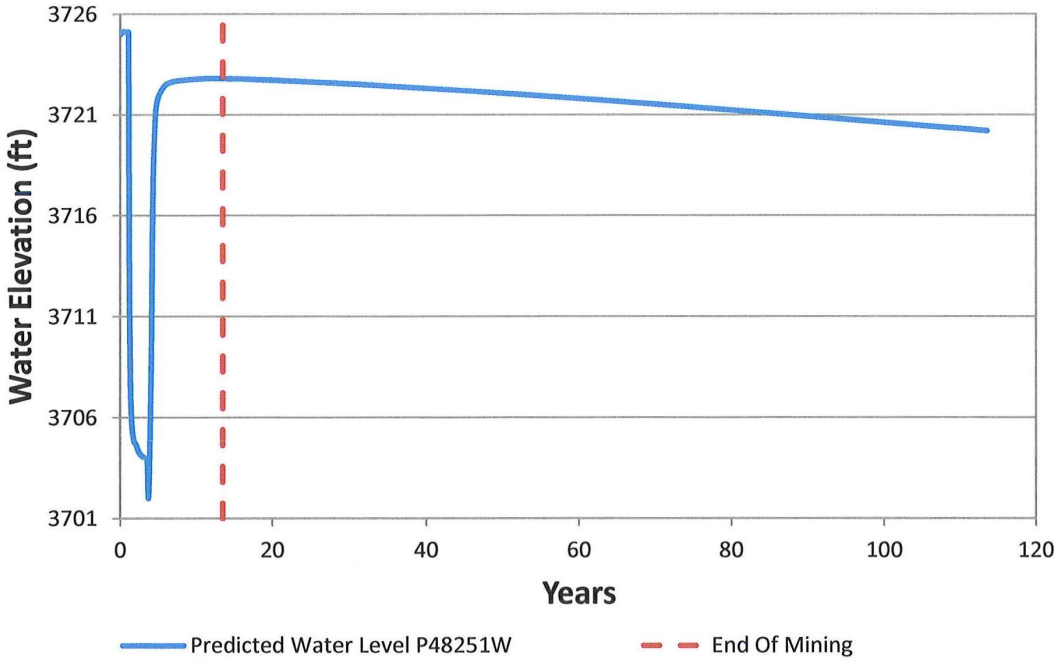
Model Predicted Hydrograph at Well P33064W



Model Predicted Hydrograph at Well P48251W



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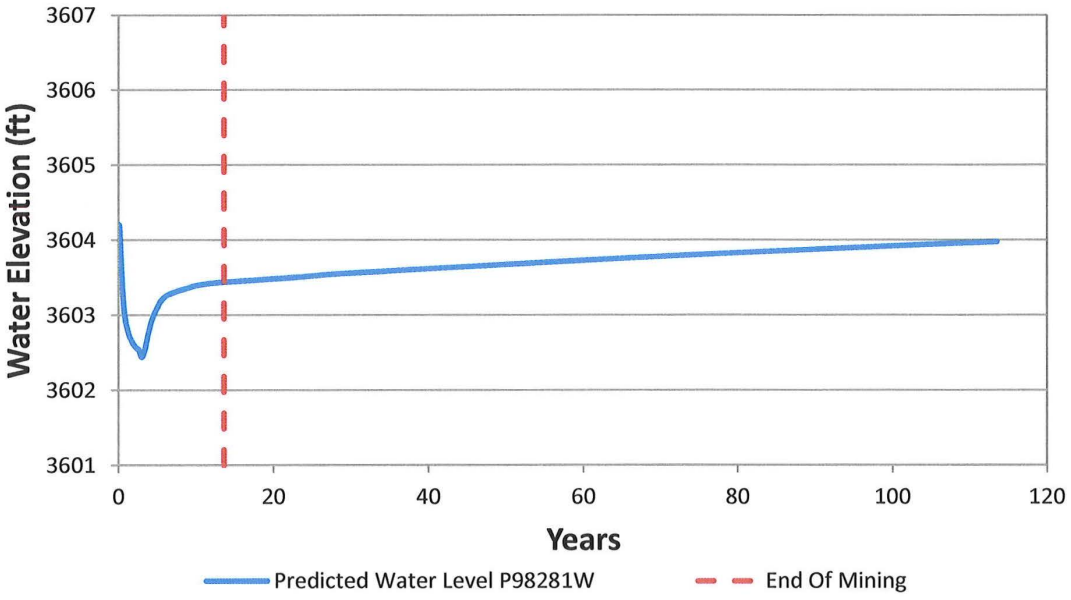
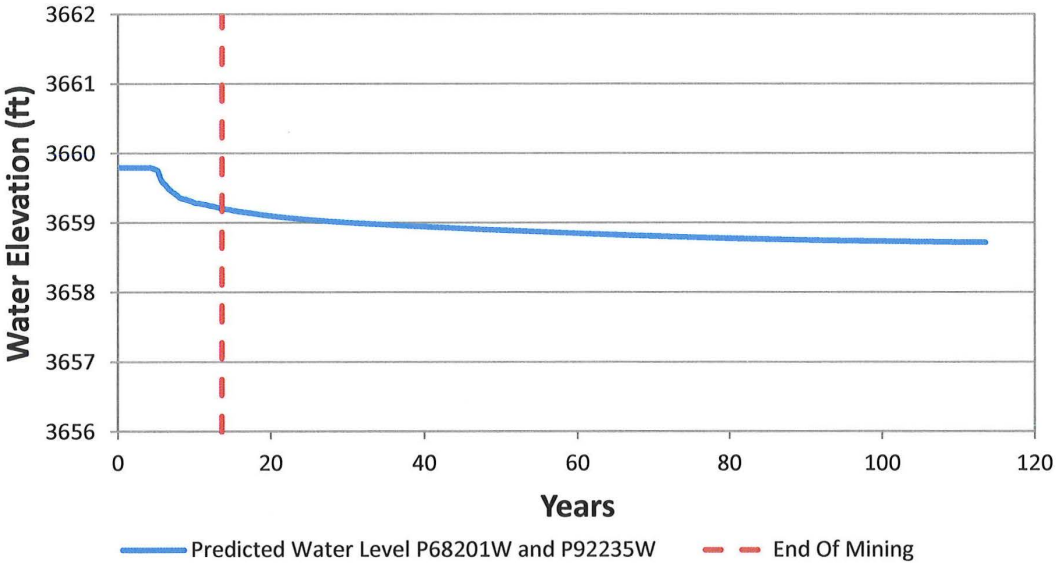
Model Predicted Hydrograph at Well P98281W



Model Predicted Hydrograph at Wells P68201W, P92235W



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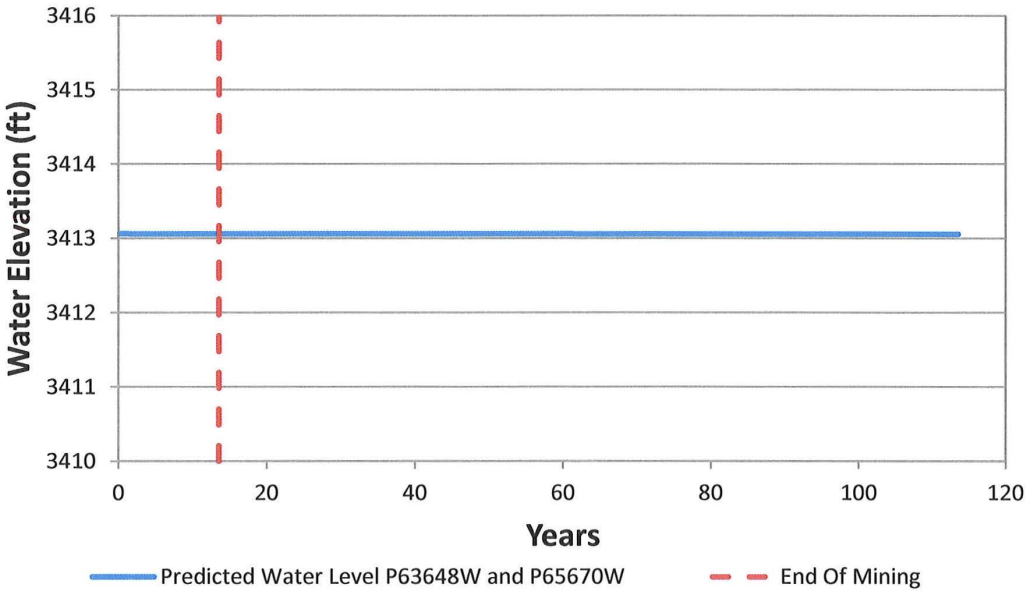
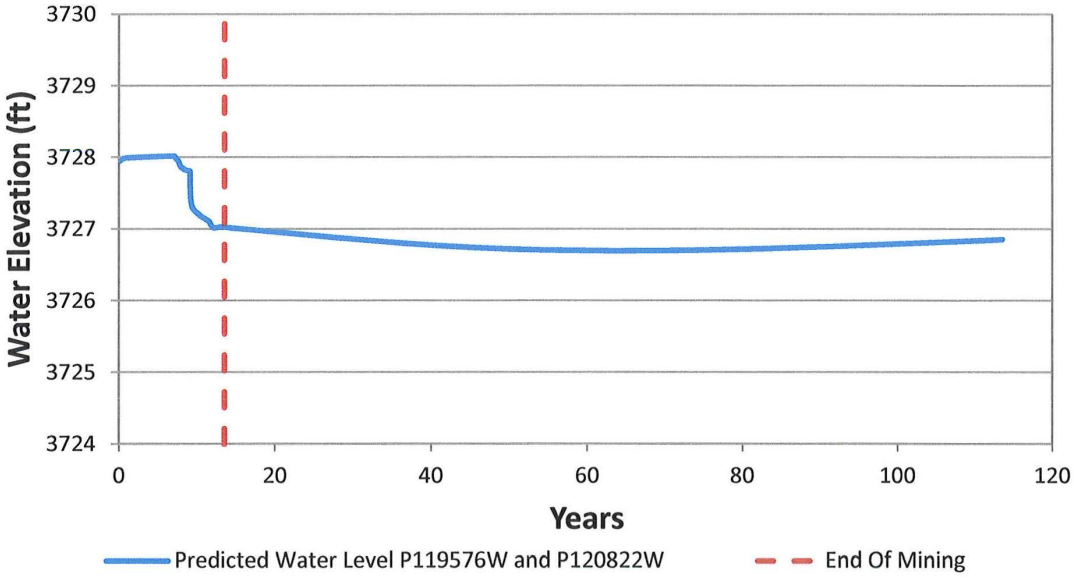
Model Predicted Hydrograph at Wells P63648W, P65670W



Model Predicted Hydrograph at Wells P119576W, P120822W



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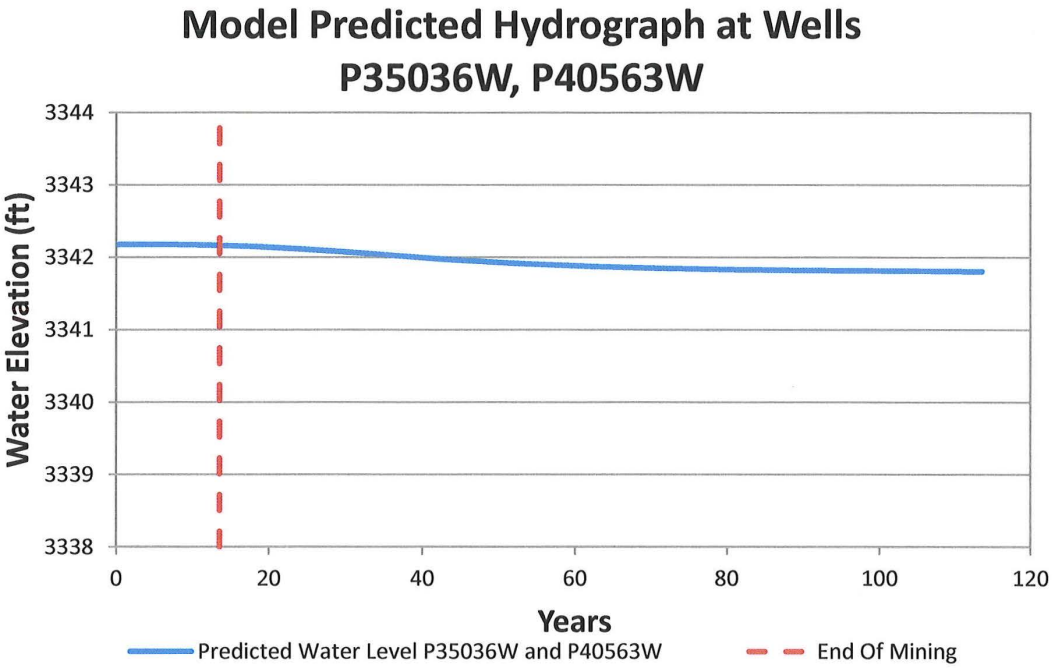

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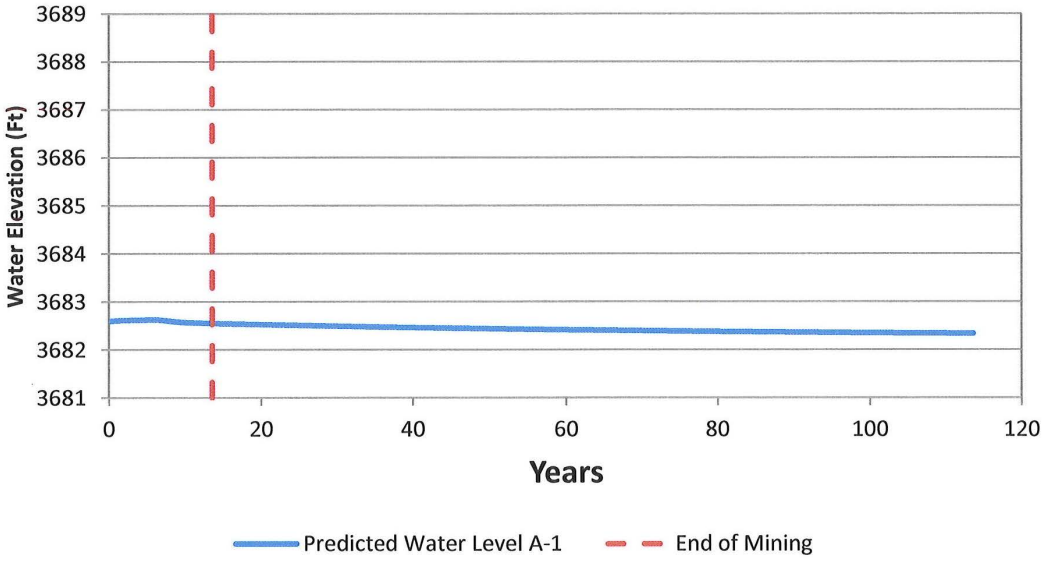
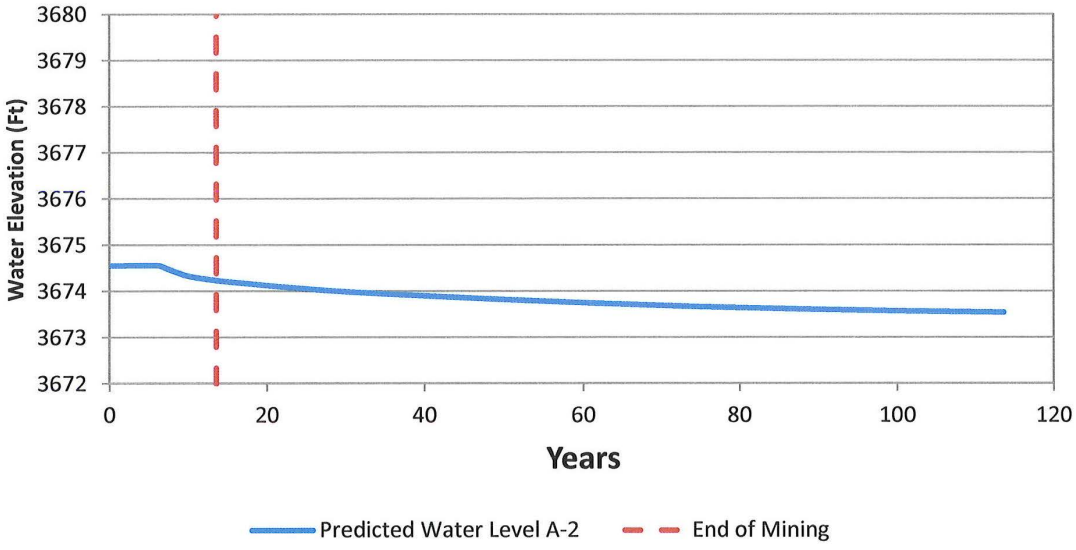
Model Predicted Hydrograph at Alluvial Target A-1



Model Predicted Hydrograph at Alluvial Target A-2



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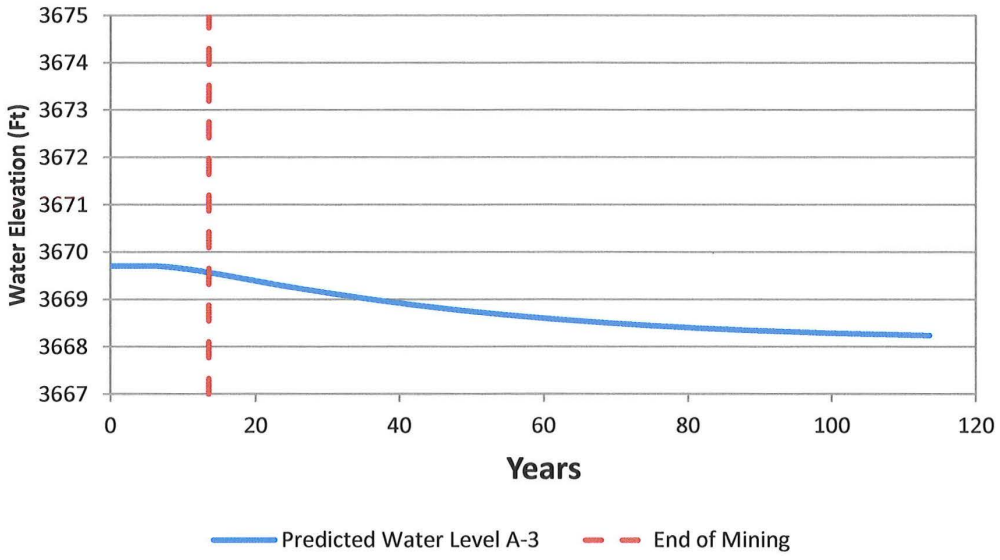
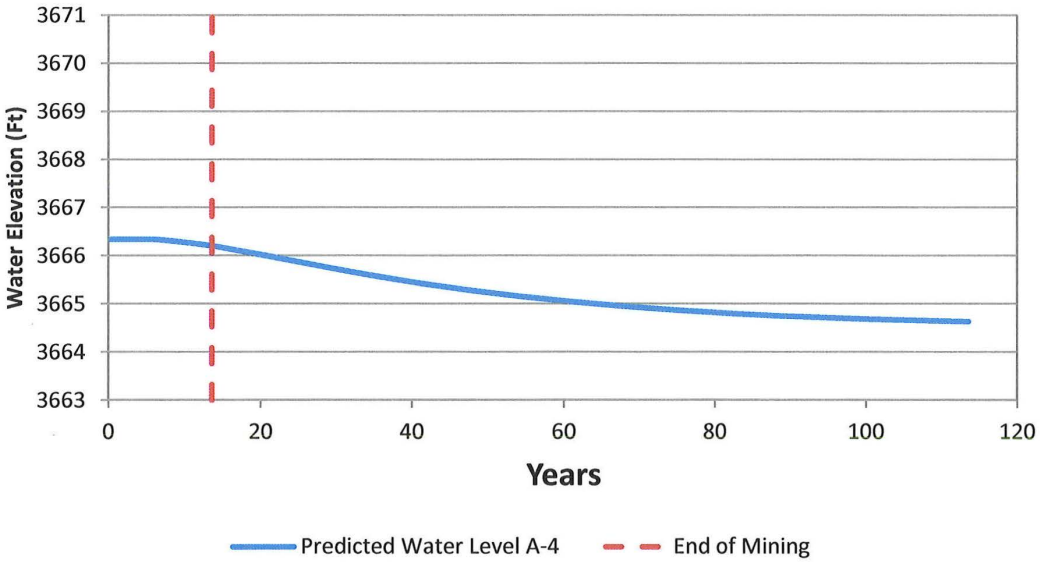
Model Predicted Hydrograph at Alluvial Target A-3



Model Predicted Hydrograph at Alluvial Target A-4



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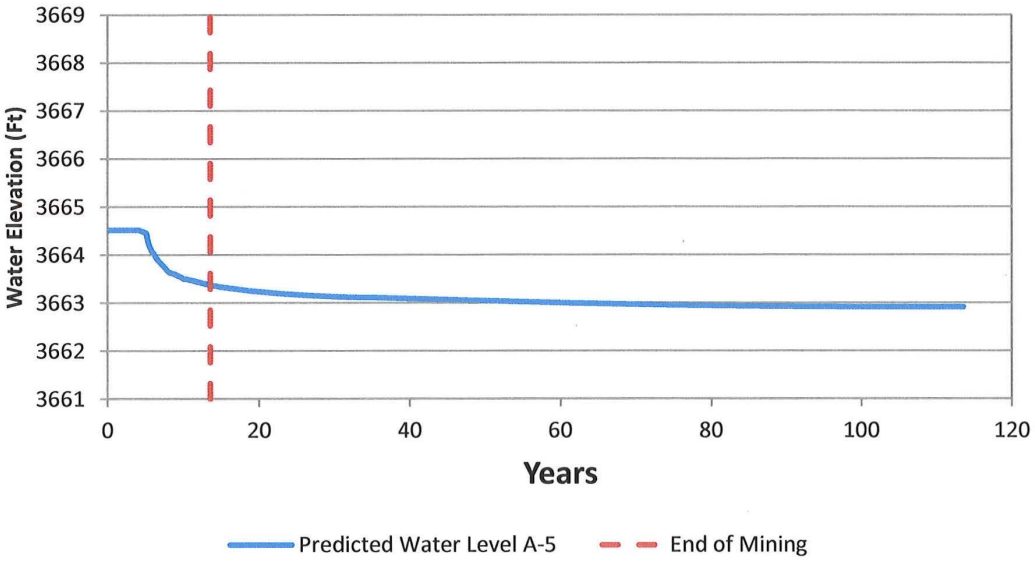
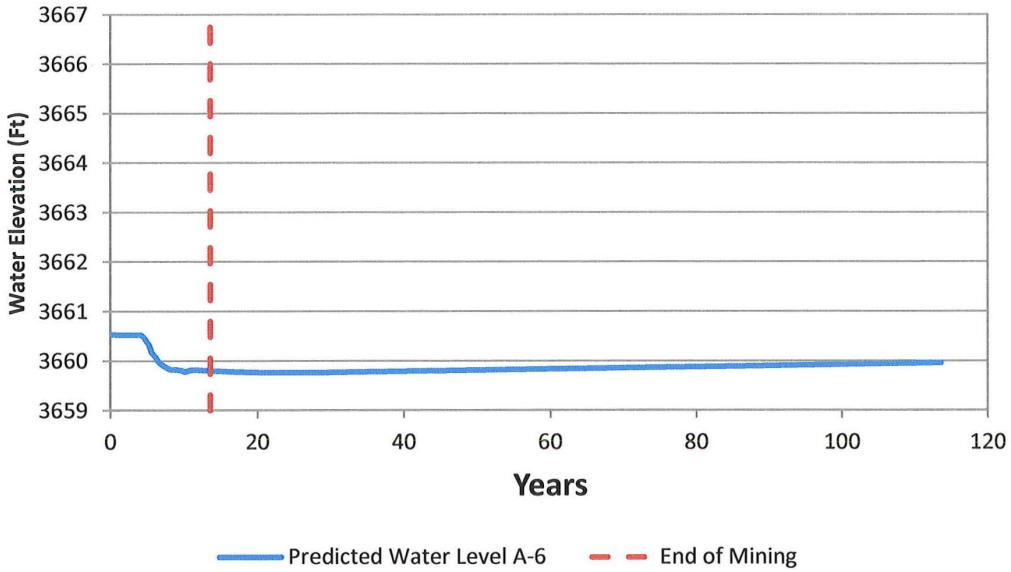
Model Predicted Hydrograph at Alluvial Target A-5



Model Predicted Hydrograph at Alluvial Target A-6



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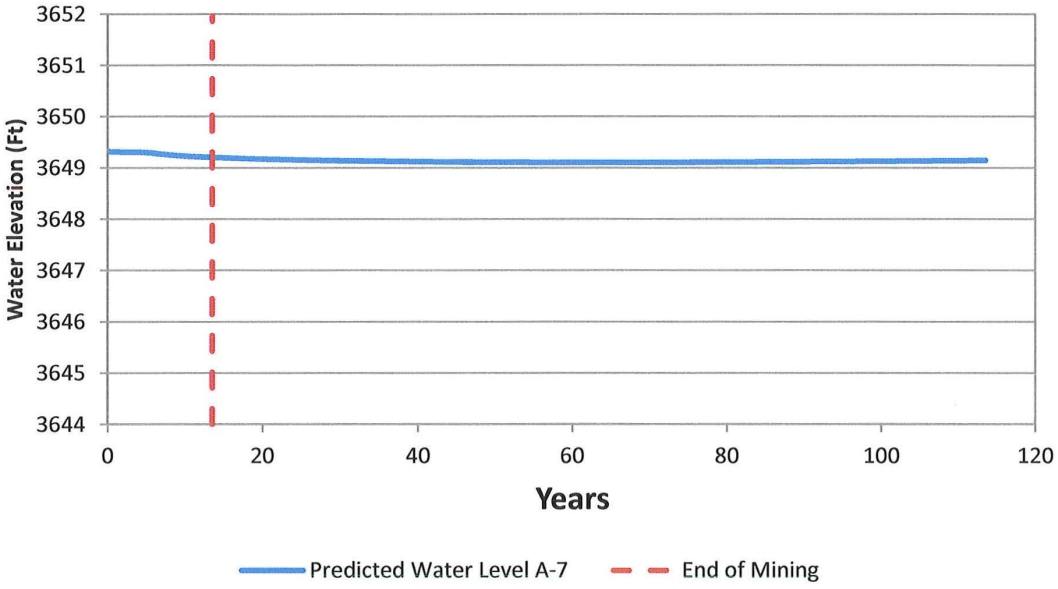
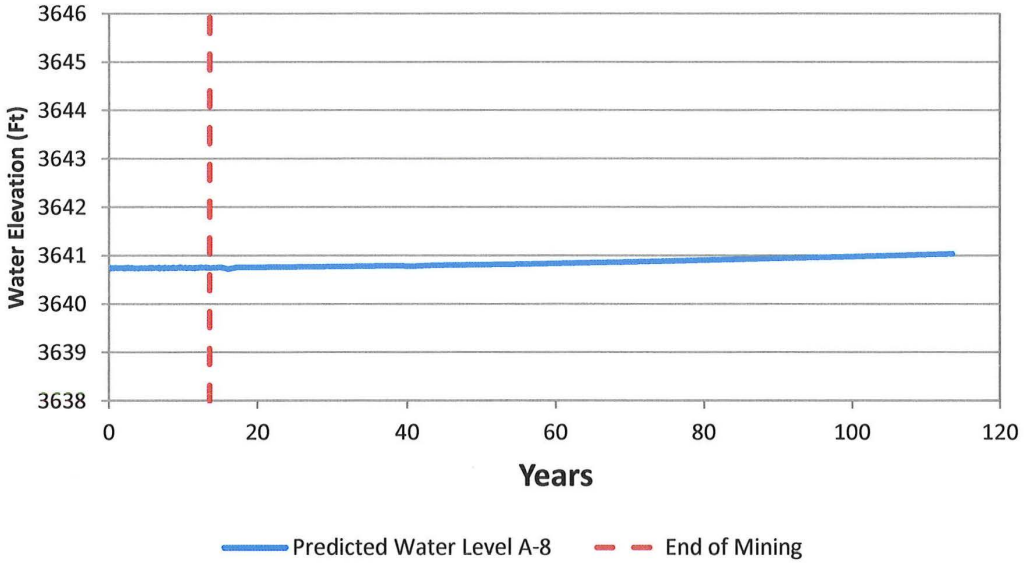
Model Predicted Hydrograph at Alluvial Target A-7



Model Predicted Hydrograph at Alluvial Target A-8



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APPENDIX B

Simulated Impacts from Operations

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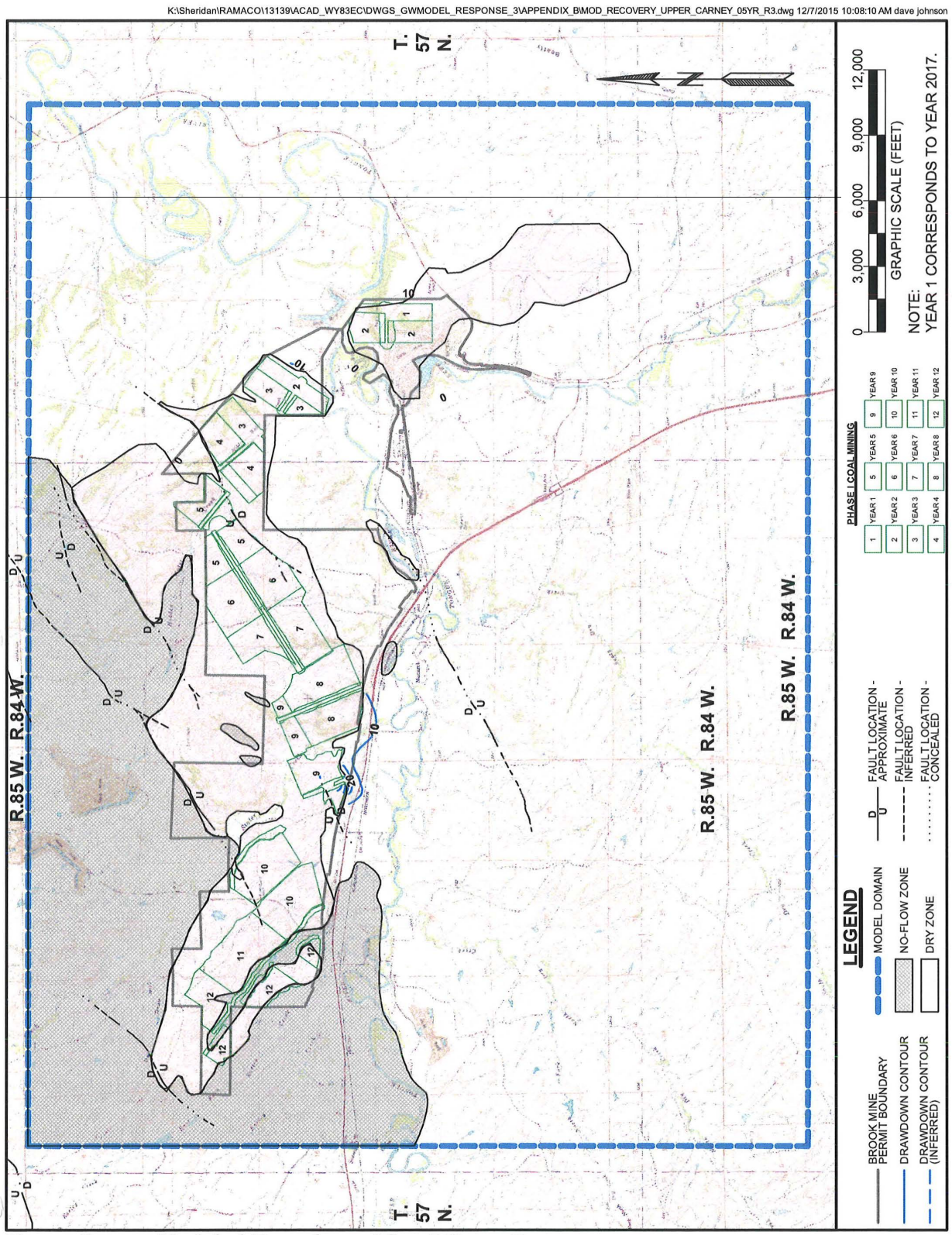

Upper Carney Modeled Drawdown After 5 Years Recovery.

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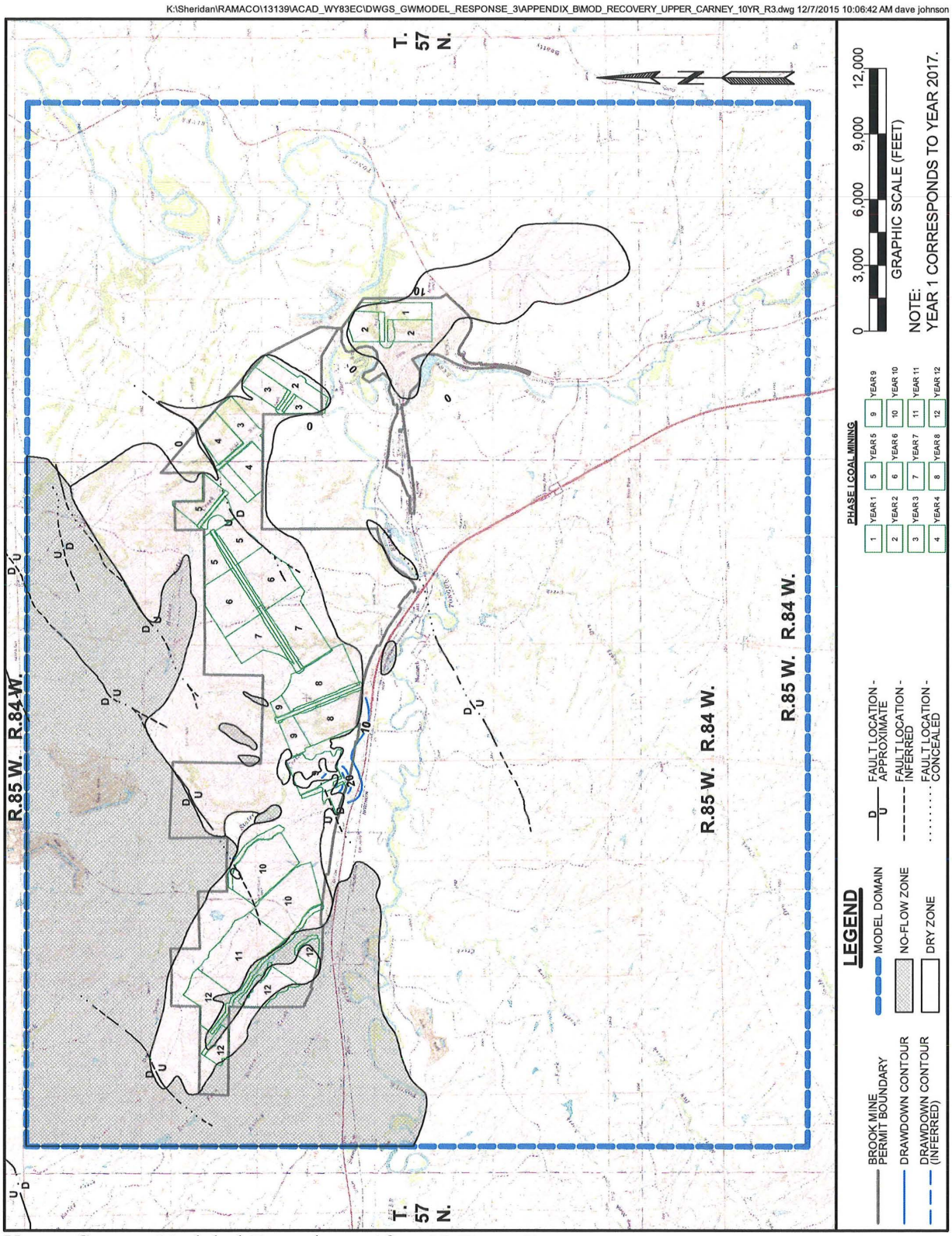

Upper Carney Modeled Drawdown After 10 Years Recovery.

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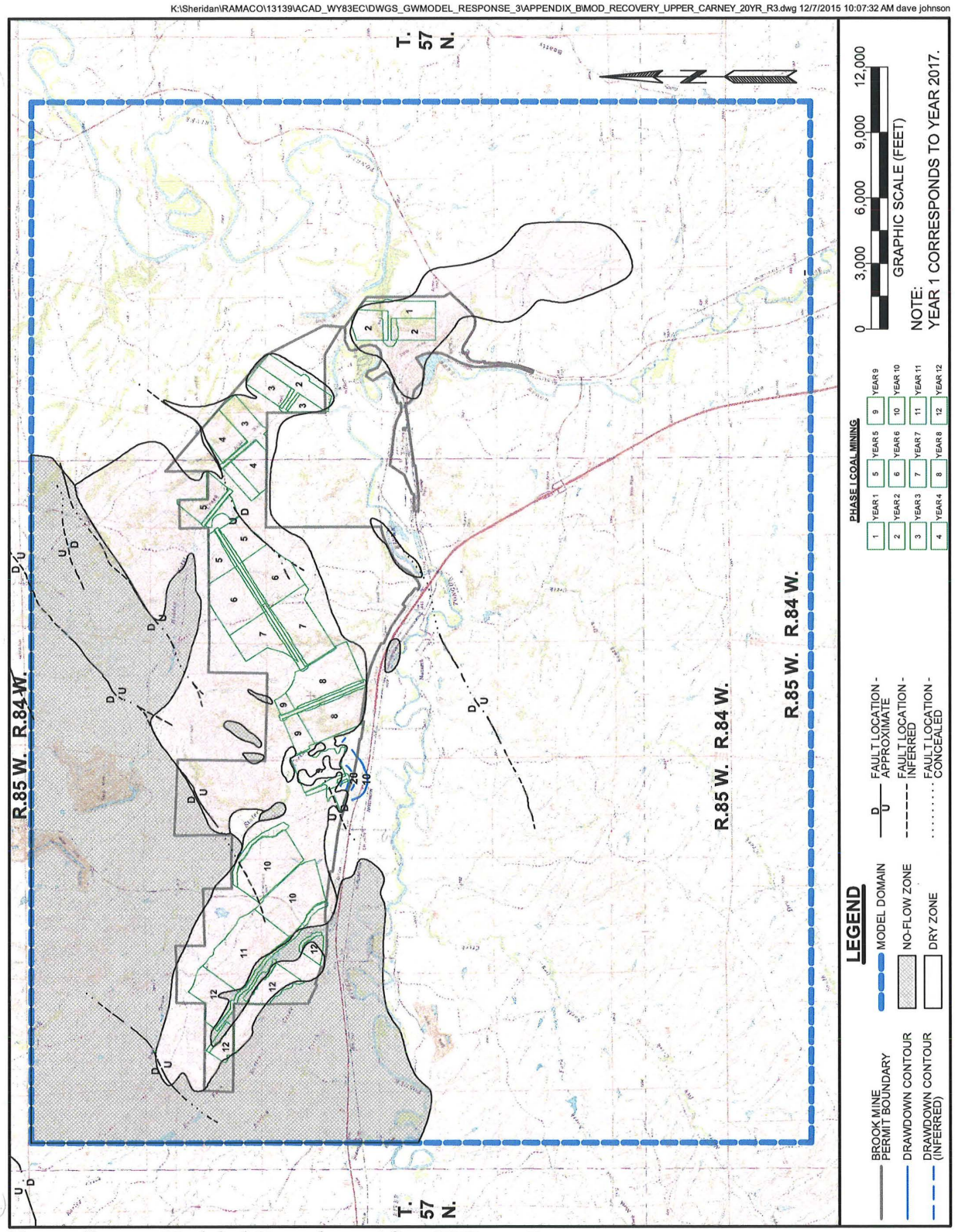

Upper Carney Modeled Drawdown After 20 Years Recovery.

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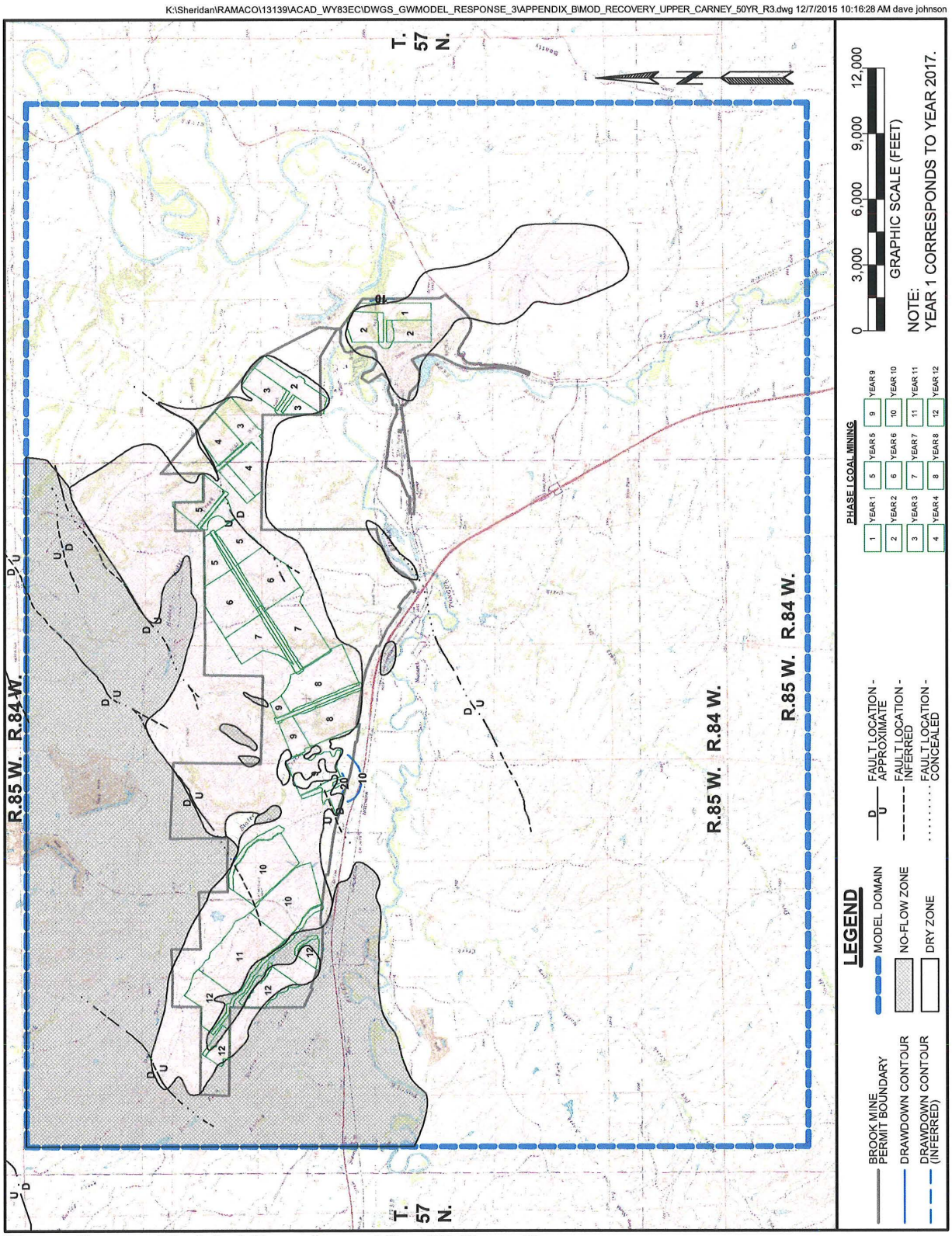

Upper Carney Modeled Drawdown After 50 Years Recovery.

December 2015

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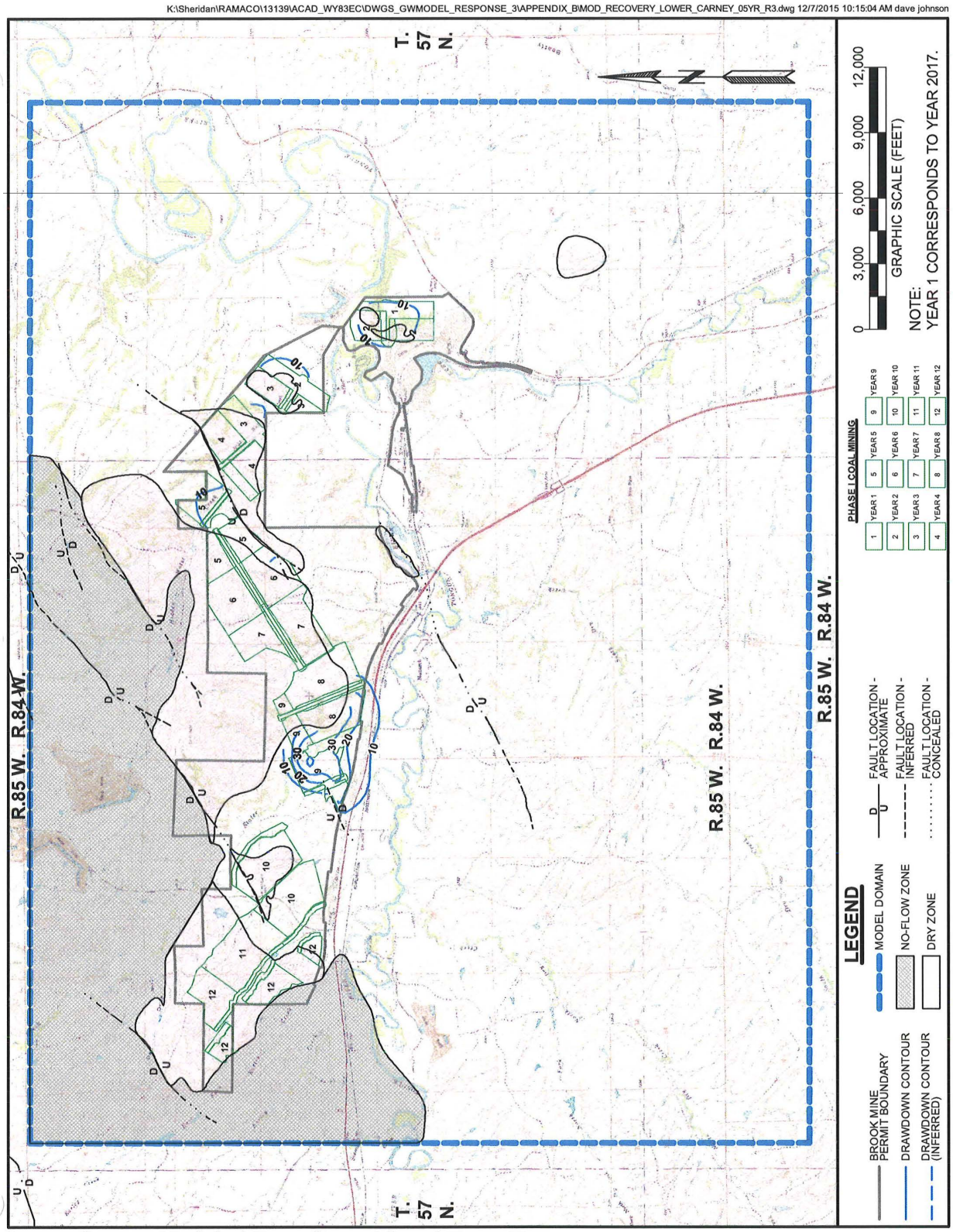

Lower Carney Modeled Drawdown After 5 Years Recovery.

December 2015

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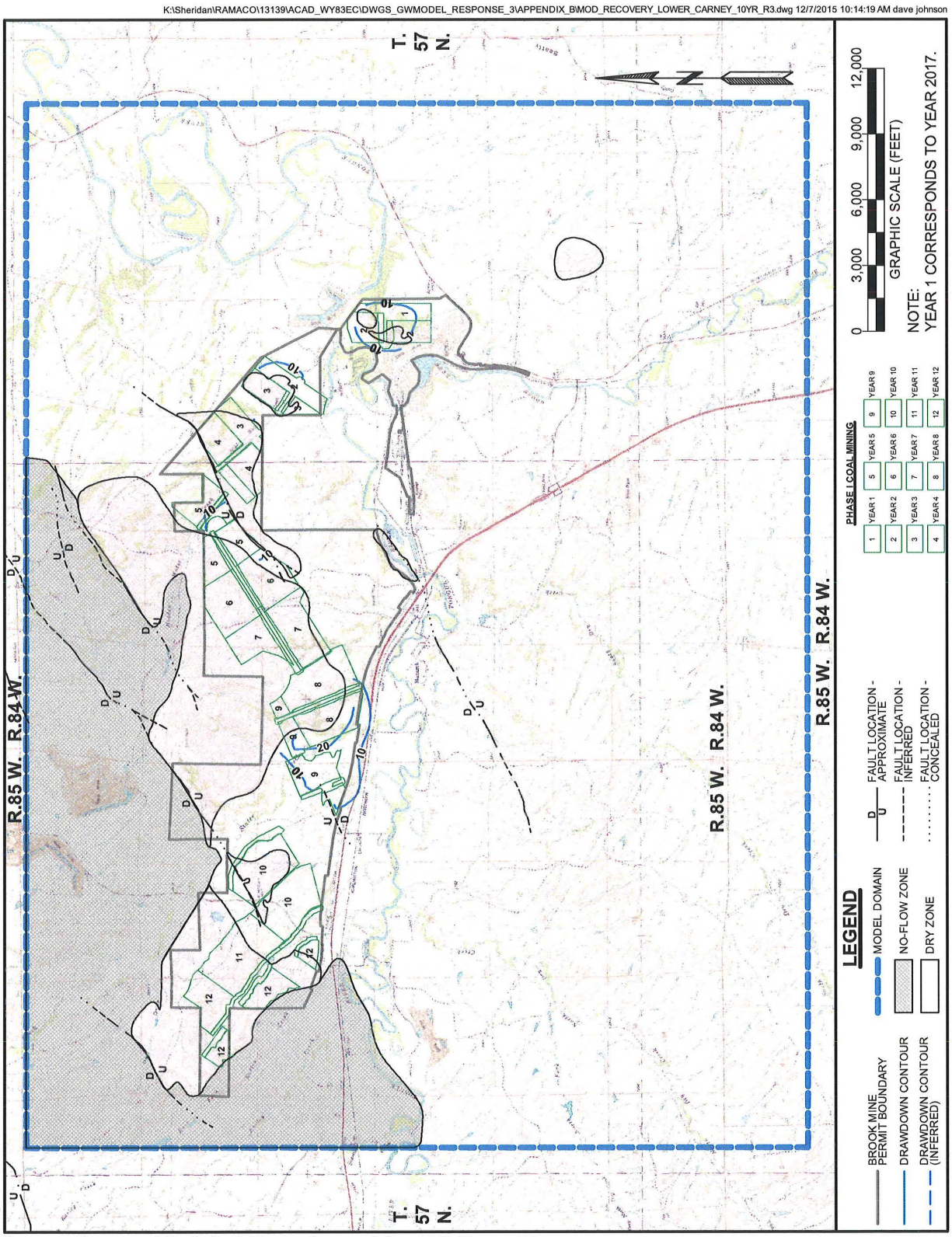

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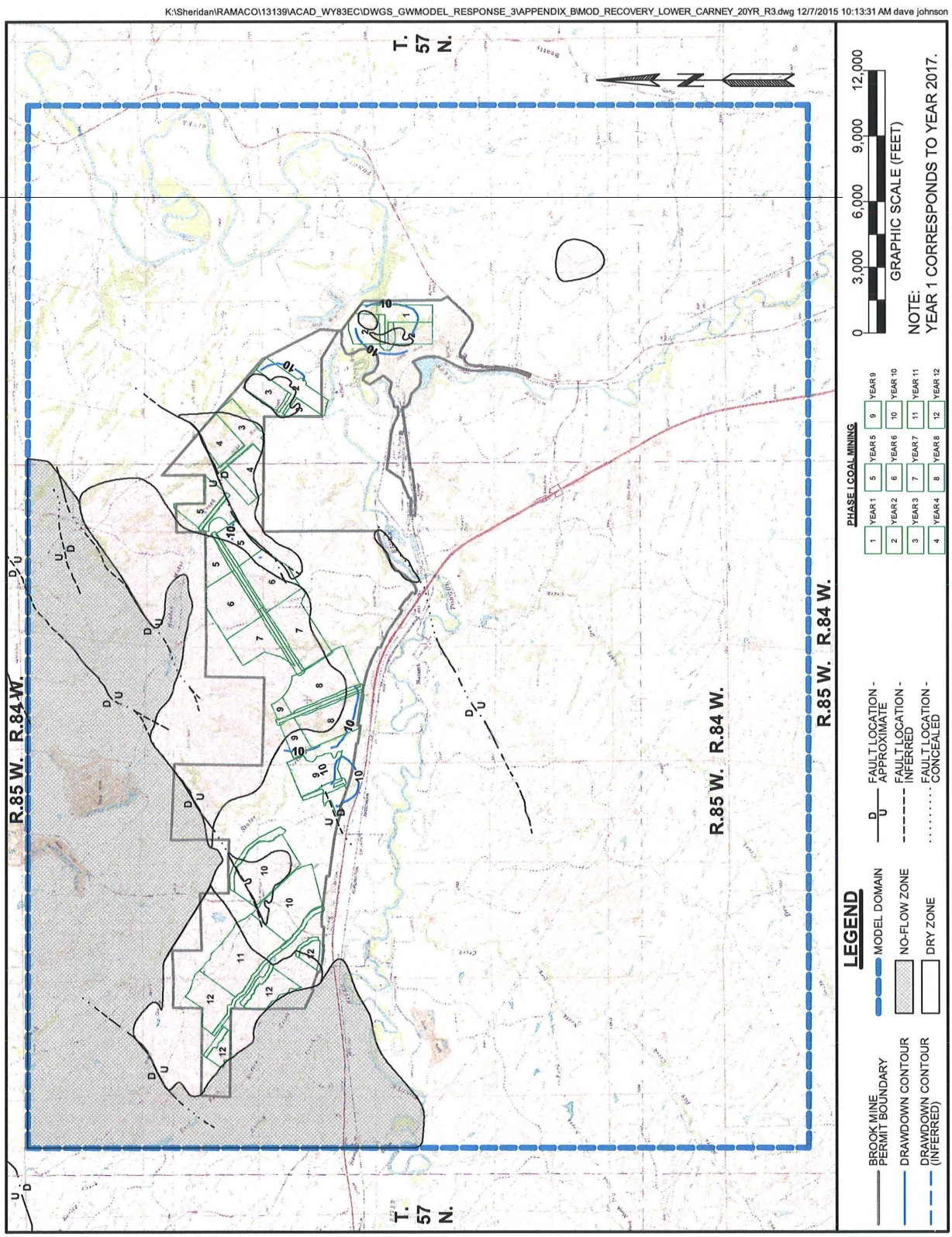

Lower Carney Modeled Drawdown After 20 Years Recovery.

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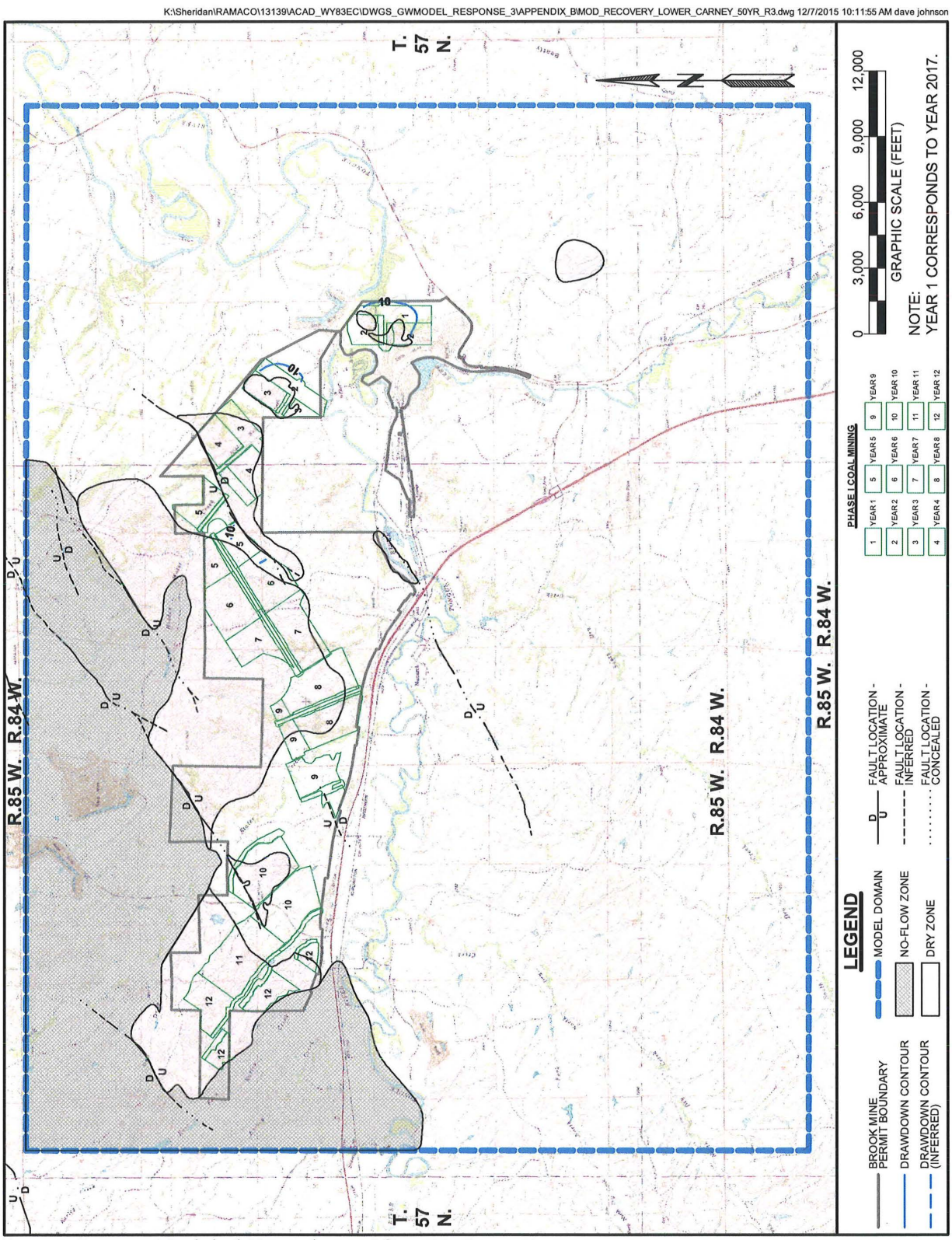

Lower Carney Modeled Drawdown After 50 Years Recovery.

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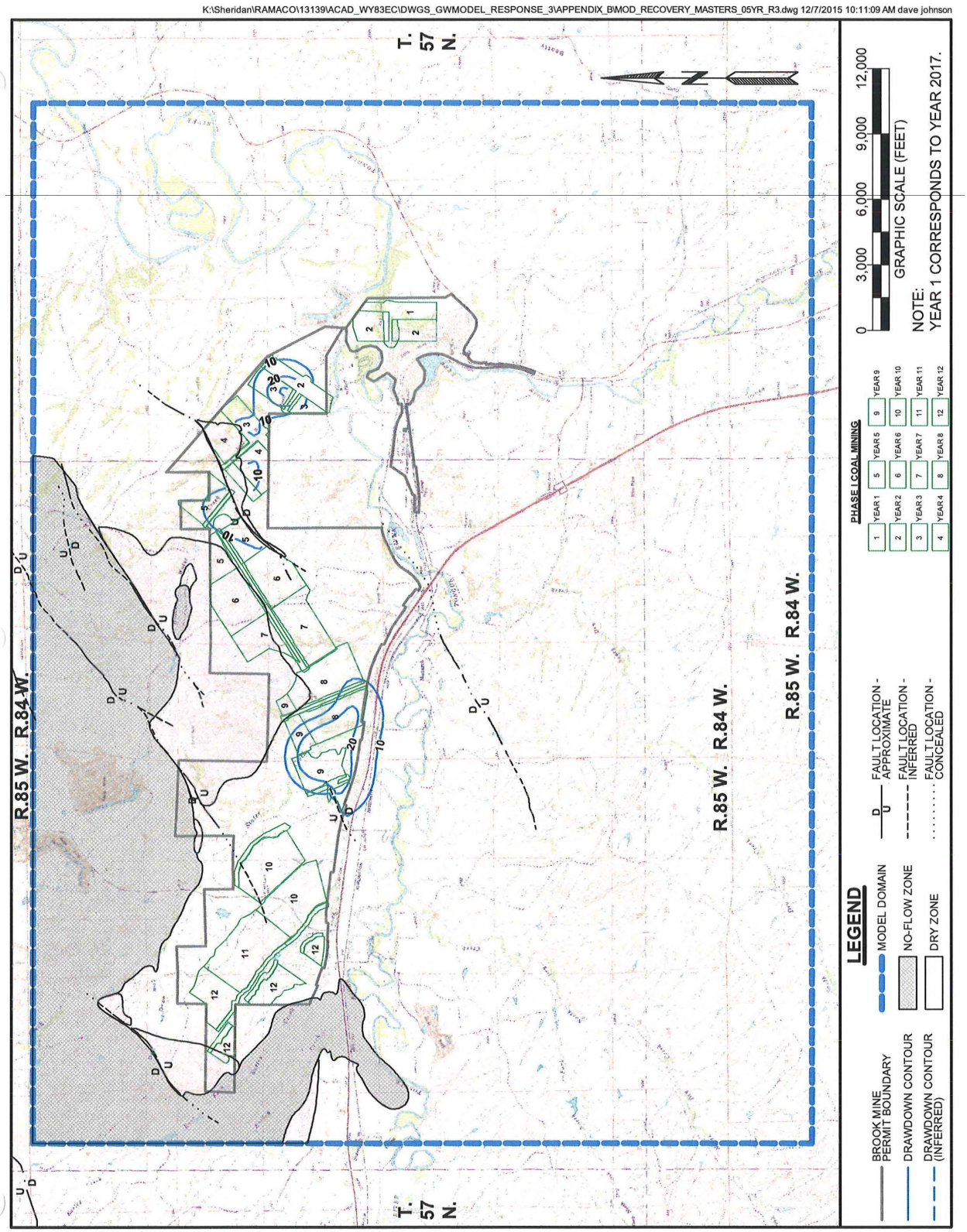

Masters Modeled Drawdown After 5 Years Recovery.

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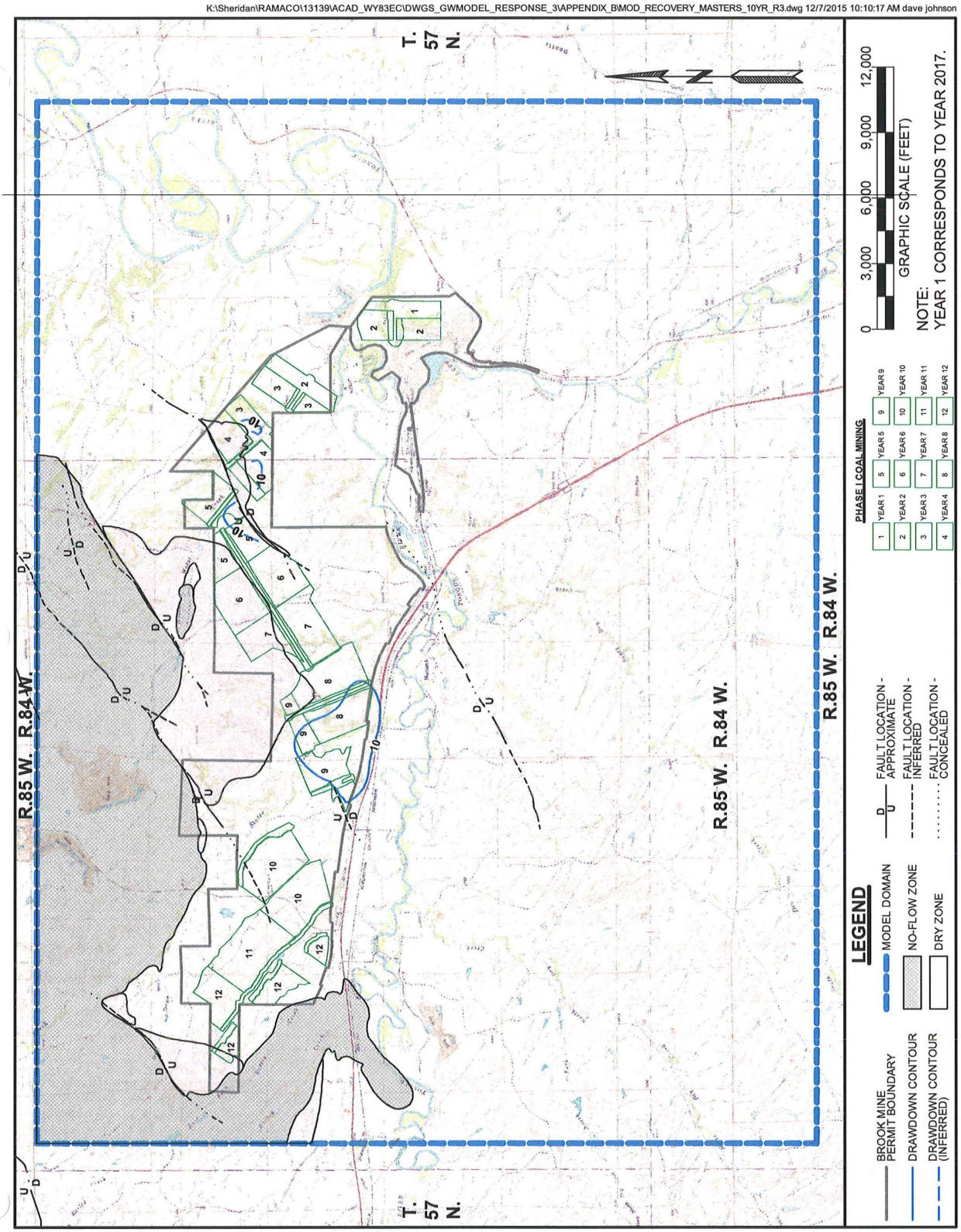

Masters Modeled Drawdown After 10 Years Recovery.

TFN 6 2/025 Addendum MP-3-110
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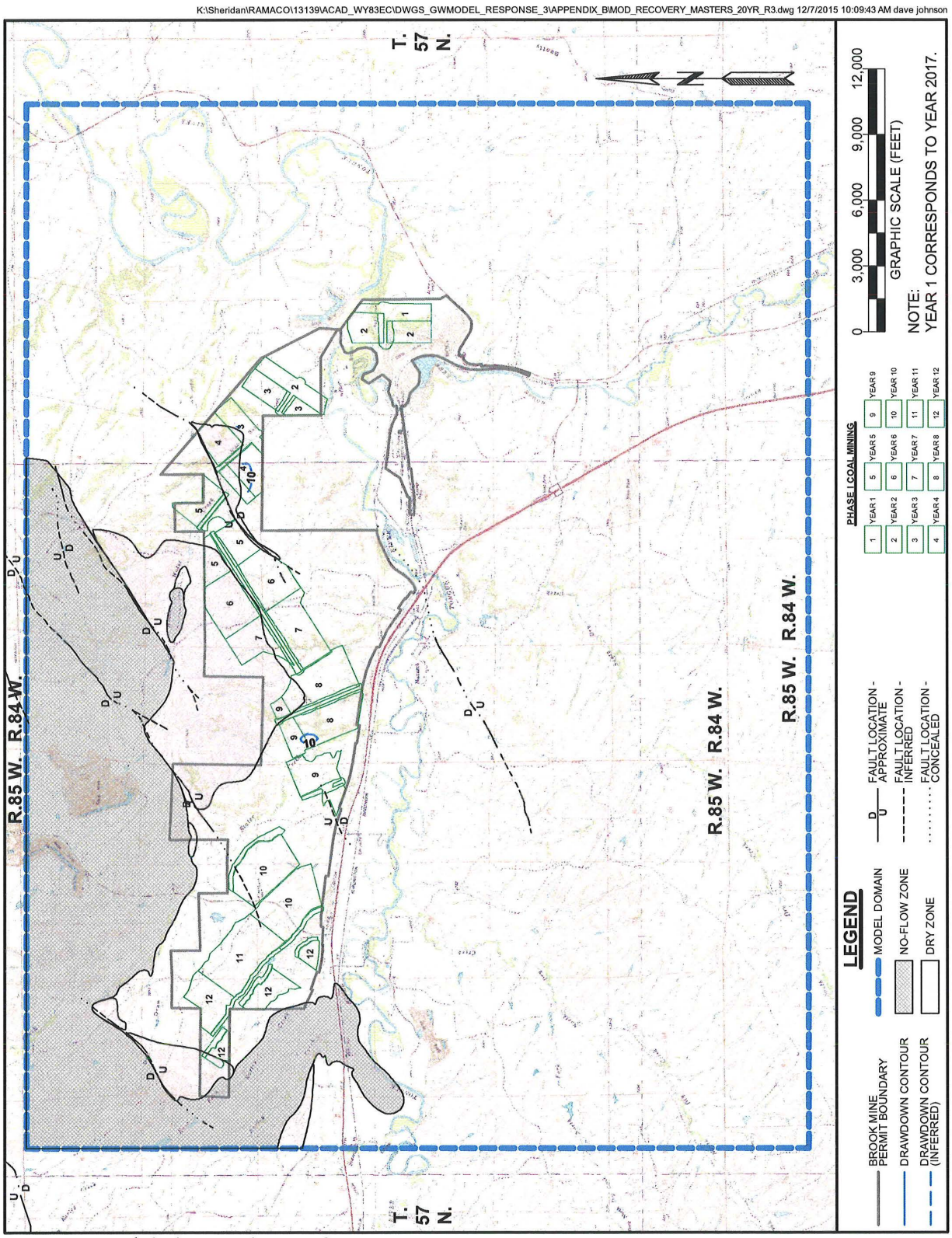

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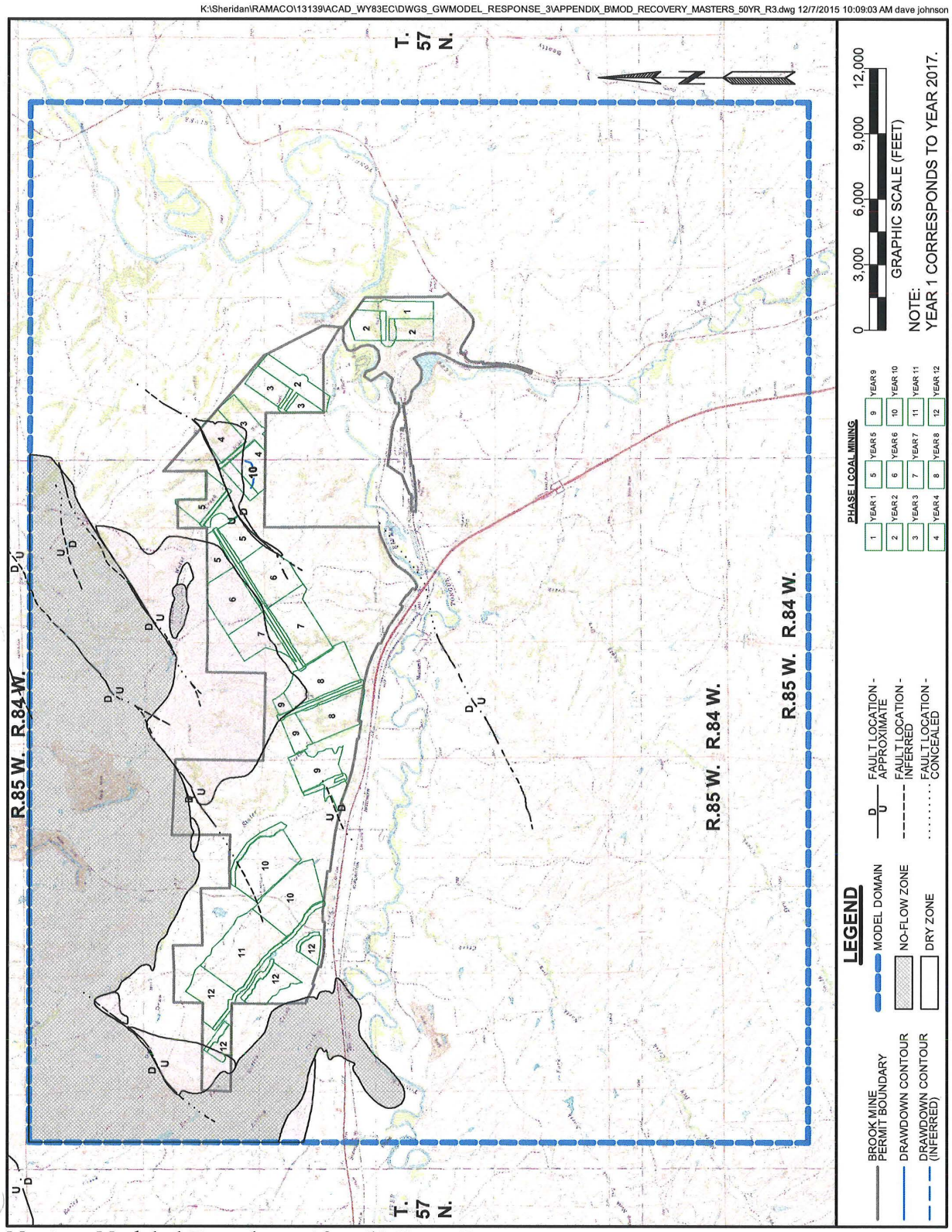

Masters Modeled Drawdown After 50 Years Recovery.

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ADDENDUM MP-4

ADDENDUM MP-4

Refuse Disposal

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MP-4.1 INTRODUCTION

The Brook Mine will apply to Wyoming Department of Environmental Quality (WDEQ) to operate an industrial landfill facility within its mine permit boundary. This addendum to the Mine Plan provides a flexible operating plan for solid waste disposal that the Brook Mine; it has been prepared to comply with applicable regulations governing solid waste disposal.

The Brook Mine has not yet operated an on-site landfill. If on-site disposal of mine-generated solid waste occurs, it will be performed in compliance with the conditions stated herein.

Most wastes will be hauled off-site for special treatment, recycling, or to the Sheridan County landfill. On-site disposal will be limited to specified, nonhazardous wastes. Small quantities of petroleum-contaminated soils will also be landfarmed and disposed of on-site.

The pre- and post-mining potentiometric surfaces are much deeper than where solid waste might be placed.

MP-4.2 WASTE TYPES, QUANTITIES, AND GENERAL HANDLING/DISPOSAL METHODS

Solid wastes routinely generated at the Brook Mine will be office and shop wastes, which could be hauled off-site to the Sheridan County landfill (county landfill); and small quantities of coal cleanings and burning coal, which will be disposed of in an overburden stockpile or the backfill. Small quantities of petroleum-contaminated soils will also be generated, landfarmed, and disposed of on-site as described in Section MP-4.5.

This section 1) describes the types of waste which will be generated at the Brook Mine; 2) indicates which wastes will be recycled/reclaimed, disposed of off-site, or disposed of on-site; and 3) gives quantity estimates where pertinent. This section also describes handling procedures for wastes which will be recycled or otherwise disposed of off-site. On-site disposal methods and standards are detailed in Section MP-4.3.

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MP-4.2.1 Office and Shop Wastes

Waste originating in office and shop buildings includes solids such as paper, lunchroom waste, shop rags, and spent aerosol cans. These wastes will be placed in dumpsters and hauled off-site for disposal at the county landfill. An independent contractor hauls the waste at regular intervals.

These wastes will be screened to ensure they are void of petroleum or other chemical residues, and are in compliance with the EPA "Empty Rule" (Title 40 CFR Part 261.7).

MP-4.2.2 Equipment Waste

Equipment-related solid waste includes machinery parts, tires, belts, non-terne-plated filters, and batteries. These wastes will be recycles or reclaimed where feasible. Used tires will be sold for recycling. Lead acid batteries will be stored on a steel grate above a concrete pad in the shop building where they will be picked up periodically for recycling by an independent contractor. Unrecyclable wastes such as equipment parts and air filters will be disposed of on-site or placed in dumpsters for off-site disposal to the county landfill. Waste to be disposed of on-site shall be void of free petroleum or chemical residue. Fuel and oil filters will be hot drained and crushed. It is permissible to place items such as oily rags, absorbent material, and crushed and hot-drained fuel and oil filters in the dumpsters for disposal at the county landfill.

MP-4.2.3 Supply and Scrap Wastes

Supply waste and scrap materials include scrap metal, concrete, and untreated scrap wood such as crates and skids. These wastes will be disposed of on-site, with the exception of most scrap iron which will be sold for recycling. Unsalable scrap metal (rebar, culverts, etc.) will be disposed of on-site.

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MP-4.2.4 Equipment Lubricants and Fluids

All waste oil, grease, and antifreeze (ethylene or propylene glycol) will be recycled or reclaimed. Waste oil will be stored in a tank and transported off-site by an approved and licensed contractor. Antifreeze will be recycled on-site or shipped to an approved recycler. Used grease and antifreeze will be stored on spill pallets in a designated, signed area, and periodically shipped off-site for recycling or incineration.

MP-4.2.5 Solvents

Any spent solvent not consumed by use will be recycled or, where allowed by hazardous waste regulations, mixed with used oil and shipped off-site for recycling or burning for energy recovery.

MP-4.2.6 Hazardous Wastes

Any hazardous wastes generated (such as paints and thinners) will be stored on spill pallets in a designated, properly signed area where they will be picked up periodically for shipment to a licensed hazardous waste facility or incinerator. If at any time the amount of hazardous waste accumulated on-site exceeds 1000 kg, it will be shipped to a licensed hazardous waste facility within the time frames set forth in EPA regulations (Title 40 CFR Part 261.5); however, the accumulation of such a quantity of hazardous waste is not anticipated.

MP-4.2.7 Petroleum-Contaminated Soil

The Brook Mine outdoor service areas for equipment typically generate very small quantities of oil- or petroleum-fuel contaminated soil: approximately 5 to 10 cubic yards annually, depending on spill volume. Any contaminated soil will be landfarmed on-site as described in Section MP-4.5.

MP-4.2.8 Empty Drums

Empty drums and barrels will generally be returned for deposit whenever possible. Containers not returned for deposit will be disposed of on-site in

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accordance with the EPA "Empty Container Rule" (Title 40 CFR Part 261.7). Empty drums and barrels will be stored in a designated area in a manner which avoids the accumulation of precipitation or other fluid in them.

MP-4.2.9 Sump Sediment

Drive-in sediment sumps will be constructed near washdown areas at the maintenance shop and coal processing facilities. Sumps or traps will provide a mechanism to intercept sediment load prior to waters being conveyed.

The shop sump accommodates an oil/water separator, minimizing or negating potential contributions of oil contaminated waters. Petroleum products and trapped sediment from washdown will be characterized by an analytical method approved by WDEQ/LQD for Resource Conservation and Recovery Act (RCRA) hazardous constituents. Sediment deemed suitable for on-site landfill disposal will be placed accordingly. If it contains non-hazardous petroleum products, it will be landfarmed on-site as described in Section MP-4.5. Hazardous wastes, if characterized by the WDEQ/LQD approved analysis, will be disposed of via an off-site licensed contractor.

Coal processing facilities primarily generate coal fines in washdown waters, and these fines will be trapped by a similarly designed drive-in sump (to the sediment sumps) near the source of the coal fines. Brook Mine anticipates that the water quality will contain no hazardous materials, and fines excavated at the sump(s) will be disposed of on-site.

MP-4.2.10 Wastewater Reservoir Sediments

Industrial wastewater and sedimentation reservoirs will occasionally have sediments removed to maintain required reservoir capacity. Reservoir sediments will be disposed of on-site in the trenches or surface mine pits or overburden stockpiles.

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MP-4.2.11 Sewage

Sewage wastewater will be handled separately from industrial wastewater by means of a septic leach field. The sewage wastewater will flow by gravity to each of the leach fields. Holding tanks for sewage wastewater from the transfer towers and other sources will be emptied by approved waste disposal contractors.

MP-4.2.12 Coal Waste and Unsuitable Overburden

Brook Mine will have no coal processing wastes which require disposal. Coal reject, thin partings, and any burning coal will be selectively mined, loaded, and hauled to an overburden stockpile or backfill burial. Acid-forming, carbonaceous, and other geochemically unsuitable overburden materials encountered during mining will be identified, handled, and disposed of as described in the Mine Plan.

MP-4.2.13 Asbestos

No asbestos, or asbestos-containing solid waste, will be generated or disposed of at the Brook Mine.

MP-4.3 ON-SITE WASTE DISPOSAL METHODS AND OPERATING STANDARDS

This section describes wastes suitable for on-site disposal; on-site disposal methods; location restrictions; operating standards; and operating schedule.

MP-4.3.1 Wastes Suitable for On-Site Disposal

Only mine generated solid wastes will be disposed of on-site. Petroleum-contaminated soil or sediment will not be placed in the disposal sites, but will be landfarmed as described in Section MP-4.5. Waste for on-site disposal will be screened before disposal to ensure that potential hazardous wastes and unsuitable materials are not placed in the disposal sites. Table MP-4-1 lists wastes suitable for on-site disposal.

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Table MP-4-1. Typical Wastes Suitable for On-Site Disposal at the Brook Mine

Waste Category	**Examples**
Paper	Polypropylene-lined paper bags
	Cardboard boxes
	Seed and fertilizer bags
	Paper trash
Non-treated wood	Packaging crates
	Pallets and skids
	Scrap lumber
Metal	Metal banding on crates
	Spent welding rods
	Unsalvagable scrap metal
	Miscellaneous small empty cans
	Empty drums (after meeting EPA "Empty Rule")
Pipe and Culverts	Steel
	Polyethylene, PVC
	Concrete
Rubber	Worn conveyor belt pieces
	Belts and hoses
Plastic	Foam packaging material, empty small containers
	Primer cord, conduit, electrical cable
	Broken plastic pallets
Glass	Broken glass
	Empty bottles and jars
	Light bulbs
Organics	Food scraps
	Reservoir residues
Earth Materials	Concrete
	Bricks
	Floor sweepings
	Reservoir sediments

NOTE: All items shall be screened as necessary to ensure they are void of free petroleum or chemical residue.

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In addition to the wastes listed in Table MP-4-1, wastewater and sediment reservoir sediments and geochemically unsuitable overburden will be disposed of in the highwall trenches or surface area mine pits.

MP-4.3.2 Disposal Site Construction

On-site disposal of solid waste will occur on spoils in the active mining areas either in the highwall trenches or the surface area mine pits. All solid waste disposal sites will be located in conformance with the following standards.

Each solid waste disposal site will be a five- to ten-foot deep pit placed on spoils at least 20 feet above groundwater or the postmining potentiometric surface to avoid degradation of groundwater. Size of each site will vary. Each site will be surrounded by a retaining berm approximately 5 feet high, or as safety requires; an opening in the berm will be provided for access. Typically, only one refuse disposal site will be open at a time, and will be used as long as operationally feasible.

Compaction and coverage of wastes will be conducted often and as necessary to control windblown litter. Wastes will be covered by back-dumping with haul trucks. The area above the completed disposal sites will be covered with a minimum of 4 feet of suitable overburden, and reclaimed concurrently with pit backfill. Operation of the disposal site shall be conducted in accordance with all local, State, and Federal requirements.

MP-4.3.3 Location Standards and Restrictions

Solid waste will not be placed:

1. Within 4 feet of the final graded backfill spoil surface;
2. Within 8 feet of any coal outcrop;
3. Directly on the trench or pit floor;

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4. Within 1000 horizontal feet of any drinking water source, such as a well, which furnishes water to a public water system for human consumption;

5. Within 1000 feet of any occupied dwelling, excluding mine dwellings, nor within 300 feet of any building unless provisions are made for protection from methane gas accumulation;

6. Within 1000 feet of any primary highway;

7. Within 300 feet of any perennial river or stream; within the surficial boundaries of a 100-year floodplain of any perennial river or stream; or within any wetland;

8. Within 1000 horizontal feet of any perennial pond or lake which occurs naturally or is not used for any purpose related to mining;

9. Within the high water line of any permitted impoundment;

10. Less than 20 feet above groundwater or the postmining potentiometric surface.

MP-4.3.4 Surface Water/Drainage Control

Surface water will be diverted to avoid contact with solid waste disposal sites. Typically this will be accomplished by drainage control structures (diversions, ditches, pipelines, and reservoirs) which route surface water around the mining activity, or collect and treat water that accumulates in the pit. Although precipitation cannot be controlled, waste will not be intentionally placed in standing water. Care will be taken to prevent ponding over filled disposal areas.

MP-4.3.5 Litter Control

Waste disposal sites will be partially protected from the wind by their position at the toe of spoils inside the highwall mining trenches or the surface area mine pits. Windblown litter will also be minimized by confining wastes to the smallest practical area, compacting wastes on a regular basis, and covering wastes as necessary.

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MP-4.3.6 Access Control and Signing

Mine access and haul roads will provide access to the disposal sites. Mine roads will be designed, and will be built and maintained for all-weather use by heavy equipment; subsequently, weather conditions will not normally restrict of hinder solid waste disposal activities.

The active mine site is fenced, which will effectively control access to the disposal sites. Active disposal sites will be identifiable by the placement of the sites and their appearance. Training and informing mine personnel will be an important part of the proper use and recognition of the disposal sites.

MP-4.3.7 Open Burning and Fire Control

Open burning of solid wastes is prohibited.

MP-4.3.8 Operating Schedule

Solid waste disposal may occur at any time; disposal sites will be operated on a continuous basis, 24 hours per day, 365 days per year. Disposal will not take place any time that the site or weather conditions preclude safe and proper operation.

MP-4.3.9 Reporting

The location of solid waste management and disposal sites will be reported to WDEQ/LQD in the Annual Report.

MP-4.4 GROUNDWATER MONITORING

The groundwater monitoring system in place at the Brook Mine to monitor mining impacts and reclamation efforts will concurrently monitor for leachate from on-site solid waste disposal.

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MP-4.5 TREATMENT AND DISPOSAL OF PETROLEUM-CONTAMINATED SOILS

Small quantities of petroleum-contaminated soils generated at the Brook Mine will be landfarmed on-site in accordance with WDEQ's Solid Waste Management Rules and Regulations, Chapter 8: Special Waste Management Standards. This section describes types of wastes which will be landfarmed, documentation and reporting of landfarming activities, and landfarming methods and operating standards.

MP-4.5.1 Allowable and Non-Allowable Wastes for Landfarming

Fuel, grease and oils are the typical petroleum products in soils to be landfarmed at the Brook Mine. The used oil waste stream at the mine is monitored for hazardous characteristics because it is recycled and/or burned off-site for energy recovery in accordance with Title 40 CFR Part 266, Subpart E. Hazardous wastes, liquids, semiliquids, and other types of solid waste will not be placed in landfarm treatment areas.

MP-4.5.2 Documentation and Reporting

The mine operator will verify and document the source and type of petroleum contamination, and that the soils to be landfarmed are not a liquid or semiliquid. Any spill of 25 gallons or more of refined product will be reported to WDEQ/Water Quality Division (WQD). Landfarming of greater than 40 cubic yards of petroleum-contaminated soils at any one time is not anticipated; however, prior authorization will be requested from WDEQ/LQD to do so. Records of the following information will be maintained at the Brook Mine, and reported to WDEQ/LQD in the Annual Report:

1. Location, type, and quantity of petroleum-contaminated soils;
2. Copies of any physical or chemical analyses performed on the soils;
3. Date of the spill (if known or applicable) and the date(s) the petroleum-contaminated soils were taken to the landfarm area, tilled/turned/disked, and disposed;

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4. Location of landfarm treatment area(s); and

5. Documentation that the soils were treated and/or disposed of in accordance with this Refuse Disposal Plan.

MP-4.5.3 Landfarming Methods and Operating Standards

Landfarm treatment areas will be located on inactive overburden benches or inactive backfill or unreclaimed areas. Landfarm sites will be:

1. Relatively flat;

2. At least 100 feet from any occupied dwellings, buildings, public parks, or recreation areas;

3. Large enough to treat the anticipated volume of soil;

4. Separate from solid waste disposal sites; and

5. Located to minimize the threat of contaminating groundwater or surface water.

Active landfarm sites will be marked with identifying signs and signs prohibiting smoking with, at minimum the following wording:

"RESERVED FOR PETROLEUM-CONTAMINATED SOILS

NO SMOKING"

Access will be restricted by the same procedures governing mine site access.

Aforementioned, treatment areas will be carefully located to minimize the threat of contaminating groundwater or surface water. Treatment areas will be situated only on sites where groundwater or the postmining potentiometric surface is at least 20 feet below the treatment surface. Due to the depth to groundwater and the postmining potentiometric surface over most of the Brook Mine Permit Area, it is anticipated that treatment sites will typically be located where depth to groundwater and the postmining potentiometric surface is much deeper. Surface water will not be allowed to flow into or out of landfarm treatment sites. Although precipitation cannot be controlled, petroleum-contaminated soils will not be intentionally placed in standing water.

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Petroleum-contaminated soils will be applied to the treatment area in lifts of a 6-inch thickness, or less. Diesel- or gasoline-contaminated soil will be aerated for at least one month in warm weather (50°F or warmer). Soils contaminated with used oil will be aerated for three to four months in warm weather. When temperatures are below 50°F for extended periods, the aeration period will be extended as necessary, possibly as long as six months. Soils will be disked or tilled at least once during the aeration period.

A composite 3- to 5-point sample of the treated soil will be taken after completion of the aeration period and submitted for laboratory analysis. Soils may be disposed of at the end of the aeration period:

1. When Total Petroleum Hydrocarbon (TPH) content by an appropriate EPA method (such as EPA 418.1 or EPA 8015) is 100 parts per million or less, if the treated soils are to be disposed of or backfilled in an area where groundwater is at least 50 feet below the location of the treated soils backfill, or if the treated soils will be used for asphalt aggregate or road base; or

2. When TPH concentration is 30 ppm or less, in the unlikely event that the treated soils are to be disposed of or backfilled into an area where the groundwater is within 50 feet of the treated soils backfill; or

3. When disposal is authorized by WDEQ based on discussions of the soil volume, petroleum hydrocarbon type and/or concentration, and other relevant factors.

Contaminated soils which do not achieve the above-listed TPH standards will undergo the weathering and tillage process until the standards are met. If the standards are not achieved within one year, WDEQ will be contacted to discuss alternative treatment and/or disposal. Any treatment other than natural aeration and tilling (such as addition of fertilizer or microbes) will be approved by WDEQ/LQD prior to use.

Treated soils will be disposed of in one of the following manners:

1. By burial below the final reclaimed surface (disposal will not occur in the upper 4 feet of regarded spoil);

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2. By use as cover material in the solid waste disposal sites; or

3. By use as road base.

Treated soils will not be disposed of outside the Brook Mine Permit Area.

MP-4.6 REFERENCES

Wyoming Department of Environmental Quality/Land Quality Division (WDEQ/LQD). (December 2012). *Rules and Regulations Chapter 4: Environmental Protection Performance Standards for Surface Coal Mining Operations.* Cheyenne, Wyoming. Retrieved 2014, from http://soswy.state.wy.us/Rules/RULES/8882.pdf

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ADDENDUM MP-5

ADDENDUM MP-5

Fire Control Plan

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MP-5.1 INTRODUCTION

The following is a description of the contingency plan to preclude sustained combustion of any materials constituting a fire hazard.

MP-5.2 FIRE PREVENTION

The first line of fire control will be fire prevention. Prevention of fires will be accomplished by recognizing potential fire hazards and correcting the situation before the fire starts. A conscientious effort will be made to avoid the possibility of a fire breaking out; various safeguards have been incorporated into the system in order to ensure this.

MP-5.2.1 Monitors

Various types of monitors will be utilized in the mine facilities to detect conditions that could lead to fire. Methane detectors will be employed at the storage and load-out facilities to determine the presence of methane gas. Portable methane detectors will be used at other areas of the mine where needed.

MP-5.2.2 Coal Dust Suppression

Coal dust will be controlled to prevent fires and explosions. Baghouses will be used at all crushing facilities to remove dust from the air. Dust accumulations on surfaces will be kept to a minimum. Explosion-safe motors will be used in critical areas where coal dust might be ignited by an electric arc.

MP-5.2.3 Spontaneous Combustion

The potential exists for spontaneous combustion of coal. In order to minimize this hazard, coal will be blasted ahead of coal loading only as far as is necessary. The blasted coal will then be processed through the coal handling facilities, and placed in storage for load-out. If the coal becomes "hot" while in storage, it will be removed from storage and hauled to the pit where it will be spread, compacted, and buried as necessary.

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All flammable materials will be properly stored and identified. Flammable liquids will be cleaned from mine equipment. Mine equipment will be kept free of flammable liquid leaks.

MP-5.2.4 Maintenance

All mine equipment will be kept as free as possible of any fire hazard. The shop and warehouse will be kept free of grease buildup. Electrical equipment will be kept in good repair. In general, a conscientious effort will be made to prevent the development of fire hazards.

MP-5.2.5 Warning Signs

Appropriate signs warning against smoking and open flames will be placed in any area where a fire or explosive hazard exists. Flammable liquids or any other explosive material will be kept in properly identified containers.

MP-5.3 FIRE CONTROL EQUIPMENT

Fire control equipment will be kept in good condition and repair, and will be fully operational at all times. Fire control equipment will be kept readily available for use. Portable fire extinguishers will be in every building, on boards all vehicles and mobile equipment, and at all combustible liquid storage areas.

During large scale operations, the mine will maintain a fire-water reserve of suitable capacity for a Type IA and IB building of approximately 100,000 square feet. This equates to 3500 gallons per minute for 3 hours (630,000-gallon capacity) (International Code Council, 2012). There will be a fire truck, and the facilities will all have access to fire hydrants. The water trucks may be used to supply water to isolated areas of the mine for firefighting purposes. All mine employees will receive evacuation procedures and basic fire control training (i.e. the use of fire extinguishers). A firefighting group will be instructed in more advanced methods of fire control in accordance with the

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approved fire control plan. The firefighting group will respond to any fire that cannot be immediately extinguished.

MP-5.4 FIRE CONTROL

If a fire starts, it will be brought under control in a safe and expeditious manner. All personnel at the mine will have basic training in fighting fires in order to rapidly and effectively bring a small fire under control. Generally, small fires will be put out by personnel at the scene. However, if the fire is too large to be extinguished in this manner, the designated firefighting group will be called to the scene.

The firefighting group will consist of personnel trained to control any type of fire that might occur at the mine, and trained to use all of the fire control equipment.

MP-5.4.1 Rangeland Fires

Rangeland fires will be controlled by accessing the area of the fire with the fire control truck and extinguishing the fire with hand-held fire extinguishers, shovels, the water truck or other equipment, depending on conditions.

MP-5.4.2 Coal

A coal fire in the pit will be extinguished by excavating the burning or smoldering coal and then spreading, compacting, and burying it as necessary.

MP-5.4.3 Coal Processing Facilities

A fire in the coal processing facilities will be controlled by using extinguishers or water from the hydrant system.

Fire control water will be available at the top of the load-out and silo storage through a dry pipeline running from the ground to the top of the facilities. This system will provide an adequate supply of fire control water.

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MP-5.4.4 Shop

A fire in the shop will be controlled by extinguishers of appropriate type, or by water from the hydrant system.

MP-5.4.5 Mobile Equipment

All mobile equipment will be equipped with hand-held fire extinguishers that will be used to control fires. Some larger equipment may be equipped with a fire control suppression system. The water trucks and fire control truck will be used when necessary.

MP-5.5 REFERENCES

International Code Council. (2012). *International Fire Code, Appendix B.*

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ADDENDUM MP-6

RAMACO

ADDENDUM MP-6

Subsidence Control Plan

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MP-6 SUBSIDENCE CONTROL PLAN

The subsidence control plan for RAMACO's Brook Mine was prepared by Cardno MM&A of Bluefield, Virginia.

MP-6.1 Highwall Mining Plan

Figure MP-6.1-1 shows the locations of the planned trench and highwall mining activities at the Brook Mine. The majority of highwall mining will be conducted in the two splits of the Carney seam. West of the Carney Seam's split line shown in Figure MP-6.1-1, the highwall mining activity will be concentrated primarily in the Carney lower split due to its greater thickness. East of the split line the two splits merge allowing full seam thickness extraction within the limits of the highwall mining machine. Figure MP-6.1 also shows the additional highwall mining planned in the lower Master's seam.

An ADDCAR highwall mining system was selected as the basis for the mine design. When only one of the two splits of the Carney Seam will be highwall mined, a lower profile cutter head that creates an 11.5-foot wide opening will be used. When the full Carney Seam is highwall mined, a larger cutter head that creates an 11.0-foot wide opening will be used. This machine is expected to have a 15.1-foot maximum cutting height. The Masters Seam is located approximately 10 to 15 feet beneath the Carney seam and is approximately 5 feet in thickness.

Highwall miner hole penetration depths of 2,000 feet are planned to the limits of known faulting and underground working within the mined seam. Highwall mining openings will be created in the bottom of the excavated trench. The majority of the excavated spoil will be used to backfill the trench and to cover the seam and associated highwall mining hole openings following completion of highwall mining in that area.

The ADDCAR highwall mining system was selected due to seam height and high tonnage output requirements associated with the proposed Brook Mine, and its highly accurate Mk_4 Navigational System that enables creation of

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very straight holes. The Mk4 Navigational System provided by Applied Mining Technologies obtains real time information on the cutter head from its Honeywell Tactical Advanced Land Inertial Navigator (*TALIN*) as it advances within a given hole. The operator is able to compare actual alignment relative to the preferred design azimuth. The TALIN (previously known as the Horta Inertial Guidance System) has been tested and confirmed to an accuracy of less than 100 mm off centerline over a distance of 384 meters of penetration. The navigational system should assure that intersection of the cutter head with previously completed highwall miner drives (that could lead to excessive unsupported roof spans and potentially lead to subsequent roof collapse or pillar failure) should not occur. Based on discussions with highwall mining equipment manufacturers, intersecting previously completed holes is a leading cause of roof instability in highwall mining operations.

Support pillars will be designed to have a width equal to or exceeding the maximum extraction thickness anticipated in a highwall mining hole based on the mine's geologic model. This width-to-height ratio of at least 1:1 results in pillar stability factors that exceed recommended values suggested by National Institute for Occupational Safety and Health's (*NIOSH*) ARMPS-HWM stability program for the overburden thicknesses expected. Pillar dimension will also be in accordance with Brook Mine's Ground Control Plan approved by MSHA.

MP-6.2 Review of Previous Mining Activity

Previous mining activity in the Carney seam has primarily been limited to underground extraction. Other seams in the area also have recorded underground extraction. The underground mining activity spanned a period of about 60 years ending in 1953. Based on a review of available mine mapping, the largest mine in the Carney seam was the historic Sheridan Wyoming Coal Company Mine No. 44 (Figure MP-6.2-1). Its relative location with respect to the proposed Brook Mine is shown in Figure MP-6.1-1.

Under certain circumstances, underground mining can result in a lowering of the ground surface, otherwise known as subsidence. Generally,

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subsidence is a function of the amount of underground extraction, the overburden thickness, coal thickness, and the properties of the supporting pillars and overlaying strata. Subsidence begins with either failure of the supporting pillar and or immediate roof within the mine. If the void space created by mining is larger than the volume of the collapsed overlaying rock strata (depending on the bulking factor of the overlying strata) the failure ultimately propagates to the surface resulting in a depression. Despite failure of supporting pillars and immediate roof in a given area, subsidence does not always occur, particularly in cases where the collapsed overburden swells sufficiently to fill the void space and provide some support to the overlying strata.

A review of aerial imagery shows that subsidence in the area of permitting has to a large degree been in the form of chimney type subsidence. Chimney type subsidence is characterized by small bowl-like surface depressions. Chimney subsidence is generally a result of the mine's immediate roof collapse rather than pillar failure. Over time, successive collapsing of overlying strata causes a "chimney like" rubble zone directly above the room opening.

High-induced stresses that could lead to roof collapse are usually created where roof spans are at that their greatest such as mine room intersections and/or areas of secondary recovery.

If the chimney does not stabilize by the natural bulking (self-choking) of the caved rock or the intersection with more competent and stronger strata, the propagation eventually reaches the surface.

Figure MP-6.2-2 shows historical imagery of highly concentrated chimney subsidence that overlays the southwestern portion of historic Mine No 44. This area ultimately became an Abandoned Mine Lands (*AML*) project and has since been reclaimed. Underground mapping of Mine No. 44 in the area of the AML work indicates that the high extraction panel rooms measured 20 feet in width. Entries in low extraction mains and submains measured 15 feet in

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width. Connecting crosscut openings generally measured 10 feet or less in width.

Overlaying the historical imagery and mine mapping shows that the chimney subsidence is primarily limited to the high extraction panel rooms of the underground mine (Figure MP-6.2-3). Mine mapping shows broad hatching through the panels and associated submains generally indicating secondary recovery of some portion of the supporting pillars. The effective increase in span length due to the selective process of secondary recovery is believed to have contributed to roof failure and subsequent chimney subsidence in the panels and submains.

Modeled seam thickness based on drilling indicates the Carney seam is approximately 14 feet in thickness in this area. The chimney type subsidence area shown in Figure MP-6.2-3 appears to be limited to areas of overburden cover depths of less than 120 to 150 feet.

Dyne (1998) derived an equation (Equation MP-6.2-1) to compute subsidence chimney height (z) assuming that roof failure occurs at the intersection of underground rooms.

Equation MP-6.2-1

$$z = 12/(\pi\,(k\text{-}1)\,(d_{base}^{\,2} + d_{surf}^{\,2} + d_{base}d_{surf}))\,(\pi/12\;t\,(d_{base}^{\,2} + D^2 + Dd_{base}) - ((D - w)/6\tan\theta)\,(D^2\arccos(w/D) - D^2/2\sin(2\arccos(w/D)) - \pi D^2/4 + w^2))$$

The equation is based on the following variables:

- w = width of mine rooms (ft)
- t = height of seam (ft)
- k = bulking factor = V_B/V where V is the initial volume and V_B is the volume of rubble
- Ø = angle of repose of caved rock within mine room
- d_{base} =diameter of collapse-chimney at base (ft)
- d_{surf} = diameter of collapse-chimney at surface (ft)

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- D = diameter of caved rock foot print on mine room floor (ft)

Figure MP-6.2-1-4 shows an explanation of the variables.

The equation confirms that roof spans of 20 to 25 feet in 14-feet high Carncy Scam that fail can produce chimney subsidence of approximately 150 feet in height if the chimney diameters are of the same width as the roof span. Based on the overburden strata composed generally of interbedded siltstones, sandstones, and mudstones, a bulking factor of 1.33 and angle of repose 35° were assumed.

If the shorter roof spans in the mains and submains had failed, there would have been evidence of chimney subsidence at depths in excess of 200 feet based on the above equation. The mining void space would have been able to accommodate the swelled volume of a higher, yet smaller, diameter chimney. Aerial imagery does not indicate chimney subsidence at these depths. Evidence of subsidence in mains and submains (Figure MP-6.2-3) is likely attributed to effective span lengthening associated with secondary recovery of adjacent pillars.

It is logical to assume that if the roof failure occurred in areas other than intersecting rooms, the lesser excavated void space (due to no crosscut opening) would result in a lower chimney height and reduced likely hood of surface subsidence (everything else being equal).

Proposed highwall mining opening widths of 11 to 11.5 feet are significantly less than the underground mine panel entry widths and the effective roof spans of any secondary recovery that likely contributed to ultimate roof failure in the aforementioned example for historic Mine No. 44.

Highwall miner holes will be oriented in the same azimuth as the holes in the Carney Seam located directly above. Its pillar dimensions will be sized based on the thicker Carney Seam so that "pillar stacking" is achieved.

Highwall mining should not result in surface subsidence due to:

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- Highly accurate guidance system on highwall mining system that will assure straight hole alignment
- Conservative pillar design based on a W:H ratio >= 1:1
- Pillar stacking for multiple-seam mining
- Narrow entry widths of 11 to 11.5 feet

MP-6.3 Subsidence Monitoring and Assessment

Although subsidence is not expected at the Brook Mine, the mine personnel will develop a program to monitor elevation changes that might be attributed to highwall mining activity. Elevation data will be collected for the ground surface above proposed highwall mining panels to construct a highly accurate pre-mining surface model. The majority of the elevation data will be obtained from airborne lidar surveys of the permit area. Survey control used to record (daily) mining activity will be used to verify the elevation model prior to commencement of mining activity.

The surface of each individual areas to be highwall mined will be evaluated 6 months prior mining to determine if there are pipelines, structures, streams or and other items that could be impacted by potential subsidence due to the highwall mining. Any items found during this evaluation will be inspected and documented as their pre-mining condition.

Visual monitoring of the surface will be conducted on a monthly basis to determine if cracking and subsidence has developed in areas of previous highwall activity. If any such locations of subsidence are discovered, surveys will be conducted and checked against digital records of hole penetrations in the area.

Stream profiles in areas directly overlaying proposed highwall mining activity will be developed prior to commencement of the activity. Once highwall mining has been completed beneath the stream, additional surveys will be conducted semi-annually to verify that subsidence has not occurred for three consecutive surveys.

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Any observed subsidence will be documented. Such occurrences will be given a unique identification number, photographed during each visual monitoring inspection, and located on a map. This information along with associated highwall mining mapping will be maintained in a subsidence report that will be available for inspection.

These areas will be monitored for at least 6 months after highwall mining of the individual areas are completed. If there is no evidence of subsidence then the monitoring of the area will be discontinued.

MP-6.4 Subsidence Control and Remediation

If evidence of subsidence is discovered, the area will be staked to mark its location and will be given sufficient time to stabilize and self-heal. Backfilling of any subsidence will be performed on a selective/as-needed basis so that the surface land can be restored to a condition capable of supporting the uses that it was capable of supporting prior to subsidence. Backfilling will also be performed if it is determined that the introduction of water and oxygen could contribute to spontaneous ignition of the remaining coal not extracted from the highwall mining operations. Backfilling will commence within 12 months of a subsidence location being identified if self-healing is not providing sufficient remediation.

Once backfilled, topsoil will be placed over the impacted area. WDEQ/LQD – approved seeding found in the Reclamation Plan will be applied to complete the remediation work.

Regardless of its right to subside the surface, the operator acknowledges that, if subsidence due to its mining operation causes material damage or reduces the value of the reasonable foreseeable use of the surface lands, the land will, to the extent technologically feasible, be restored to a condition capable of supporting the uses it was capable of supporting prior to subsidence. The operator will continue to perform remediation on any subsidence, detected during or subsequent to the 6 month monitoring period, until bond release is approved.

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MP-6.5 References

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NIOSH (August 2013). *Mining Product: ARMPS-HWM - Analysis of Retreat Mining Pillar Stability - Highwall Mining.* Retrieved from http://www.cdc.gov/niosh/mining/works/coversheet1811.html

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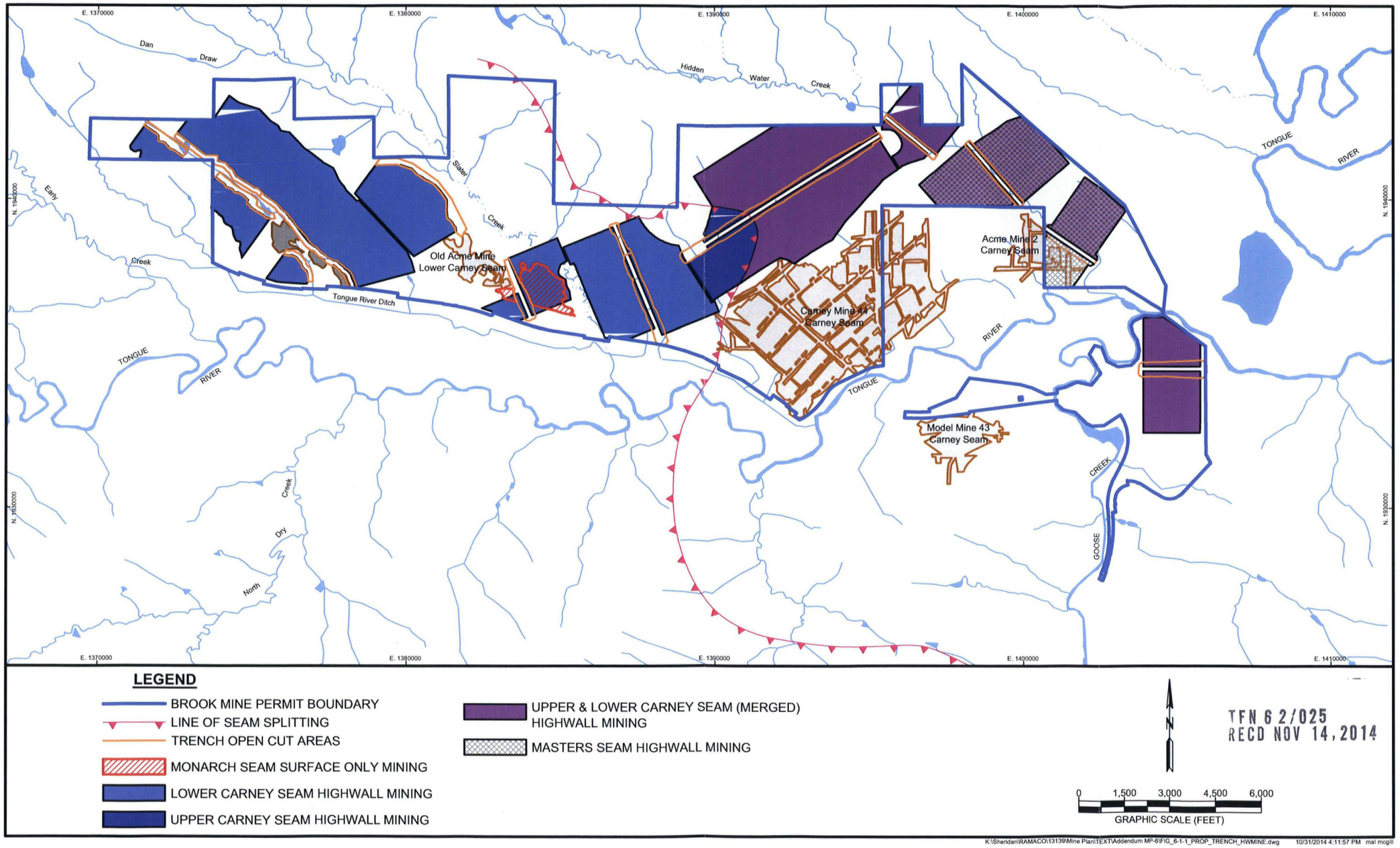

Figure MP-6.1-1 Showing Brook Mine Proposed Trenches and Highwall Mining Panels

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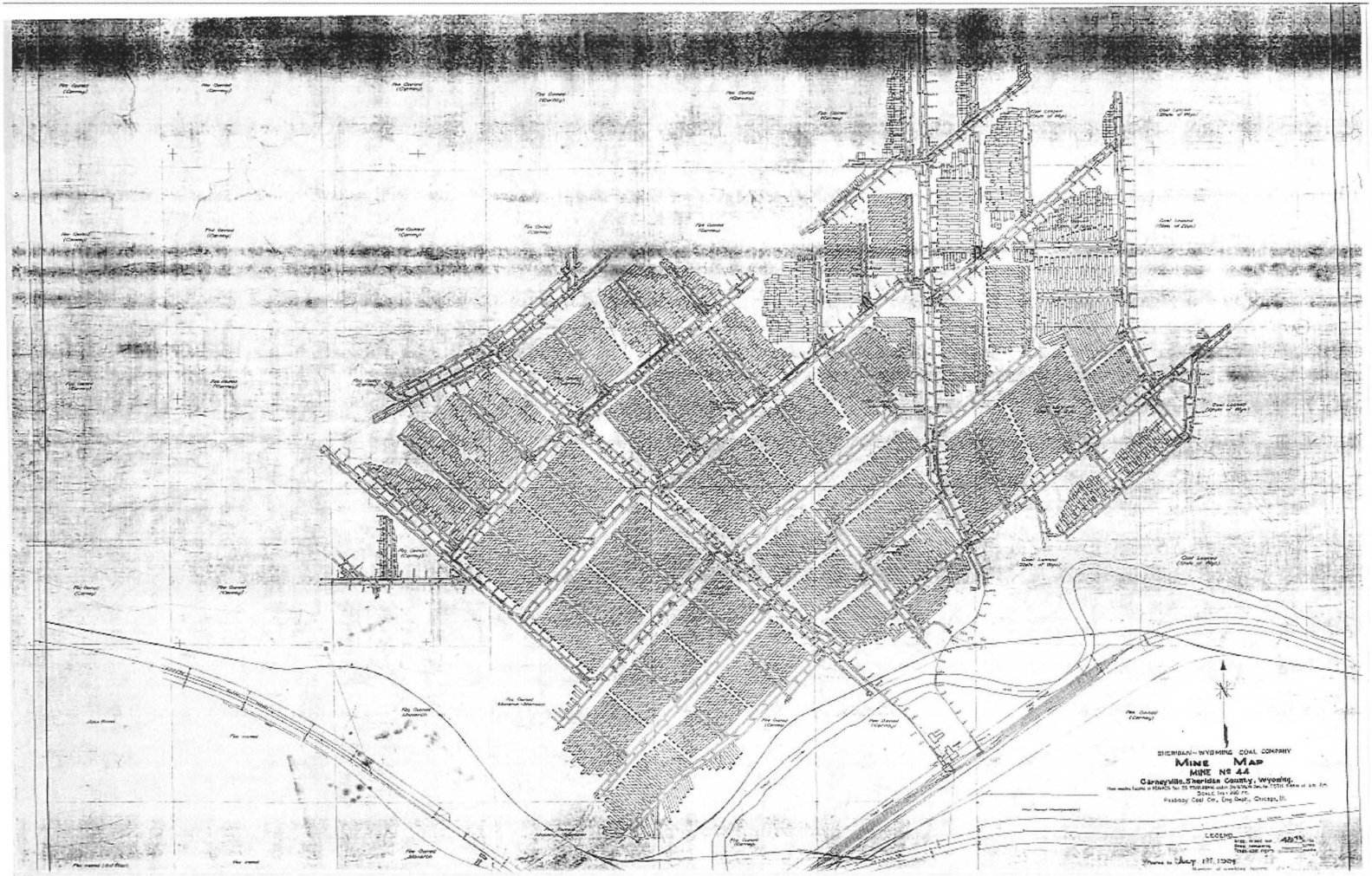

Figure MP-6.2-1 Sheridan Wyoming Coal Company Mine No. 44 in Carney Seam

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Figure MP-6.2-2 Chimney Subsidence Above Portion of Mine No. 44

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Figure MP-6.2-3 Chimney Subsidence Concentrated in High Extraction Panels (with Overburden Cover Depths)

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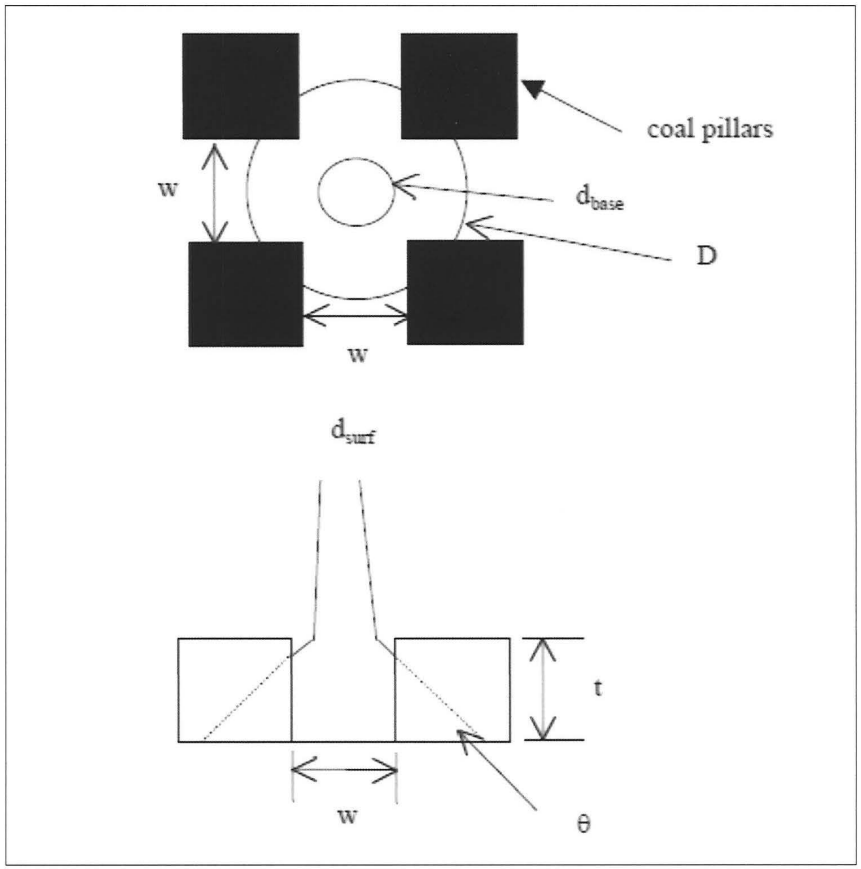

Figure MP-6.2-4 Explanation of Variables in Equation MP-6.2-1 (Dyne, 1998)

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ADDENDUM MP-7

ADDENDUM MP-7

Blasting Plan Supplemental Materials

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BLASTER'S LOG
RAMACO: BROOK MINE
SHERIDAN COUNTY, WYOMING

NOTE: THIS LOG MUST BE COMPLETED IN ITS ENTIRITY.

BLAST
LOCATION:_____
DATE:_____TIME:_____

NEAREST WELL, PIPELINE, OR ENGINEERED STRUCTURE
NAME:_____DISTANCE:_____DIRECTION:_____

NEAREST INHABITED STRUCTURE
NAME:_____DISTANCE:_____DIRECTION:_____

WEATHER CONDITIONS
TEMPERATURE:_____CLOUDS:_____
WIND DIRECTION:_____WIND VELOCITY:_____
OTHER:_____

MATERIAL BLASTED
TYPE:_____

HOLES
NUMBER:____DEPTH:____SPACING:____DIAMETER:____BURDEN:____

EXPLOSIVES
TYPE:_____TOTAL WEIGHT PER HOLE: _____
TYPE:_____TOTAL WEIGHT PER HOLE: _____
TYPE:_____TOTAL WEIGHT PER HOLE: _____
NUMBER OF ANFO BAGS:_____

DETONATED WITHIN ANY 8-MILLISECOND DELAY PERIOD
MAXIMUM WEIGHT OF EXPLOSIVES:_____MAXIMUM NUMBER OF HOLES:_____
INITIATION SYSTEM:_____

STEMMING
TYPE:_____LENGTH:_____
TYPE OF PROTECTION USED:_____

DETONATORS
TYPE:_____DELAY PERIODS:_____
AMOUNT OF DETONATING CORD:_____

BOOSTERS
TYPE:_____NUMBER:_____

DELAYS
TYPE:_____LENGTH:_____

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RECD JUL 30,2015

SKETCH DRILL PATTERN AND DELAY PATTERN (ATTACH TO LOG)

SEISMOGRAPH (IF REQUIRED)
CALIBRATION SIGNAL OF GAIN SETTING:_____
READING:_____
LOCATION:_____
DISTANCE:_____
NAME OF PERSON TAKING READING:_____
NAME OF PERSON OR FIRM ANALYZING THE RECORD:_____
VIBRATION AND/OR AIRBLAST RECORDED:_____

PROTECTIONS USED:_____
TIME OF DETONATION:_____
NOTE ANY MISFIRES:_____
NUMBER OF PERSONS IN BLASTING CREW:_____

BLASTER-IN-CHARGE
NAME:_____LICENSE NUMBER:_____

SIGNATURE:_____

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RAMACO: BROOK MINE
SHERIDAN COUNTY, WYOMING

Blasting will be limited to daylight hours (between sunrise and sunset) Monday through Sunday of each week.

Access to the blasting area will be controlled by fences and mine personnel. Signs stating "BLASTING AREA" will be posted at the public access points to the Brook Mine Permit Area, and in the vicinity of the immediate blasting site. Mine personnel will prevent unauthorized entry to the immediate blasting area starting at least 10 minutes prior to the blast, and after the blast until the area has been declared free from unusual hazards due to the blasting operation.

Warning of a blast will consist of one siren blast given for one minute, five minutes prior to the explosives blast. One minute prior to the blast, a siren blast will be given ending with blast detonation. A 15-second siren blast will be given as an all-clear signal after the blast site has been inspected by authorized personnel for proper detonation of explosives. All sirens will be audible for one-half mile from the blast site. Meanings of the signals will be displayed.

It may be necessary to blast at times other than those specified before due to emergencies caused by changing weather conditions or to meet operator and public safety requirements.

Any resident or owner of a man-made dwelling within one-half mile of any part of the Brook Mine Permit Boundary may request a preblast survey. Contact the Wyoming Department of Environmental Quality, Land Quality Division, 2100 West 5th Street, Sheridan, Wyoming, 82801 to request a preblast survey.

RAMACO, LLC
Brook Mine
1101 Sugarview Drive, Suite 201
Sheridan, WY 82801

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ADDENDUM MP-8

ADDENDUM MP-8

Wildlife Monitoring Plan

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MP-8.1 INTRODUCTION

RAMACO, LLC (RAMACO) will conduct annual wildlife monitoring at the proposed Brook Mine permit area and in the lands adjacent to the permit area. The following wildlife monitoring plan is based on regulations approved by Wyoming Department of Environmental Quality/Land Quality Division (WDEQ/LQD). Depending on the type of survey being conducted, the survey area will include the Brook Mine permit area and up to a one-mile perimeter. Monitoring procedures are described by the following animal groups:

- Upland Game Birds
- Raptors
- Migratory Birds of Conservation Concern
- Threatened and Endangered Species

MP-8.2 UPLAND GAME BIRDS

MP-8.2.1 Lek Searches

All suitable lek habitat on the term of permit area and a one-mile perimeter will be searched for new leks at least once each spring. Every third year (i.e., 2017, 2020, 2023, etc.) the entire permit area and a one-mile buffer will be searched for upland game bird leks. Lek searches will be conducted from late March through early May.

Ground surveys will be employed to search for leks. Each morning search will be started approximately one-half an hour before sunrise and last until one hour after sunrise. A biologist will search for leks by slowly traversing roads in the area. Frequent stops will be made at vantage points to scan and listen for strutting birds. Sites where grouse are found displaying will be mapped and checked two more times during the breeding season.

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MP-8.2.2 Lek Attendance Surveys

Several sage-grouse leks are located within the study area for the Brook Mine, but none are located within the Brook Mine permit area or within one

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mile. The Brook Mine is not situated within a designated sage-grouse core or connectivity area. Refer to Appendix D9 for a detailed discussion of lek attendance in the area. Any new sage-grouse leks that become established within one mile of the mine permit area, as identified during the wildlife monitoring surveys will be checked three times, from April through early May. In subsequent years, those leks will be monitored annually on three mornings.

MP-8.2.3 Data Presentation

The results of all surveys will be reported annually to WDEQ/LQD. Lek locations, including inactive leks, will be shown on a report map. Lek attendance will be reported as number of males and number of females observed.

The distance from each lek to the closest regular human or equipment activity will be determined annually and documented. The presence or absence of direct line-of-sight from leks to disturbance will also be noted. Acreage disturbed during the annual reporting period will be delineated by habitat type; cumulative disturbed acreage will also be calculated. Cumulative acreage of permanent reclamation (classified as upland or bottomland) will also be reported.

MP-8.3 RAPTORS

MP-8.3.1 Nest Surveys

Surveys for nesting raptors in the Brook Mine study area began in 2013. Additional raptor surveys have been completed in the area for the nearby Big Horn Coal Mine, Young's Creek Mine, and Welch No. 1. During the Brook Mine surveys, 9 intact raptor nests were located within the permit area, and an additional 50 intact nest sites were located within two miles. Of the 59 total nest sites, 6 had been constructed for mitigation of nest sites removed by mining on adjacent areas, or due to powerline conflicts. The raptors known to nest on, or within two miles, or the permit area include the bald eagle, golden

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eagle, red-tailed hawk, great horned owl, burrowing owl, and osprey. Raptor nest sites are provided in the tables and on the map in Appendix D9.

Monitoring of known nests and searches for new nests will be continued annually for the permit area and one-mile perimeter using the baseline sampling methods. Guidelines will be followed to prevent nest abandonment or loss of eggs or young. On or before mid-February, surveys for bald eagle, golden eagle and great horned owl nests will be initiated within one-half a mile of existing mining activities and those activities proposed for the coming year. Additional surveys of the permit area and one-mile buffer will be conducted in March to locate all bald eagle, golden eagle and great horned owl nests, and in April to locate all nests of most other species. From mid-May through mid-June, surveys will be completed to locate new raptor nests and check the status of all known nests.

Scheduling of follow-up visits to previously identified nests will be timed to coincide with the breeding chronology of the species present. The objective of monitoring will be to document the occupation or territories, nest building, incubation, and fledgling success.

Nests will be found by traversing the study area, primarily by vehicle, and looking for pairs of individual adult raptors. Once spotted, birds will be observed until it can be determined if they are breeding in the area. If their behavior does not provide conclusive evidence about breeding status, birds will be approached on foot. If that causes birds to display nest defense behavior, the surrounding area will be thoroughly searched for a nest.

Nests will also be located by using a spotting scope to examine nesting habitat such as creek banks, trees and rimrocks. Because many raptors nest in trees, groves of trees may also be searched on foot. Whenever a nest is found, its location will be plotted on a topographic map.

The status of nests will be recorded annually. The productivity of active nests will be determined prior to young birds having fledged.

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MP-8.3.2 Prey Abundance

A spotlight driving survey for lagomorphs will be conducted on two consecutive nights in August or September. The survey route will utilize roads within the permit area or adjacent lands. All major habitat types in the area will be included on the route. As reclaimed areas become available, these will also be included in the surveys.

MP-8.3.3 Data Presentation

Nesting raptor data will be presented in the annual reports submitted to WDEQ/LQD. Comparisons with previous years' data will be made and a table documenting history of all nests during the most recent five-year period will be presented. All nest locations will be shown on a wildlife monitoring map.

The distance from all nests to the closest regular human or equipment activity will be measured annually. The presence or absence of visual barriers between the nest and disturbance will also be recorded.

MP-8.3.4 Raptor Mitigation Plan

Prior to each permit renewal or major amendment or revision, RAMACO will update the Raptor Monitoring and Mitigation Plan provided in Addendum MP-9. The plan will be submitted to the U.S. Fish and Wildlife Service (USFWS) for review and comment. A letter stating USFWS approval of the plan will be included with the permit application.

MP-8.4 MIGRATORY BIRDS OF CONSERVATION CONCERN

A monitoring and mitigation plan for migratory birds of conservation concern at the Brook Mine is provided in Addendum MP-9. Annual surveys will be conducted in conjunction with other wildlife monitoring from February through July. The dates and locations of all observations of migratory birds of conservation concern that are considered uncommon or rare will be reported to WDEQ/LQD in the annual reports.

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MP-8.5 FEDERALLY LISTED THREATENED AND ENDANGERED SPECIES

Observations of any threatened and endangered species on or near the Brook Mine permit area will be reported in the annual reports to WDEQ/LQD. Any dead or impaired individual of a listed species found in the permit area will be reported to the USFWS within one working day. As of June 2015, the USFWS recognizes the greater sage-grouse (candidate species), Canada lynx (threatened species), and Ute ladies'-tresses (threatened species) as species that could potentially be impacted by projects in Sheridan County, Wyoming. The following subsections discuss these three species as well as other species of concern.

MP-8.5.1 Greater Sage-Grouse

The sage-grouse is not currently a listed threatened species. However, it is a candidate species. The sage-grouse has been documented in the Brook Mine study area. No leks have been found in the permit area or one-mile perimeter. The nearest sage-grouse lek is a little over one mile from the permit area. The Brook Mine is not located in a designated sage-grouse core area. Sagebrush shrublands are present in the permit area and provide the primary habitat for sage-grouse. Sage-grouse presence will be monitored. Refer to Section MP-8.2 for the upland game bird monitoring plan.

MP-8.5.2 Canada Lynx

The Canada lynx requires mountainous forest habit. The Brook Mine is not located in an area with this type of habitat. Therefore, the Canada lynx should not be affected by this operation.

MP-8.5.3 Ute Ladies'-Tresses

Ute ladies'-tresses is a plant species. It is addressed in Appendix D8. Baseline studies did not find this plant species in the study area. Should either the plant or appropriate habitat be identified, the following protective measures will be implemented:

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- The mine will conduct surveys in areas of suitable habitat.
- The mine will evaluate indirect effects, if any, of changes in hydrology on known Ute ladies'-tresses habitat, both on and off the permit area.
- If the orchid is found, the mine will attempt to avoid direct removal of the plant or its habitat, including loss of the suitable hydrology which supports the habitat.
- If avoidance is not possible, plant seeds and plant tissue shall be collected. Additionally, as many individuals as possible shall be "salvaged" and transported to an approved greenhouse facility for propagation.
- If Ute ladies'-tresses occur in the permit area, and avoidance is not possible, the mine shall pursue easements for known populations on private lands to protect those existing populations.
- To minimize potential competition in occupied Ute ladies'-tresses habitat, weed invasions in reclamation should be minimized.

MP-8.5.4 Northern Long-Eared Bat

The USFWS announced on April 1 of 2015 that the northern long-eared bat (*Myotis septentrionalis*) would be listed as a threatened species under the Endangered Species Act (ESA) with an effective date of May 1, 2015. This bat requires forested habitats for roosting and foraging. The bat has only been found in Wyoming in the northeastern part of the state in the Black Hills. Suitable habitat for the bat is not present on the Brook Mine and at this time the USFWS does not believe any projects in Sheridan County will impact this species (USFWS IPAC, 2015).

MP-8.5.5 Bald Eagle

The bald eagle is common in the Sheridan County area as a winter migrant and breeder. Bald eagles are commonly observed along the Tongue River and Goose Creek area in the winter. They tend to be scattered with few high concentration roost areas. Bald eagles breed and nest near the Brook Mine but not within the permit area. Bald eagle roost surveys are conducted during the winter period (December – February).

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If an active bald eagle nest or roost is found, the mine will establish a no disturbance buffer around the nest/roost as agreed upon with the USFWS until nesting/roosting is complete. This no disturbance buffer may be modified if justified by local topography (i.e., limited sight lines from the nest/roost). Modification of the buffer zones must be approved by USFWS. Mining should avoid removing nesting or roosting areas and trees. Avoidance should not be an issue at the Brook Mine because surface disturbance is more limited than typical surface mines. If disturbance must occur in a nesting or roosting area, it will occur outside of the nesting/roosting season. Any tree lost in these areas will be replaced by replanting trees of the same species as soon as possible; or trees may be replaced through construction of an approved artificial nest after mining in the affected area.

MP-8.5.6 Mountain Plover

Mountain plovers were not observed during the baseline studies although habitat in the form of black-tailed prairie dog colonies is abundant. Mountain plovers were not recorded on adjacent lands either. However, if active nesting areas are located and mining is proposed within one-quarter mile of any nest in the area, all mining activities will be planned to occur outside of the nesting period of early April through early July. If the nest(s) becomes inactive, and nesting is not reinitiated, mining can proceed in the areas prior to early July. If mining is planned for a nesting area, surveys for plovers will occur in the same year as the mining activity, within the proposed disturbance area, and in accordance to USFWS-approved guidelines. If an active nest not located during nesting surveys is found within 200 meters (0.12 mile) of active mining, mining activities in the area will cease until nesting is completed and the chicks leave the nest, or until the nest is no longer active. Reclamation of active nesting areas will return the area to similar premining topography and vegetative conditions.

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MP-8.5.7 Black-Footed Ferrets

In February 2004, the USFWS Ecological Services Office in Cheyenne, Wyoming issued a letter stating "black-footed ferret surveys are no longer necessary in black-tailed prairie dog colonies state wide" (USDI, Fish and Wildlife Service, February 2, 2004). Due to the fact that only black-tailed prairie dog colonies are present within the Brook Mine study area, no black-footed ferret surveys or mitigation measures are required.

MP-8.6 REFERENCES

USDI, Fish and Wildlife Service (USFWS). (February 2, 2004). *Black-footed Ferret Block Clearance Letter.* Cheyenne, Wyoming: Ecological Services Office.

USDI, Fish and Wildlife Service (USFWS) Information, Planning and Conservation System (IPAC). (June, 2015). Threatened and Endangerd Wildlife Species and Migratory Birds of Conservation Concern. USFWS Wyoming Ecological Services Office.

Wyoming Department of Environmental Quality/Land Quality Division (WDEQ/LQD). (1994, August). *Guideline Number 5: Wildlife.* Retrieved 2014, from http://deq.state.wy.us/lqd/guidelns/Guideline5.pdf

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ADDENDUM MP-9

ADDENDUM MP-9

Migratory Birds of Conservation Concern and Raptor Monitoring and Mitigation Plan

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MP-9.1 INTRODUCTION

RAMACO, LLC (RAMACO) intends to mine coal at the proposed Brook Mine within Sheridan County, Wyoming approximately 8.5 miles north of the city of Sheridan, Wyoming. The proposed Brook Mine is located within the Sheridan Coal Field of the Powder River Basin.

To supplement the wildlife baseline data provided in Appendix D9, and the Brook Mine Mine Plan, the following document provides a mitigation plan for migratory birds of conservation concern (migratory birds) and raptors. Wyoming Department of Environmental Quality/Land Quality Division (WDEQ/LQD) stipulates in Guideline Number 5 "Wildlife" that prior to permit approval, and each subsequent renewal, amendment, or revision, the U.S. Fish and Wildlife Service (USFWS) must be consulted to develop (or update) a raptor and migratory bird protection/mitigation plan.

Wildlife baseline studies were conducted at the Brook Mine permit area from 2013 through 2014. Additional to the Brook Mine wildlife baseline study, wildlife baseline studies were conducted in the vicinity for the Youngs Creek Coal Mine (Permit No. 407), the Big Horn Coal Mine (Permit No. 213-T7), and the Welch No. 1 Coal Mine (Permit No. 497).

The following discussion is a description of the Brook Mine permit area and the migratory bird /raptor study areas. Items of discussion include survey methods; status and expected occurrence of migratory birds and raptors; nesting history; potential impacts; and proposed monitoring and mitigation during operations. This monitoring and mitigation plan will be updated as necessary with any permit renewals, amendments, or revisions.

MP-9.2 STUDY AREA

The Brook Mine is located in north-central Sheridan County, Wyoming approximately 8.5 miles north of the city of Sheridan, Wyoming. The area is primarily rolling rangeland with steep hills and deep gullies that drain to the Tongue River south of the permit area. The bottomlands immediately adjacent

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to the Tongue River are relatively flat, and tend to have more trees along the Tongue River banks. Bottomland habitat also occurs in a minor extent along Slater Creek and Hidden Water Creek. Though less dense than along the Tongue River, trees do grow in the Slater Creek and Hidden Water Creek channels, and other draws within the permit area. Several small stock ponds lie within the permit area, and in the surrounding vicinity. Other bodies of water include abandoned mine pits related to historic coal mining activities. For a more detailed description of topography, refer to Appendix D5. For the baseline vegetation report, refer to Appendix D8. For habitats surveyed during the wildlife inventorying studies, refer to Appendix D9.

MP-9.3 MIGRATORY BIRDS OF CONSERVATION CONCERN

MP-9.3.1 Survey Methods

The USFWS has currently expressed concern about 24 species of migratory birds in Sheridan County, Wyoming. This list of species is available from the USFWS website and will be updated as they make revisions. The potential status of these birds was assessed by reviewing literature on each species' life history and habitat requirements. General information on their occurrence and status in the region was derived from Wyoming Game and Fish Department's *Atlas of Birds, Mammal, Reptiles, and Amphibians in Wyoming* (2012 and subsequent revisions). Site-specific information was obtained by reviewing baseline and monitoring data from the Youngs Creek Coal Mine (Permit No. 407), the Big Horn Coal Mine (Permit No. 213-T7), and the Welch No. 1 Coal Mine (Permit No. 497).

Surveys of migratory birds at the Brook Mine were conducted during the wildlife baseline studies for all avian species. On survey days, biologists drove and walked through the area scanning for migratory birds MBHFI. However, efforts were concentrated in habitats most likely to attract these species, such as reservoirs, playas, riparian areas, treed areas, and black-tailed prairie dog (*Cynomys ludovicianus*) colonies. In addition to specific searches, observers also watched for migratory birds while conducting other field studies

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throughout the year and breeding bird transects were sampled in important habitats. All migratory bird sightings were recorded, including notes on location, habitat, and activity.

MP-9.3.2 Migratory Bird Status and Expected Occurrence

The seasonal and breeding status of migratory bird species of conservation concern in the region, and in the vicinity of the Brook Mine, are summarized in Table MP-9-1. General and site-specific records, and information on habitats available at the Brook Mine, were used to hypothesize the expected occurrence of each species listed in the area. Migratory bird sightings made during baseline and monitoring studies were also noted. Twenty of the twenty-four species listed for the Sheridan County region have been recorded on or near the Brook Mine permit area. However, only four species observed were considered common, four species were occasionally observed and 12 were uncommonly observed.

MP-9.3.2.1 Raptor Species of Concern

Seven raptor species of concern are recognized for the region. All of those species have been observed in the vicinity of the Brook Mine permit area and include:

- Bald Eagle scientific names are already provided in referenced Table MP-9-1
- Burrowing Owl
- Ferruginous Hawk
- Golden Eagle
- Prairie Falcon
- Short-Eared Owl
- Swainson's Hawk

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Of the seven raptors observed, only golden eagles and bald eagles are common. The other five raptors are only uncommonly observed as summarized in Table MP-9-1. Birds of prey are discussed in more detail in the section on raptors.

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MP-9.3.2.2 Non-Raptor Migratory Birds of Concern

Fourteen species of non-raptor migratory birds of conservation concern have been identified by the USFWS for the Sheridan County region. Eleven of these fourteen species of concern were observed on or in the vicinity of the permit area during the various baseline wildlife inventories completed in the area including:

- Brewer's Sparrow
- Calliope Hummingbird
- Grasshopper Sparrow
- Greater Sage-grouse
- Lewis's Woodpecker
- Loggerhead Shrike
- Long-billed Curlew
- McCown's Longspur
- Pinyon Jay
- Red-headed Woodpecker
- Sage Thrasher
- Upland Sandpiper
- Willow Flycatcher

The Brewer's sparrow, grasshopper sparrow, Lewis woodpecker, loggerhead shrike, McCown's longspur, red-headed woodpecker, sage thrasher, upland sandpiper and willow flycatcher were have breeding habitat in the vicinity of the permit area. These species have a high probability of nesting within suitable habitats in the area.

The sage-grouse, a candidate species, was not observed on or within one mile of the permit area in 2014 but has been observed in the area in the past. Suitable habitats in the form of sagebrush shrublands are still present on the site. The mountain plover was removed from the proposal to list in 2011 and has not been recorded on the study area in 2014 or prior years.

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The black rosy-finch, calliope hummingbird, Cassin's finch, long-billed curlew and pinyon jay have not been recorded nesting in the area and may only be present as seasonal migrants.

MP-9.3.3 Migratory Bird Monitoring and Mitigation

Wildlife monitoring on Brook Mine will include surveys from February through July for determination if migratory bird species of conservation concern are nesting on the permit area or adjacent lands. Surveys are conducted in conjunction with all other wildlife monitoring surveys. Potential nesting habitat for mountain plovers is searched during the April through July period to determine the presence of these species. Sage-grouse lek surveys are conducted annually, as required. Bald eagle roost surveys are conducted during the winter period (December – February). Many other species of federal concern may migrate through the area because potential nesting habitat is not available to entice them to reside there. If rare or uncommon species are observed nesting on the permit or adjacent areas where impacts may occur, the USFWS will be contacted for determination of the mitigation procedures to be implemented.

MP-9.4 CANDIDATE, THREATENED OR ENDANGERED SPECIES

Observations of any threatened and endangered species on or near the Brook Mine permit area will be reported in the annual reports to WDEQ/LQD. Any dead or impaired individual of a listed species found in the permit area will be reported to the USFWS within one working day. As of June 2015, the USFWS recognizes the candidate greater sage-grouse, threatened Canada lynx (*Lynx rufus*), and threatened Ute ladies'-tresses (*Spiranthes diluvialis*) as species that could potentially be impacted by projects in Sheridan County, Wyoming.

The sage-grouse was not observed on the permit or within one mile in 2014 but has been observed in the area in prior years. Annual lek surveys are conducted as required and any leks, nesting birds or individuals found will be

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protected. The reestablishment of sagebrush on reclaimed lands will provide habitat for the species following mining.

The Canada lynx has never been recorded in the study area and would not be expected on the site because habitat is not present. Therefore no specific monitoring or mitigation measures are proposed for the-is species.

The Ute ladies'-tresses occupies wetland habitats that contain subirrigated conditions usually into August. Prior surveys for this species have been conducted on site and no Ute ladies'-tresses were found. Additional surveys will be conducted for this species prior to disturbance of suitable habitats.

The northern long-eared bat (*Myotis septentrionalis*) was listed as a threatened species under the Endangered Species Act (ESA) in 2015. The USFWS has not included this bat on their list of species that would be affected by projects in Sheridan County so no monitoring or mitigation is proposed.

MP-9.5 RAPTORS

A raptor nest inventory was completed for the RAMACO Brook Mine permit area and one to two mile perimeter in 2013 and 2014. The results of those surveys are provided in Table MP-9-2 and locations are shown on map Exhibit MP-9-1. The bald eagle, golden eagle, red-tailed hawk (*Buteo jamaicensis*), great horned owl (*Bubo virginianus*), osprey (*Pandion haliaetus*) and burrowing owl have been recorded nesting within the study area. Several other species have been observed on the site but nests of those species were not found or confirmed and some were seasonal migrants.

MP-9.5.1 RAPTOR MONITORING

Monitoring of known nests and searches for new nests will be continued in the future for the permit area and one-mile perimeter using the baseline sampling methods. Guidelines will be followed to prevent nest abandonment or loss of eggs or young. On or before mid-February, surveys for golden eagle and great horned owl nests will be initiated within one-half a mile of existing mining

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activities and those activities proposed for the coming year. Additional surveys of the permit area and one-mile buffer will be conducted in March to locate golden eagle and great horned owl nests, and in April to locate nests of most other species. From mid-May through mid-June, surveys will be completed to locate new raptor nests and check the status of all known nests.

Scheduling of follow-up visits to previously identified nests will be timed to coincide with the breeding chronology of the species present. The objective of monitoring will be to document the occupation or territories, nest building, incubation, and fledgling success.

Nests will be found by traversing the study area, primarily by vehicle, and looking for pairs of individual adult raptors. Once spotted, birds will be observed until it can be determined if they are breeding in the area. If their behavior does not provide conclusive evidence about breeding status, birds may be approached on foot. If that causes birds to display nest defense behavior, the surrounding area will be thoroughly searched for a nest.

Nests will also be located by using a spotting scope to examine nesting habitat such as creek banks and rimrocks. Because many raptors nest in trees, groves of trees will be searched on foot. Whenever a nest is found, its location will be plotted on a topographic map.

The status of nests will be recorded annually. The productivity of active nests will be determined prior to young birds having fledged.

Prey abundance will be determined by a spotlight driving survey for lagomorphs. This lagomorph survey will be conducted on two consecutive nights in August or September. The survey route will utilize roads within the permit area or adjacent lands. All major habitat types in the area will be included on the route. As reclaimed areas become available, these will also be included in the surveys.

Nesting raptor data and prey abundance will be presented in the annual reports submitted to WDEQ/LQD. Comparisons with previous years' data will

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be made and a table documenting history of all nests during the most recent five-year period will be presented. All nest location will be shown on a wildlife monitoring map.

The distance from all nests to the closest regular human or equipment activity will be measured annually. The presence or absence of visual barriers between the nest and disturbance will also be recorded.

MP-9.5.2 RAPTOR MITIGATION

Map Exhibit MP-9-1 shows the five year term of permit disturbance area in relation to currently known raptor nests. Under the present plan mining operations during this permit term may be within the buffers, and impact nests, of the golden eagle, red-tailed hawk, osprey and great horned owl. The current USFWS buffers for raptor species commonly known to occur in the region or study area are listed below:

	Spatial Buffer (miles)	Seasonal Buffer
Golden Eagle	0.5	January 15 –July 31
Ferruginous Hawk	1.0	March 15 –July 31
Swainson's Hawk	0.25	April 1 – August 31
Bald Eagle	0.5	January 1 – August 15
Bald Eagle Roosts	0.5	November 1 – April 1
Prairie Falcon	0.5	March 1 – August 15
Short-eared Owl	0.25	March 15 – August 1
Burrowing Owl	0.25	April 1 – September 15
Osprey	0.25	April 1 – August 31
Red-tailed Hawk	0.25	February 1 – August 15
Great Horned Owl	0.125	December 1 – October 1
Cooper's Hawk (*Accipiter cooperii*)	0.25	March 15 – August 31
Northern Harrier (*Circus cyaneus*)	0.25	April 1 – August 15
American Kestrel (*Falco sparverius*)	0.125	April 1 – August 15

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Timing and buffer stipulations may be adjusted on a nest specific basis with prior approval from the USFWS.

Prior to impacting a raptor nest site the USFWS and WGFD will be consulted and the appropriate permits obtained. Currently most of the osprey nests that may be impacted are located on man-made nesting platforms or power poles. Moving these nesting platforms or erecting new platforms will be the most likely mitigation strategy for ospreys as well as some of the other nesting raptors. However all mitigation strategies will be approved by the USFWS and WGFD.

Electric power lines will be constructed in accordance with "Suggested practices for Avian Protection on Power lines: The State of the Art in 2006" Avian Power Line Interaction Committee (APLIC). 2006. Edison Electric Institute, APLIC, and the California Energy Commission. Washington, D.C. and Sacramento, CA. 209 pp) to lessen the chance of raptor electrocution

MP-9.6 MITIGATION PLAN REVISIONS

RAMACO may revise the Brook Mine MBHFI Mitigation Plan prior to any permit revision, amendment, or renewal which will result in changes in the mining sequence or timing of nest site disturbances. RAMACO will first contact the USFWS to solicit their opinion regarding the need to revise the Mitigation Plan. If the USFWS determines the Mitigation Plan needs to be updated, a revised Mitigation Plan will be submitted to the USFWS for approval. A letter stating USFWS-approval of the revised Mitigation Plan will be included with the revision, amendment, or renewal.

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MP-9.7 REFERENCES

USDI, Fish and Wildlife Service (USFWS) Information, Planning and Conservation System (IPAC). (June, 2015). Threatened and Endangered Wildlife Species and Migratory Birds of Conservation Concern. USFWS Wyoming Ecological Services Office.

Wyoming Department of Environmental Quality/Land Quality Division (WDEQ/LQD). (1994, August). *Guideline Number 5: Wildlife.* Retrieved 2014, from http://deq.state.wy.us/lqd/guidelns/Guideline5.pdf

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Table MP-9-1. USFWS Migratory Bird Species of Conservation Concern in Sheridan County, Wyoming (Updated July 2015)*

Species	Regional Seasonal Status	Observed in Brook Mine Area or in Vicinity	Expected Occurrence in Study Area
American Bittern (*Bataurus lentiginosus*)	Breeder	No	Uncommon
Bald Eagle (*Haliaeetus leucocephalus*)	Year-round	Yes	Common
Black Rosy-Finch (*Leucosticte atrata*)	Year-round	No	Uncommon
Brewer's Sparrow (*Spizella breweri*)	Breeder	Yes	Common
Burrowing Owl (*Athene cunicularia*)	Breeder	Yes	Uncommon
Calliope Hummingbird (*Stellula calliope*)	Breeder	Yes	Occasional
Cassin's Finch (*Carpodacus cassinii*)	Year-round	No	Occasional
Ferruginous Hawk (*Buteo regalis*)	Breeder	Yes	Occasional
Golden Eagle (*Aquila chrysaetos*)	Year-round	Yes	Common
Grasshopper Sparrow (*Ammodramus savannarum*)	Breeder	Yes	Occasional
Greater Sage-grouse (*Centrocercus urophasianus*)	Year-round	Yes	Uncommon
Lewis's Woodpecker (*Melanerpes lewis*)	Breeder	Yes	Uncommon
Loggerhead Shrike (*Lanius ludovicianus*)	Breeder	Yes	Uncommon
Long-billed Curlew (*Numenius americanus*)	Breeder	Yes	Uncommon
McCown's Longspur (*Calcarius mccownii*)	Breeder	Yes	Uncommon
Mountain Plover (*Charadrius montanus*)	Breeder	No	Rare
Pinyon Jay (*Gymnorhinus cyanoceohalus*)	Year-round	Yes	Uncommon
Prairie Falcon (*Falco mexicanus*)	Year-round	Yes	Occasional

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Table MP-9-1. USFWS Migratory Bird Species of Conservation Concern in Sheridan County, Wyoming (Updated July 2015)*

Species	Regional Seasonal Status	Observed in Brook Mine Area or in Vicinity	Expected Occurrence in Study Area
Red-headed Woodpecker (*Melanerpes erythrocephalus*)	Breeder	Yes	Unommon
Sage Thrasher (*Oreoscoptes montanus*)	Breeder	Yes	Common
Short-Eared Owl (*Asio flammeus*)	Breeder	Yes	Occasional
Swainson's Hawk (*Buteo swainsoni*)	Breeder	Yes	Occasional
Upland Sandpiper (*Batramia longicauda*)	Breeder	Yes	Uncommon
Willow Flycatcher (*Empidonax trailii*)	Breeder	Yes	Occasional

* Based on USFWS Wyoming Ecological Services Field Office, Cheyenne, Wyoming and IPAC (Information, Planning, and Conservation System), July 2015.
Regional Seasonal Status and Expected Occurrence compiled from Wyoming Game and Fish Department Atlas of Birds, Mammals, Reptiles, and Amphibians in Wyoming, 2012. Specific records of observations from wildlife baseline surveys for Youngs Creek Mine, Big Horn Coal Mine, and the Welch No. 1 Coal Mine.

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Table MP-9-2 Raptor Nests Recorded on the Brook Mine Study Area in 2013 and 2014.

Species / Nest Site	Location	Nest Substrate	Status	Activity 2013	Activity 2014
Bald Eagle (BE)					
BE1	T57N R85W NWNE Sec. 24	Cottonwood	Intact	A,?,?	A,1+,?
BE2	T57N R85W SENE Sec. 21	Cottonwood	Intact	A,1+,1	A,2,2
BE3	T57N R84W SWSE Sec. 14	Cottonwood	Intact	A,0,0	Goose
BE4	T57N R84W NWNW Sec. 13	Cottonwood	Intact	RT26a	A,2,2
	Total BE Nests = 4		Total	3,1+,1+	3,5+,4+
Golden Eagle (GE)					
GE1a	T57N R84W SESE Sec. 5	Pine	Intact	I	A,0,0
GE1b	T57N R84W NENE Sec. 8	Pine	Intact	I	I
GE1c*	T57N R84W NESE Sec. 9	Pine	Intact	A,0,0	I
GE2	T57N R84W NENE Sec. 27	Pine	Intact	A,2,2	A,2,2
GE3	T57N R85W NWNW Sec. 11	Cottonwood	Intact	A,2,2	A,2,1
GE4	T57N R85W NESW Sec. 15	Cottonwood	Intact	A,1,1	I

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Table MP-9-2 Raptor Nests Recorded on the Brook Mine Study Area in 2013 and 2014. (Continued)

Species / Nest Site	Location	Nest Substrate	Status	Activity 2013	Activity 2014
Golden Eagle (GE) - Continued					
GE5	T57N R84W SESW Sec. 2	Pine	Intact	A,1,1	A,0,0
GE6	T57N R85W NENE Sec. 8	Cottonwood	Intact	A,0,0	I
	Total GE Nests = 8		Total	6,6,6	4,4,3
Red-tailed Hawk (RT)					
RT1*	T57N R84W SWNW Sec. 18	Cottonwood	Intact	A,0,0	A,3,3
RT2a*	T57N R85W NWNE Sec. 13	Cottonwood	Intact	--	A,3,3
RT2b*	T57N R84W NWNE Sec. 13	Cottonwood	Intact	A,2,2	I
RT3a*	T57N R84W NWSW Sec. 18	Cottonwood	Intact	I	I
RT3b*	T57N R84W NESW Sec. 18	Cottonwood	Intact	I	I
RT4	T57N R84W NWSW Sec. 17	Pine	Intact	I	I
RT5	T57N R84W SESW Sec. 15	Cottonwood	Intact	A,0,0	A,0,0
RT6*	T57N R84W NWNW Sec. 22	Mitigation Platform	Intact	I	I
RT7	T57N R84W NENW Sec. 23	Cottonwood	Intact	I	A,0,0

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DEQ 12-366

Table MP-9-2 Raptor Nests Recorded on the Brook Mine Study Area in 2013 and 2014. (Continued)

Species / Nest Site	Location	Nest Substrate	Status	Activity 2013	Activity 2014
Red-tailed Hawk (RT) - Continued					
RT8	T57N R85W SWSE Sec. 9	Cottonwood	Intact	A,0,0	I
RT9a	T57N R84W SESW Sec. 16	Cottonwood	Intact	I	I
RT9b	T57N R84W SESW Sec. 16	Cottonwood	No Longer Intact	I	DN
RT10	T57N R84W NENW Sec. 21	Cottonwood	Intact	A,2,2	A,2,2
RT11	T57N R84W NENW Sec. 21	Mitigation Platform	Intact	I	I
RT12	T57N R84W NENE Sec. 20	Cottonwood	Intact	I	GH1
RT13a	T57N R84W SWNW Sec. 20	Cottonwood	Intact	A,2,2	A,3,2
RT13b	T57N R84W SWNW Sec. 20	Cottonwood	Intact	Goose	I
RT14	T57N R84W NENE Sec. 19	Cottonwood	Intact	A,2,2	I
RT15a	T57N R84W SWNE Sec. 19	Cottonwood	Intact	A,?,?	Goose
RT15b	T57N R84W SWNE Sec. 19	Cottonwood	Intact	--	A,?,?
RT16	T57N R85W NENW Sec. 23	Cottonwood	Intact	A,?,?	A,?,?

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DEQ 12-367

Table MP-9-2 Raptor Nests Recorded on the Brook Mine Study Area in 2013 and 2014. (Continued)

Species / Nest Site	Location	Nest Substrate	Status	Activity 2013	Activity 2014
Red-tailed Hawk (RT) - Continued					
RT17a	T57N R85W SESW Sec. 15	Cottonwood	Intact	I	I
RT17b	T57N R85W SWSE Sec. 15	Cottonwood	Intact	--	A,?,?
RT18	T57N R85W SWSE Sec. 16	Cottonwood	Intact	I	A,0,0
RT19	T57N R85W NESW Sec. 3	Cottonwood	Intact	I	I
RT20	T57N R84W SWSW Sec. 3	Pine	Intact	--	A,3,3
RT21	T57N R84W NWSE Sec. 10	Pine	Intact	A,0,0	A,0,0
RT22	T57N R84W NENW Sec. 14	Pine	Intact	I	I
RT23	T57N R84W NESW Sec. 21	Pine	No Longer Intact	I	DN
RT24	T57N R84W NWSE Sec. 20	Cottonwood	Intact	I	I
RT25	T57N R84W SWSE Sec. 14	Cottonwood	Intact	BE3	Goose
RT26a	T57N R84W NWNW Sec. 13	Cottonwood	Intact	A,2,1	BE4
RT26b	T57N R84W NESW Sec. 13	Cottonwood	Intact	--	A,3,3

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DEQ 12-368

Table MP-9-2 Raptor Nests Recorded on the Brook Mine Study Area in 2013 and 2014. (Continued)

Species / Nest Site	Location	Nest Substrate	Status	Activity 2013	Activity 2014
Red-tailed Hawk (RT) - Continued					
RT27	T57N R84W NWSE Sec. 11	Cottonwood	Intact	I	I
RT28a	T57N R84W NESW Sec. 12	Cottonwood	Intact	A,2,2	I
RT28b	T57N R84W NWSW Sec. 12	Cottonwood	Intact	--	A,3,3
RT29	T57N R84W SWNE Sec. 11	Cottonwood	No Longer Intact	I	DN
RT30	T57N R84W NWSE Sec. 3	Pine	Intact	A,2,2	I
RT31	T58N R84W SWSE Sec. 32	Pine	No Longer Intact	A,0,0	DN
RT32	T58N R85W SESW Sec. 36	Cottonwood	Intact	A,0,0	A,0,0
RT33	T57N R84W SWSW Sec. 24	Cottonwood	Intact	GH3	A,0,0
	Total RT Nests = 41		Total	15,14+,13+	16,20+,19+
Great Horned Owl (GH)					
GH1	T57N R84W NENE Sec. 20	Cottonwood	Intact	I	A,3,3
GH2	T57N R84W NENW Sec. 21	Platform	Intact	I	I
GH3	T57N R84W SWSW Sec. 24	Cottonwood	Intact	A,1,1	A,0,0

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DEQ 12-369

Table MP-9-2 Raptor Nests Recorded on the Brook Mine Study Area in 2013 and 2014. (Continued)

Species / Nest Site	Location	Nest Substrate	Status	Activity 2013	Activity 2014
Great Horned Owl (GH) - Continued					
GH4	T58N R85W SESW Sec. 36	Cottonwood	No Longer Intact	A,2,2	DN
GH5	T57N R85W SWNE Sec. 17	Cottonwood	Intact	--	A,2,2
	Total GH Nests = 5		Total	2,3,3	3,5,5
Osprey (OS)					
OS1	T57N R84W SESE Sec. 15	Platform	Intact	Goose	I
OS2	T57N R84W SESE Sec. 15	Platform	Intact	Goose	AT
OS3	T57N R84W NWNW Sec. 22	Platform	Intact	A,0,0	A,3,3
OS4	T57N R84W SWSE Sec. 15	Platform	Intact	I	I
OS5	T57N R84W NWNW Sec. 24	Light Pole	Intact	A,2,2	A,3,3
	Total OS Nests = 5		Total	2,2,2	3,6,6

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DEQ 12-370

Table MP-9-2 Raptor Nests Recorded on the Brook Mine Study Area in 2013 and 2014. (Continued)

Species / Nest Site	Location	Nest Substrate	Status	Activity 2013	Activity 2014
Burrowing Owl (BO)					
BO1	T57N R84W NWNW Sec. 4	Prairie Dog Burrow	Intact	A,3+,3+	A,4+,4+
	Total BO Nests = 1		Total	1,3+,3+	1,4+,4+
	All Total Nests = 59 (Adjusted for nests used by more than one species)		**Total**	**29,29+,28+**	**30,44+,41+**

Abbreviation/Symbol Codes

X,#,# = Nest Status (A-active, I-inactive), number of young hatched, number of young fledged
Totals rows: #,#,# = total active nests, total young hatched, total young fledged

*	=	Denotes Nest Within Permit Area
--	=	Nest Not Present
DN	=	Destroyed Naturally
AT	=	Nest Actively Tended

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DEQ 12-371

C-French Springs
C-Ash Creek
C-Slater Creek
Pit 5 West
Pit 5 East
R. 85 W. R. 84 W.
T. 58 N.
T. 57 N.
Permit Boundary
Intact Raptor Nest
Intact Raptor Platform Nest
Former Raptor Nest
BE - Bald Eagle
GE - Golden Eagle
RT - Red-tailed Hawk
GH - Great Horned Owl
BO - Burrowing Owl
OS - Osprey
Sage-grouse Lek
Sharp-tailed Grouse Lek
Black-tailed Prairie Dog Colony
TOPSOIL REMOVAL SEQUENCE
YEAR 1
YEAR 2
YEAR 3
YEAR 4
YEAR 5
NAMING CONVENTION
HR HAULROAD
TR TRENCH/SURFACE MINING
OB OVERBURDEN STOCKPILE
GRAPHIC SCALE (FEET)
RAMACO
BROOK MINE
SHERIDAN COUNTY, WY
1101 SUGARVIEW DR. STE. 201
SHERIDAN, WY 82801
TFN 6 2/025
RECD DEC 18, 2015
REVISIONS
Date | Description
10/12/15 | Disturbance Boundaries Updated - RET
11/20/15 | Disturbance Boundaries (OB-3 & TR-1) Updated - RET
Exhibit MP-9-1
Migratory Birds of Conservation Concern and Raptor Monitoring and Mitigation Plan
Drawn By: MBM/RET
Checked By: JGB/JEO
Date: 7/6/2015
WWC ENGINEERING
www.wwcengineering.com
FILE: RC_Raptor_Mitigation Map_2015_(11-20-15_Revision_#3)