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Grassy Mountain Coal Project
Hydrogeology

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1.0 INTRODUCTION

1.1 Background

Benga Mining Limited (Benga) is proposing to develop the Grassy Mountain Coal Project (the "Project"); a steelmaking coal property located 7 km north of the town of Blairmore, Alberta within the Municipality of Crowsnest Pass (Figure 1.1-1). The majority of the proposed mining activities are located in the Municipal District of Ranchland No. 66, with some infrastructure being located in the Municipality of Crowsnest Pass. The Crowsnest Pass area has a long standing history of coal mining, and the Project is located within 50 km of Teck Resources Limited's metallurgical coal mines in British Columbia.

Benga acquired land in August 2013 from Devon Canada and Consol of Canada. Surface mining and underground mining occurred in the early to mid-1900s within the proposed Mine Permit Boundary (Figure 1.1-1), and the Project will target the same coal seams. Coal exploration programs were conducted by Benga in 2013, 2014, 2015 and 2016 to assess the quality and extent of the coal seams. The Project will include the recovery and processing of raw coal and is planned to produce up to 4.5 million tonnes of clean steelmaking coal annually over 24 years of active mining. The Project will include an access road, an overland conveyor, a rail and load-out, storage and disposal areas, the open pit coal mine and the coal handling processing plant (CHPP), *etc.* (Figure 1.1-2). The Project footprint is 1520.7 ha with the Mine Permit Boundary covering 3,701.4 ha.

This report describes the existing hydrogeological conditions in the area of the Project and provides an evaluation of potential effects to groundwater resources related to the proposed Project. In this report, all figures are presented in Appendix A and all tables in Appendix B unless indicated otherwise.

2.0 ASSESSMENT APPROACH

The overall assessment approach for the Project is outlined in Section D.3 of the Application (Benga 2016). Specific details regarding the approach for the hydrogeology assessment are outlined in the following subsections.

2.1 Terms of Reference

The Terms of Reference identifies information required by government agencies for an Environmental Impact Assessment as it relates to the Project. The final Terms of Reference were issued by the Alberta Energy Regulator (AER) on March 19, 2015, and requirements relating to hydrogeology are identified in Section 4.2 of the document (Alberta Energy Regulator 2015b). Hydrogeology related requirements in accordance with the *Canadian Environmental Assessment Act* (CEAA) are identified in

Section 6.1.4 of the Guidelines for the Preparation of an Environment Impact Statement (Canadian Environmental Assessment Agency 2015). Table B1 includes concordance references and summarizes the hydrogeology Terms of Reference conditions.

2.2 Regulatory Considerations

This report was prepared considering applicable provincial and federal legislations, codes of practice, guidelines, policies, standards and directives. Key government regulations or guidelines applicable to the Project and relevant to hydrogeology include:

- Alberta *Environmental Protection and Enhancement Act* (EPEA) as amended (Alberta Government 2000);
- Guide to Content for Industrial Approval Applications (EPEA) (Alberta Government 2014);
- *Canadian Environmental Assessment Act*, 2012 (Government of Canada 2012);
- Approved Water Management Plan for the South Saskatchewan River Basin (Alberta Environment 2006); and
- Province of Alberta *Water Act* (Alberta Queen's Printer 2014).

2.3 Study Areas

The hydrogeological local study area (LSA) was defined as a 1.6 km buffer (one land section) around the proposed Mine Permit Boundary excluding part of the access road to the south. The LSA is intended to include the extent of Project related impacts beyond which the potential effects are expected to be non-detectable. The regional study area (RSA) was defined based on natural features that are likely to represent groundwater flow divides, such as river valleys (*e.g.*, Crowsnest River) or mountain ridgelines. The RSA was extended to the north to include Daisy Creek as part of the assessment to evaluate potential impacts to groundwater in the southernmost portion of its watershed (headwaters). Both the LSA and the RSA are presented on Figure 1.1-1. Temporal boundaries are described in Section 3.3.1.

2.4 Assessment Cases

The Project EIA considers the following assessment scenarios:

1. **Baseline Case**, which includes existing environmental conditions, existing projects and "approved" activities;
2. **Application Case**, which includes the Baseline Case plus the Project; and
3. **Planned Development Case (Cumulative Effects)**, which includes the "Application Case" combined with past studies, existing and anticipated future environmental conditions, existing projects or activities, plus other "planned" projects or activities.

The Application Case will present a few scenarios representative of key stages of the mining activities and the post-closure conditions. To date, there are no known proposed projects or activities within the LSA or RSA that would act cumulatively with the Project, therefore no planned development case is presented.

2.5 Impacts and Assessment Criteria

Components of the Project that have been identified as having the potential to affect groundwater resources and are included in this assessment are as follows:

- pit dewatering on groundwater quantity, including surface water and groundwater interactions;
- potential impacts from mine spoil or waste rock on groundwater quality, including the potential release of selenium;
- accidental release of chemicals at the coal handling process plant (CHPP) altering groundwater quality; and
- the potential effect of residues from blasting on groundwater quality.

The potential impacts to groundwater resources are evaluated in terms of the following criteria for residual effects as identified in the methodology section of the Application (Section D), Benga 2016:

- magnitude;
- geographic extent;
- duration;
- frequency;
- reversibility;
- project contribution;
- confidence rating;
- probability of occurrence; and
- impact rating or significance.

The **magnitude** is classified as follows: nil (no change from background conditions anticipated after mitigation), low (disturbance predicted to be somewhat above typical background conditions; residual effect is detectable, but well within environmental standards), moderate (disturbance predicted to be considerably above background conditions, within range of natural variability; residual effect is approaching environmental standards), and high (disturbance predicted to exceed established criteria, beyond the range of natural variability; residual effect exceeds environmental standards).

The **geographic extent** is defined as local (within the LSA), regional (within the RSA) or provincial (outside of the RSA).

The **duration** of impact is determined to be short (effect occurring within the development phase), long (effect occurring after the development and during operation of facility), extended (effect occurring after facility closes but diminishing with time) or residual (effect persisting after facility closes for a long period of time).

The **frequency** is determined to be continuous (effects occur continually over the assessment period), isolated (effects are confined to a specified period), periodic (effect occur intermittently but repeatedly), or occasional (effect occur intermittently and sporadically).

The **reversibility** of an impact is determined to be reversible in short-term (effects are reversible and diminish upon cessation of activities), reversible in long-term (effects remain after cessation of activities but diminish with time) or irreversible - rare (effects are not reversible and do not diminish upon cessation of activities and do not diminish with time).

The **project contribution** is classified as, positive (net benefit), negative (net loss) or neutral (no net benefit or loss).

The **confidence rating** is defined as low if the impact is based on an incomplete understanding of cause-effect relationships and incomplete data, moderate if based on a good understanding of the relationships using data from elsewhere or incompletely understood relationships using data pertinent to the study area or it is rated as high if the impact is based on a good understanding of the relationships and data pertinent to the study is used.

The **probability of occurrence** can be considered low (unlikely), medium (possible or probable) or high (certain).

The determination of **significance** of residual effects will be identified as not significant (effects predicted to be within the range of natural variability and below guidelines or threshold levels) or significant (effects predicted to cause irreversible changes to the sustainability or integrity of a population or resource).

2.6 Valued Components

The valued components (VCs) selected for this assessment include bedrock aquifers, water wells and the groundwater discharge to surface water bodies including Blairmore, Gold and Daisy Creeks. MEMS identified that the groundwater quality of these VCs could be impacted by operations of surface facilities and mine waste rock and that the groundwater quantity could be impacted due to effects of pit dewatering. Key indicators and rational for choosing the VCs are presented in Table 2.6-1.

Table 2.6-1 Valued Components

VC	Key Indicator	Rationale for Indicator
Bedrock Aquifers	Quantity (hydraulic head)	Pit dewatering will create a drawdown cone that may affect the hydraulic heads within aquifers reducing availability for other use and users.
	Quality (groundwater chemistry)	Mine waste rock and mining operations may create upset conditions resulting in change in water quality in the aquifers.
Water Wells	Quantity (hydraulic head)	Pit dewatering may transmit away from the Project and affect hydraulic heads at water wells screened across surficial and/or bedrock aquifers. Change in water availability in aquifers may affect users.
	Quality (groundwater chemistry)	Change in groundwater quality could impact the water usability, depending on the change in quality.
Discharge to Surface Water Bodies	Quantity (aquifer drawdown near surface water bodies)	Changes in hydraulic heads associated with pit dewatering have the potential to modify the current groundwater-surface water interactions and impact surface water base flow.
	Quality (groundwater chemistry and mine waste rock discharge)	Water discharged from mine waste rock may have elevated concentration in metals. Changes in groundwater quality in the bedrock and surficial aquifers (assessed above) could affect surface water quality through groundwater discharge.

Surficial deposits (mostly alluvium) and springs were not selected as hydrogeological VCs. The presence of alluvial deposits is expected to be limited to small areas in close proximity to watercourses. If aquifers are present within those deposits, the water would be classified as surface water (groundwater under the direct influence of surface water – GWUDI) under the *Potable Water Regulation* (Alberta Queen's Printer 2015) as residence time is anticipated to be very short (days to weeks as opposed to years).

3.0 METHODOLOGY

3.1 Information Sources

The baseline study was completed based on a literature review and field investigations. A desktop review was completed to identify available information and potential data gaps. Subsequent to the literature review, a field program was conducted to obtain site specific information. Key information sources included:

- published regional geological and hydrogeological maps, reports, and air photos from the Alberta Geological Survey (AGS), and government agencies for the study areas;
- field investigations and hydrogeological data collection conducted by MEMS;
- drilling logs and reports from oil and gas wells from Abacus Datagraphics (2016);
- lithological logs from oil and gas wells from Canstrat (2016);
- geophysical logs (gamma ray, neutron, sonic and resistivity) and water analyses from oil and gas wells from IHS (2016);
- water well records from Alberta Environment and Parks (AEP), formerly Alberta Environment and Sustainable Resource Development (ESRD), Water Well Information Database (2016a) for the RSA area;
- groundwater and surface water licenses issued by AEP (2016b) within the RSA;
- geological logs (526 drill holes currently exist in Benga's database) and geological cross-sections provided by Benga;
- studies completed by Norwest Corporation (2014a and 2014b) on behalf of Benga;
- hydraulic testing (packer testing) on seven geotechnical boreholes and installation of nested vibrating wire piezometers (VWP) with daily water level data measurements at four selected locations (Golder 2014);
- pumping tests conducted at an artesian flowing borehole (RGOH3012) by Benga and Golder (2015);
- monthly flow monitoring at the main Greenhill Portal conducted by Benga; and
- monthly sampling for chemistry analysis including routine, dissolved metals and occasionally for hydrocarbons and isotopes at the main Greenhill's Portal and at selected ponds and watercourses by Benga.

MEMS monitoring wells, vibrating wire piezometers, pumping test and Benga's corehole locations are presented on Figure 3.1-1.

3.2 MEMS Field Investigation

The hydrogeological data collection program consisted of:

- drilling and installing 19 monitoring wells targeting either one of three coal seams across the Project, or the upper water table at the CHPP, and near a future rock disposal area, water management pond and Blairmore Creek;
- collecting water samples from the monitoring wells for routine, metals and hydrocarbon analyses;

- recording water levels at the monitoring wells, including the daily collection of long term water level data using pressure transducers at five monitoring wells;
- conducting hydraulic conductivity tests at the monitoring wells;
- collecting spring, watercourse (*i.e.*, creek), water body (*i.e.*, pond) and portal water samples and analyzing for one or more of routine, metals, polycyclic aromatic hydrocarbons (PAHs), phenols and selected isotope parameters; and
- conducting a field-verified survey to confirm groundwater and surface water users.

3.2.1 Monitoring Well Drilling and Completion

Monitoring wells installation was coordinated with the coal exploration programs and was completed with three wells installed in January 2014, ten wells installed in September/ October of 2014, four wells installed in July 2015 and two additional wells installed in May 2016 (Figure 3.1-1).

The geologic materials were logged during drilling. Monitoring wells were constructed with two inch schedule 80 PVC pipe and machine slotted 0.010 inch screen. The filter pack was created using Colorado Silica Sand 10/20. The wells were sealed using coated bentonite pellets, bentonite chips and bentonite grout and/or cement, depending on the depth of the well. Monitoring wells were developed using an air compressor, a Grundfos pump or a weighted bailer.

Four monitoring wells were completed in Seam 1 (S1), which is the shallowest coal seam, three monitoring wells were completed within Seam 2 (S2) and six monitoring wells were completed in Seam 4 (S4), which is the deepest coal seam. In addition, three wells were completed in bedrock overlying the coal seams and three monitoring wells were completed within surficial deposits. Monitoring well completion details are summarized in Table B3a.

3.2.2 Monitoring and Sampling

In this report, the following convention applies when discussing water levels. Water level corresponds to the distance either from the top of casing or ground level to the surface of water within a well and is used to determine total hydraulic head. The total hydraulic head (or "hydraulic head") is the sum of the elevation head plus the pressure head and represents the total mechanical energy per unit weight of water (Fetter 1994). The elevation head represents the height of the point of measurement relative to a geodetic datum, while the pressure head represents the (water) pressure at the point of measurement. In this instance, the point of measurement for both the elevation head and the pressure head corresponds to the bottom of the well. The pressure head is thus equivalent to the height of the water column present within a well.

Water levels were measured at all monitoring wells following completion and during subsequent monitoring events. In addition, level loggers installed at five locations collected daily water levels between October 2014 and March 2016, providing information on water levels for over a year. Groundwater samples were collected following the development of the monitoring wells and during subsequent sampling events which occurred in February 2014, October 2014, July 2015 and March 2016. Samples were submitted to laboratories for analysis. The groundwater monitoring and sampling technical procedure can be found in Appendix D. Field data can be found in Table B6 and chemistry results in Tables B7 to B10.

Hydraulic conductivity tests were completed to determine hydraulic conductivity of the formations, including falling and/or rising head tests on monitoring wells by MEMS and packer tests completed on test holes by Golder. The monitoring wells were completed with short screens ranging 1.5 to 3 m in length. Most of the wells targeted the coal seams in the Kootenay Formation, with a few of the wells completed within the Blairmore Group or the surficial deposits. Hydraulic conductivity measured at the monitoring wells is representative of a short interval and of a given formation. Packer tests were conducted over long intervals, ranging from 32 m to 116 m, covering both the targeted coal seams and the interburdens. Hydraulic conductivity measured by packer test is representative of a long interval and of multiple units and/or formations. Despite a difference in interval tested, both tests of monitoring wells and packer tests provide hydraulic conductivity values that are in good agreement and have a similar order of magnitude. This indicates that in both case, the highest hydraulic conductivity is driving the overall measured value, which is believed to be representative of the average hydraulic conductivity parallel to bedding. The fact that wells and packer tests were completed at an angle relative to the bedding planes, rather than perpendicular to bedding as the units dip (due to the presence of faults and folds) does not alter this interpretation.

A field survey was conducted in fall 2013 to locate ephemeral streams, ponds, portals and toe springs within the RSA, specifically at the locations of the historical surface or underground mines. Water samples were collected for routine analysis. Known springs and portals located outside of the RSA were also visited to collect regional data for comparison. Chemistry results are summarized in Tables B7 to B9.

3.2.3 Water Wells Field-Verified Survey

The hydrogeology RSA includes the communities of Coleman, Blairmore and Frank (Figure 1.1-1), and a desktop search of the AEP water well database (2016a) on April 2016 returned 177 water wells and ten springs. Within the LSA, a total of 47 water wells and one spring were identified. The field-verified survey was focused on water wells and springs located within the LSA, which are closer to the pit and potential dewatering impact.

The field-verified survey was conducted in October 2014 in an effort to confirm locations of groundwater and surface water users within the LSA. MEMS personnel attempted to establish contact in person with landowners within the LSA. Of the 48 records, 6 water wells and 2 springs were surveyed. Water wells were sampled for routine parameters and the results were provided to the respective landowners.

Water well information is presented in Table B14.

3.3 Assessment of Potential Pit Dewatering Impacts

Potential concerns associated with pit dewatering are due to change in hydraulic head in the nearby aquifer(s). The change in hydraulic head is generally quantified as drawdown, which is the decrease of pressure head from the static water level (*i.e.*, baseline conditions) within the aquifer(s). Depending on the magnitude of the drawdown, surface-water interactions may be modified from baseline conditions, which could include changes to groundwater discharge (*i.e.*, creek base flow).

3.3.1 Groundwater Numerical Model

To assess the drawdown associated with pit dewatering activities and the potential changes in surface water- groundwater interactions, a numerical groundwater model was utilized. The model was developed by SRK Consulting Canada Inc. (SRK) using FEFLOW, a professional software package for modeling fluid flow and transport of dissolved constituents. A detailed description of the model is presented in Appendix C. A surface water flow model was also developed by SRK using GoldSim. The water balance information generated by the surface water flow model was used to support the groundwater flow simulations.

Using the FEFLOW model, groundwater flow was simulated for three scenarios:

- Baseline: representing the current, pre-disturbance condition;
- End-of-Mine (EOM): representing the open pit developed to full extent with in-pit backfill, saturated rock fill, and an active or operating surface water management system (including ditches and sedimentation ponds); and
- Long-Term Closure (LTC): representing the completed open pit, with in-pit backfilling, saturated rock fill, the open pit lake, and reclaimed surface water management system (presented in Section 5.1 and described in greater detail in CR#4 – Hydrology).

The baseline scenario does not include any pre-existing groundwater withdrawals as no active industrial users are located within the LSA. Other users within the RSA are located in the Crowsnest Valley and are primarily targeting groundwater stored in the alluvium deposits. Given the distance to the Project and this difference in the water source, these users were not included in the baseline scenario.

In addition to the above, the model was run for the following scenarios:

- in steady-state for each mining year, including all mining development and associated features, to assess net impact on a year by year basis;
- for three years in transient conditions to assess base flow fluctuation from month to month for baseline and LTC; and
- after varying input parameters, to conduct the sensitivity analysis.

Outputs from the model include:

- baseline hydraulic head distribution map;
- EOM and LTC hydraulic head distribution and drawdown maps; and,
- change to surface water base flow (associated with groundwater discharge) at Blairmore Creek, Gold Creek, Daisy Creek and the Crowsnest River.

Some of the results from the baseline model are presented in Section 4 Baseline Setting to support the description of the groundwater flow system and groundwater-surface water interactions. Results from the EOM and LTC are presented in Section 5 Environment Assessment. In addition, some of the outputs from the groundwater numerical model were used for the surface water assessment. These results are further presented and discussed in CR#4 – Hydrology and CR#5– Water Quality.

3.3.2 Effects Assessment Approach

Baseline studies demonstrated variable hydraulic heads and seasonal variations in water levels of up to 3.2 m in the monitoring wells and over 10 m in the vibrating wire piezometers installed across the LSA. Continuous monitoring was conducted for approximately seventeen months, but a longer monitoring period could reasonably be expected to identify greater variations between years or seasons. Therefore, water level changes of over 10 m may be within the range of natural variation.

In Alberta, a maximum of 70 % reduction in available head is applied to licencing of groundwater diversions (AENV 2003). The available head is defined as the distance between the non-pumping water level and the top of the aquifer for confined aquifers or two thirds of the saturated aquifer thickness for unconfined aquifers (AENV 2003). This regulation is not directly applicable to pit dewatering at coal mines, but provides some reference for a regulatory standard. Applying this guidance to Seams 2 and 4, which exhibit a pressure head of around 30 m or greater, up to 18 m of drawdown would fall within a 70% reduction. Most of the wells have pressure heads close to 30 m or greater, meaning a drawdown of up to 18 m would likely be a conservative representation of a 70% available head reduction in most wells.

Based on the above, changes in pressure head of less than 5 m associated with pit dewatering are expected to be indistinguishable from natural variation. Changes in pressure head of between 5 m and 15 m may be within natural variation at some locations, but could reflect changes in pressure head outside of natural variation at other locations. Changes in pressure head greater than 15 m could represent a substantial reduction in available head at some locations and likely reflects a change greater then what would be anticipated from natural (seasonal) variations at others. Accordingly, the magnitude effect criterion (as described in Section 4.2) for drawdown and head reduction was assessed using the following definitions;

- Nil (no change from background conditions, residual effect is not detectable): percent reduction in groundwater level likely not detectable, *i.e.*, predicted drawdown of less than 5 m, near the pit;
- Low (change above background conditions), residual effect is detectable but well within environmental standards): percent reduction in groundwater level is negligible at the LSA boundaries (*i.e.*, drawdown of less than 5 m);
- Moderate (changes considerably above background conditions, residual effect is approaching environmental standards): percent reduction in groundwater level is detectable at the LSA boundaries (*i.e.*, drawdown of up to 15 m); and
- High (residual effect exceeds environmental standards): percent reduction in groundwater level is detectable at the LSA boundaries (*i.e.*, drawdown of more than 15 m).

Effects of pit dewatering to watercourse base flow is reported, but not evaluated, in this assessment. Base flow reduction was quantified during the hydrogeological assessment as base flow which is closely related to groundwater discharge and is an output from the groundwater numerical model. As base flow of watercourses is a VC for the CR#4 - Hydrology, CR#5 - Water Quality and CR#6- Aquatic Resources, the effects are included in those assessment reports.

3.4 Water Quality Guidelines

As outlined in Section 3.2 of this hydrogeology report, water chemistry data were collected to establish baseline conditions. Two sets of guidelines (“guidelines”) were used to assess quality:

- *Environmental Quality Guidelines for Alberta Surface Waters* (ESRD 2014); and
- *Guidelines for Canadian Drinking Water Quality* (Health Canada 2014).

The *Environmental Quality Guidelines for Alberta Surface Waters* (or Freshwater Aquatic Life Guidelines - FWAL) are protective of aquatic life in general, including fish, invertebrates and aquatic plants. The *Guidelines for Canadian Drinking Water Quality* (CDW) are protective of potable water and are applicable as several users, within or near the LSA, rely on surface water or groundwater for domestic use (including drinking, showering or bathing).

Selenium in surface waters was identified as an important potential issue for this Project. Therefore, a site-specific objective for selenium for the protection of aquatic life has been developed linked to concentrations of sulphate (CR#5 – Water Quality). The proposed selenium objective range from 0.0017 mg/L to 0.0093 mg/L based on sulphate concentration between 10 mg/L and 400 mg/L.

Guidelines are presented within the summary chemistry tables included in Tables B7-B11. Tables present the generic FWAL value for total selenium at 0.001 mg/L as the surface water results presented in this report are only for comparison with groundwater quality.

4.0 BASELINE SETTING

4.1 Physiography and Climate

The topography of Grassy Mountain consists of rounded hills at lower elevations with moderate to steep slopes at higher elevations. The regional area is characterized by relatively high relief, with numerous valleys where watercourses are present (Figure 4.1-1). Major ridgelines and valleys are generally oriented north-south, causing run-off from precipitations to flow generally east-west downslope, away from topographic highs towards watercourses. Blairmore Creek and Gold Creek flow in a north to south direction along the western and eastern margin of the Mine Permit Boundary, respectively, before discharging into the Crowsnest River. Their headwaters are generally located at high elevations (2,100 metres above sea level (m asl)), and their discharge point is at 1,390 m asl. Daisy Creek flows from south to north, with headwaters at an elevation of about 1,800 m asl.

Based on 20 year climate records, the coldest month is December and the warmest month is July, with average monthly temperatures of -6.4 °C and 15.4 °C, respectively (Norwest Corporation 2014a). There are four natural physiographic regions located within the RSA; the Montane and Foothills Fescue regions in the topographic low areas, and the Alpine and Subalpine Natural Regions at higher elevations to the north of the Crowsnest River Valley (Natural Regions Committee, 2006). Alpine and Subalpine regions have mean annual temperatures lower than 0°C while the Montane and Foothills Fescue regions have mean annual temperatures higher than 0°C. Average annual precipitation ranges from 470 mm at lower elevation to 989 mm at higher elevation. The Alpine and Subalpine regions receive approximately 40% more precipitation than the Montane and Foothills Fescue regions (Norwest Corporation, 2014a). Table 4.1-1 summarizes these climate characteristics.

Table 4.1-1 Natural Regions and Elevations Summary

Sub-Region	Elevation of Upper Limit (m asl)	Mean Annual Temperature (°C)	Average Annual Precipitation (mm)
Alpine	-	-2.4	989
Subalpine	2,100	-0.1	755
Montane	1,550	2.3	589
Foothills Fescue	1,300	3.9	470

Source: (Waterline 2013)

4.2 Geology

The Project is located within the Rocky Mountain Thrust Belt. The Project is underlain by Quaternary, Cretaceous, Jurassic, and Upper Paleozoic deposits within the RSA boundaries. The following sections provide a discussion of the geological units and a structural overview. A stratigraphic column is presented on Figure 4.2-1. Additional description of the geology is provided in the Application in Sections B.6 and B.7 (Benga 2016).

4.2.1 Bedrock Geology

Bedrock units present beneath the Project include rocks from the upper Paleozoic, upper Jurassic and the Cretaceous. Units are described in detail from oldest to youngest in the following sections. Figure 4.2-2 presents the regional geology of the RSA, while Figure 4.2-3 shows the regional distribution of the formations on a northwest to southeast cross-section parallel to the Crowsnest River. Major faults present within the RSA include, from east to west, the Livingstone Thrust, the McConnell Thrust, the Turtle Mountain Fault, and the Mutz Fault (Figure 4.2-2).

4.2.1.1 Paleozoic

Paleozoic bedrock subcrops locally directly east and south of the Project and consists of Cambrian carbonate, shale and sandstone, Devonian limestone and dolomite and Mississippian (Carboniferous) shale and carbonate. Formations from the Pennsylvanian and Permian were not identified within the RSA. Thrust faulting and folding is common (Waterline, 2013).

4.2.1.2 Upper Jurassic and Lower Cretaceous

4.2.1.2.1 Fernie Group

The Upper Jurassic Fernie Formation is predominantly composed of recessive brown sandstones, siltstones and black-dark gray-green shales, which may be fractured (CSPG 1997). Generally becoming more fine grained with depth, interbedded units include dark phosphatic sandstones and limestones, and black, cherty limestones in the lower parts; resistant, well-bedded siltstones, sandstones and black oolitic limestones, coquinas and concretionary bands in the middle parts; and, in the upper parts glauconitic sands, concretionary bands and brown weathering siltstone and sandstones. Five shallowing upward depositional cycles are recognized within the formation (CSPG 1997).

Within the RSA, the Fernie Group consists of up to 200 m of dark grey to black marine claystones that turn green in colour when weathered. Towards the base of the group, phosphatic sandstone, limestone and cherty limestone may be present locally. The dark gray shales of the lower part of the formation characteristically form gentle grass- and tree-covered slopes and occasionally crop out in road cuts (Consolidated Coal 1975). The upper contact with the Kootenay Group is gradational with increasing interbedded siltstone and sandstone of the non-marine Passage Beds.

4.2.1.2.2 Kootenay Group

The Kootenay Group conformably overlies the upper Jurassic Fernie Formation. The group occurs throughout the Rocky Mountain Foothills and parts of the eastern front ranges of Southwestern Alberta and Southeastern British Columbia. The group attains a regional composite maximum thickness of 1,335 m, thinning to zero towards the east (CSPG 1997). Within the LSA the unit is 120 to 200 m thick, but the unit can reach up to 450 m where sediments thicken to the west of the LSA. The upper Jurassic to lower Cretaceous Kootenay Group is comprised of three formations; Morrissey, Mist Mountain, and Elk formations, which are predominantly sandstone with some interbedded siltstone, mudstone, coal and shale.

4.2.1.2.2.1 Morrissey Formation

The Morrissey Formation ranges in thickness from 20 to 80 m within the Rocky Mountains, and is subdivided into two members; the lower Weary Ridge Member, which is not present at the Project; and the upper Moose Mountain Member, which is a cliff-forming hard siliceous grey sandstone recognized at the base of the Kootenay Group. It is a coarsening-upward sequence of medium dark to brownish grey, very fine- to coarse-grained sandstone with rare carbonaceous mudstone and coal (CSPG 1997). The Moose Mountain Member ranges in thickness from a minimum of 4 m south of Blairmore to a maximum of 36 m near Mist Mountain and Highwood Pass, Alberta (Lexicon, 2004).

The contact between the Moose Mountain Member and the overlying Mist Mountain Formation is distinct and conformable, and is recognized where resistant, cliff forming sandstone of the Moose Mountain is overlain abruptly by darker grey weathering siltstone, mudstone, shale and coal of the Mist Mountain Formation (CSPG 1997).

4.2.1.2.2.2 Mist Mountain Formation

Regionally, the Mist Mountain Formation consists of 66 to 194 vertical metres of strata and thins rapidly from west to east because of sedimentary thinning and/ or erosional truncation by the overlying Cadomin Formation of the Blairmore Group. The Mist Mountain Formation contains the economic coal for the Project and is comprised of the Adanac, Hillcrest and Mutz members. The formation is a floodplain succession up to 150 m thick at the Project and comprising a cyclic succession of interbedded sandstone, mudstone, siltstone, shale, thin to thick seams of bituminous to semi-anthracite coal and some conglomerate. Coals of the Mist Mountain Formation outcrop on the property in a general north-south direction for a strike length of approximately 7 km. The following describes the members within the LSA:

- The **Mutz Member** is the stratigraphically-uppermost unit of the Mist Mountain Formation and comprises up to 90 m of fluvial siltstone with minor interbedded claystone and coaly partings. Seams 1 and 2 occur at the top and base of this unit respectively.
- The **Hillcrest Member** is up to 30 m of fluvial channel sandstone deposits with interbedded siltstone and claystone. Seam 3 has not been correlated to the Project's deposit and has probably been removed by an erosional surface at the base of the Hillcrest Member.
- The **Adanac Member** consists entirely of Seam 4 and is a coaly unit up to 30 m thick, with numerous siltstone and claystone interbeds at the base of the Mist Mountain Formation.

Four cross-sections illustrate the geology at the Project. Alignments are presented on Figure 4.2-4, with Figures 4.2-5 to 4.2-8 presenting the east-west cross-sections within the LSA. Coal-bearing sediments of the Late Jurassic to Early Cretaceous were strongly deformed during the Late Cretaceous Laramide Orogeny resulting in the development of north to northwest trending folds and steeply dipping reverse faults, which locally causes the strata to be thrusted upwards. Coal zones are relatively continuous between major reverse faults however their thickness and distribution is variable within relatively short distances. Target coal seams crop out for about 7 km along the limbs of north trending anticlines and synclines transected by reverse faults. Twelve reverse faults that dip to the west at 50-80% have been identified. Bedding dips along fold limbs and between reverse faults varies considerably over relatively short distances. In the west of the deposit, strata generally dip towards the west at 25 º in the south up to 60 º in the north. In the east of the deposit, seams occur along the east (up to 90 º dip) and west (up to 45º dip) flanks of an anticline.

4.2.1.2.2.3 Elk Formation

The Elk Formation of the Kootenay Group is absent in the Blairmore-Coleman area of the Crowsnest Pass and within the RSA, where the Mist Mountain Formation is unconformably overlain by the Cadomin Formation (Richardson, 1992).

4.2.1.2.3 Blairmore Group

Resting disconformably over top of the Kootenay Group is the lower Cretaceous Blairmore Group, consisting of interbedded sandstone, mudstone, conglomerate, and shale deposited in a fluvial setting (CSPG 1997). The Blairmore Group is divided into four formations which are defined by type successions: Cadomin, Gladstone, Beaver Mines and Mill Creek (Ma Butte) (CSPG 1997). The Cadomin and the Gladstone formations are the only formations from the Blairmore Group present within the RSA and are described below.

4.2.1.2.3.1 Cadomin Formation

The Cadomin Formation is a distinct marker unit in the Crowsnest Pass, as it is a highly-resistive, hard unit at the base of the Blairmore Group that truncates the underlying Mist Mountain Formation. The Cadomin Formation is typically a white, grey and green alluvial conglomerate of well-rounded pebbles, cobbles and boulders of chert and quartzite. Regionally the formation includes beds of quartzose sandstone and forms prominent outcrops that range from less than 1 m to over 170 m, which are generally thicker towards the west (CSPG 1997). Within the LSA, the unit is up to 10 m thick. Clasts are dominantly chert and quartzite, with average size of 1 to 5 cm, with occasional clasts up to 40 cm, and the matrix is generally fine to coarse grained sand with silica cement. Some sections may consist of more than one bed of conglomerate with interbedded sandstone, siltstone, and mudstone, often with high carbonaceous content and occasional coal beds (CSPG 1997).

4.2.1.2.3.2 Gladstone Formation

Divided into two informal members, the lower half of the Gladstone Formation is a quartzose, cherty pale grey sandstone that is fine - to medium-grained with a distinct upward decrease in grain size. It is sometimes interbedded with dark grey siltstone, mudstone and dark grey, green and red claystone. The upper member is a mudstone with minor limestone and sandstone interbeds (CSPG 1997). Within the LSA, the Gladstone Formation is up to 100 m. The Gladstone Formation lays abruptly, but conformably, over the top of the Cadomin Formation. The Blairmore Group is overlain gradationally by the Crowsnest Formation volcanics.

4.2.1.3 Upper Cretaceous

4.2.1.3.1 Crowsnest Formation

The Crowsnest Formation volcanics is a distinctly recognized marker in the Crowsnest Pass region, and is divided into an upper and lower member. The lower member has a conformable and interfingering lower contact with the Ma Butte and is composed of recessive thin-thickly bedded air-fall pyroclastic flow, surge and lahar deposits that are crystal-rich and range from pink to green to purple. The upper member is unconformably overlain by the Blackstone Formation of the Alberta

Group and is composed of dark green resistant pyroclastic breccias containing fragments up to 3 m (CSPG 1997).

4.2.1.3.2 Alberta and Brazeau Groups

The Alberta Group consists mainly of silty mudstone with the Blackstone Formation in its lower succession, followed by a prominent sandstone unit of the Cardium Formation, and the Wapiabi Formation in its upper succession (Waterline 2013). The Alberta Group is present in the western portion of the LSA and RSA and in a small area north of the LSA (Figure 4.2-2).

The Brazeau Group includes the Belly River, Bearpaw and St. Mary River formations. The Belly River Formation consists of grey thick-bedded sandstone, clayey siltstone and mudstone (Waterline 2013). The Bearpaw Formation consists of dark gray blocky silty shale and grey clayey sandstone (Waterline 2013). The St. Mary River Formation consists of non-marine sandstones, which are coarse- to fine-grained, pale brown, massive to well-bedded, interbedded with grey carbonaceous shale. The lower part of the St. Mary River Formation consists of sandstone, shale and coal; whereas the upper portion is composed of sandstone, shale and limestone. The upper and basal contacts of the St. Mary River Formation are gradational (Waterline 2013). The Brazeau Group is not present within the RSA (Figure 4.2-2).

4.2.2 Surficial Geology

Surficial geology of the Crowsnest Pass area was compiled by Bayrock and Reimchem (1975) and is summarized in Figure 4.2-9. The Crowsnest River valley was shaped by Quaternary glaciers forming U-shaped valleys, resulting in steepening of valley walls following pre-glacial drainage (Waterline 2013). Near-surface deposits consist of alluvial sediments deposited by ancient (post-glacial) and present-day rivers and streams, and materials deposited prior to or during glaciation (Waterline 2013). Along the Crowsnest River valley, recent sand and gravel form an alluvial deposit (Waterline 2013).

Mountains and steeply sloping terrain are generally mapped as having thin colluvium and till horizons (Bayrock and Reimchen 1975). The river beds of Blairmore Creek and Gold Creek along with the Crowsnest River are mapped with coarse-grained alluvium. The Crowsnest River valley, away from the alluvial deposits, is mapped with kames, kame terraces and kame moraines, outwash plains and tills (Bayrock and Reimchen 1975). Regionally, the thickness of surficial deposits is generally less than 50 m, with an average of approximately 7 m (Waterline 2013).

Surficial deposits in the LSA are limited. During drilling targeting the coal seams, no surficial deposits were encountered for the monitoring wells located south of MW14-04-12 (Figure 4.2-4). Surficial deposits were encountered at four monitoring wells including MW14-05-114 and to the north. Surficial deposits in this area consisted of gravel and range between 2 and 7 m with thickness generally increasing northward.

In addition to the bedrock wells targeting the coal seams, two pairs of nested wells were installed in July 2015 at the CHPP and near Blairmore Creek (Figure 3.1-1). Geology at the CHPP (MW15-11-18 and MW15-11-9) includes 1.8 m of sandy clay overlying sandstone (down to 4.5 m below ground surface (bgs)) and interbedded mudstone and siltstone. Near Blairmore Creek (MW15-12-14 and MW15-12-7), 1.5 m of sandy clay was encountered from surface underlain by rafted bedrock and gravel down to 7.5 metres below ground surface (m bgs), followed by interbedded siltstone and mudstone.

4.2.3 Structural Geology

The Project lies between two major thrust faults, in an area known as the Disturbed Belt at the leading edge of the Rocky Mountain chain. The Livingstone Thrust Fault forms the boundary between the Foothills and the front ranges of the Rocky Mountains and is located approximately 6.5 km east of the Project. Cretaceous and older rocks are folded and thrust faulted in between these two thrust faults and within the disturbed belt

The McConnell and Turtle Mountain Thrusts are two major west-dipping thrust faults in the vicinity of the Project. Movements along the thrust faults resulted in the emplacement of older rocks over younger rocks, causing repetition of stratigraphy in the east-west direction perpendicular to the north-south trending faults (Figure 4.2-2). Fault offsets are common, but fault-bounded plates generally retain normal stratigraphic thickness (Section B.6, Benga 2016). The west-dipping thrust faults sometimes cause substantial local thinning of coal seams from west to east as a result of structural deformation (Norwest Corporation, 2014b).

Geology beneath the RSA and LSA is structurally complex. The stratigraphic succession represents a transition from marine to alluvial deposition coinciding with a period of uplift during the Columbian Orogeny of Late Jurassic age. Sediments were deposited in a foreland basin from a rising landmass to the west and south due to tectonic collision and terrane accretion. These sediments reach a maximum thickness west of the border between Alberta and British Columbia and progressively thin to the east. Later compressional deformation during the Late Cretaceous Laramide Orogeny produced a series of sub-parallel folds transected by reverse faults that dip steeply to the west.

Anticlines and synclines are present with axial planes that plunge to the north. Anticlines are overturned in the north of the LSA and are transected by a series of reverse faults with general dip of about 80° to the west with associated drag folds (Benga 2014). Major faults limit the extent of the coal both laterally and at depth. Folds and faults are illustrated on the cross-sections presented in Figures 4.2-5 to 4.2-8.

4.3 Mining History in the Area

Mines have targeted coal in the Crowsnest Valley area since the early 1900s by using both underground and surface mining methods. All of these mines targeted the same coal seams as the Project as a result of the structural deformation of the region. The following are the underground mines that are located in the area and all of which have been abandoned:

- McGillivray Creek Mine – located west of Coleman and north of the Crowsnest River (a portal still exists, local name is McGillivray Mine);
- International Mine – portals were located in Coleman; the mine extended both north, south of and under the Crowsnest River (a "spring" now exists, local name is International Spring);
- Greenhill and the Greenhill-Boisjoli Mines – located north of Blairmore (two portals still exist informally called Greenhill Portal (Main) and Greenhill Portal (Secondary));
- Lille Mine – located east of Blairmore and north of Frank;
- Hillcrest Mine - located east of Blairmore and south of Frank;
- Bellevue Mine - located east of Blairmore east of Frank and is now used as a museum (a portal is locally named Bellevue Mine); and
- Maple Leaf Mine - located east of Blairmore.

Historical surface mines are also present north of Blairmore. The workings from these surface mines were quite extensive and four pits that are now full of water remain called South Pond, West Pond, East Pond and Small South Pond.

All of the aforementioned mines targeted coal from the Lower Cretaceous-Upper Jurassic Mist Mountain Formation. Figure 4.3-1 presents the location of these legacy mines as well as the known portals and springs that remain.

4.4 Groundwater Conditions

The groundwater flow system in the area is not simplistic as a result of the complex geology within the LSA and RSA. Waterline (2013) conducted a regional study of the Crowsnest River watershed including aquifer mapping. Monitoring of water levels in wells up to 25 m deep indicated that in general, the groundwater flow direction is locally towards the Crowsnest River and regionally from west to east paralleling the Crowsnest River. Groundwater follows along the path of least resistance, flows across formational boundaries and is controlled by faults and fracture, which strike approximately perpendicular to the Crowsnest River (Waterline 2013). Groundwater predominantly moves downward with local upward movement in the vicinity of the Crowsnest River valley. Based on base flow interpretation of Blairmore Creek and Gold Creek (CR#4 - Hydrology), groundwater in the RSA mostly discharges to these local creeks and the creek water eventually flows to the Crowsnest River.

Despite the effort of the regional study to collect all available data and supplement them with additional drilling, the study concludes that the scarcity of water level data, coupled with the significant topographic relief, and the complexity of the flow system makes it impossible to create regional potentiometric contour maps with any degree of accuracy (Waterline 2013). Therefore, no regional potentiometric contour maps are presented for surficial deposits or bedrock formations. In addition, as the Project is located within the Disturbed Belt, the elevation of the base of groundwater protection is arbitrarily set at 600 metres below ground surface (m bgs)(AER 2015a).

The highest aquifer yields are observed in alluvial gravels adjacent to the Crowsnest River. Bedrock aquifers are expected to produce generally very low to moderate yields. There are three main bedrock sequences within the RSA and LSA including the upper Paleozoic, the upper Jurassic and lower Cretaceous (*i.e.,* Fernie, Kootenay and Blairmore groups) and the upper Cretaceous (Alberta Group). The following subsections provide a description of the hydrostratigraphic units.

In general hydraulic conductivity was assessed by conducting slug tests at the monitoring wells following well completion and development. Transmissivity and storage coefficient values were not measured for the units at the Project as no pumping tests were conducted given the relative low hydraulic conductivity of the geological units.

4.4.1 Upper Paleozoic

The Upper Paleozoic sequence includes carbonate deposits such as limestone and dolomite of the Cambrian, Devonian and early Mississippian (Carboniferous) (Figures 4.2-1 and 4.3-2). Outcrops (including subcrops with thin layers of overburden) of the Upper Paleozoic sequence are present within the eastern and southern margins of the LSA (Figure 4.3-2). Groundwater in the Upper Paleozoic sequence was reported to generally flow with an upward gradient near the Crowsnest River (Figure 4.2-3) (Waterline 2013).

Karstic features associated with carbonates in the upper Paleozoic sequence are reported in the region (Worthington, 1991; van Everdingen, 1972). Five karst springs are located approximately 13 km west of the Grassy mine permit boundaries (Figure 4.3-3). These springs developed in areas where Paleozoic formations with extensive carbonates are present, located in a north-south corridor of carbonate outcrops (Worthington, 1991). No karstic springs were observed during MEMS field investigation or having been reported within the RSA, including areas where the Upper Paleozoic sequence outcrops. Vuggy voids are observed within units of the Upper Paleozoic sequence in two of the oil and gas wells located in 7-35-008-04 W5 (log C-1503) and 03-20-009-03 W5 (log C-1579) (Figure 3.1-1; Canstrat, 2016). These two wells are the only wells with detailed geology available to total depth. Vuggy voids are generally associated with dolomite at depth of 366-396 m; 550-610 m; 760-765 m; 880-915 m and 1,585-1,680 m on log C-1579, and 915-975 m and 1,890-1,950 m on log C1503. Karstic features are not identified on either of the two logs to a maximum depth of 4,417 m and 4,148 m.

Water chemistry analyses from drill stem tests at wells located 06-11-009-04 W5, 07-35-008-04 W5, and 15-33-007-03 W5 (Figure 3.1-1) indicate TDS is in the order of 90,000 mg/L for the Fairholme Formation (Cambrian, at the depth of 4,536 m), 55,000 mg/L for the Palliser Formation (Devonian, at the depth of 3,900 m) and 50,000 mg/L for the Misty Formation (Pennsylvanian, at the depth of 3,970 m) (IHS 2016).

4.4.2 Upper Jurassic and Lower Cretaceous

The main bedrock formations present within the RSA are of Upper Jurassic and Lower Cretaceous age. Bedrock aquifers may be associated with sandstone and coal deposits, but other units may also be water-bearing as a result of fracturing. Nielson (2009) tabulated the main bedrock formations versus well yield using water well data from the Crowsnest Pass, and the largest average yields were noted in the porous sandstones of the Blairmore Group (Waterline 2013).

4.4.2.1 Fernie Group

The Fernie Group within the RSA consists of 200 m of dark grey claystone. Formations constituting the Fernie Group are not anticipated to have any major water-bearing units, except locally and associated with fractures. A few wells completed within the Fernie Group in the region are “dry” or interpreted as having very low yields (less than 2.3 L/min) and the group is generally not interpreted as an aquifer (Waterline 2013).

The TDS of formation water was estimated based on geophysical logs (gamma, sonic and resistivity) at an oil and gas well located 01-20-009-03 W5 (Figure 3.1-1). The TDS value is in the order of 6,500 mg/L, at the depth of 2,700 m.

4.4.2.2 Kootenay Group

The Kootenay Group includes coal and sandstones units interbedded with siltstone, mudstone and shale. Regionally a few wells completed within the Kootenay Group are “dry” or interpreted as very low yielding (less than 2.3 L/min) and the group is generally not interpreted as an aquifer (Waterline 2013). Within the LSA, potential water bearing units investigated during the field program were the three main coal seams of the Mist Mountain Formation.

4.4.2.2.1 Groundwater Heads and Flow

A total of 13 monitoring wells targeting one of the three coal seams (Seam 1, Seam 2 and Seam 4) were installed across the LSA and within the proposed Mine Permit Boundary, including 4 nested locations. In addition, four locations were drilled and completed with vibrating wire piezometers at shallow, intermediate and deep depth (no correlation with the coal seam numbers).

The distribution of the wells and hydraulic heads across the study area are presented on Figure 4.4-1 for data collected in October 2014. Four of the wells are located on the east side of Grassy Mountain, where surface runoff drains towards Gold Creek. All the other wells are located on the west slopes, with surface runoff draining towards Blairmore Creek. In general, pressure head within the monitoring wells is significantly greater at the monitoring wells located on the west slope parallel to the bedding plane (maximum of 110 m) than at monitoring wells located on the east slope (maximum of 31 m). Observations regarding pressure head in each of the coal seams are provided in the following;

- four monitoring wells target coal Seam 1. Two of the wells, MW14-04-12 and MW14-06-32, are located at the highest elevation (1,900 to 1,950 m asl respectively) on the site and were monitored as almost dry (10 cm of water) or with about 6.7 m of water, respectively. The two other wells, MW14-03-28 and MW14-10-22, are located at lower elevation (1,750 and 1,850 m asl, respectively) and were both dry;
- three monitoring wells target coal Seam 2. MW14-05-114 is located at an elevation of approximately 1,950 m asl and has the most water with about 110 m of pressure head. MW14-08-79 is located mid-mountain at about 1,850 m asl and had about 29 m of pressure head. MW 14-01-64 is located downslope at about 1,550 m asl and had about 29 m of pressure head; and
- six monitoring wells target the lower coal Seam 4. MW14-04-93 and MW14-06-105 are located at the higher elevations (about 1,900 and 1,950 m asl, respectively) and had the highest pressure head at 75 and 87 m, respectively. The three wells located mid-slope, MW14-07-48, MW14-09-129 and MW14-03-90, are located at an elevation of 1,850 m asl, 1,800 m asl and 1,750 m asl, respectively and had between 17 and 37 m of pressure head. Finally, MW14-02-73 located down slope at 1,550 m asl had the least amount of water within about 2 m.

Thus, the water level data shows that:

- Seam 1 is only partially saturated with unconfined conditions at higher elevation, and generally dry at lower elevation;
- Seam 2 is generally saturated and confined across the mountain and regardless of elevation; and

- Seam 4 is saturated and generally confined, with greater heads encountered at higher elevation.

Vertical hydraulic gradients were calculated between seams where sufficient head data was available. Generally, downward gradient between Seam 1 and Seam 4 and/or between Seam 2 and Seam 4 were encountered across the mountain within the Kootenay group. Downward gradients were estimated to range between 0.1 and 4 m/m. A couple locations in LSD 36-008-04 W5 were monitored to have an upward gradient between Seam 4 and Seam 1 or between Seam 2 and Seam 1. Upward gradients were estimated to range between 0.1 and 0.8 m/m.

Six drill holes (RGOH3012, RGOH3029, RGOH3047, RGOH3049, RGOH3052 and RHOG3059) encountered artesian flowing conditions upon completion. The core exploration holes were drilled to a maximum depth of between 83 and 252 mbgl, and intersected all three coal seams, except for RGOH3029 which intersected Seam 2 and Seam 4 only, and RGOH3052 which intersected Seam 1 only. The flowing artesian holes are located mid to down slope on either side of Grassy mountain's crest as presented on Figure 3.1-1. The two holes located north and on the east slope (RGOH3029 and RGOH3059) had artesian conditions encountered between 1,650 and 1,660 masl, while the four holes located on the west slope had artesian conditions encountered between 1,307 and 1,447 masl.

Long term water level information was collected from selected monitoring wells and vibrating wire piezometers between summer/fall 2014 and spring 2016. Hydrographs are presented on Figure 4.4-2. In general, hydrographs show a decline in hydraulic heads between August and March and an increase in hydraulic heads between April and July. The decline in hydraulic heads is interpreted as corresponding to a decrease in recharge during the fall and winter (*i.e.,* as rain is replaced by snow), while the increase in hydraulic heads can be explained by snowmelt and spring precipitation (freshet). Groundwater response to precipitation is observed in all three coal seams, but the response is attenuated with depth. The amplitude of water level variation is generally within the range of 2 to 5 m with the greater variations at shallower depth. Hydrographs from VWP installed near Test Well 1 show no groundwater variation in the intermediate and deeper interval monitored and are interpreted as installed above the water table. VWP locations show the amplitude in water level variation is about 10 m at shallow depth and between 2 and 5 m for the intermediate and deep intervals.

Seam 1 and Seam 2 were the target of the historical underground mining that occurred in the early 1900s. Two of the original portals used to access the lower Greenhill Mine are still present. The portals are at an elevation of about 1,324.5 m asl. From April 2014 to June 2014, the flow rate at the Greenhill Portal (Main) steadily increased from approximately 950 cubic metres (m^3/day) to 1,728 m^3/day (Figure 4.4-2). Between June 2014 and March 2015, the flow rate steadily decreased from

1,728 m^3/day to 260 m^3/day. Groundwater discharge at the portal appears to mimic the hydrographs, with higher discharge in the spring and lower discharge during fall and winter.

4.4.2.2.2 Hydraulic Conductivity

Eight slug tests conducted at the monitoring wells show that hydraulic conductivity values of the coal seams range from less than 1.3×10^{-8} to 2.3×10^{-6} m/s, with a geometric mean of 1.6×10^{-7} m/s. Hydraulic conductivity data is summarized on Figure 4.4-3 and in Table B3a. Reviewing hydraulic conductivity seam by seam, the following comments can be made:

- Seam 1 - hydraulic conductivity is estimated at 4.2×10^{-7} m/s (one well);
- Seam 2 - hydraulic conductivity was measured as 3.6×10^{-8} and 2.3×10^{-6} m/s (two wells). A value estimated at less than 1.0×10^{-10} is interpreted to be representative of the claystone between Seam 2 and Seam 4;
- Seam 4 - hydraulic conductivity ranges from 1.3×10^{-8} to 4.2×10^{-7} m/s (five wells), with a geometric mean of 1.0×10^{-7} m/s; and
- RGOH3012 - a flowing well, hydraulic conductivity is estimated at 4.0×10^{-7} m/s (transmissivity of 4×10^{-5} m^2/s) as measured for over 100 m of saturated thickness (Golder 2015).

Packer tests targeting one or more of the coal seams (and including bedrock between coal seams) have hydraulic conductivity values ranging from 5.0×10^{-9} to 5.0×10^{-6} m/s. Three tests targeting specifically bedrock between the coal seams have a hydraulic conductivity ranging between 2.0×10^{-8} and 7.0×10^{-8} m/s. A summary table of the packer tests results is located in Table B3b.

Freeze and Cherry (1979) report hydraulic conductivity values of shallow lignite coal to range from 10^{-6} to 10^{-4} m/s, with decreasing values at depth greater than 50 – 100 m. In addition they indicate that the bulk hydraulic conductivity of coal seams is generally attributed to joints and openings along bedding planes, with the bulk fracture porosity generally a small fraction of 1%. The testing shows that hydraulic conductivity of coal seams from the Mist Mountain Formation appears to be lower than the generic literature values. A general decrease of hydraulic conductivity values with depth was observed across the Project (Figure 4.4-3).

4.4.2.2.3 Groundwater Chemistry

Groundwater sampled and analyzed at eight of the 13 monitoring wells installed within the LSA; the remaining five wells were not sampled as they were either dry or had an insufficient amount of water for sampling. Results from the groundwater sampling program are presented in Tables B7 to B10 and indicate several monitoring wells failed the QA/QC review due to elevated pH or ion balance outside the acceptable range or both, which is likely attributed to the influence of cement.

Groundwater from the coal seams is characterized as being of the calcium-bicarbonate, with a few location of the calcium-sulfate type as mapped on Figure 4.4-4. Calcium-sulfate type water appears to be associated with Seam 2 and Seam 4. A piper plot is presented on Figure 4.4-5. The following summarizes the groundwater chemistry in the coal seams;

- total dissolved solids ranges between 101 and 398 mg/L. Similar values were inferred from the geophysical logs from an oil and gas well located 01-20-009-03 W5 at depth ranging between 2,500 m and 2,750 m bgs;
- chloride concentration is less than 10 mg/L and concentrations of nitrate and nitrite are generally below detection limit and all below the FWAL guidelines;
- both dissolved and total aluminum and iron were detected at concentrations above the CDW and/ or FWAL guidelines at a few of the monitoring wells;
- concentrations of arsenic, antimony, barium, chromium, lead and manganese (total and/or dissolved) were occasionally detected above the CDW; and
- total and dissolved mercury and selenium, and total arsenic, cadmium, copper, lead, silver and zinc concentrations were occasionally detected above the FWAL.

No correlation is identified between parameter concentrations and the coal seam targeted, well elevation or depth. Benzene, toluene and xylenes were detected at one of the monitoring wells (MW14-07-48). Toluene was confirmed during the subsequent monitoring event; however, all other parameters were below the detection limits.

Selenium is one of the potential parameters of concern for coal mining activities. Dissolved selenium concentrations in groundwater were reported ranging from less than the detection limit (0.0004 mg/L) to 0.00252 mg/L. Total selenium was reported at concentration ranging from less than detection limit (0.0001 mg/L) to 0.0231 mg/L (Tables B8 and B9). The FWAL guideline for selenium is 0.001 mg/L while the CDW is set at 0.05 mg/L. The maximum selenium concentration in groundwater exceeds the FWAL, but is below the CDW at all monitoring wells. Concentrations above the FWAL could be naturally occurring in groundwater within the LSA.

4.4.2.2.4 Groundwater Age

Isotope analyses were conducted on groundwater samples collected at the main Greenhill's Portal and selected surface water locations as presented on Figure 4.4-6. Analyses included ^{3}H, ^{14}C (dissolved inorganic carbon - DIC), $\delta^{18}O$, $\delta^{13}C$ (dissolved organic carbon - DOC) and $\delta^{34}S$.

Tritium (^{3}H) is used to assess the age of groundwater. Tritium is not naturally occurring in the environment and was released into the environment in the 1960s during nuclear testing. Tritium in the atmosphere mixes into precipitation and the concentration is fixed at the time that precipitation infiltrates into the ground to become groundwater. Tritium was monitored at 9.9±1.1 TU at the Greenhill Portal (Main). Clark and Fritz (1997) indicate tritium values between 5 and 15 TU in continental regions are likely indicative of modern waters. Therefore, groundwater discharging at the Greenhill Portal (Main) appears to be of modern age.

Sulphur compounds participate in the geochemical evolution of groundwater. Negative $\delta^{34}S$ isotope ratios are typical of a diagenetic environment where reduced sulphur compounds are formed. The most common reaction product is pyrite, which is present in many shales and organic-rich sedimentary rocks such as coal (Clark and Fritz 1997). Early Paleozoic calcium sulfates ($CaSO_4$) have $\delta^{34}S$ around +30‰ while coal has values between -5 and +10‰ (Clark and Fritz 1997). At the Greenhill's Portal, $\delta^{34}S$ ranges between 22.5 and 28.7 ‰, which is different from the other water samples. A comparison of $\delta^{34}S$ with sulphate (SO_4^{2-}) shows that the Greenhill Portal (Main) water is deriving sulphur from a different source than surface water in the creeks (Figure 4.4-6).

Carbon compounds provide some insight on the type of rocks in contact with the groundwater. A comparison of the $\delta^{13}C$ with bicarbonate (CO_3^{2-}) demonstrate that the carbon present in surface water and the carbon present in the water discharging from the Greenhill Portal (Main) are quite distinct (Figure 4.4-6).

4.4.2.3 Blairmore Group

Within the LSA the Blairmore Group includes two formations. The Cadomin Formation is approximately 10 m thick and consists of alluvial conglomerate. The Gladstone is approximately 100 m thick and consists of sandstone with interbedded mudstone. Wells installed in the sandstone units of the Gladstone Formation are reported to have good yield (67 m^3/day on average) with only 15% of the wells considered as having poor yields (Waterline 2013).

The Blairmore Group, overlying the Kootenay Group, is both located east and west, downslope of the proposed pit. Three monitoring wells are interpreted as completed within the upper portion of the Gladstone Formation. MW15-11-9 and MW15-11-18.5 are nested and located at the CHPP (Figure 4.4-7). The wells are completed within two different mudstone beds and have a tested hydraulic conductivity of 5.2×10^{-7} and 5.2×10^{-6} m/s. Hydraulic heads indicate an upward vertical gradient of 0.4 m/m. MW15-12-14 is located near Blairmore Creek and also completed across mudstone. The hydraulic conductivity was determined as 2.6×10^{-6} m/s. Hydraulic conductivity values appear to be high for the material type, but could be related to fracturing. Chemistry analyses indicate groundwater is of the calcium bicarbonate type (Figures 4.4-5 and 4.4-6).

- total dissolved solids ranges between 327 and 392 mg/L;

- chloride concentration is less than 10 mg/L and concentrations of nitrate and nitrite are less than 0.62 and 0.008, respectively;
- dissolved and/ or total aluminum or iron was detected at concentrations above the CDW and FWAL guidelines at one of the monitoring wells;
- total arsenic and lead was detected at concentration above the CDW and FWAL guidelines at one of the monitoring wells during one of the sampling events;
- concentrations of dissolved and total barium, chromium and manganese were occasionally detected above the CDW; and
- dissolved selenium and total cadmium, copper, mercury, nickel, selenium, silver and zinc concentration were occasionally detected above the FWAL.

4.4.3 Upper Cretaceous

Bedrock units included in the upper Cretaceous include the Alberta Group. The Alberta Group consists mainly of silty mudstone and massive shale with a sandstone unit in the middle. Formations comprising the Alberta Group are only present in the westernmost portion of the LSA. Regionally, half of the wells completed within the Alberta Group have yields greater than 3.3 m^3/d, and the other half are interpreted as dry (Waterline 2013). The average yield for the formation is 15 m^3/d (Waterline 2013).

4.4.4 Quaternary (Surficial deposits)

Mapping of potential alluvial aquifers (Waterline 2013) indicates that an alluvial aquifer may be associated with some portions of Blairmore Creek and Gold creek, and near the confluence with the Crowsnest River.

Surficial deposits within the LSA and RSA are limited and as a result only one monitoring well was completed within gravel deposits (Figure 4.4-7). At the CHPP only 1.7 m of sandy clay is present above bedrock, thus no monitoring well was completed due to the shallow depth of the materials. Near Blairmore Creek, MW15-12-7 is completed across gravelly material. Monitoring of water levels recorded about 2 m of pressure head and hydraulic conductivity is estimated at 5.1×10^{-6} m/s. The well is nested with MW15-12-14 completed across the underlying mudstone. Review of the hydraulic heads indicates an upward vertical gradient of 0.3 m/m, from the bedrock to the surficial gravel deposits.

Chemistry analyses indicate groundwater is of the calcium bicarbonate type (Figures 4.4-5 and 4.4-6). Maximum concentrations were 349 m/L for TDS and 10.5 mg/L for chloride. Dissolved aluminum and manganese concentrations were above the CDW and the cadmium, copper, selenium and zinc concentration was above the FWAL. Total aluminum and iron concentrations were above the CDW, and total cadmium, copper, selenium, silver and zinc were above the FWAL.

4.5 Groundwater and Surface Water Interactions

Groundwater in the RSA exhibits extensive interactions with the surface water bodies. Most of the groundwater in the RSA is expected to eventually discharge to the Crowsnest River, except for the deep regional groundwater system that flows from west to east paralleling the Crowsnest River (Waterline 2013). Locally groundwater discharges to the Blairmore and Gold creeks and tributaries, to the Crowsnest River, through underground flows or springs. Existing historic mine workings and features create additional groundwater and surface water interactions, such as groundwater discharge through mine portals, discharge to or recharge from mine ponds, and toe springs from mine dumps.

4.5.1 Natural Springs

A number of natural springs are identified in the Crowsnest area. Most of the springs are located in the Crownest River valley, indicating that the Crownest River is receiving recharge from groundwater in the area. The valley represents a low point and acts as a discharge point for water.

A Crowsnest River Watershed study conducted in 2013 by Waterline indicated three types of springs to be present in the Crowsnest Pass area, including karst-related springs, fault-related springs and other springs. Locations of the springs are presented on Figure 4.3-3.

No majors natural springs are reported within the LSA and RSA. The Turtle Mountain Spring is located just south of RSA in the Crowsnest valley (Figure 4.5-1). It is a fault-related spring and associated with a thrust fault that places the Upper Paleozoic Sequence (Banff Formation) over the Fernie Formation (Waterline, 2013). Suspended sulfur gives the discharging water a milky appearance and a strong odour of hydrogen sulfide (rotten egg). The spring water is of the calcium sulfate type (Borneuf 1983). Field sampling conducted in fall of 2013 indicated TDS of 427 mg/L, but relatively high sulphate concentration (200 mg/L) as compared to other springs and surface water features in the area (Tables B7 and B8 in Appendix B).

There are a number of small springs and groundwater discharge points observed within the LSA (Figure 4.5-1). Some of them represent groundwater discharges to the creeks and others caused by historic mining activities and are further discussed in the following sections.

4.5.2 Mining Related Groundwater Discharges

4.5.2.1 Mine Portals and Historic Mine Discharge

The Greenhill Portal (Main) and Greenhill Portal (Secondary), and one spring, Spring 1 (Upstream), are associated with drainage from old mine workings specifically the Greenhill Mine and Greenhill Boisjoli Mine, respectively, within the LSA (Figures 4.3-1 and 4.5-1). The Greenhill Portal (Main) has a continuous groundwater discharge (as discussed in Section 4.4.2.2.1); however, Greenhill Portal (Secondary) is blocked with only a little water trickling out (Table B5).

Chemistry from the Greenhill Portals was compared to other historical mines located in the vicinity of the RSA, including International Spring, McGillivray Mine and Bellevue Mine. Most discharge waters are of bicarbonate type with a few demonstrating a sulphate type (*i.e.,* Greenhill Portal (Secondary), McGillivray Mine and Spring 1 (Upstream)). Most of the discharge waters have dominant calcium and/or magnesium cations, with only the International Spring having a sodium-bicarbonate type. Figures 4.5-1 and 4.5-2 present the type water associated with each mine discharge and the piper plot.

Dissolved manganese concentrations are above the CDW at the Greenhill Portal (Main), Spring 1 (Upstream) and the McGillivray Mine and dissolved iron concentrations occasionally exceeds the FWAL and the CDW. Iron staining and deposits are visible at Spring 1 (Upstream). Other metals occasionally found at concentrations above the FWAL include aluminum (Spring 1 (Upstream) and Bellevue Mine), cadmium (Spring 1 (Upstream) and Bellevue Mine), selenium (Greenhill Portal (Main) and Bellevue Mine) and zinc (Spring 1 (Upstream), Greenhill Portal (Secondary) and Bellevue Mine).

Selenium concentration above the FWAL guideline is observed at the Greenhill Portal (Main) (maximum of 0.0022 mg/L), and Bellevue Mine (maximum of 0.0018 mg/L). At the Greenhill Portal (Secondary), selenium is observed at 0.00041 mg/L, which is below the FWAL guideline. Selenium is below the detection limit at the International Spring and McGillivray Mine.

4.5.2.2 Historic Mine Ponds

Numerous ponds associated with historical surface mining activities are present within the LSA. In general, chemistry from the different ponds is very similar as presented on the piper plot on Figure 4.5-2. Groundwater is generally of the calcium-magnesium bicarbonate type. Occasionally, manganese was detected above CDW and cadmium above FWAL and CDW. Selenium is generally present in pond water at concentrations above the FWAL guideline. The maximum dissolved selenium concentration is observed at 0.0059 mg/L at the Small South Pond (Figure 4.5-1). Pond chemistry is interpreted with caution as it may be influenced by depth of sampling, ambient temperatures and the potential development of algae.

4.5.2.3 Historic Toe Springs

Four toe springs (Spring two to five) associated with old waste dumps and spoil piles were identified within the LSA. Water at these locations is of the calcium bicarbonate type (Figure 4.5-1). Occasionally, manganese is detected above the CDW, and iron above the FWAL and CDW. Selenium was only detected above FWAL at 0.00264 mg/L at Spring 3.

4.5.2.4 Comparison with other Groundwater Discharge

To compare with the water quality of the mine related discharges, six small creeks in the LSA were sampled within the LSA (Figure 4.5-1 – watercourses are labelled as 'Stream'). Water is of the calcium bicarbonate type, and all data points plot very closely on a piper diagram as presented on Figure 4.5-2. TDS is generally low and ranges from 40 mg/L to 300 mg/L. Selenium is the only element above FWAL with concentrations from 0.00071 mg/L to 0.0073 mg/L. General water chemistry from the sampled watercourses within the LSA is very similar to chemistry of Blairmore Creek, Gold Creek and Crowsnest River; however the latter do not present selenium concentrations above CDW and FWAL. Further discussion on the hydrology and surface water quality of Blairmore Creek, Gold Creek and Crowsnest River can be found in CR#4 - Hydrology and CR#5 - Water Quality.

4.5.3 Groundwater Interaction with Major Creeks

There are two major creeks in the LSA; Blairmore Creek and Gold Creek. The Blairmore Creek watershed (Figure 4.1-1) is relatively steep, with an average slope of 22% and elevations ranging between 1,300 m and 2,300 masl. Gold Creek has similar geomorphological characteristics with an average slope of 19% and elevations ranging from 1,300 to 2,500 masl (CR#4 - Hydrology). Both creeks ultimately discharge into the Crowsnest River. The substrate of Gold Creek is almost exclusively cobble associated with gravel or boulder with limited portions including silt, fines and legacy coal mine sediments. The substrate of Blairmore Creek is predominantly of cobble, with a few portions where the creek directly flows over bedrock.

Field observations indicate that both Blairmore Creek and Gold Creek are generally receiving creeks (*i.e.*, groundwater discharging into the surface water). A number of groundwater seeps exist along Blairmore Creek and Gold Creek as well as their tributaries (GCT06, GCT08, GCT09, GCT10, GCT11, GCT14). Along Blairmore Creek, groundwater seeps were observed along BCT07, creating small marshes adjacent to the creek channel.

Creek base flow studies concluded both Blairmore Creek and Gold Creek receive groundwater (Sections 3.4 and 3.6 in CR#4 - Hydrology). The contribution of the groundwater to the creeks was estimated based on the creek flow separation analysis. The creek flow rates were separated into two components; quick flow and base flow. Quick flow is defined as the portion of stream flow that comes either from surface run-off or interflow. Base flow is the portion of stream flow that comes from the sum of deep subsurface flow and delayed shallow subsurface flow (Section 3.6 in CR#4 - Hydrology). A review of the base flow data show that the base flow rate generally increases in a downstream direction for both creeks, indicating continuous groundwater discharge to the creeks within the LSA (Figure 3-14 in Appendix C).

This general groundwater and surface water relationship is mainly determined by the topography in the area. Topographic relief within the LSA is substantial, with the crest of Grassy Mountain being up to 580 m above Blairmore Creek and 540 m above Gold Creek. Groundwater receives precipitation infiltration at higher elevations and discharges to the creeks and their tributaries at lower elevations.

Two hydrogeological cross-sections AA′ and DD′ (Figures 4.2-5 and 4.2-8), illustrate the relationship between groundwater and surface water (creeks). The cross-sections present the lithology around the proposed new mine pit as well as baseline groundwater elevation contour lines. Contour lines are extracted from the numerical model presented in Appendix D. The baseline average contour lines present the long term average groundwater condition without the influence of the proposed mining activities. Groundwater flow is very complex due to complex geology and topography but some trends are clearly visible:

- recharge occurs at higher elevation and groundwater generally flows downward at higher elevation; and,
- discharge occurs at lower elevation and groundwater generally flows upward at lower elevation, towards the creek where it discharge and contributes to base flow.

4.6 Groundwater Flow System

Groundwater recharge occurs on topographic highs, where precipitation is the most abundant. Recharge water infiltrates through the ground and percolates to bedrock to depth equivalent or greater than coal Seam 1 (Kootenay Group), as demonstrated by the large number of dry wells completed within Seam 1. Overall, the bulk of the system is saturated, with a relatively shallow water table, as illustrated on Figures 4.2-5 and 4.2-8.

Hydraulic conductivity of units belonging to the Kootenay Group, including coal, range from less than $1x10^{-10}$ to $5x10^{-6}$ m/s as tested by falling and/or rising head tests and packer tests, indicating that the rocks are not very permeable. The higher conductivities in the 10^{-6} m/s range are not common indicating that no significant aquifers are present within or beneath the mine pit.

Groundwater hydraulic heads generally indicate a downward hydraulic gradient at elevation and depth. Beneath topographic highs, groundwater primarily flows downward to great depth as illustrated on Figure 4.2-8 showing the flow pattern beneath Grassy Mountain. As the slope becomes more gradual and the elevation decreases towards the topographic lows and the river valleys, groundwater primarily flows upward and discharges into local surface water features, including Blairmore Creek and Gold Creek (Figures 4.2-5, 4.2-8 and 4.6.1). At the south end of the Project the hydrogeological regime is influenced by the presence of the historic underground Greenhill Mine as supported by lower observed hydraulic heads in the area. Groundwater flow direction and divides are presented on Figure 4.5-3. Groundwater divides are correlated and match the main surface water divides separating the watersheds of Blairmore Creek, Gold Creek and Daisy Creek.

The groundwater flow path indicates that two systems coexist, with a deep system driving groundwater recharge to depth and a shorter pathway driving groundwater discharge to the river valleys within a relatively short timeframe. Modeling of groundwater shows that the average groundwater residence time is over 50 years, with travel time of over 100 years beneath the topographic highs, and shorter residence time in the vicinity of the creeks. Life expectancy or residence time is defined as the average time needed for groundwater to exit the domain *via* an outlet and corresponds to the expected travel time from the current location to an outlet (generally surface water). Groundwater is expected to reside in the system for period of time greater than 50 years. Isotope analyses support the interpretation of a relatively rapid water cycle, as the isotopic signatures of discharging groundwater are consistent with water in recent contact with the atmosphere.

Major thrust faults are expected to be a control mechanism for lateral groundwater flow. Locally, fractures appear to be parallel to bedding planes, enhancing flow within units, rather than across bedding planes. Where the bedding planes are intersected by faults (transecting the bedding planes), groundwater is expected to then follow strike, either northward or southward, or will keep on percolating downward across bedding planes. The actual behavior of each fault is uncertain, as some may act as barriers, while others may act as conduits likely depending in part on the rock type at a particular location.

4.7 Groundwater Users

4.7.1 Water Wells

A review of the Alberta Environment and Parks (AEP) Water Well Information Database indicated that there are 177 water well records and 10 records of springs within the RSA. The vast majority of the wells (75% or 133 records) are reportedly for domestic use. Approximately 11% (15 records) are listed as industrial and another 9% (14 records) are listed as municipal. The remaining wells are listed as dewatering (one record), domestic and stock (one record), investigation (one record), observation (three records) and unknown (nine records). The vast majority of the wells are located in the vicinity of the towns of Frank, Blairmore and Coleman. The water records are mapped on Figure 4.6-1 and well details are summarized in Table B14 (Appendix B).

Out of the 177 active water wells within the RSA, 47 water well records and one spring are located within the LSA. About 73% of the wells (35 records) are for domestic use, 23% are for industrial use (11 records) with the remaining records listed as unknown use. Eight records are located within the mine permit boundaries; six records are listed as industrial (Scurry Rainbow Oil and Devon) and two as domestic (located in the south portion in NE-10-08-04 W5 and NE-14-08-04 W5).

A field survey was conducted in fall 2014 in an effort to confirm groundwater and surface water users within the LSA. Some wells were not surveyed for the following reasons:

- wells reported in SW-16-08-04 W5 have been or are in the process of being connected to the town water system (Figure 4.6-2);
- wells and springs listed in TWP-09 were generally not accessible;
- unable to collect any information for the wells within the mine permit boundary for the following reasons:
    - a few wells listed as owned by Devon were located in 01-09-04 W5, but were fenced within a no trespassing zone. No groundwater licence exists for these wells so they are assumed to be inactive;
    - the other wells could not be located due to inaccurate coordinates provided from the database (accuracy to the quarter section). A well located in NE-10-08-04 W5 was drilled in 1984 to a maximum depth of 12.19 m. Static water level was reported to be 4.57 m bgs. A well located in NE-14-08-04 W5 was drilled to 7.62 m (a drill date is not available). Based on the surficial geology information presented on Figure 4.2-9, these two potential wells would be completed within surficial deposits, either in till or stream alluvium.
- six additional records located within the LSA, but outside of the mine permit boundary and distant from the communities could not be located. A review of recent air photos did not show any access road or clearing in the vicinity of these wells and it is likely that the recorded location of a number of the wells within the LSA is incorrect.

During the survey, six water wells and two springs (an additional spring was surveyed at the request of the landowner although not in the AEP database) used for domestic purposes were verified. Some of the wells reportedly used for domestic purpose in NW and SE-16-08-04 W5 were not surveyed as access to the wells was not granted by the owners. Location of the wells and springs visited during the survey are shown in Figures 4.6-1 and 4.6-2 and analytical results are included in Table B13. In general, water sampled from the landowner wells and springs is of the calcium bicarbonate type with various concentrations of sodium and magnesium. TDS ranges from 264 mg/L to 651 mg/L, with about half having concentrations elevated as compared to the CDW guideline (500 mg/l).

4.7.2 Groundwater Licences

There are 11 licensed groundwater users within the RSA. Nine of the licences are for domestic use, including one for subdivision use and eight for the Municipality of Crowsnest Pass. The other two records include a registry for a farm and another for industrial use at a wood processing facility.

All of the licensed wells are relatively shallow, with a production interval generally between 15 and 30 mbgs. All of the wells except one are located within the alluvium of the Crowsnest River, where surficial deposits are mapped as coarse-grained stream alluvium, outwash plain and kames (Figure 4.2-9). Waterline (2013) indicated that the Municipality of Crowsnest Pass obtains its water from groundwater, which is extracted from the alluvial sand and gravel in the vicinity of the Crowsnest River. All the water licences within the RSA are expected to be extracting groundwater from surficial aquifers and not from bedrock aquifers.

In addition to the 11 groundwater licences, there are 101 surface water licences, withdrawing from the Crowsnest River, Gold Creek, Blairmore Creek, Morin Creek, Caudron Creek, York Creek, Pelletier Creek, unnamed tributaries and unnamed lake, within the RSA. The licensed groundwater and surface water user locations are shown in Figure 4.6-3 and details are summarized in Table B15.

Based on the review of the water wells there are eight records located within the RSA, specifically within the Mine Permit Boundary. Six of the water well records are listed as industrial and located in the vicinity of the proposed pit, but no groundwater licence is associated with them; subsequently, the industrial wells are likely inactive. It is unclear if the two other water wells located within the mine permit boundary exist or not. These specific wells are listed as domestic; however, no associated residences have been identified. The closest confirmed domestic well is located 3.1 km southwest of the proposed CHPP location and 3.7 km southwest of the mine pit boundary (Figure 4.6-1).

5.0 ENVIRONMENTAL ASSESSMENT

Bedrock aquifers, water wells, and groundwater discharge to surface waterbodies have been identified as hydrogeological VCs related to the Project (Section 2.5). The potential impacts to these VCs are assessed in the following sections. Key indicators for all the VCs relate to groundwater quantity (availability) and groundwater quality (chemistry).

5.1 Overview of the Mine activities and Impact Issues

The mine plan and environmental management are described in the Application, Section C.1 to C.7 (Benga 2016). Figure 5.1-1 presents the key water management infrastructure and design features associated with the Project footprint.

Key design components and/or assumptions of the mine plan relevant to this assessment include:

- The mine life is estimated to be 24 years, including a pre-development year and excluding final closure and reclamation.
- Construction will occur in 2018 and mining will begin commence in 2018 or 2019 and progress to 2041.
- The proposed pit will be approximately 6 km long and up to 1.8 km wide. The maximum pit floor depth below current topography will be approximately 430 m at the north-central area of the pit.
- All cover soil will be stripped and stockpiled southwest of the mine facilities for future use during the Project reclamation.
- The open pit will be excavated using standard surface mining techniques. Drilling and blasting will be used to break the rock ahead of excavation by diesel powered shovels. First the waste rock will be removed, and then the coal will be mined.
- Waste rock will be removed from the pit using large haul trucks. During the initial stage of operations, waste rock will be removed to disposal areas outside of the pit. During the initial years of mining, rock will be transported by haul trucks to the south rock disposal area located near the southern extent of the mine. Disposal areas will be located south and north of the pit, then as operations progress in-pit disposal will backfill the mined out areas.
- The mined coal will be hauled to the raw coal stockpile before being processed in the CHPP. Process waste from the CHPP will be co-disposed with waste rock in the disposal areas or as pit backfill. The clean coal will then be transported to the load out facility *via* a covered, overland conveyor. The coal will be loaded onto trains, which will transport final product to ports located on the west coast of British Columbia.
- There will be no tailings pond required for the Project.
- A water management and treatment strategy has been developed for the mine to control water as well as water quality. The CHPP will require 900,000 m^3 annually for process water. In addition, 60,000 m^3 will be required annually for peripheral activities such as road suppression or washing vehicles. These water needs are expected to be covered by groundwater infiltrating the pit and the management of surface water.

- The water management and treatment system will be comprised of surge ponds, sedimentation ponds, saturated zones, diversion ditches and drainage controls. Water from pit dewatering (groundwater interception) and surface run-off is not anticipated to require selenium attenuation. These waters will be directed to sedimentation ponds to decrease the total suspended solids prior to being released to Blairmore Creek and Gold Creek.
- Water that percolates through rock dumps is anticipated to have elevated selenium concentrations and will require treatment. Water will be collected at the toes of the ex-pit disposal areas and stored in surge ponds before being directed to saturated zones or transferred to the raw water pond for use at the CHPP. The saturated zones will be sub-oxic and designed to reduce selenium (and nitrogen) through microbial activity.
- Through operations, surface water quality monitoring will be conducted on the attenuation zones. Based on the results of the surface water quality monitoring, if required, water will then be directed to a water treatment plant to remove metals prior to being released to the environment. All water will be tested prior to any release to ensure the water quality meets the applicable guidelines. A full description of the water management plan can be found in Section C.5.3 of the Application (Benga 2016).
- Domestic wastewater will be collected and treated in a sewage treatment package plant. Effluent water quality will be in accordance with relevant regulations as well as appropriate standards. The treatment plant effluent produced will be pumped to the plant site sediment pond (PSSP) located adjacent to the CHPP product stockpiles. Excess sludge will be collected for removal from the package treatment plant by vacuum trucks and disposal off site.
- Solid waste will be recycled if possible, and if not recycled it will be disposed of at an approved facility. Hazardous waste including waste oil and lubricants will be stored on-site before being trucked to an approved facility.
- The Project will include a refuelling bay and will also have mobile refueling and lube trucks to service the field equipment.
- Reclamation is to be conducted throughout the life of the project, commencing in Year 1 with 930 ha reclaimed by the end of mining in Year 23 (2041). The majority of the remaining reclamation area will be reclaimed in the four years following end of mining, with 1,431 ha of reclaimed area reclaimed to the end of Year 27 (2045) and the final 32 ha reclaimed at completion of the water treatment and selenium management program.

5.2 Hydrogeology Assessment Valued Components and Assessment Components

VCs for the hydrogeological assessment include bedrock aquifers, groundwater discharge to surface water bodies and water wells as described in Section 2.5. The measurable parameters for hydrogeology are water quantity (hydraulic head) and water quality (chemistry). This assessment evaluates each the following in the subsequent sections:

- effect of pit dewatering on water quantity;
- effect of mine waste rock on groundwater quality;
- effect of mine operations on groundwater quality; and
- effect of surface facilities on groundwater quality.

5.3 Potential Effects of Pit Dewatering on Groundwater Quantity

5.3.1 Description of Potential Effects

All surface water that enters the active mining area and all groundwater that reports to the pit will be removed from the active mining areas so equipment can have a dry work space. Dewatering of the mine pit will be conducted using a series of drainage ditches, sumps and pumps to control water within the pit and pump it to one of the sedimentation ponds for treatment and release to the environment. Water will be collected, treated and discharged throughout the year which will provide flow to the main stems of Blairmore and Gold creeks. The locations of these sedimentation ponds are shown on Figure 5.1-1.

Pumping of groundwater out of the open pit will cause the water level (hydraulic head) within the subsurface geological materials to decrease. This effect spreads outward as the cone of depression (or drawdown cone) increases with the pit depth and with time. This will result in a reduction of hydraulic head in the formation. This could result in a reduction of water available in the adjacent bedrock unit or hydraulically connected units and could alter the seepage or discharge to hydraulically connected surface water bodies. The dewatering method selected for the Project will limit the amount of drawdown of the water table, to the lowest elevation of the active pit, which will increase in depth as the pit deepens. The effects associated with pit dewatering are generally less than those observed when using dewatering wells, which are drilled to depth at the start of mining and the full effects are noticed more quickly.

Due to the geological structure of the Project (the units dip downward to the west away from the ridge), the drawdown cone will expand across the units as it expands laterally. The head response is anticipated to be different from settings where the bedding planes are approximately horizontal and the drawdown expands laterally within each unit. The ability for water to transmit from one unit (discussed previously in Section 4.6) (*i.e.,* coal) to an adjacent one (*i.e.,* siltstone or mudstone) is expected to be substantially lower than within the unit, due to the contrast in hydraulic conductivity existing between units (*i.e.,* coal is expected to have a higher permeability than siltstone and mudstone) and the presence of a poorly developed vertical fracture system. The vertical hydraulic gradients and decrease of conductivity with depth observed at the site are indicative of these differences in hydraulic conductivity. The geological structure and the contrasting hydraulic conductivities are to likely reduce the drawdown influence away from the pit.

5.3.2 Impact Assessment

5.3.2.1 Assessment Approach

A numerical groundwater model was completed to estimate the predicted drawdown associated with the mining operations. The model was also used to assess potential changes to groundwater-surface water interactions and evaluate potential base flow reduction. A detailed description of the model and results are presented in Appendix C.

There are no planned projects within the RSA that could interact cumulatively with the predicted drawdown of the Project; therefore, the baseline and application cases were simulated with the model and no planned development case was evaluated. The following sections present the key findings regarding changes in groundwater quantity as predicted by the groundwater numerical model.

5.3.2.2 Assessment results

Simulated hydraulic heads from the numerical model for the baseline case show a close correlation between hydraulic heads and elevation, with decreasing heads towards the valley bottoms (Figure 4.5-3). This is consistent with recharge at higher elevations associated with deep groundwater recharge (long pathway) and travel down to the valley bottoms and areas of groundwater discharge (short pathway).

For the EOM scenario (year 23 of mining, prior to reclamation), predicted drawdowns are highest in the vicinity of the pit and range between 30 m and 430 m, as presented on Figure 5.3-1. The head at the base of the pit is predicted to be between 1600 and 1800 m asl on average (Figure 5.3-2). Figure 5.3-1 predicts that measurable drawdowns (considered, in the context of annual natural fluctuations, to be greater than 5 m) are mostly located within 400 m of the pit boundary, and are contained within the Mine Permit Boundary. Measurable drawdown from the pit dewatering does not extend to Blairmore Creek, Gold Creek and Daisy Creek, but does extend below some of their headwater tributaries. Groundwater flow directions are consistent between the baseline and EOM simulations as presented on cross-sections AA' and DD' on Figures 4.2-5, 5.3-3 and 5.3-4. Recharge will still occur on the topographic highs and travel at depth, with discharge occurring near the topographic lows towards the creeks. Most of the changes are expected directly beneath the pit, associated with the pit dewatering and drawdown. Existing groundwater divides are not affected, except within the pit boundaries. The ridge of Grassy Mountain corresponds with the surface water and groundwater divide. The removal of the rock in the pit will remove this ridge and is predicted to create a new small separated basin, resulting in localized changes to the flow directions. Drawdowns at the mine permit boundary are not predicted to be measurable and are expected to be within the natural range of variation. The area of measurable drawdown is predicted to be contained within the LSA.

For the LTC scenario (long term equilibrated conditions following closure), predicted drawdowns are similar in magnitude as for the EOM with the maximum drawdown predicted at 388 m and the drawdown cone similar in extent (Figure 5.3-5). Heads are presented on Figure 5.3-6. Groundwater flow direction patterns are similar as for the EOM, with some slight changes beneath the mine pit, but with the general pattern of recharge and discharge consistent with baseline conditions (Figures 5.3-7 and 5.3-8). Similar to EOM, the pattern of the groundwater divides will be modified within the pit boundaries with the saturated zones of the pit and the end-lake capturing local groundwater. Predicted drawdowns at the mine permit boundary are within the natural range of variation of groundwater. The area of measureable drawdown is predicted to be contained within the Mine Permit Boundary and within the LSA.

Sensitivity analysis conducted on the model (Appendix C) indicated hydraulic conductivities (including anisotropy) and recharge are the most sensitive parameters (Tables 11 and 12 in Appendix C); however, predictions from the model are expected to be reliable as the conditions used for calibrating the model are considered to be reasonable. The model integrated all available data and was found to acceptably replicate the site observations, which provides good confidence that potential effects associated with mining operations and pit dewatering were reasonably predicted.

5.3.2.2.1 Potential Effects to Bedrock Aquifers

Only marginal bedrock aquifers are present within the project boundaries. Most of the coal units of the Kootenay Group were determined to have a hydraulic conductivity of less than 1×10^{-6} m/s which means they would not be classified as a *domestic use aquifer* by the AER Tier 2 Guidelines. In this section, the term "bedrock aquifers" relates to water bearing units, but does not imply that groundwater would be available in quantity or rate sufficient to be useful.

As discussed above and presented on Figures 5.3-1 to 5.3-9, results from the numerical models indicate drawdown in the bedrock units associated with pit dewatering will occur within and beneath the pit, and will be contained within the LSA and Mine Permit Boundary. The drawdown in the vicinity of the pit is to be expected, as part of the mountain will be physically removed, with the open pit acting as a drain. The 430 m of drawdown predicted at EOM are consistent with the depth of the pit which will be close to 430 m. The drawdown cone diminishes quickly with distance away from the pit. This is consistent with the conceptual site model that has moderate to low hydraulic conductivity values that decrease with depth, a general increase in hydraulic head as topography rises, and less flow across bedding planes than within units. Conclusions are that drawdown is local in extent, *i.e.*, in the immediate vicinity of mining. Changes in topography associated with mining (*i.e.,* the physical removal of the top of the mountain) will permanently change the groundwater regimen to a slightly altered new equilibrium as presented in the LTC scenario and the corresponding shift in the groundwater divides.

Operational monitoring will confirm whether effects are consistent with predictions. A monitoring program will be implemented during the mining operations, which is described in Section 5.3.3, and will provide verification of the actual magnitude and extent of drawdown associated with the dewatering program.

Potential effects related to mine dewatering on groundwater quantity in bedrock aquifers resulting from Project activities have been assessed as follows:

- The **magnitude** of the effect is assessed as low (residual effect is detectable but well within environmental standards) as drawdown within the bedrock aquifers will be negligible at the LSA boundaries (*i.e.,* drawdown of less than 5 m).
- The **geographical extent** of the effect is defined as local as all of the detectable drawdown will be contained within the mine permit boundaries. Effects are not predicted to be measurable at the LSA boundaries.
- The **duration** of the impact is determined to be residual in duration as the effects will last past the Project decommissioning.
- The **frequency** is determined to be continuous as drawdown will be consistent through the assessment period.
- The **reversibility** of the effect is determined as irreversible as the effects will remain after cessation of the mining activities but will be diminishing with time as new groundwater equilibrium develops away from the pit.
- The **project contribution** is classified as negative as the heads within the bedrock aquifers will be decreased.
- The **confidence rating** is moderate as the assessment is based on data pertinent to the study area integrated into a site specific conceptual model and used for the development of a groundwater numerical model and a good understanding of cause-effect relationships; however, some data gaps exist.
- The **probability of occurrence** is high as pit dewatering will certainly create a decrease in head (drawdown) within the bedrock aquifers.
- The **significance** of residual effects is identified as not significant. After mitigation, effects within a portion of the mine permit boundary may exceed natural variability and/or guideline or threshold levels, but these impacts will not measurably change potential use of groundwater from bedrock aquifers across most of the LSA.

The residual Project impact from pit dewatering on bedrock aquifers is not significant as effects will be contained within the Mine Permit Boundary and the LSA.

5.3.2.2.2 Potential Effects to Water wells

Water wells monitored during the field survey and other wells potentially operated for domestic use but not surveyed, are located in NW and SE-16-08-04 W5 and NW and NE-9-08-04 W5 (Figure 4.7-1). These domestic wells are located approximately 3.7 km south west of the closest proposed pit boundary and 3.1 km south west of the proposed CHPP. Drawdown associated with pit dewatering is predicted to be less than 5 m at EOM and LTC near the domestic wells (Figures 5.3-2 and 5.3-4). This is within the expected natural variation of the groundwater heads. Potential effects related to mine dewatering on groundwater quantity in the water wells resulting from Project activities have been assessed as follows:

- The **magnitude** of the effect is assessed as nil as no residual effects are predicated to be measurable at the water wells.
- the **geographical extent** of the effect is defined as local as measurable drawdown will be contained within the mine permit boundaries. Effects will be not be measurable at the LSA boundaries and thus at the local water well users.
- **Duration**, **frequency** and **reversibility** are not applicable since there is no effect.
- The **project contribution** is classified as neutral as the heads within the water wells are predicted to be unaffected by the pit dewatering operations.
- The **confidence rating** is high as the assessment is based on data pertinent to the study area integrated into a site specific conceptual model used for the development of a groundwater numerical model and a good understanding of cause-effect relationships. Some data gaps exist however the water wells are located 3.7 km southwest from the pit boundary and the distance is anticipated to minimize the importance of these data gaps.
- The **probability of occurrence** is low as it is unlikely pit dewatering will have any effect of the local water well users.
- The **significance** of residual effects is identified as not significant. No adverse effects are predicted.

No impacts are predicted to groundwater quantity in local water wells related to mine dewatering during operations and after closure of the Project; therefore, the residual Project impact is not significant. Monitoring of water levels located within the mine area will be conducted during operations to verify consistency with the model predictions. Provided monitoring data within the LSA are consistent with model predictions, domestic water wells are not proposed to be monitored.

5.3.2.2.3 Potential Effects to Surface Water

Pit dewatering is predicted by the model to affect watercourse base flow for both the EOM and LTC application scenarios. Due to the interpretation that watercourse base flow is supported by groundwater discharge, a reduction in groundwater discharge would reduce base flow by the same amount. In the groundwater numerical model, a change in groundwater discharge to watercourse was calculated, which is then interpreted as a change in base flow. At a local scale, change in base flow was evaluated for five gauging stations for Blairmore Creek and Gold Creek and an average for each creek was also estimated. At a regional scale, Daisy Creek and the Crowsnest River were assessed using one representative station for their entire watershed. The percentage reduction for each station is presented in Table 5.3-1 and locations of the surface water stations are presented on Figure 5.1-1.

Table 5.3-1 Summary of Base Flow Reduction at EOM and LTC

Watershed	Station	Base flow Reduction (EOM)	Base flow Reduction (LTC)
Blairmore Creek	BL-03	0%	0%
	BC-07	23%	13%
	BL-02	25%	16%
	BC-03	**30%**	**11%**
	BC-01	27%	10%
	Average	*26%*	*9%*
Gold Creek	GC-13	10%	10%
	GC-09	13%	11%
	GC-04	10%	9%
	GC-02	**19%**	**18%**
	GC-01	12%	6%
	Average	*12%*	*6%*
Daisy Creek	D1	0%	0%
Crowsnest River	CR-01	0%	0%

Data from the numerical model (Appendix C)
Bold: stations with maximum base flow reduction

On average, Blairmore Creek is predicted to have greater base flow reduction than Gold Creek. Blairmore Creek is predicted to see a base flow reduction of 26% at EOM and of 9% during LTC. Gold Creek is predicted to have base flow reduction of 12% at EOM and 6% during LTC. Maximum base flow reductions are predicted for both EOM and LTC at station BC-03 for Blairmore Creek and station GC-02 for Gold Creek. Base flow reduction at station BL-03, which is located upgradient of the mining activities, Daisy Creek and the Crowsnest River, is predicted to be negligible at both EOM and LTC.

The base flow reductions described above are from the numerical model and do not take into account any mitigative measures that will be implemented by the surface water management system. The magnitude of the base flow reduction for EOM and LTC for both creeks is largely due to the fact that groundwater is captured in the pit, pumped into the sediment ponds and not able to contribute to base flow of the creeks. The numerical model does not recognize that this water gets pumped to the sedimentation ponds and still contributes to the base flows. The base flow reductions for Blairmore and Gold creeks is thus over predicted by the model.

At LTC, base flow reduction is still observed for both creeks even though mining and active pit dewatering has ceased, as the groundwater levels in the new equilibrium conditions are lower than under baseline conditions. Water levels in the saturated zones and the end-pit lake are either controlled by spill points or horizontal drains (Section C of the Application and Figure C.5.3-5, (Benga 2016)). Base flow reduction assessed by the model is predicted to be a lasting effect during LTC, as the groundwater flow system will not return to the pre-mining conditions. The physical removal of a portion of Grassy Mountain will alter recharge to groundwater and results in a shift in the groundwater divide. These changes will alter the groundwater flow system, which will affect the surface water conditions through changes to base flow.

Base flow reduction values from the model (for EOM, LTC and other intermediate modelling steps) were incorporated to a surface water flow model (GoldSim) taking into account surface run-off and water discharge from the ponds, pit lake and saturated zones to assess the actual predicted base flow changes for both Gold Creek and Blairmore Creek. Accounting for all source of water, base flow is estimated to decrease slightly for Gold Creek and increase for Blairmore Creek (with the amount of decrease or increase varying seasonally and depending of the mining stage). Further discussion on the predicted flow changes in Blairmore and Gold creeks is provided in CR#4 – Hydrology (Section 5.2).

The drawdown of hydraulic head and interception of the groundwater by the pit will reduce baseline groundwater discharge to local surface watercourses. Under baseline conditions, the upper reaches of the associated tributaries to Blairmore Creek, Gold Creek and Daisy Creek receive minimal to no groundwater discharge. By contrast, the lower portions of the tributaries (*i.e.*, within topographic low areas), as well as the main stems of Blairmore Creek, Gold Creek and Daisy Creek, would be expected to receive groundwater recharge throughout the year. The amount of groundwater recharge would be a small proportion of total flow during the spring and summer months (with higher surface flows as a result of the spring freshet and summer storm events); however, a higher proportions would be expected during the fall and winter months. Pit development will intercept groundwater that would provide groundwater discharge to the watercourses. During spring and summer runoff from precipitation and surface runoff dominate the total creek flow; consequently, groundwater base flow contributions would not be a key contributor to the overall base flow. During low flow periods (*i.e.*, fall and winter) the reduction in groundwater contributions as a result of pit interception would likely be more noticeable. One of the key water management mitigations during operations is to offset this loss in intercepted groundwater and to pump it to the sedimentation ponds for treatment and release to the main stems of Blairmore Creek and Gold Creek.

Potential projects effects are related to effects of mine dewatering on water quantity in surface water bodies resulting from the operation and post-closure condition of the Project. Overall, the estimated changes in creek flow are well within the range of variability that would naturally occur between wet and dry years. The overall significance rating for the hydrology assessment for Blairmore and Gold Creeks was judged to be not significant (Section 5 of the CR#4 – Hydrology). Assessment of the related impacts on surface water bodies is further discussed in the CR#4 - Hydrology.

5.3.3 Mitigation and Monitoring

5.3.3.1 Mitigation

Pit dewatering is necessary for the mine operations; therefore, drawdown of groundwater in the bedrock units will occur during the Project, but effects to bedrock aquifers are predicted to be localized so that no mitigation measures are required. No impacts are predicted at the water wells, therefore no mitigation is proposed. Specific to watercourses' base flow reduction, the approach to determine the final effect is discussed in Section 5 of the CR#4 – Hydrology and in Section C.5.4 and C.5.5 of the Application (Benga 2016).

5.3.3.2 Monitoring

Monitoring of water levels in bedrock aquifers near the open pit and up-gradient of any receptors will be undertaken as part of the monitoring program. Monitoring will provide verification of the magnitude and extent of predicted impacts to hydraulic head. Further description of the monitoring program is presented in Section 7. Monitoring of domestic water wells is not proposed at this time.

Simulations from the numerical modelling predict groundwater drawdown will affect base flow of surface water bodies. Surface water quantities have also been modeled with the predictions provided in Section 5 of the CR#4 – Hydrology. Proposed monitoring of the surface water is also presented in Section 7 of the CR#4 - Hydrology.

5.4 Potential Effects of Mine Waste Rock and Mine Operations on Groundwater Quality

5.4.1 Description of Potential Effects

Effects of mine waste rock and mine operations on groundwater quality relate to the composition of the coal and waste rock and to the use of explosives for the mining. A geochemical assessment was conducted for the Project and indicates that sulphide sulphur and selenium, and to a lesser degree cadmium, are the main elements present in the rock that have the potential to be affect water quality (Appendix 10A). Units from the Cadomin Formation, Mutz, Adanac and Moose members have been identified has having the potential for acid rock drainage generating (PAG) while rocks from the other units were identified as non-PAG (*i.e.* they are not interpreted as having the ability to generate acid rock drainage - ARD). Under saturated (sub-oxic) conditions, as encountered in the ground pre-disturbance, selenium and sulphate are stable and remain within the rock (*i.e.*, no release to groundwater or the environment). During mining, as the coal and associated deposits are brought to surface, the rock is exposed to air and may result in the oxidation of pyrite, generating acidity, and the potential release of selenium.

Explosives used for mining will be a blend of ammonium nitrate and fuel oil (ANFO); consequently, nitrate and nitrite associated with blasting residues may be present within the pit and the waste rock disposal areas.

Surface runoff and rainfall that percolates into and seeps from the external rock disposal areas are expected to contain selenium and nitrate concentrations that will require further management prior to release to the environment. This portion of the assessment will consider potential impacts related to nitrate from residual explosives and potential leaching of substances (including selenium) from waste rock and the CHPP process waste. The assessment will also look at the potential migration pathways (including surface water, hypothetical karst features or the existing historical underground mines) and the risk to local users including domestic water wells and municipal wells in the Municipality of Crowsnest Pass.

5.4.2 Impact Assessment

5.4.2.1 Assessment Approach

Grassy Mountain was partially mined from the early 1900s to the mid-1960s, using both surface and underground mining techniques. Vestiges from the historical mines are still visible within the LSA, including old portals, mine shafts, pit lakes, and waste rock piles. Characterization of the impact by the historic mining activities on surface water and groundwater quality helps in assessing potential additional impacts by the new mining activities, as well as the cumulative impacts on the environment.

A geochemical characterization of mine waste was conducted by Benga and a summary of the geochemical characteristics of the Grassy Mountain area is provided in Appendix 10A. The study focused on historical mine waste material, rock samples collected from the coal exploration program, which were selected to represent future waste rock and CHPP residues, and a few groundwater seeps (toe springs).

Mineralogical analysis from future waste rock and CHPP waste residue indicates that sulphur occurs mainly as pyrite. Sulphide sulphur ranges from less than 0.01 to 3.9%, with concentrations greater than 0.1% associated with the Cadomin, Mutz, Adanac, and Moose Mountain samples. Waste rock associated with Coal seam 1 is classified as having the potential for acid rock drainage (ARD) generation (PAG) while waste rock associated with coal seams 2 and 4 is classified as non-PAG. Iron-bearing carbonates account for 60 to 80% of the total inorganic carbon. They do not contribute to acid neutralization. Selenium concentrations in rock range from less than 0.1 to 4.8 mg/kg with the highest concentrations associated with claystone samples from the Mutz and Adanac members. Selenium is not found to be enriched but leaching is a consideration for the project. Mild cadmium enrichment was identified in samples from the Mutz Member.

In historical mine spoil (legacy waste), sulphide sulphur is present at low concentrations (0.01 to 0.06%) and therefore rocks from historical spoil are interpreted as non-PAG unless a fresh surface is exposed. Cadmium and selenium concentrations are typically intermediate compared to the concentrations found in the future waste rock samples.

A review of the surface water and groundwater samples collected from springs, toe springs, ponds and streams located in the vicinity of the historical mine for the hydrogeological assessment indicates that overall very few exceedances of FWAL guidelines occur. Selenium is the only element which was frequently detected above FWAL in surface water and groundwater samples; however it was not measured above the CDW. Sulphate was occasionally detected above FWAL guidelines at locations associated with historical mining activities (*i.e.*, portal, toe springs and end pit lakes). Nitrate and cadmium were not measured above FWAL, with just two exceptions for cadmium. All samples had pH within guidelines with no observation of potential acidic conditions. Table 5.4-1 presents a summary of the FWAL exceedances.

Table 5.4-1 Summary of FWAL Exceedances for Key Parameters in Surface Water and Groundwater

Location	Selenium	Sulphate, Nitrate, Cadmium	Low pH (<6.5)
Surface water[1]	Concentration between 0.00045 and 0.0073 mg/L	All samples below FWAL	No
Greenhill Portal[2]	33% samples exceed FWAL	All samples below FWAL, Except for sulphate: 50% samples exceed FWAL	No
Groundwater[3]	38% samples exceed FWAL	All samples below FWAL	No
Springs and Ponds[4]	50% samples exceed FWAL, mainly at ponds and Spring 3	All samples below FWAL, Except for sulphate and cadmium at Spring 1 and cadmium at the Small South Pond	No

1: Streams, Blairmore Creek, Gold creek and Crowsnest River

2: Greenhill Portal (Main)

3: Monitoring Wells

4: Springs (toe springs) and ponds (end pit lakes) associated with or near historical mine spoil

Based on the chemistry results discussed above, it appears selenium, occasionally sulphate and rarely cadmium, are the only elements present at concentrations above FWAL guidelines. No occurrence of elevated nitrate concentrations, a blasting residue, or the presence of acidic conditions was observed in any of the samples. Selenium concentrations above guidelines were observed at surface water locations, including the Crowsnest River, streams, the Greenhill Portal (Main) and ponds. Selenium was monitored at the toe springs of the historical mine spoil (waste rock), but generally at concentrations below guidelines, which may be interpreted as indicative of no notable residual effect related to historical mining activities. Sulphate and cadmium (both potentially released from the waste rock) have predicted concentrations below guidelines in groundwater 50 years following the latest mine activities.

The low concentrations in nitrate observed during baseline characterization are consistent with observation made at other mines. Hackbarth Environmental (1999) and Hackbarth (1981) conducted studies regarding nitrate concentrations associated with blasting residues from active mining operations at the Coal Valley, Luscar, Gregg River, Obed Mountain and Smoky River mines, all coal mines located in the Rocky Mountains or Foothills of Alberta. These studies demonstrated that nitrate leaching from mining operations follows a predictable trend of increase in concentration during operations then concentration decrease, with elevated concentrations ending 5 to 10 years after placement of the waste rocks. Nitrate values may go up during high precipitation events, due to increased leaching, but eventually return to background values.

Selenium can be treated using sub-oxic saturated backfills, potentially enriched with carbon, to favour microbial activity to degrade selenium (Appendix 10A). The selenium management plan for the Project will rely on this attenuation mechanism. Saturated zones will be created by backfilling the mining pits. The saturated zones will be engineered and constructed to facilitate removal of the selenium, and operated as an effective semi-passive "bioreactor". Long term carbon source will be provided to enhance the selenium attenuation and could come from plant-refuse. Nitrate denitrification will also be implemented in the saturated zones through a similar mechanism as the selenium attenuation. Acidity (ARD) will be neutralized by carbonate minerals, and by blending PAG rock with non-PAG rock. The management plan includes capturing and diverting water run-off from the waste rock dumps to surge ponds for temporary storage before disposing of it in the saturated zones.

Results from the above studies and site specific sampling indicate that the potential effects of mining are expected to dissipate with time and are hardly measureable in the environment approximately 50 years after the last mining activities. This indicates that some natural mechanisms already exist allowing for the attenuation of elements with potential negative effects. As stated selenium, ARD and nitrates will need to be managed over the life of the Project. Selenium may enter the groundwater system though the open pit, the saturated zones and/or the rock disposal areas. Measures will be taken as part of the water management plan to pro-actively treat PAG rocks, selenium and nitrate before the release of water to the environment. This will ensure that released water meet the FWAL guidelines and is protective of the fresh water receptors. For selenium, the site specific objectives (0.0017 mg/L to 0.0093 mg/L) are more stringent and lower than the CDW (0.05 mg/L), thus meeting the site specific objectives will automatically meet the CDW guidelines and be protective of drinking water receptors, including domestic and municipal wells.

The presence of the historical underground mine workings and potential karst features could represent a pathway to water wells located in the Crowsnest River Valley near Blairmore. However, the groundwater flow pattern and location of the underground workings is such that a constant conduit does not exist from Grassy Mountain, through Bluff Mountain and into the Crowsnest River Valley. If groundwater impacted by the Project were to find a pathway into the known historical underground mine workings or potential karst features, the travel times would likely be increased from the current situation of decades to weeks, months or years, reducing the risk of impacted water from reaching the groundwater users. This is further discussed in Section 5.4.2.2.2.

5.4.2.2 Assessment Results

Baseline groundwater flows radially from two topographic highs present within the Mine Permit Boundary, *i.e.*, Grassy Mountain and Bluff Mountain, which is just to the south of the Mine Permit Boundary (Figure 4.5-3). Groundwater generally flows west and east of these features towards Blairmore Creek and Gold Creek, respectively. In between, groundwater moves south from Grassy Mountain and north towards Grassy Mountain from Bluff Mountain, before both flows discharge into Blairmore Creek and Gold Creek. EOM and LTC head distributions show that other than local groundwater flow being re-directed towards the pit, groundwater flow directions will remain the same as current baseline conditions. Water from the pit and saturated zones will be confined within these features. Groundwater underlying the north rock disposal area will flow towards Blairmore Creek and groundwater underlying the south rock disposal area will flow north from Bluff Mountain or south from Grassy Mountain and then towards Blairmore Creek or Gold Creek. These flow patterns at EOM and LTC are illustrated in Figures 5.3-2 and 5.3-6, respectively. These flow paths indicate that the primary concerns are the surface water receptors; consequently, the management and mitigation of these potential effects is required and outlined in CR#5 – Water Quality.

Groundwater residence time (travel time to the creeks) from the LTC scenario is predicted to be mostly greater than 10 years (Figure 5.3-9), except below sedimentation ponds and close to creeks and tributaries. Within the proposed ex-pit and in-pit rock fill footprint, groundwater residence time is predicted by the model to be approximately less than 20 years (Figure 5.3-9). The groundwater modelled with longest residence time (greater than 50 years) is close to the topographic highs and the shortest (less than 20 years) are close to the topographic lows. Therefore, most basal leakage from the waste rock dumps would reside in the groundwater system for a duration that substantially exceeds the critical residence time to attenuate any selenium. Areas with short residence time (*i.e.,* less than 10 years) are of limited extent (*i.e.*, less than 5%) in comparison to areas with long residence time; therefore, substantial mixing will occur with groundwater where selenium has attenuated or remains at baseline levels. The pit saturated zones and end pit lake will form their own small groundwater basin, as illustrated by the groundwater divide pattern on Figure 5.3-6. Groundwater flow will actually be towards the pit and, therefore, migration of water away from the pit would not occur, providing further residence time and opportunity for mixing.

5.4.2.2.1 Potential Effects to Bedrock Aquifers

Groundwater flow direction patterns for EOM and LTC, as predicted by the numerical model, indicate that the pit will capture nearby groundwater towards the pit. It is predicted that the end pit lake will take approximately 13 years to fill. Head distribution indicates that groundwater further away from the pit will flow southward away from Grassy Mountain, but will flow northward from Bluff Mountain. Groundwater accumulating between the two mountains will ultimately discharge to Blairmore and Gold creeks and will therefore be discharged from the groundwater system.

The average residence time for groundwater in the system is generally greater than 10 years providing ample time for attenuation of selenium and nitrate to occur.

Potential effects related to mine waste rock and mine operations on the bedrock aquifers' groundwater quality from Project activities have been assessed as follows:

- The **magnitude** of the effect is assessed as low as mitigative measures (*i.e.*, the selenium management plan) will effectively manage potential impacts at the Project.
- The **geographical extent** of the effect is defined as local as potential impacts will be managed within the mine permit boundaries and LSA.
- The **duration** of the impact is determined as long as mitigative measures are expected to be in place beyond the period of active mining.
- The **frequency** is determined to be continuous as the effect will occur continually over the assessment period.
- The **reversibility** of the effect is determined as reversible in long-term as effects remain after cessation of activities, but would diminish with time and the implementation of the management plan.
- The **project contribution** is classified as negative.
- The **confidence rating** is moderate as the assessment is based on a good understanding of the cause-effect relationships and the use of pertinent data to the study area (including the development of a management plan) and the use of data from elsewhere pertinent to the assessment.
- The **probability of occurrence** is medium (possible or probable) with the management plan in place.
- The **significance** of residual effects is identified as not significant as effects after mitigation are expected to be below guidelines or threshold levels.

5.4.2.2.2 Potential Effects to Water Wells

The pit is planned to be 430 m below topography and will cut through the Blairmore Group, the Kootenay Group and the upper part of the Fernie Formation. The pit will not intersect with Paleozoic units; however, the surface rock disposal areas, (specifically the south rock disposal area), will partially overlay sub-cropping Paleozoic formations as presented on Figure 4.3-2, which form the bulk of Bluff Mountain. The Paleozoic formations, which have not been identified as presenting karstic features, potentially include more permeable units such as limestone and dolomite. The presence of more permeable units, creates a potential groundwater flow path between the pit and the Crowsnest River Valley.

Two historical underground mines, the Greenhill Boisjoli Mine and the Greenhill Mine (Figure 4.3-1) are present directly south of the main mine development area, between the Project and the Crowsnest River Valley. Groundwater stored or transiting through the underground mines is interpreted to discharge at Spring 1 and the Greenhill Portals (Main & Secondary), respectively. Figure 5.3-6 presents a north south cross-section aligned from the southern portion of the mine pit and following the upper elevations of the two underground mines, down and across the Crowsnest River Valley. As presented on the figure, the mine pit will intersect the Greenhill Boisjoli Mine, stopping approximately at the location of Spring 1. Spring 1 is believed to correspond to the location of the historical adit of the Greenhill Boisjoli Mine. The presence of the underground mines directly downgradient from the pit has the potential to act as a conduit for groundwater flow, decreasing the travel time between the pit and the Crowsnest River Valley.

It was presented in Section 5.4.2.2 that groundwater stored in the Paleozoic units, forming the bulk of Bluff Mountain, will flow radially, including northward before discharging into Blairmore or Gold creeks. Groundwater contours also indicate that a divide exists within the Greenhill Mine, with part of the water flowing primarily to the south while the remaining flows north and east (Figure 5.4-1). This is consistent with the interpretation of a radial groundwater flow around Bluff Mountain. Particle paths (from particle tracking conducted in the numerical model) indicate that groundwater within the Greenhill Boisjoli will travel primarily to the north, towards the open pit, as the pit will intersect the mine and act as a drain. Particles within the Greenhill Mine confirmed the presence of a divide, with particles travelling north, south and east. Groundwater flow direction and particle path tracking indicates that groundwater potentially impacted from mining operations will not travel from north to south through hypothetical karstic features or the existing underground mine. There is no apparent ability for impacted groundwater to travel southwards towards the Crowsnest River valley where the municipal water wells utilize the alluvial aquifer. As a result, municipal water wells are not predicted to have any groundwater quality impacts associated with mine spoil and mining activities.

The closest domestic wells are located 3.1 km southwest of the CHPP. The residence time of the groundwater located between the mine and the water wells is generally over 50 years (except locally close to the creeks where groundwater discharges; Figure 5.3-6) providing sufficient time for selenium attenuation to occur. In addition, groundwater supplying these wells is mostly coming from topographic highs located west of the Project, which not have been impacted by mining activities or mine spoil. Potentially impacted groundwater would discharge to Blairmore Creek, located between the Project and the domestic wells, before discharging into the Crowsnest River. As a result, these water wells are not predicted to have any groundwater quality impacts associated with mine spoil and mine activities.

Potential effects related to mine waste rock and mine operations on water wells from Project activities have been assessed as follows:

- The **magnitude** of the effect is assessed as nil as mitigative measures (*i.e.*, the selenium management plan) will effectively manage potential impacts at the Project.
- The **geographical extent** of the effect is defined as local as potential impacts will be managed within the mine permit boundaries. The closest confirmed domestic well is located 3.1 km southwest of the proposed CHPP location and 3.7 km southwest of the mine pit and should not be affected by the mining activities.
- **Duration**, **frequency** and **reversibility** are not applicable since there is no effect.
- The **project contribution** is classified as neutral as water wells are not expected to be affected by the Project activities.
- The **confidence** rating is high as the assessment is based on a good understanding of the cause-effect relationships and the use of pertinent data to the study area (including the development of a management plan) and the use of data from elsewhere pertinent to the assessment.
- The **probability of occurrence** is low (unlikely).
- The **significance** of residual effects is identified as not significant.

5.4.2.2.3 Potential Effects to Surface Water

Assessment of the related to effects of mine waste rock and mine operations on surface water quality is discussed in Sections 4.1 and 4.6 in CR#5 - Water Quality. The following presents a very high level summary.

A total of 39 variables were modelled, of which 21 variables have published Alberta water quality guidelines. Predicted concentrations of all of these 21 regulated water quality variables during the construction, operation, closure and post-closure periods of the Grassy Mountain Mine fell within published Alberta guidelines (or for Se, the proposed site-specific objective) in Gold Creek. In Blairmore Creek, predicted concentrations of all variables fell within these guidelines or the proposed Se objective except sulphate, for which concentrations are predicted to increase steadily over mine life. Sulphate is predicted to remain below the AB guideline during mine life until the mid-to-late 2030s, when it is predicted to exceed this guideline in all seasons until mine closure, after which time concentrations are predicted to decline to a stable, long-term average, which would still remain consistently above this guideline at all modelled locations downstream of the West Sedimentation Pond water release.

Based on the anticipated management of runoff and controlled release rates from sedimentation ponds, negligible effects are anticipated on surface water quality from sediment-associated inputs. All process water with elevated selenium, nitrogen species, and other constituents will be treated in surge ponds and saturated zones with sufficient water residence time. All other elevated metal concentrations will be treated in treatment facility before releasing to the environment.

After mitigation, the residual effect of the Project on water quality in the LSA is considered to be not significant**.**

5.4.3 Mitigation and Monitoring

5.4.3.1 Mitigation

Mitigation measures will include the development of a management plan as described in Section C.5. A summarized description of the water management plan is presented below.

The water management program is primarily focused on capture, treatment and release of all surface run-off and water pumped out of the pit (which also includes a groundwater component) for the removal of suspended sediment. A series of collection ditches, sumps, pumps and settling ponds will be established to manage all surface water on the mine site. Surface runoff from mining areas and haul roads is collected and directed to settling ponds for treatment or will be pumped to the raw water pond for storage and use in the coal cleaning process. Water collected at the toes of disposal areas is expected to contain elevated levels of selenium. This water will be directed initially to surge ponds before being directed to saturated zones for selenium attenuation. Saturated zones will be engineered and constructed to facilitate removal of the selenium, and operated as an effective semi-passive “bioreactor”.

Measure implemented as part of the water management program will ensure water quality is met prior to release to the environment.

5.4.3.2 Monitoring

A groundwater monitoring program will be implemented to detect any impacts on shallow groundwater quality resulting from mine waste rock and mining operations. Monitoring will focus primarily on areas in the vicinity of the ex-situ rock disposal areas and surge ponds that store captured water from mine waste rock run-off. Further details are presented in Section 7 for the groundwater monitoring program and in Section 5 in CR#5 – Water Quality.

5.5 Potential Effects of Surface Facilities on Groundwater Quality

5.5.1 Description of Potential Impacts

The environmental management and waste management plans for the Project are described in the Application, Section C.7 (Benga 2016). Waste generated on site will be stored and disposed of in accordance with regulatory requirements. Water released to the environment will be tested in advance of release to ensure that it meets water quality requirements in accordance with the operating approval.

Surface facilities of relevance for this section include the wash bay, cold storage, lube storage, fuel farm, potable and wastewater treatment plants and storage yards. The Project will use a wide array of products and chemicals during operations. Products handled at the Project CHPP will include hydrocarbons fuels (gasoline and diesel), lubricants (for light duty, mobile equipment and mining trucks), engine coolant, flotation reagents, and anionic and cationic flocculants. Explosives will be handled by a third party service provider.

Facility sewage will be collected and treated in a sewage treatment package plant located on the mine infrastructure area (MIA) pad. The treatment plant will treat all sewage produced at the MIA facilities and has been based on an estimated sewage treatment requirement of 30 m^3/day. Effluent water quality will be in accordance with relevant regulations as well as appropriate standards. The treatment plant effluent produced will be pumped to the plant site sediment pond (PSSP) located adjacent to the CHPP product stockpiles. Excess sludge will be collected for removal from the package treatment plant by vacuum trucks and disposal off site. Sewage and grey water from the CHPP service buildings will be pumped to the water treatment plant for processing and discharge.

A service bay with fuel and lube will be initially located at the plant site administrative office, shop and maintenance area, but additional satellite stations will be located at various points throughout the mine area. All fuel depots will have secondary containment berms around the storage tanks and site drainage will be managed. Regular maintenance of the fuel depots will minimize spills and leaks. Flotation reagents will be stored in a reagent farm. Flocculants will be stored in either dry-powder form (500 kg bags) or liquid form (1,000 L plastic bulk bins).

Accidental releases may allow chemicals, either fluids or solids that are dissolved or transported by precipitation events, to seep into the ground where they could alter shallow groundwater quality. The impact to groundwater quality will depend on the volume and type of product released, the characteristics of the surface materials at the release location, the presence of liners, and the underlying groundwater conditions. Given the presence of fractured bedrock overlain by thin surficial deposits, it is recommended that some additional protection measures may put in place (such as but not limited to, installation of liners).

As a result of the best management practices for material handling methods, there should be a low possibility of potential effects to shallow groundwater quality, except through upset conditions, *i.e.*, accidental spills or leak. In the event of a spill or leak, the spill response plan will be executed to control and minimize the extent of any impact. In the unlikely event that a spill resulted in groundwater quality impacts that represented a potential concern for freshwater aquatic life or other receptors, remediation activities could include source removal or groundwater recovery.

5.5.2 Impact Assessment

5.5.2.1.1 Potential Effects to Bedrock Aquifers

Potential effects related to surface facilities on the bedrock aquifers' groundwater quality from Project activities have been assessed as follows:

- The **magnitude** of the effect is assessed as moderate as environmental standards will be used to assess and remediate any impacts from the surface facilities.
- The **geographical extent** of the effect is defined as local as effects are anticipated to be limited to a small area, well contained within the mine permit boundaries and LSA.
- The **duration** of the impact is determined as long term in duration as potential adverse effects (spills) can occur during the lifetime of the Project, but may not be fully remediated until reclamation activities are undertaken.
- The **frequency** is determined as occasional as upset conditions occur from time to time. Mitigative measures in place such as the use of double-walled tanks or the presence of a leak detection.
- The **reversibility** of the effect is determined as reversible in the short term as any impacts will begin to diminish upon cessation of activities.
- The system should prevent the occurrence of leak except during upset conditions.
- The **project contribution** is classified as negative as the release of any substance to the environment typically has a negative effect.
- The **confidence rating** is moderate as efficient measures will be in place to allow for early detection of upset conditions and response (including remediation) in a timely manner. Mitigative measures implemented for the Project are typical to any other coal mine and conform to environmental standards.
- The **probability of occurrence** is medium as upset conditions are typically infrequent.
- The **significance** of residual effects is identified as not significant as no adverse effect are predicted with mitigative measures in place.

5.5.3 Mitigation and Monitoring

5.5.3.1 Mitigation

Mitigation measures for minimizing or preventing adverse impacts on shallow groundwater quality include industry-standard operating practices, preparedness for upset conditions and the appropriate management of upset conditions.

5.5.3.2 Monitoring

A groundwater monitoring program will be implemented to detect any impacts on the shallow groundwater quality resulting from surface operations at the CHPP and selected storage areas. In the event that an impact on groundwater quality is detected, the groundwater response plan will be implemented. The response plan would include determining the magnitude of the impact and could include risk management or remediation. The response plan will serve to mitigate impacts to groundwater quality. All monitoring wells will be sampled bi-annually to evaluate water quality.

5.6 Environmental Impact Assessment Summary

The conclusions of the Projects effects evaluations are summarized in Table 5.5-1 and as follows:

- Pit dewatering through sump pumps placed at the bottom of the pit during active mining should have no impact on water wells and a moderate impact on the quantity of groundwater in bedrock aquifers.
- Mine waste rock and mining operations are assessed to have a low residual impact on the quality of groundwater within bedrock aquifers and no impact to water wells.
- Surface facilities are assessed to have a low residual impact on groundwater quality within bedrock aquifers.

Table 5.5-1 Summary of Impacts Ratings on Groundwater Valued Components (VCs)

VC	Nature of Potential Impact or Effect	Mitigation Protection Plan	Magnitude[1]	Geographical Extent[2]	Duration[3]	Frequency[5]	Reversibility[4]	Project Contribution[6]	Confidence Rating[7]	Probability of Occurrence[8]	Significance[9]
Bedrock Aquifers	Pit dewatering on water quantity	Monitoring Program	Low	Local	Residual	Continuous	Irreversible	Negative	Moderate	High	Not significant
	Mine waste rock and mining operations on water quality	Selenium & Nitrate Management Plan Monitoring Program	Low	Local	Long	Continuous	Reversible in Long Term	Negative	Moderate	Medium	Not significant
	Surface facilities on water quality	Spill Prevention & response plan, Monitoring program	Moderate	Local	Long	Occasional	Reversible in Short Term	Negative	Moderate	Medium	Not significant
Discharge to Surface Water Bodies	Pit dewatering on water quantity	Surface Water Management Plan Monitoring Program	- [10]	- [10]	- [10]	- [10]	- [10]	- [10]	- [10]	- [10]	- [10]
	Mine waste rock and mining operations on water quality	Selenium & Nitrate Management Plan Monitoring Program	- [10]	- [10]	- [10]	- [10]	- [10]	- [10]	- [10]	- [10]	- [10]
Water Wells	Pit dewatering on water quantity	Monitoring Program	Nil	Local	N/A	N/A	N/A	Neutral	High	Low	Not significant
	Mine waste rock and mining operations on water Quality	Selenium Management Plan Monitoring Program	Nil	Local	N/A	N/A	N/A	Neutral	High	Low	Not significant

1. Nil, Low, Moderate, High
2. Local, Regional, Provincial, National, Global
3. Short, Long, Extended, Residual
4. Reversible in short term, Reversible in long term, Irreversible – rare
5. Continuous, Isolated, Periodic, Occasional
6. Neutral, Positive, Negative
7. Low, Moderate, High
8. Low, Medium, High
9. Not Significant, Significant
10. Impact rating is presented in CR#4 and CR#5.
N/A – Not applicable

6.0 CUMULATIVE EFFECTS

Groundwater levels in the vicinity of the mine pit will be impacted by the pit dewatering program. Effects associated with the reclaimed Project site are anticipated to be moderate and restricted to a localized area within the LSA. Surface facilities have the potential to result in localized changes in groundwater quality as a result of accidental spills or leak. Mine operations and mine spoil also have the potential to locally change the groundwater chemistry associated with selenium leaching or the presence of residues from blasting.

Groundwater effects associated with surface facilities, mining operation, mine spoil and pit dewatering have low to moderate impact ratings and are all local in extent within the LSA. There are no other planned or reasonably foreseeable projects within the RSA that are expected to act in cumulative manner with these effects; subsequently, a cumulative effects assessment is not required for this Project.

7.0 GROUNDWATER MONITORING PROGRAM

Groundwater monitoring for the Grassy Project will include a groundwater monitoring program (GMP) and a groundwater response plan (GRP). The combination of these two programs will ensure effects from pit dewatering and site operations are monitored, assessed and mitigative measures implemented, as required.

The GMP for the Project will have the following main purposes:

- to evaluate water level changes associated with pit dewatering; and
- to detect any impacts to shallow groundwater quality.

The details of the monitoring program will be the subject of:

- the pending EPEA Approval of this application; and
- the *Water Act* Licence (for site water management and use).

The majority of the existing groundwater monitoring wells completed for the baseline investigation are located within the proposed mine pit footprint; therefore, these wells will need to be decommissioned prior to the mining operations. As the mining progresses from south to north in several phases, it is anticipated that some of the monitoring wells may be temporarily used in the monitoring program until mining advances to that location; however, additional locations will be required. It is expected that selected locations will change, but will include the following:

- wells (nested sets where possible) in proximity of the pit for water level monitoring to monitor water quantity;

- shallow monitoring wells downgradient of waste rock disposal areas, and surge ponds, primarily for groundwater sampling to monitor water quality; and
- shallow monitoring wells downgradient of surface facilities (at the proposed CHPP) primarily for groundwater sampling to monitor water quality.

Field procedures, including monitoring protocols for the collection of existing groundwater data are presented in Appendix D.

7.1 Overview of the Approach for the Groundwater Management Plan

The GMP will monitor both groundwater quality and quantity by monitoring the both hydraulic heads, and groundwater chemistry. The GMP will be tailored to the mine activities, with hydraulic head monitoring implemented around and downgradient of the pit, and chemistry monitoring implemented near facilities handling a variety of chemicals and fuels and around the waste rock and sedimentation ponds.

Baseline data will be collected from the wells included in the GMP monitoring network to assess variations in hydraulic heads and baseline chemistry. Monitoring wells for the GMP will be installed during the construction of the Project so that baseline data are collected (and chemical parameters stabilized) prior to the commencement of mining.

The water level monitoring may be monthly during an initial period when water levels are stabilizing in order to establish baseline conditions prior to mining. Once drawdowns become more predictable, monitoring frequency may be decreased. The water sampling frequency is expected to be either bi-annual or annual. Analytical parameters are expected to include major ion chemistry, metals and hydrocarbons depending on location.

Indicator parameters will be selected and baseline data (hydraulic head and chemistry) will be used to establish upper and lower control limits (UCL and LCL) which represent the range of natural variations. The UCL and LCL will be used during operational monitoring to compare measured values with the expected range of baseline conditions. Measured parameters presenting trends, above the UCL or below the LCL will trigger the GRP.

The GRP establishes the steps to be followed once a parameter displays a trend, is detected above the UCL or below the LCL. Criteria that would trigger the GRP are as follows:

- hydraulic heads below threshold values near the pit, which would indicate a drawdown magnitude greater than predicted in this assessment;

- increase in concentrations of inorganic, dissolved and/or total metals parameters (concentration above the UCL or increasing trend), which may be related to incomplete treatment of water prior to being released to the environment; and
- detection of parameters above the detection limit for chemicals not naturally present at the site (concentration above the UCL), which could indicate incorrect handling practices or a spill near facilities storing or using chemicals.

Typically the first step consists in confirming the value that triggered the GRP (including, but not limited to, confirming value with the laboratory, re-monitoring the anomalous water level and/or resampling the monitoring wells). If the value is confirmed, additional response plan activities will be initiated such as source identification, risk assessment, remediation and/ or mitigation. A resolution of the event that triggered the GRP could result in changes to the monitoring program, such as increased frequency of monitoring, adding additional monitoring locations, *etc*.

Annual GMP reporting describing the information collected and an analysis of the results will be completed for submission to AER.

7.2 Response Plan Approach (GRP)

Decrease in hydraulic heads greater than estimated in the EIA may result in decreased groundwater discharge to surface water (*i.e.* base flow reduction) or decrease of groundwater availability to nearby users (*e.g.* water well users in the subdivision located 16-008-04 W5) or both. Decrease in groundwater discharge to surface water is planned to be addressed through flow augmentation using water stored into the surge ponds during operations. It is anticipated flow augmentation will mitigate any hydraulic head reduction that could result in a decrease of groundwater discharge to surface water. In the unlikely event of a decrease in hydraulic head in privately owned water wells that impedes use of this water supply, mitigation could include either drilling a new well, or connecting the affected user(s) to the municipal water network.

A change in groundwater quality near the pit and the selenium control ponds will be addressed as part of the management of the treatment cells. Change in chemistry near the facility will be investigated for spills or upset conditions resulting in a discharge of chemicals to the surface and seeping to the shallow groundwater. Response measures could include spill investigation, source removal, remediation, risk assessment and/or risk management.

7.3 Responsibility and Accountability

Benga will be supported by trained and registered professionals (including, but not limited to, members of the APEGA) in the execution of the GMP and GRP which will ensure monitoring and mitigation measures are conducted within regulatory and industry standards.

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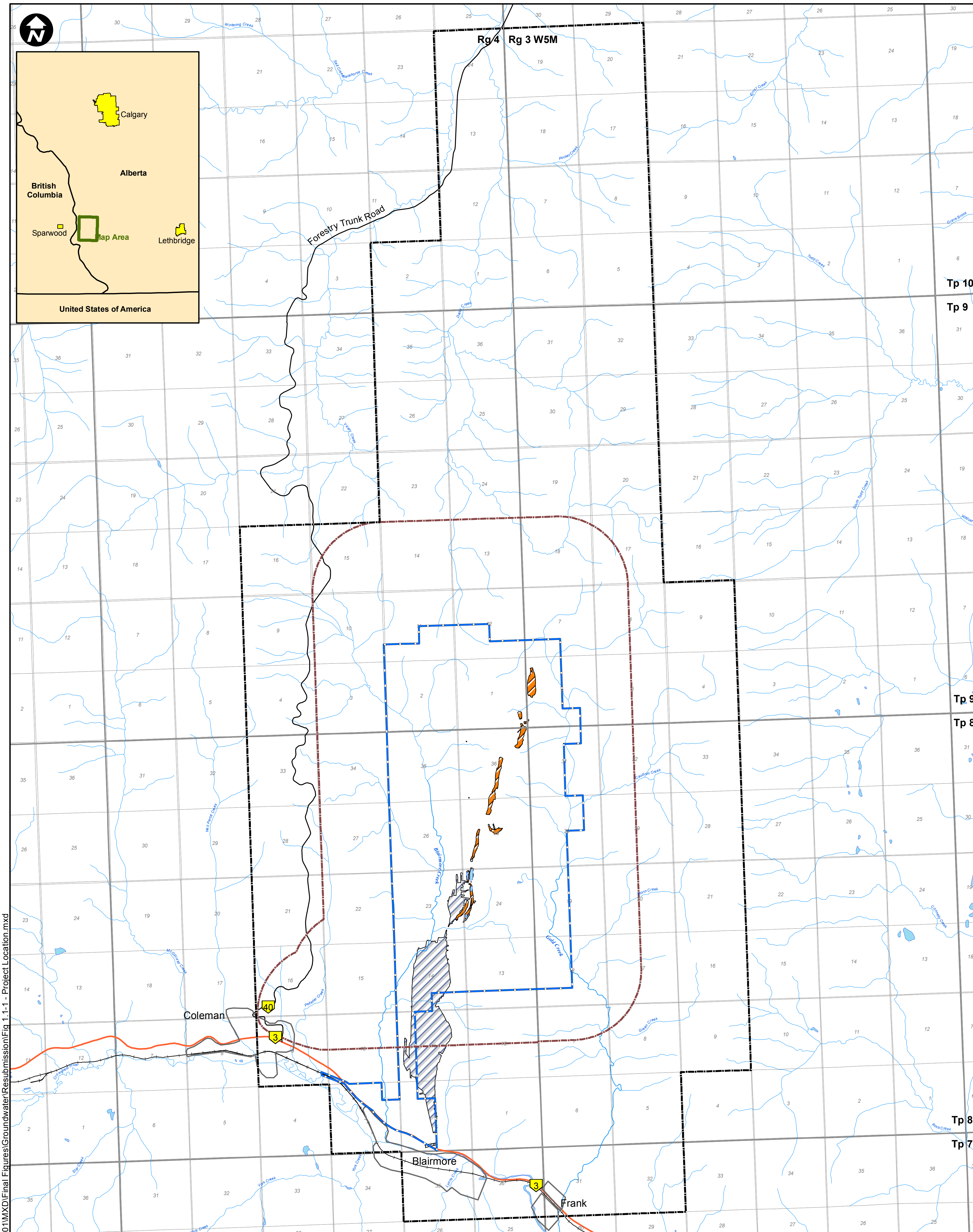
APPENDIX A: FIGURES



LEGEND

- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- Municipal Boundary
- Proposed Mine Permit Boundary
- Surface Mine (Historical)
- Underground Mine (Historical)
- Local Study Area (LSA)
- Regional Study Area (RSA)

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PROJECT LOCATION

NOTES

AltaLIS, 2016; NRCAN, 2015; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

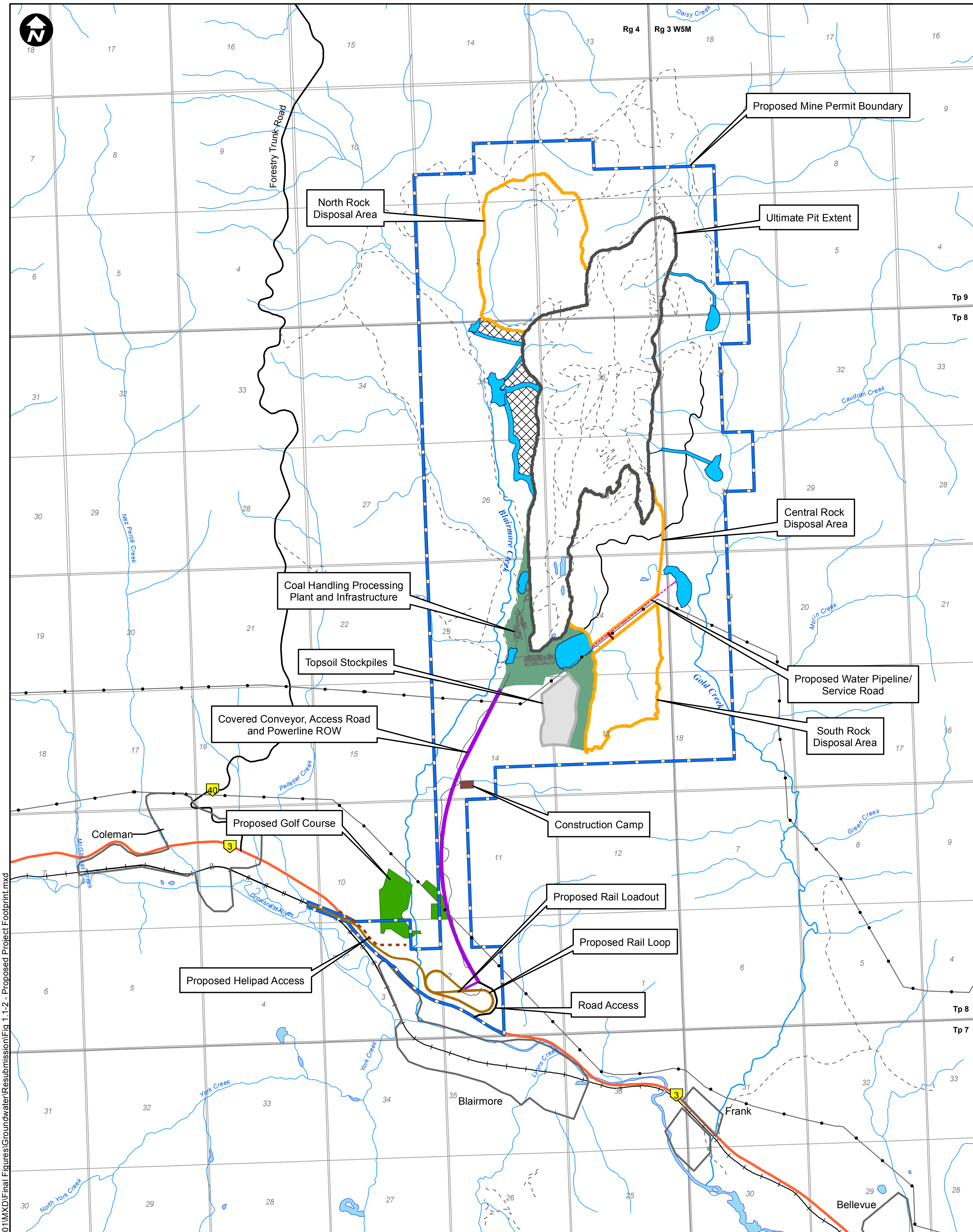
0 1.5 3 6
Kilometres

PROJECT: 14-00201-01
DRAWN BY: JDC/SL
CHECKED BY: AcK
DATE: JULY 07, 2016

FIGURE

1.1-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 1.1-1 - Project Location.mxd



LEGEND

- Primary Highway
- Secondary Highway
- Existing Access Road
- Existing Powerline
- CHPP Facilities
- Proposed Water Pipeline/ Service Road
- Railway Loop
- Proposed Helipad Access
- Proposed Mine Permit Boundary
- Ultimate Pit Extent
- Ultimate Rock Disposal Area Extent
- Topsoil Storage
- Construction Camp
- Ponds and Ditches
- Coal Handling Processing Plant and Infrastructure
- Covered Conveyor, Access Road and Powerline ROW
- Proposed Golf Course Area
- Undisturbed Area

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PROPOSED PROJECT FOOTPRINT

NOTES

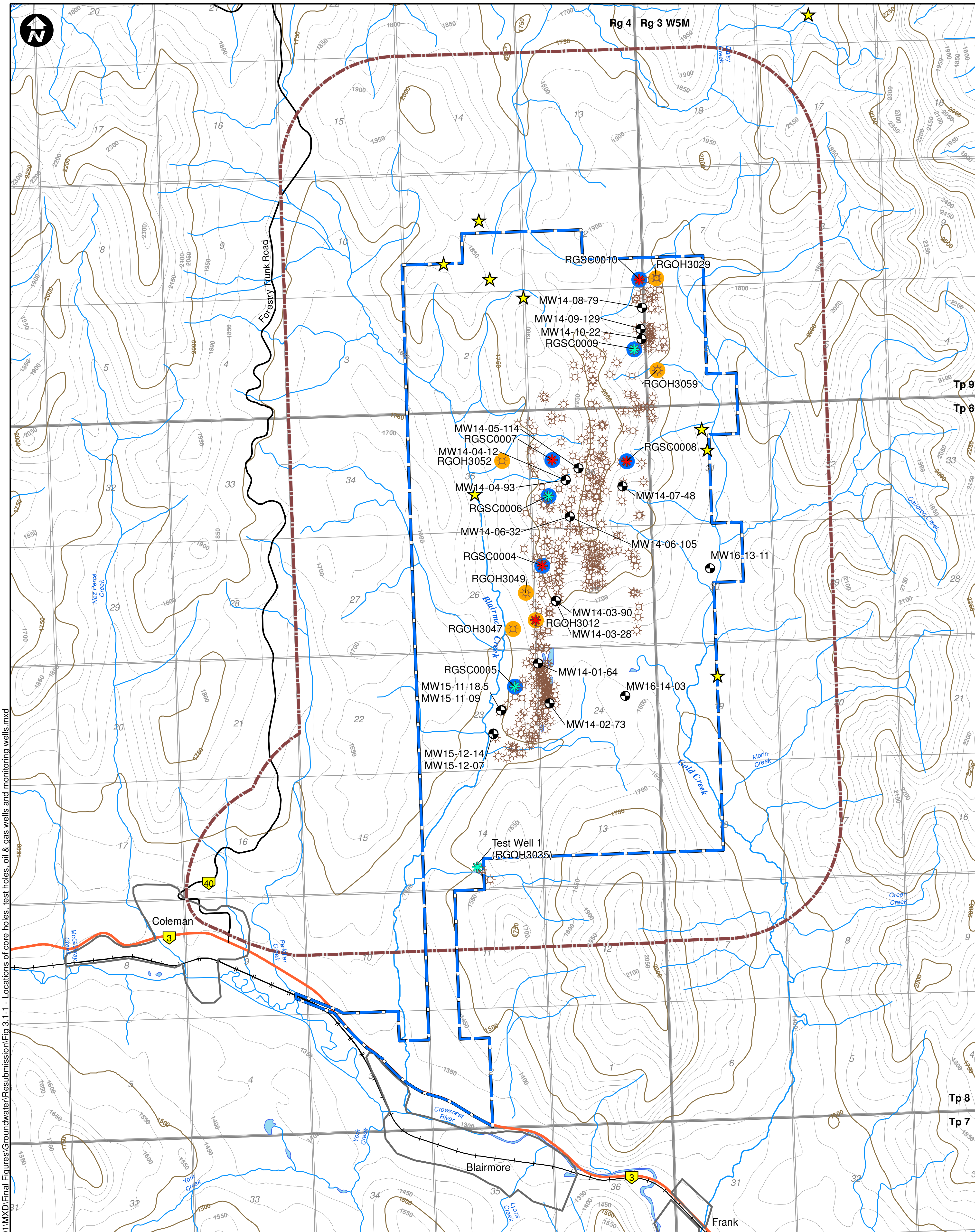
AltaLIS, 2016; NRCAN, 2015; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 1 2 4
Kilometres

PROJECT: 14-00201-01
DRAWN BY: JDC/SL
CHECKED BY: AcK
DATE: JULY 07, 2016

FIGURE
1.1-2

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 1.1-2 - Proposed Project Footprint.mxd



LEGEND

- Monitoring Well
- Coring Exploration Hole
- Test Hole
- Vibrating Wire Piezometer
- Oil and Gas Well
- Packer Test
- Pumping Test
- Artesian Flowing Hole
- Contour - Major (250m Interval)
- Contour - Minor (50m interval)
- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- LSA
- Proposed Mine Permit Boundary

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

LOCATIONS OF CORE HOLES, TEST HOLES, OIL & GAS WELLS AND MONITORING WELLS

NOTES

AltaLIS, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

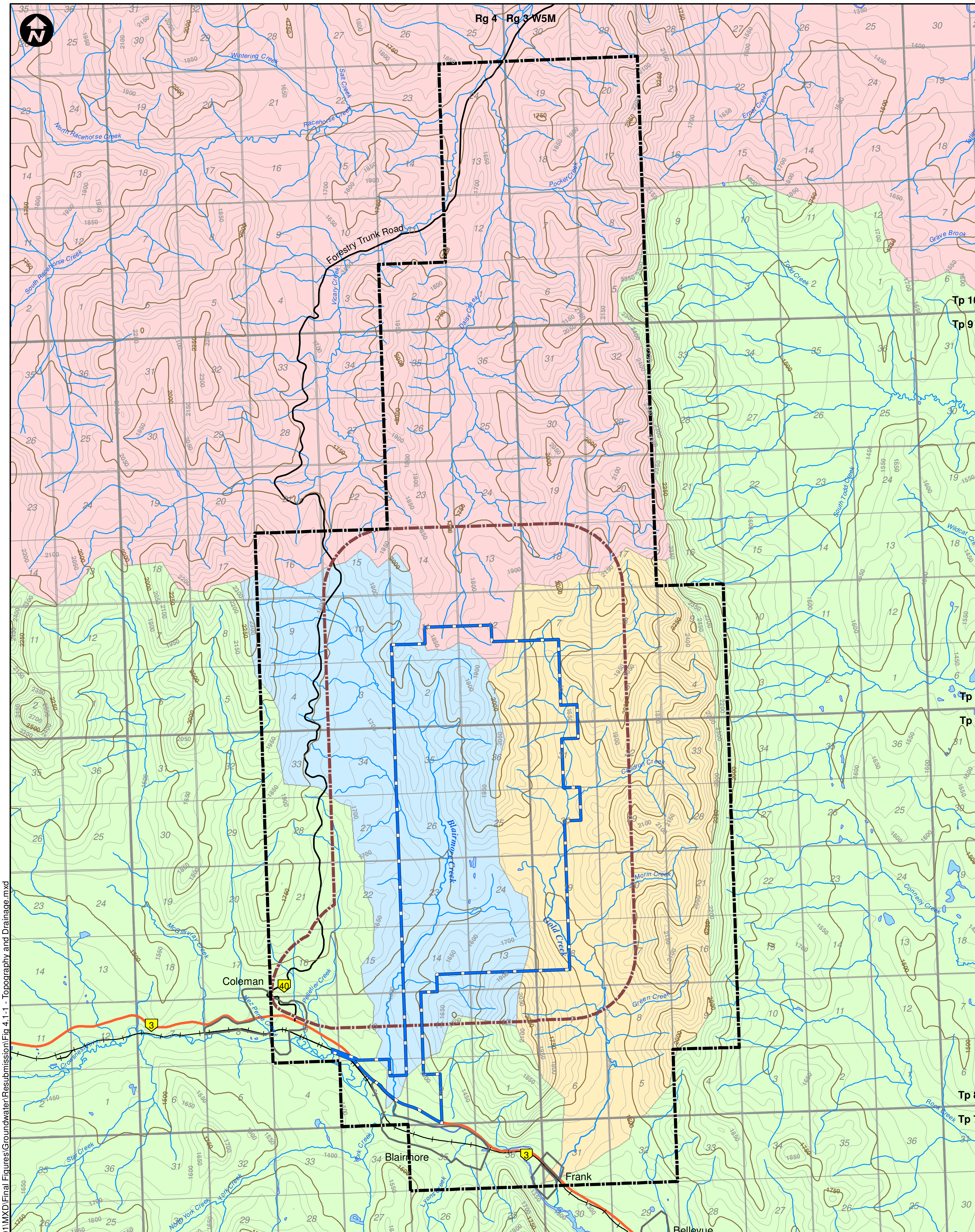
0 1 2 4
Kilometres

PROJECT: 14-00201-01
DRAWN BY: SL/JDC
CHECKED BY: AcK
DATE: AUGUST 2, 2016

FIGURE

3.1-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 3.1-1 - Locations of core holes, test holes, oil & gas wells and monitoring wells.mxd



Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 4.1-1 - Topography and Drainage.mxd

LEGEND

- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- Contour - Major (250m Interval)
- Contour - Minor (50 m interval)
- LSA
- RSA
- Proposed Mine Permit Boundary

Watershed

- Blairmore Creek
- Crowsnest River
- Gold Creek
- Old Man River

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

TOPOGRAPHY AND DRAINAGE

NOTES

AltaLIS, 2016; NRCAN, 2015; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2 4 8
Kilometres

PROJECT: 14-00201-01
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CHECKED BY: AcK
DATE: AUGUST 2, 2016

FIGURE

4.1-1

Stratigraphy							Hydrostratigraphy
Eon	**Era**	**Period**		**Group**	**Formation**	**Member/ Unit**	**Unit**
	Cenozoic	Quaternary		*Alluvium and Glacial drift*			Aquifer - Aquitard
Phanerozoic	Cenozoic	Tertiary		Porcupine Hills			Aquifer
	Mesozoic	Cretaceous	Upper	Brazeau	Willow Creek		Aquifer - Aquitard
					St Mary River		Aquifer
					Blood Reserve		Aquifer
					Bearpaw		Aquitard
					Belly River		Aquifer
				Alberta	Wapiabi	(1)	Aquifer - Aquitard
					Cardium		Aquifer
					Blackstone	Opabin	Aquifer - Aquitard
						Haven	
						Vimy	
						Sunkay	
				Crowsnest			-
			Lower	Blairmore	Mill Creek (Ma Butte)		Aquifer
					Beaver Mines	Beaver Mines	Aquifer
						Home	Aquitard
					Gladstone	Calcareous	Aquifer
						Gladstone	
					Cadomin (Dalhousie)		Aquifer
				Kootenay	Elk		Aquifer
					Mist Mountain	Mutz	Aquifer
						Hillcrest	
						Adanac	
		Jurassic	Upper		Morrissey	Moose Mountain	Aquifer
						Weary Ridge	
				Fernie	Passage Beds		Aquitard
					Green Beds		Aquifer
					Grey Beds & Highwood Shale		Aquitard
					Rock Creek		Aquifer
					Poker Chip Shale		Aquitard
					Nordegg (equivalent)		Aquifer
		Triassic	Upper to Lower	Spray River	White Horse	Winnipeg Starlight	Aquifer
					Sulphur Mountain	Llama	Aquitard
						Whistler	
						Vega	
						Phroso	
	Paleozoic	Permian	Upper	Ishbel*	Ranger Canyon		Aquifer - Aquitard
			Lower		Johnston Canyon		-
		Pennsylvanian	Upper	Spay Lake	(3)		-
		Carboniferous[2]	Lower	Rundle	(4)		Aquifer
				-	Banff		Aquitard
		Devonian	Upper	(5)			Aquifer
		Cambrian	Middle	(6)			-

LEGEND

- Unconformity
- Coal Bearing Units
- Predominantly Sandstone
- Predominantly Shale
- Predominantly Carbonate (Limestone, Dolomite)

(1) Nomad, Chungo, Hanson, Thistle, Dowling, Marshybank and Muskiki members
(2) Mississippian
(3) Kananaskis*, Misty (Tunel Mountain)*, Tobermory, Tyrwhitt and Storelk formations
(4) Etherington, Mount Head and Livingstone formations
(5) Palliser and Alexo formations; Fairholme Group
(6) Windsor Mountain, Elko, Gordon, Flathead formations
* Rocky Mountain Group

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

STRATIGRAPHY AND HYDROSTRATIGRAPHY

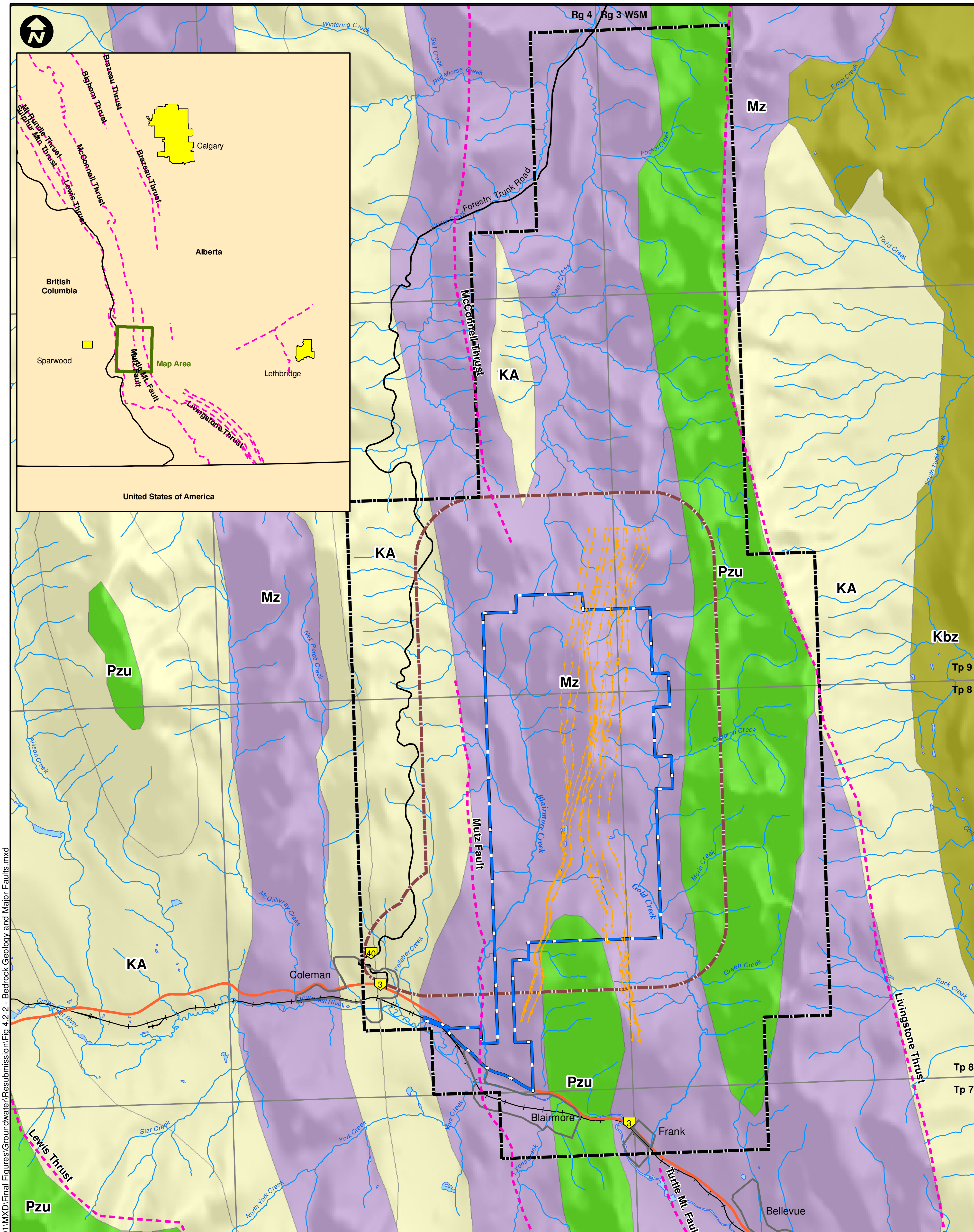
NOTES

AGAT Laboratories. 2013. Table of Formations of Alberta.

NOT TO SCALE

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: AcK
DATE: JULY 28, 2016

FIGURE
4.2-1



LEGEND

- Primary Highway
- Secondary Highway
- Existing Railway
- Thrust Fault
- Major Fault
- Surface Water Drainage
- LSA
- RSA
- Proposed Mine Permit Boundary

Geological Formation

- Brazeau Formation (Kbz)
- Alberta Group (KA)
- Lower Mesozoic-Lower Cretaceous (Mz)*
- Upper Paleozoic (Pzu)

* Include Blairmore, Kootenay, Fernie, Spray River groups

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

BEDROCK GEOLOGY AND MAJOR FAULTS

NOTES

AGS, 2015 (modified); AltaLIS, 2016; GeoBase, 2011; Golder, 2015; NRCAN, 2015; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

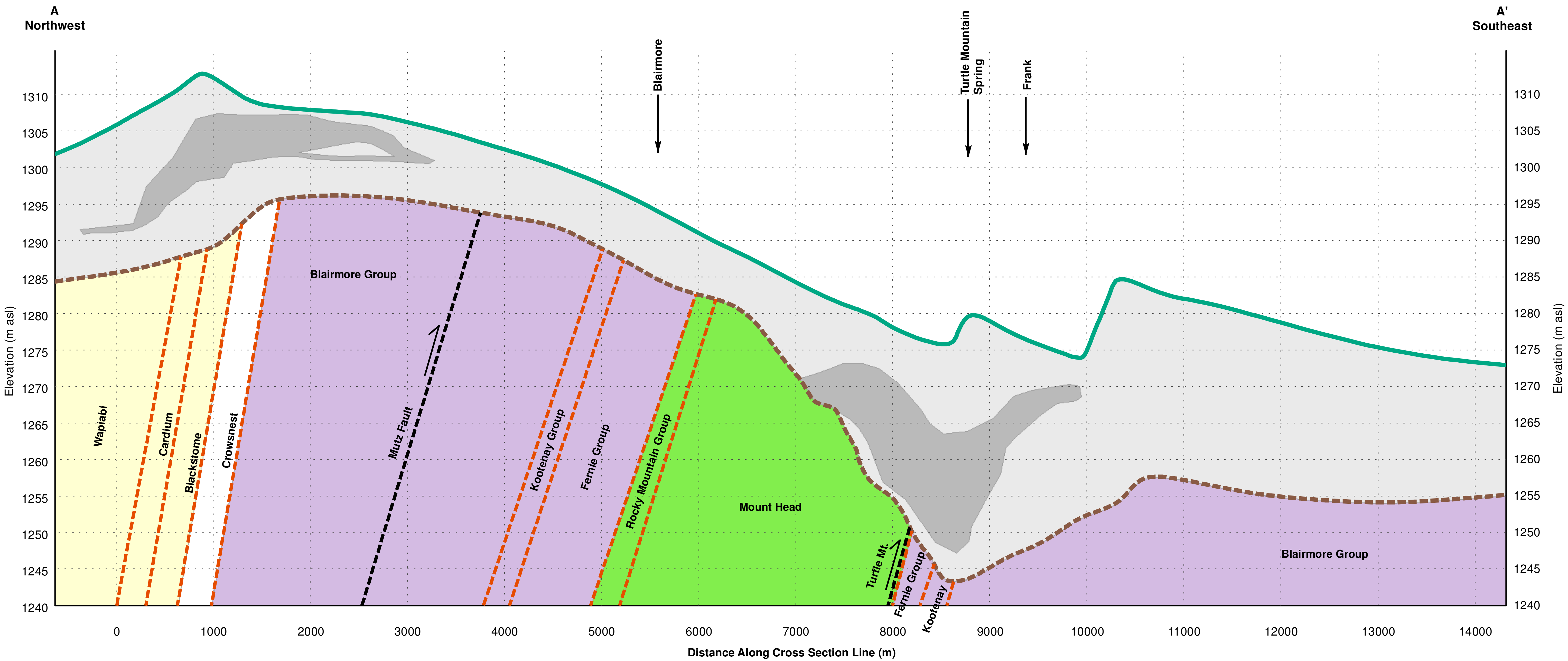
0 1.5 3 6
Kilometres

PROJECT: 14-00201-01
DRAWN BY: JDC/SL
CHECKED BY: AcK
DATE: AUGUST 2, 2016

FIGURE

4.2-2

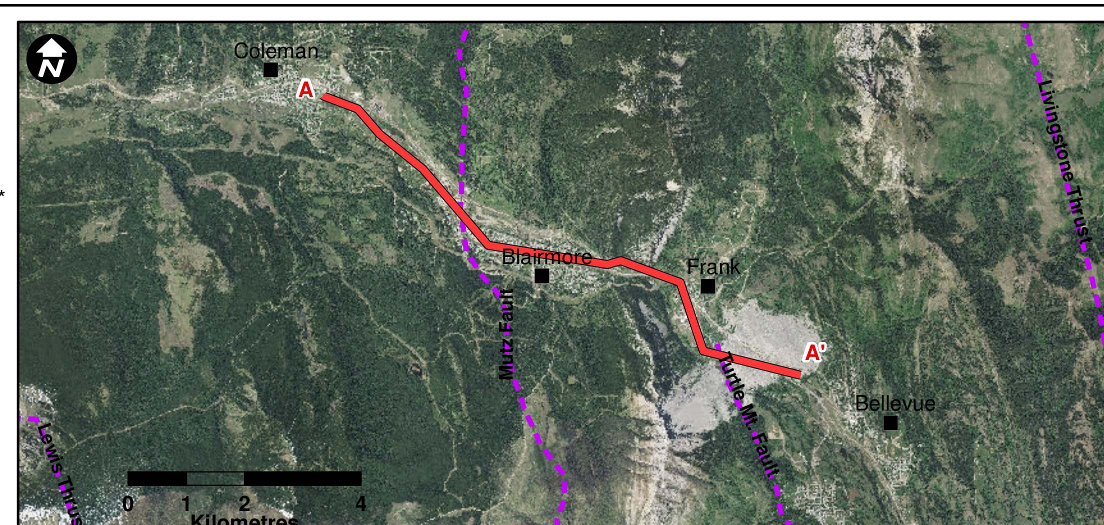
Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 4.2-2 - Bedrock Geology and Major Faults.mxd



LEGEND

- Ground Surface
- Bedrock Surface
- Estimated Formation Boundary
- Thrust Fault
- Fault
- Approximate Cross-Section Alignment AA'
- Alluvial Aquifer
- Unconsolidated Aquitard
- Alberta Group (KA)
- Lower Mesozoic-Lower Cretaceous (Mz)*
- Upper Paleozoic (Pzu)

* Include Blairmore, Kootenay, Fernie, Spray River groups



PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

GEOLOGICAL CROSS-SECTION OF THE CROWSNEST PASS VALLEY

NOTES

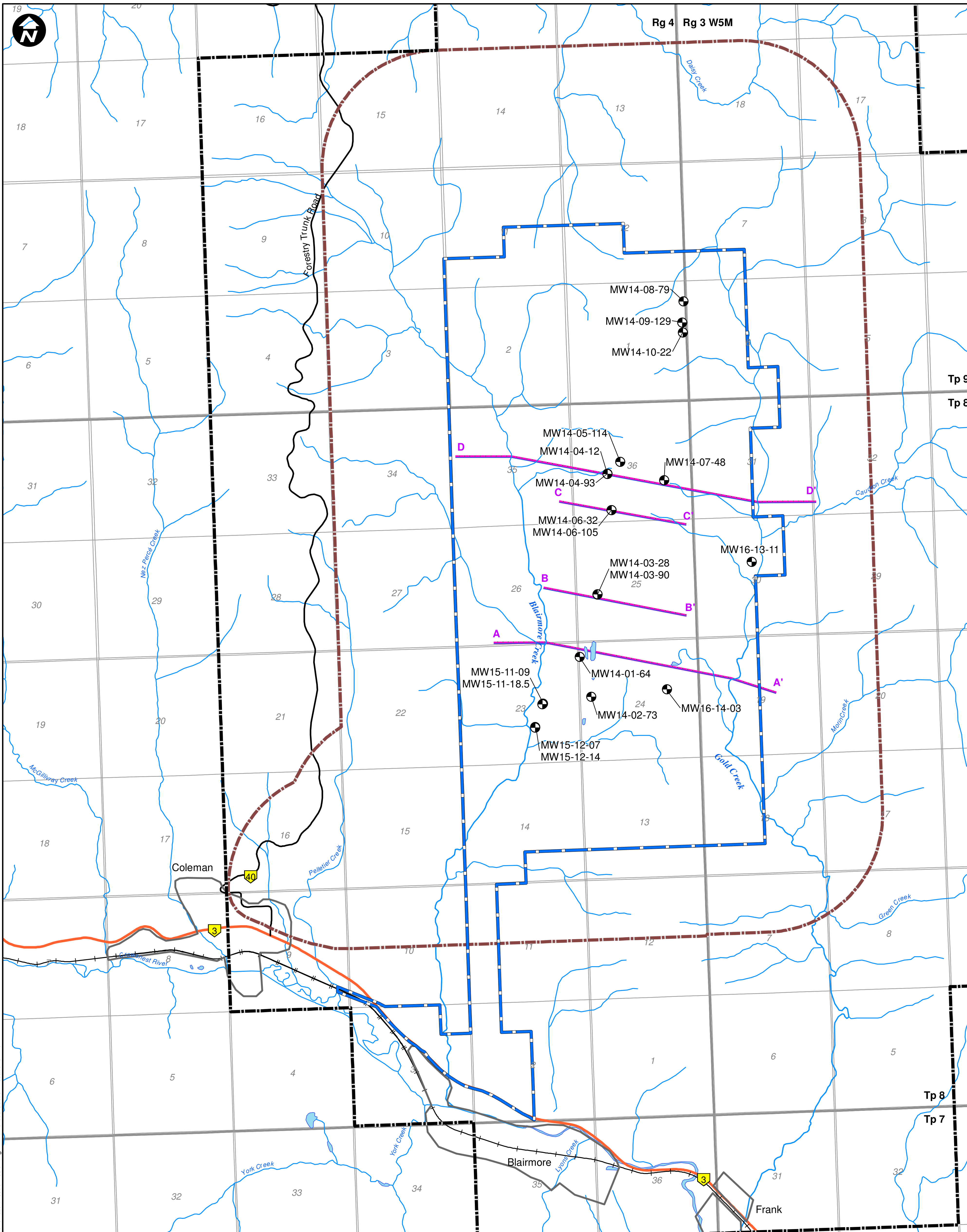
Modified from Waterline Resources Inc., March, 2013.

0 0.5 1 2
Kilometres

PROJECT: 14-00201-01
DRAWN BY: JDC/SL
CHECKED BY: AcK
DATE: AUGUST 2, 2016

FIGURE

4.2-3



LEGEND

- Monitoring Well Location
- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- Hydrogeological Cross-Section Line
- LSA
- RSA
- Proposed Mine Permit Boundary

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

CROSS-SECTION LOCATIONS

NOTES

AltaLIS, 2016; NRCAN, 2015; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

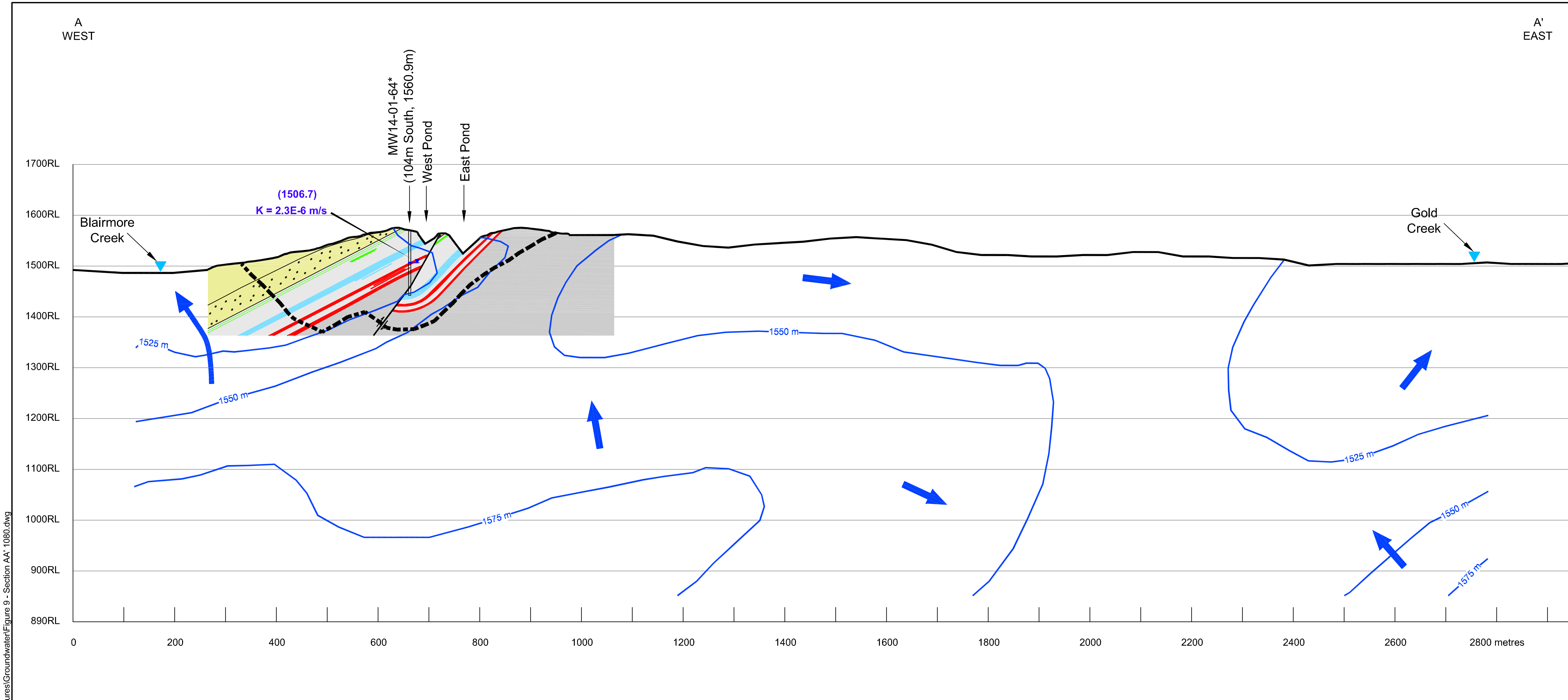
0 1 2 4
Kilometres

PROJECT: 14-00201-01
DRAWN BY: SL/JDC
CHECKED BY: AcK
DATE: JULY 19, 2016

FIGURE

4.2-4

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 4.2-4 - Cross-Section Locations.mxd



LEGEND

Geology

- Topography
- Reverse Fault
- Blairmore Group
- Cadomin Formation
- Kootenay Group
- Seam 1
- Seam 2
- Seam 4
- Fernie Group

Mine

- Approximate Ultimate Pit Depth

Hydrogeology / Hydrology

- 1575m — Potentiometric Contour (Modelled Average Baseline from Numerical Model)
- Flow Direction
- Surface Water (Creek)
- (1506.7) Groundwater Elevation (m) Measured October 2014
- Monitoring Well Screened Interval
- K = 2.3E-6 m/s Hydraulic Conductivity

* - Well is Projected into the Cross-Section Line

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

HYDROGEOLOGICAL CROSS-SECTION AA' - Baseline

NOTES

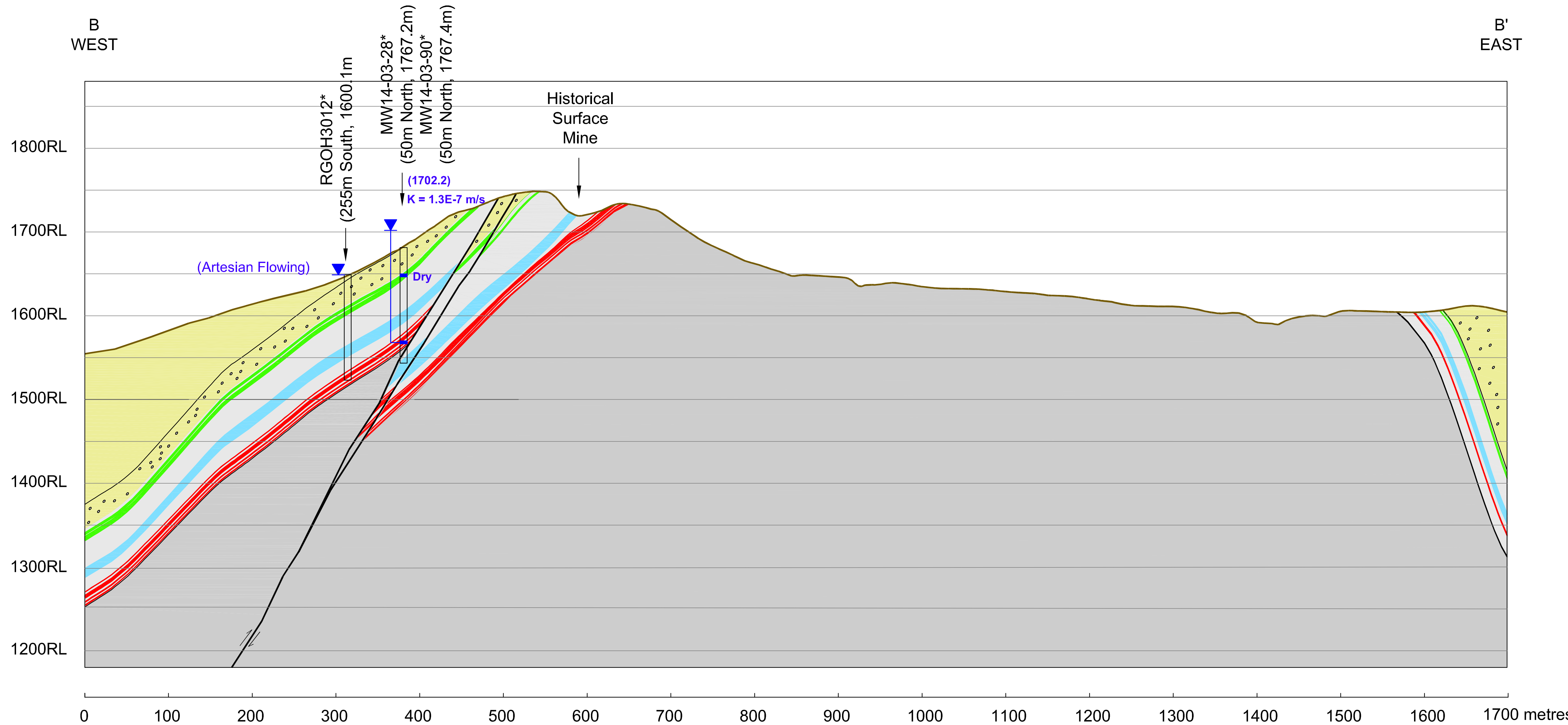
MEMS, 2016; Riversdale, 2016; SRK, 2016.

0 100 200 300 400
Metres

PROJECT: 14-00201
DRAWN BY: JDC
CHECKED BY: AcK
DATE: JULY 22, 2015

FIGURE 4.2-5

K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Figure 10 - Section BB' 1800.dwg



LEGEND

- Reverse Fault
- Blairmore Group
- Cadomin Formation
- Kootenay Group
- Seam 1
- Seam 2
- Seam 4
- Fernie Group
- (1506.7) Groundwater Elevation (m) Measured October 2014
- Monitoring Well Screened Interval
- K = 2.3E-6 m/s Hydraulic Conductivity

* - Well is Projected into the Cross-Section Line

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

HYDROGEOLOGICAL CROSS-SECTION BB'

NOTES

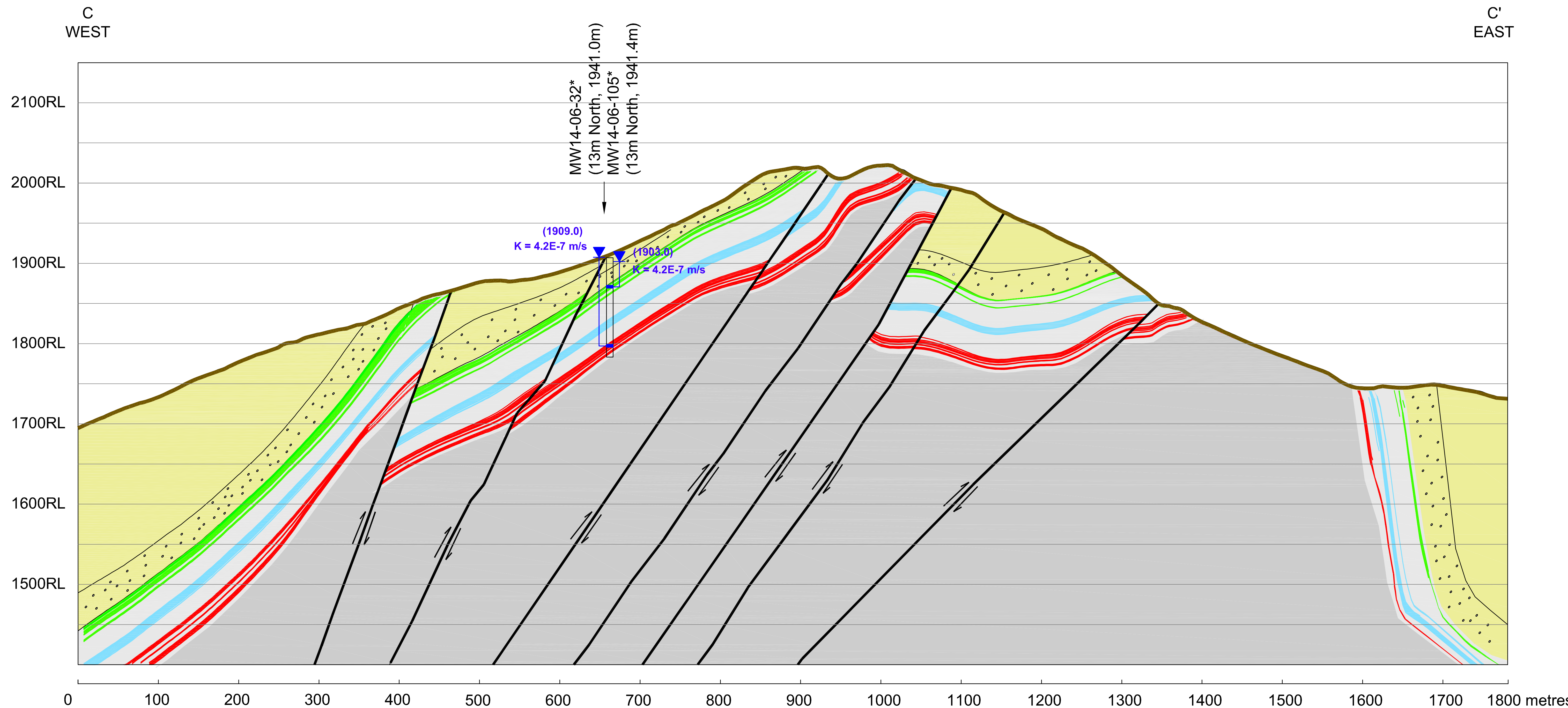
Riversdale, 2015.

0 50 100 200 300
Metres

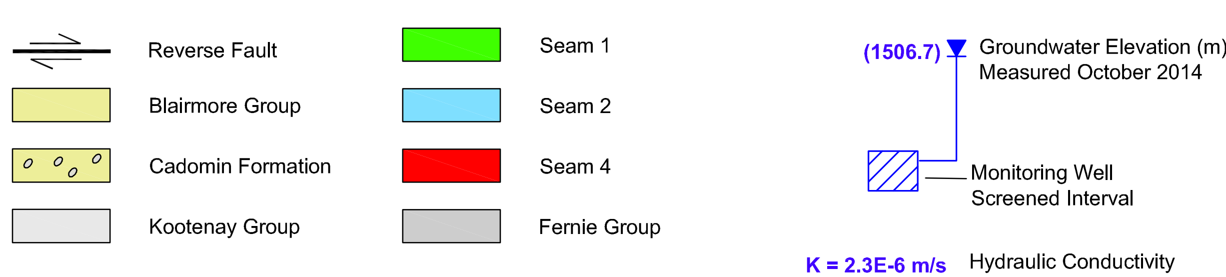
PROJECT: 14-00201
DRAWN BY: JDC
CHECKED BY: AcK
DATE: JULY 14, 2016

FIGURE

4.2-6



LEGEND



* - Well is Projected into the Cross-Section Line

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

HYDROGEOLOGICAL CROSS-SECTION CC'

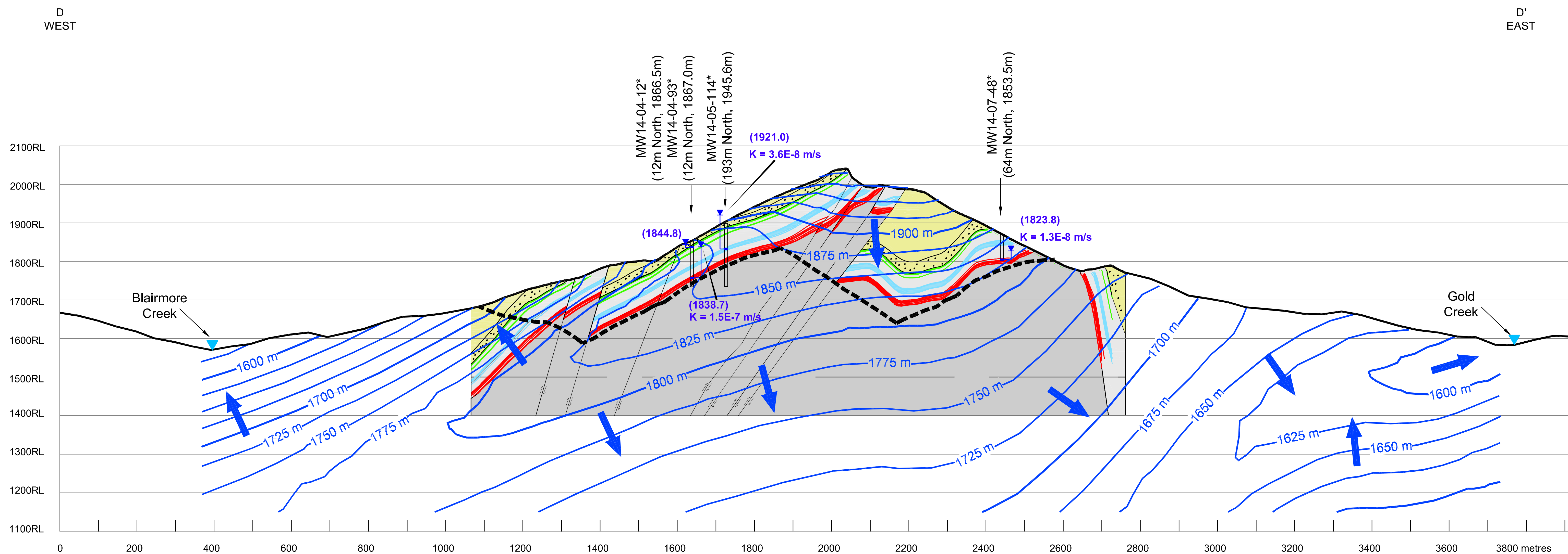
NOTES

Riversdale, 2015.

PROJECT: 14-00201
DRAWN BY: JDC
CHECKED BY: AcK
DATE: JULY 14, 2016

FIGURE

4.2-7



LEGEND

Geology

Topography

Reverse Fault

Blairmore Group

Cadomin Formation

Kootenay Group

Seam 1

Seam 2

Seam 4

Fernie Group

Mine

Approximate Ultimate Pit Depth

Hydrogeology / Hydrology

1575m — Potentiometric Contour (Modelled Average Baseline from Numerical Model)

Flow Direction

Surface Water (Creek)

(1506.7) Groundwater Elevation (m) Measured October 2014

Monitoring Well Screened Interval

K = 2.3E-6 m/s Hydraulic Conductivity

* - Well is Projected into the Cross-Section Line

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

HYDROGEOLOGICAL CROSS-SECTION DD' - Baseline

NOTES

MEMS, 2016; Riversdale, 2016; SRK, 2016.

PROJECT: 14-00201
DRAWN BY: JDC
CHECKED BY: AcK
DATE: JULY 22, 2016

0 100 200 400 600
Metres

FIGURE

4.2-8

LEGEND

- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- LSA
- RSA
- Proposed Mine Permit Boundary

Surficial Geology

- Alluvial Fans and Aprons
- Bedrock
- Cirque Tills
- Coarse Stream Alluvium
- Colluvium
- Fine Stream Alluvium
- Kames, Kame Terraces and Kame Morraines
- Landslide Deposits
- Moderately Leached Till, Cordilleran Provenance
- Outwash Plains
- Rock Glaciers
- Rockslide Deposits
- Slightly Leached Till, Cordilleran Provenance
- Talus

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

SURFICIAL GEOLOGY

NOTES

AGS, 2015; AltaLIS, 2016; NRCAN, 2015; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

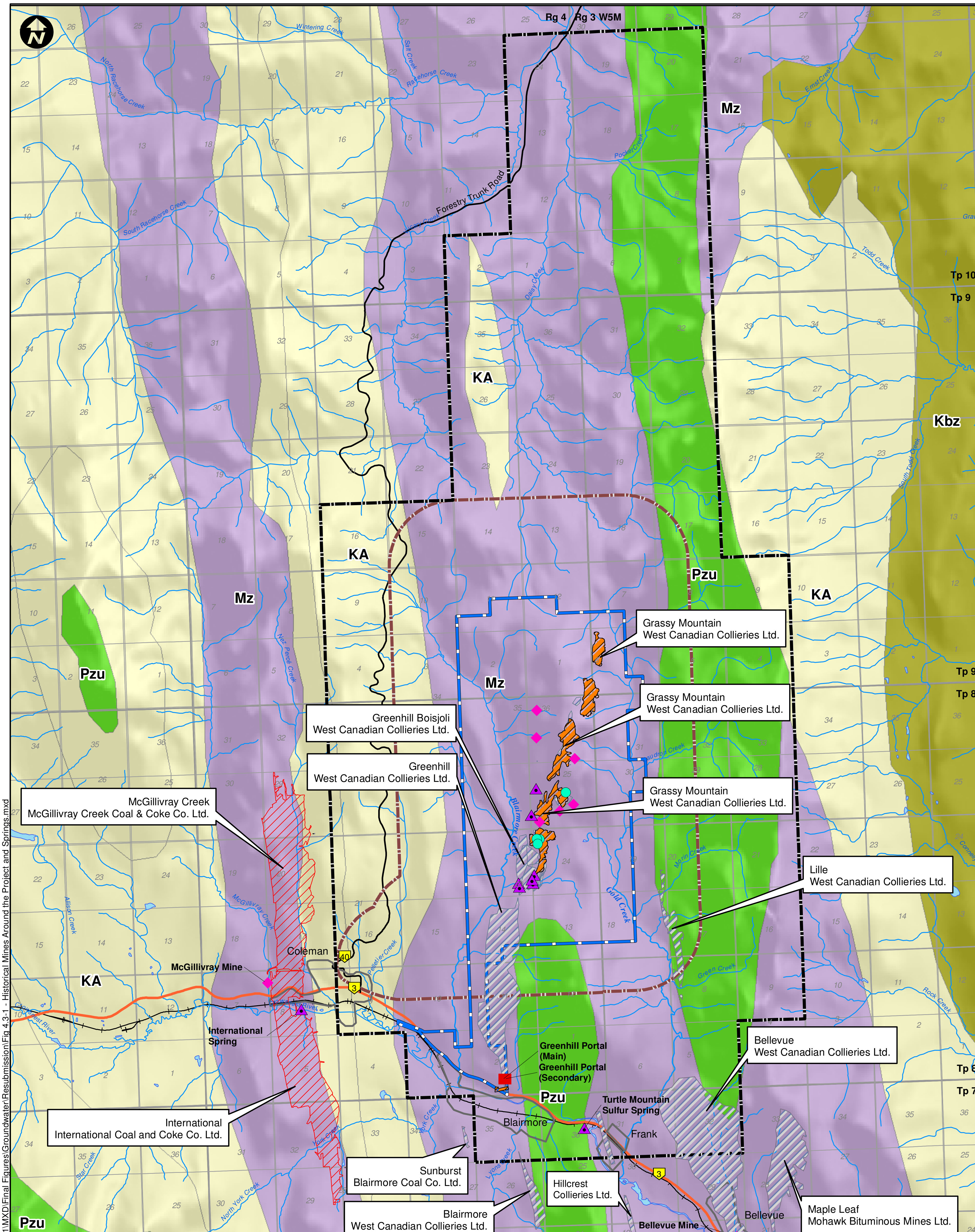
0 2 4 8
Kilometres

PROJECT: 14-00201-01
DRAWN BY: JDC/SL
CHECKED BY: AcK
DATE: JULY 07, 2016

FIGURE

4.2-9

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 4.2-9 - Surficial Geology.mxd



LEGEND

- Spring
- Creek
- Pond
- Portal
- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- Surface Mine
- Underground Mine
- Abandoned Coal Mine
- LSA
- RSA
- Proposed Mine Permit Boundary

Geological Formation

- Brazeau Formation (Kbz)
- Alberta Group (KA)
- Lower Mesozoic-Lower Cretaceous (Mz)*
- Upper Paleozoic (Pzu)

* - (Include Blairmore, Kootenay, Fernie, Spray River Groups)

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

LOCATIONS OF HISTORICAL MINES AROUND THE PROJECT, SPRINGS AND GROUNDWATER DISCHARGE FEATURES

NOTES

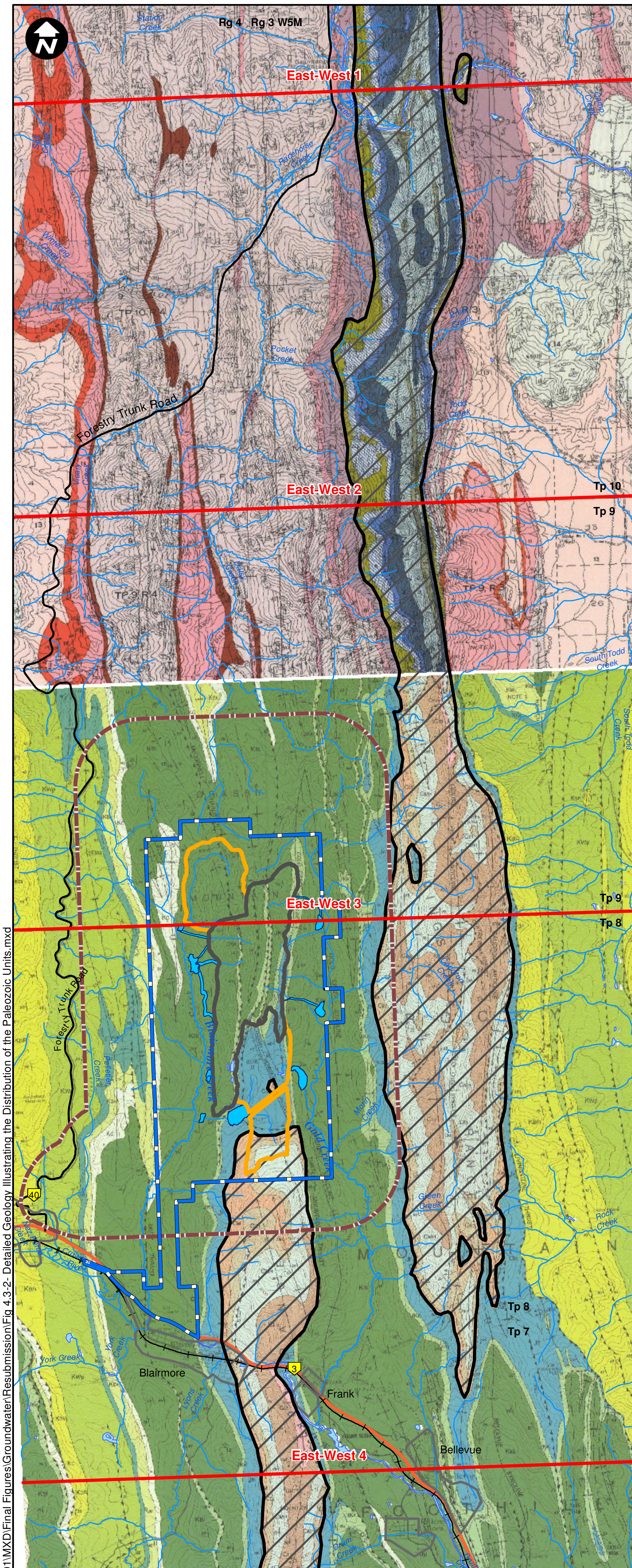
AER, 2015; AGS, 2015 (modified); AltaLIS, 2016; GeoBase, 2011; Golder, 2015; NRCAN, 2015; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

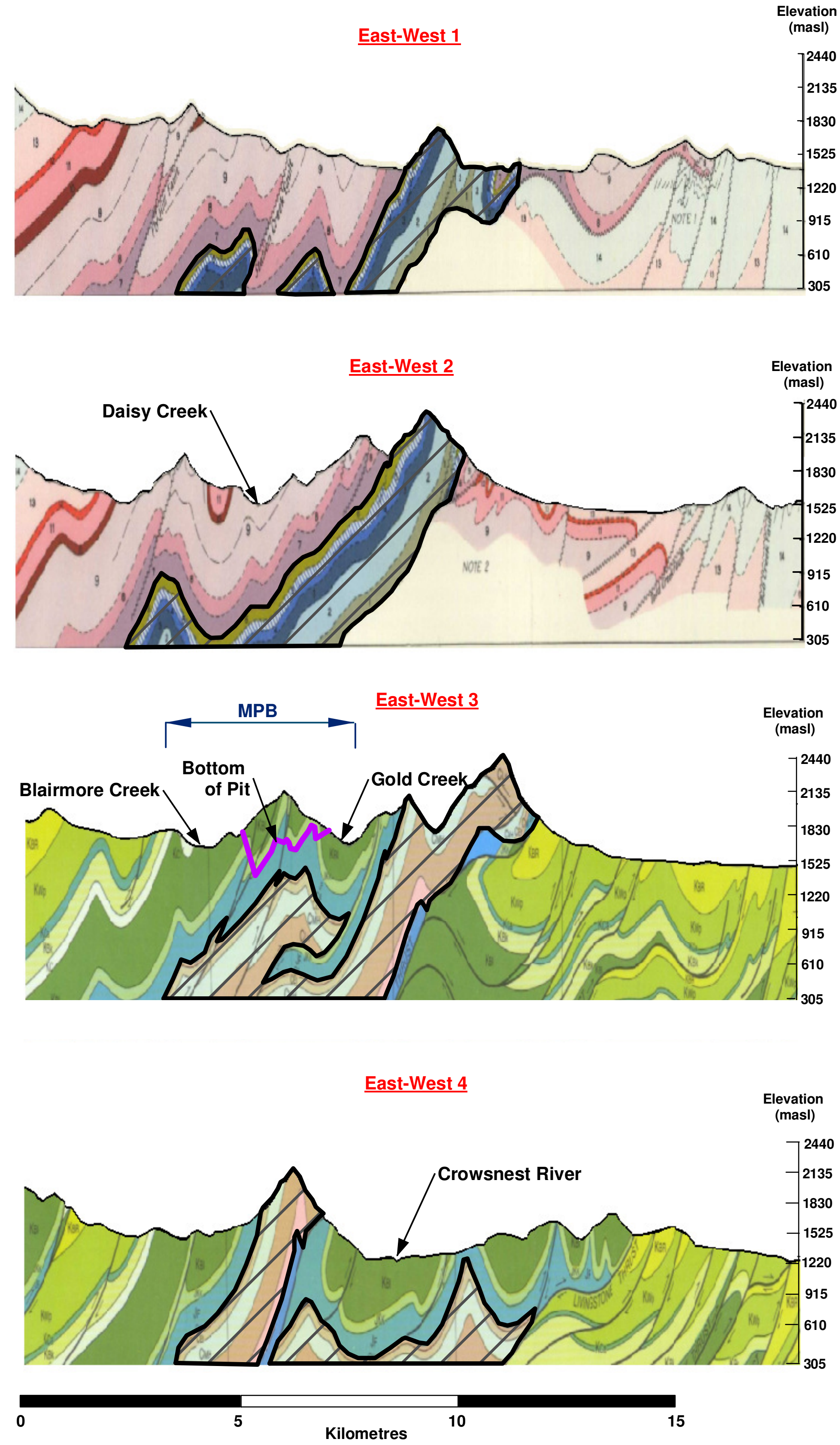
0 1.5 3 6
Kilometres

PROJECT: 14-00201-01
DRAWN BY: SL/JDC
CHECKED BY: AcK
DATE: AUGUST 2, 2016

FIGURE
4.3-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 4.3-1 - Historical Mines Around the Project and Springs.mxd





Detailed Legend for Geology

Norris (1993) | Douglas (1949)

MESOZOIC

- CRETACEOUS
  - *UPPER CRETACEOUS*
    - Belly River Formation
    - ***Alberta Group***
    - Wapiabi Formation
    - Cardium Formation
    - Blackstone Formation
  - *LOWER CRETACEOUS*
    - Crowsnest Formation
    - ***Blairmore Group***
- JURASSIC AND CRETACEOUS
  - *UPPER JURASSIC AND LOWER CRETACEOUS*
    - ***Kootenay Group***
- JURASSIC
  - Fernie Formation
- TRIASSIC
  - *LOWER TRIASSIC*
    - Spray River Formation

PALEOZOIC

- CARBONIFEROUS
  - *UPPER CARBONIFEROUS*
    - ***Rocky Mountain Group***
    - Misty Formation
  - *LOWER CARBONIFEROUS*
    - ***Rundle Group***
    - Etherington Formation
    - Mount Head Formation
    - Livingstone Formation
    - Banff Formation
- DEVONIAN AND CARBONIFEROUS
  - Exshaw Formation
- DEVONIAN
  - *UPPER DEVONIAN*
    - Palliser Formation
    - ***Fairholme Group*** and Alexo Formation
- CAMBRIAN
  - *LOWER AND MIDDLE CAMBRIAN*

LEGEND

- Primary Highway
- Secondary Highway
- Existing Railway
- Cross Section Alignment
- Paleozoic Unit
- Proposed Mine Permit Boundary (MPB)
- Ultimate Pit Extent
- Ultimate Rock Disposal Area Extent
- Ponds and Ditches
- LSA

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

DETAILED GEOLOGY ILLUSTRATING THE DISTRIBUTION OF THE PALEOZOIC UNITS BENEATH AND NEAR THE PROJECT

NOTES

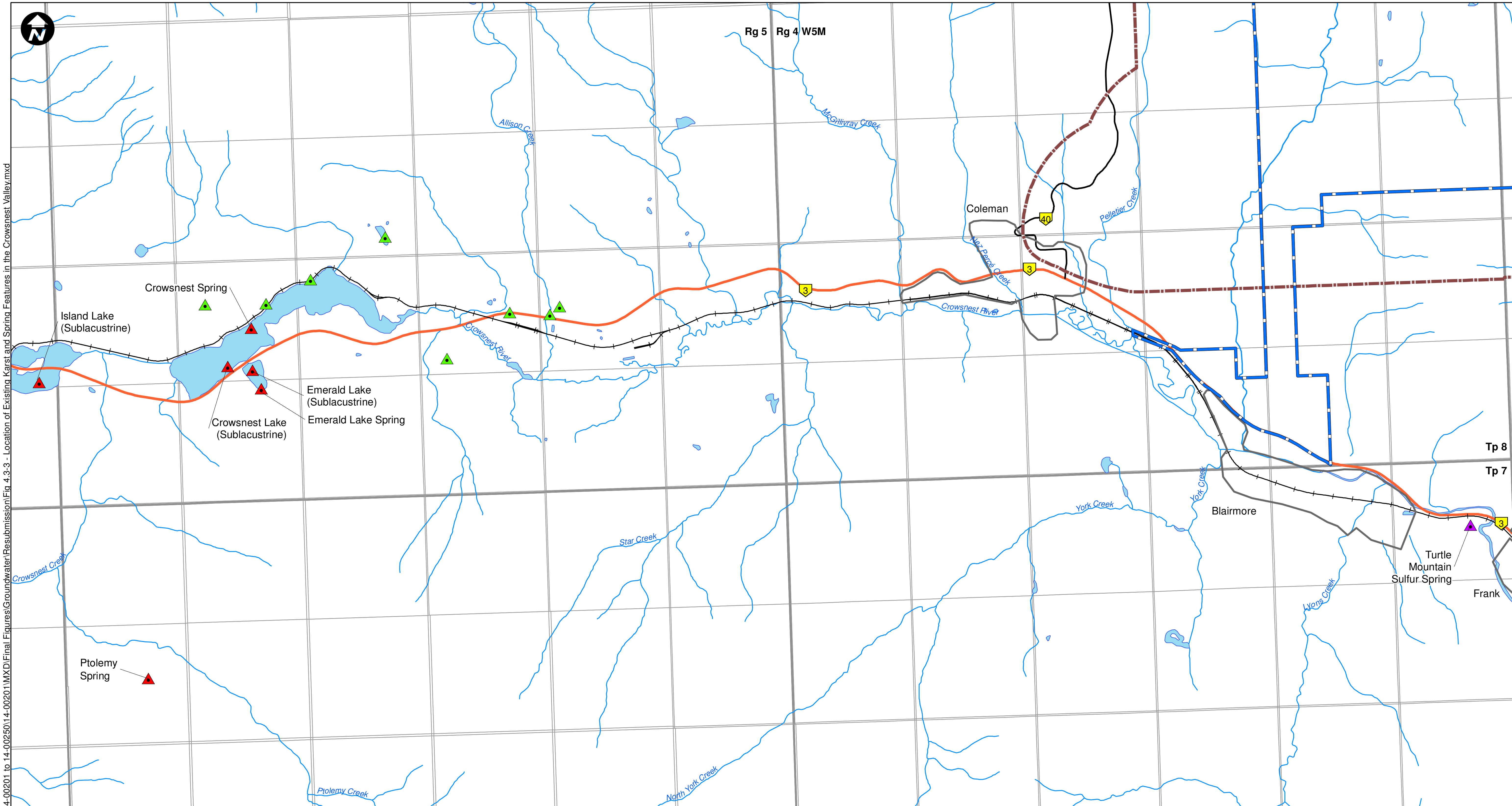
AltaLIS, 2016; NRCAN, 2016; Riversdale, 2016;
Modified from Douglas R.J.W 1946 – 47 and Norris D.K. 1993
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: AcK
DATE: AUGUST 3, 2016

FIGURE **4.3-2**

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 4.3-2- Detailed Geology Illustrating the Distribution of the Paleozoic Units.mxd



LEGEND

- Fault Controlled Spring
- Karst Controlled Spring
- Other Spring
- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- LSA
- Proposed Mine Permit Boundary

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

TITLE

LOCATION OF EXISTING KARST AND SPRING FEATURES IN THE CROWSNEST VALLEY

NOTES

AltaLIS, 2016; ESRD, 2012; NRCAN, 2016; Riversdale, 2016; Worthington, 1991
Datum/Projection: UTM NAD 83 Zone 11

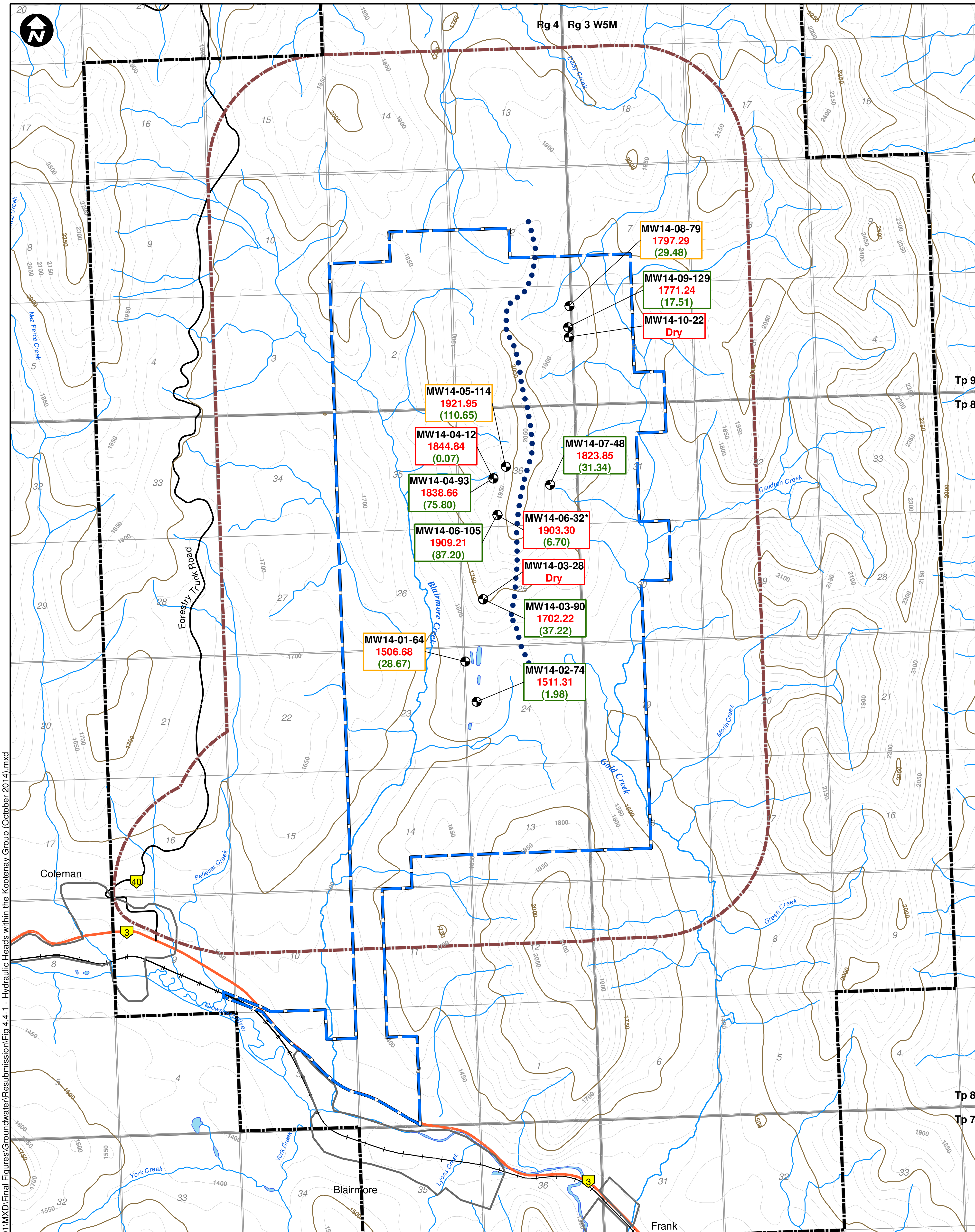
0 1 2 4
Kilometres

MILLENNIUM
EMS Solutions Ltd.

PROJECT: 14-00201
DRAWN BY: CP/JDC
CHECKED BY: AcK
DATE: JULY 29, 2016

FIGURE
4.3-3

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 4.3-3 - Location of Existing Karst and Spring Features in the Crowsnest Valley.mxd



LEGEND

- Primary Highway
- Secondary Highway
- Existing Railway
- Crest of Topography
- Surface Water Drainage
- Contour - Major (250m Interval)
- Contour - Minor (50 m interval)
- LSA
- RSA
- Proposed Mine Permit Boundary
- Coal Seam 1
- Coal Seam 2
- Coal Seam 4

1511.31 Potentiometric Head (m asl)

(1.98) Available Head (m)

* - Water Level Measured in September 2014

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

HYDRAULIC HEADS WITHIN THE KOOTENAY GROUP (OCTOBER 2014)

NOTES

AltaLIS, 2065; NRCAN, 2015; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

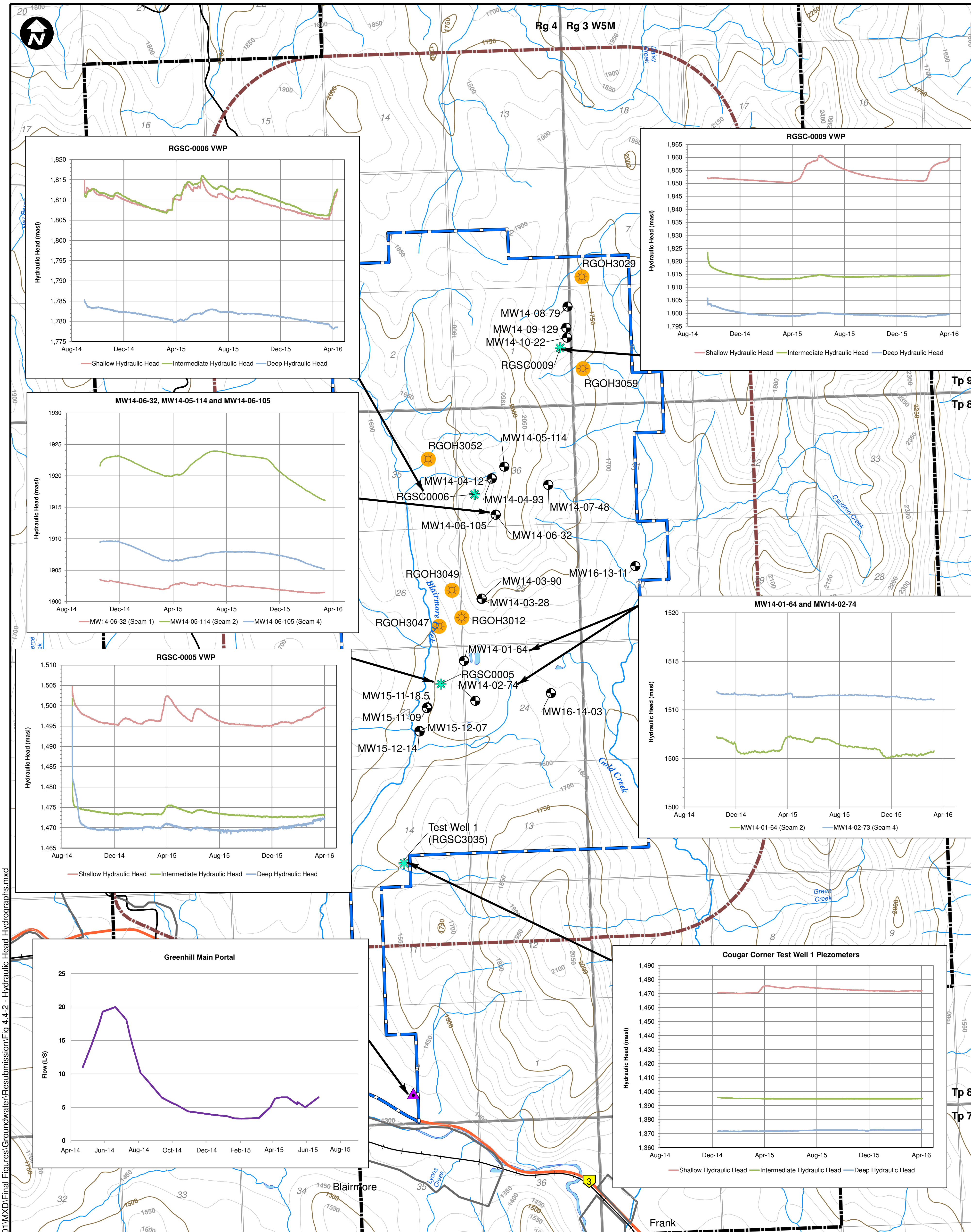
0 1 2 4
Kilometres

PROJECT: 14-00201-01
DRAWN BY: JDC/SL
CHECKED BY: AcK
DATE: JULY 07, 2016

FIGURE

4.4-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 4.4-1 - Hydraulic Heads within the Kootenay Group (October 2014).mxd



Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 4.4-2 - Hydraulic Head Hydrographs.mxd

LEGEND

- Greenhill Main Portal
- Vibrating Wire Piezometers
- Artesian Flowing Hole
- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- Contour - Major (250m Interval)
- Contour - Minor (50 m interval)
- Shallow Hydraulic Head
- Intermediate Hydraulic Head
- Deep Hydraulic Head
- Proposed Mine Permit Boundary
- LSA
- RSA

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

HYDRAULIC HEAD HYDROGRAPHS

NOTES

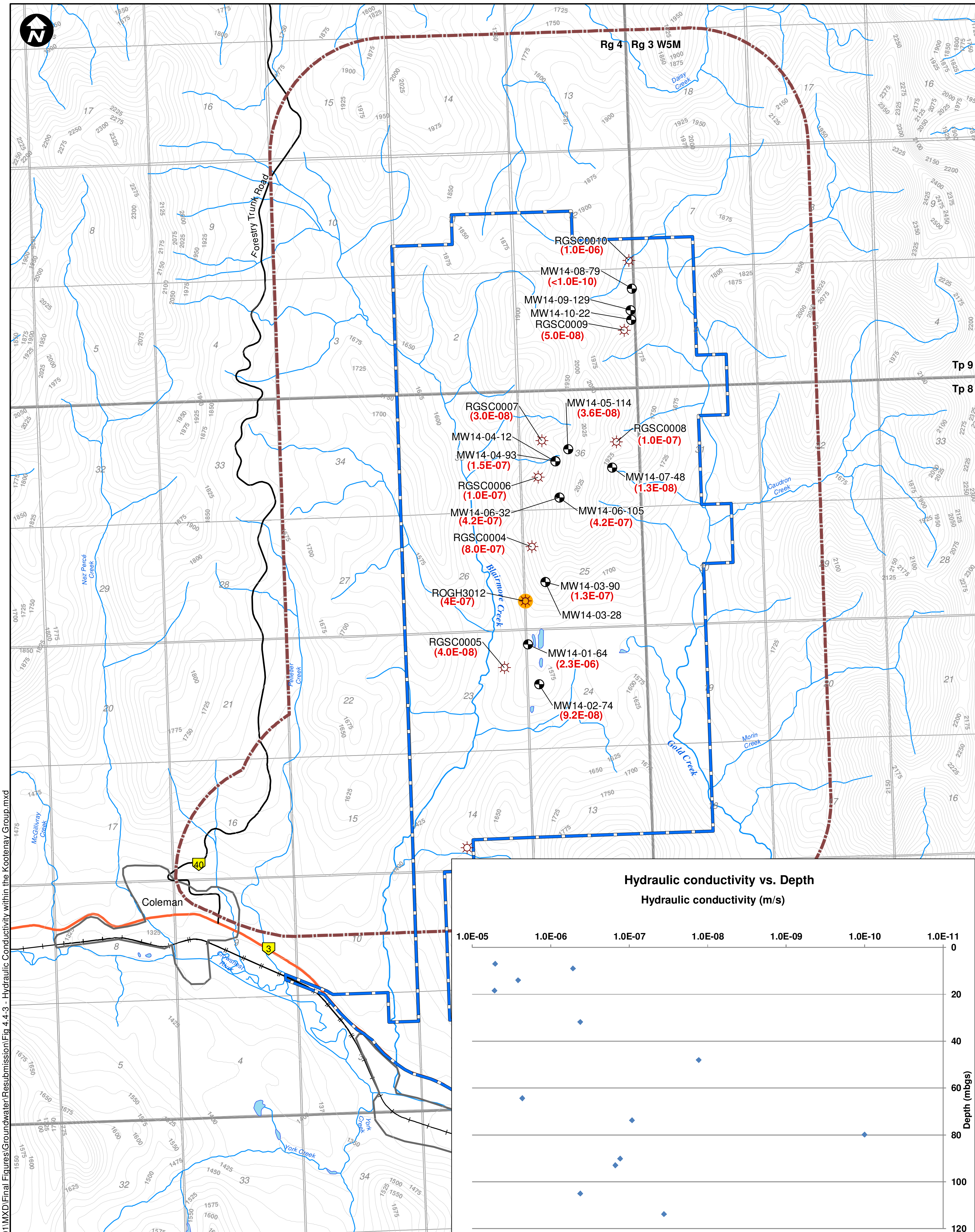
AltaLIS, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 1 2 4
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: AcK
DATE: AUGUST 2, 2016

FIGURE

4.4-2



LEGEND

- Coring Exploration Hole
- Monitoring Well Location
- Artesian Flowing Hole
- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- Contour (25 m interval)
- LSA
- Proposed Mine Permit Boundary
- (2.3E-06) Hydraulic Conductivity (m/s)

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

HYDRAULIC CONDUCTIVITY WITHIN THE KOOTENAY GROUP

NOTES

AltaLIS, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

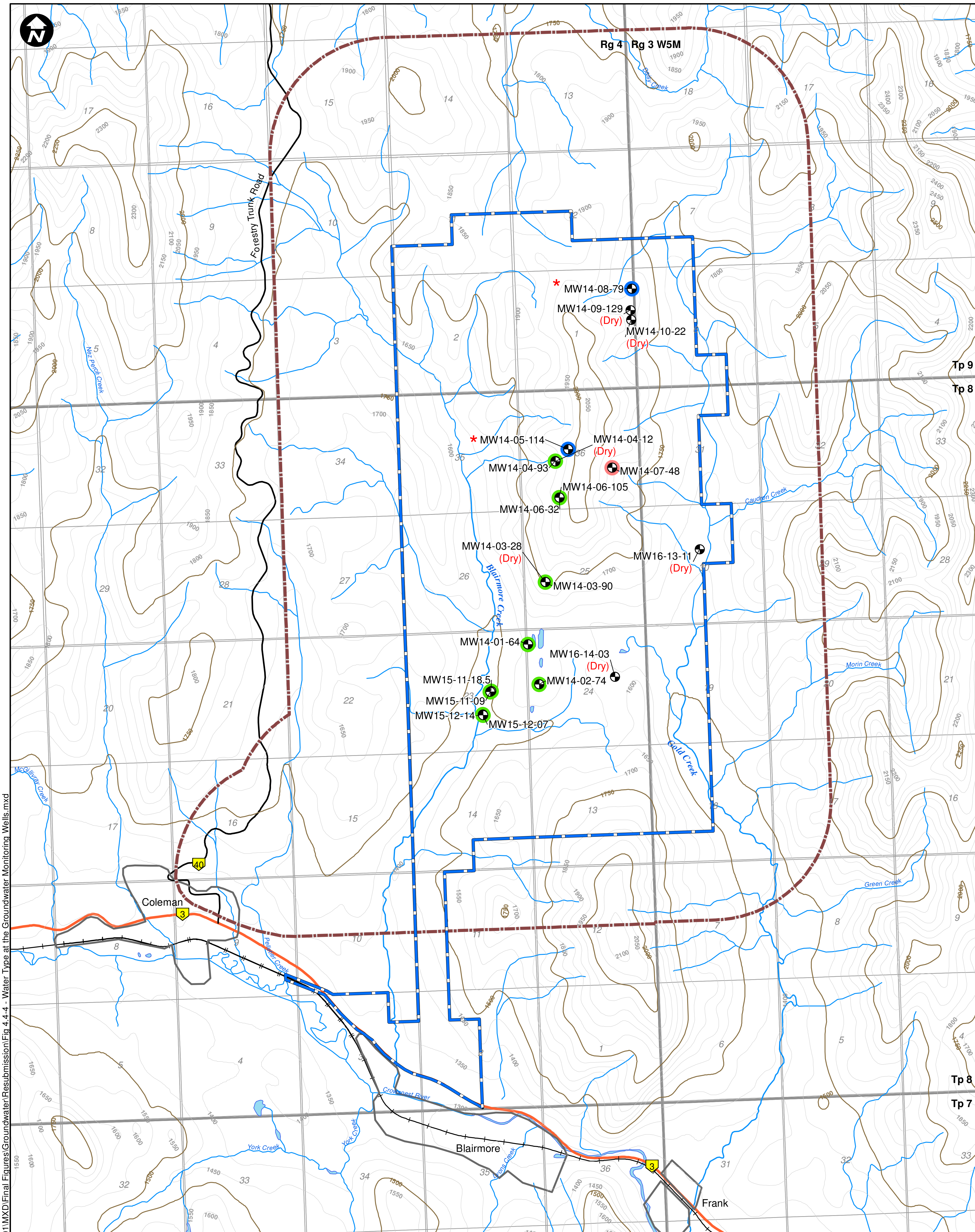
0 1 2 4
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: AcK
DATE: AUGUST 2, 2016

FIGURE

4.4-3

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 4.4-3 - Hydraulic Conductivity within the Kootenay Group.mxd



Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 4.4-4 - Water Type at the Groundwater Monitoring Wells.mxd

LEGEND

- Monitoring Well Location
- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- Contour - Major (250m Interval)
- Contour - Minor (50 m interval)
- LSA
- Proposed Mine Permit Boundary

Type Water

- Calcium-Bicarbonate
- Calcium-Sulphate
- Calcium-Bicarbonate/Sulphate
- * Unreliable Chemistry

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

WATER TYPE AT THE GROUNDWATER MONITORING WELLS

NOTES

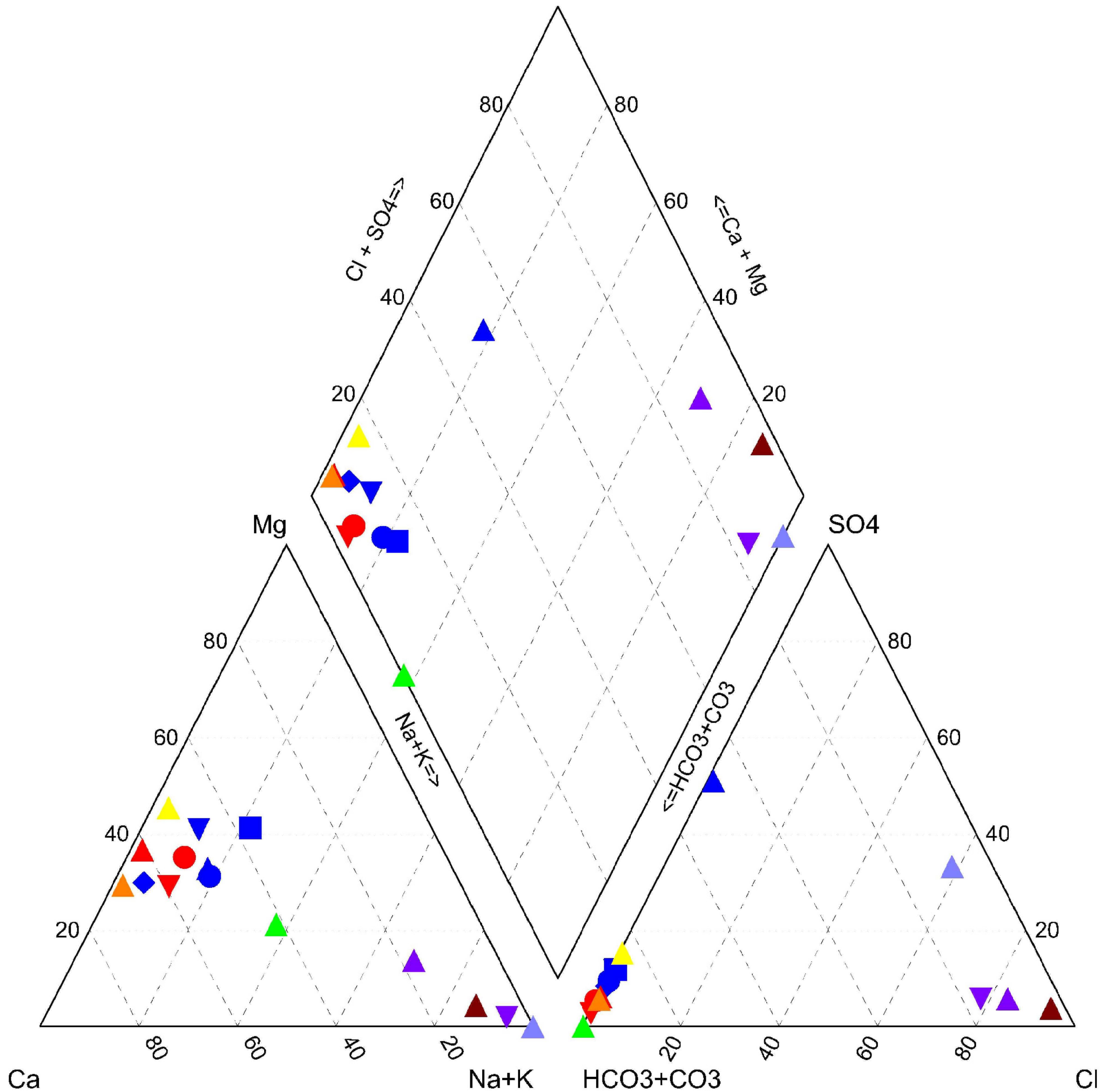
AltaLIS, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 1 2 4
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: AcK
DATE: JULY 11, 2016

FIGURE

4.4-4



Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 4.4-5 - Piper Plot - Monitoring Wells.mxd

LEGEND

- Surficial Deposits
- Blairmore Group
- Coal Seam 1
- Coal Seam 2
- Coal Seam 4
- Misty Formation
- Pallister Formation
- Fairholme Formation

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PIPER PLOT - MONITORING WELLS AND OIL & GAS WELLS

NOTES

MEMS, 2015

PROJECT: 14-00201-01

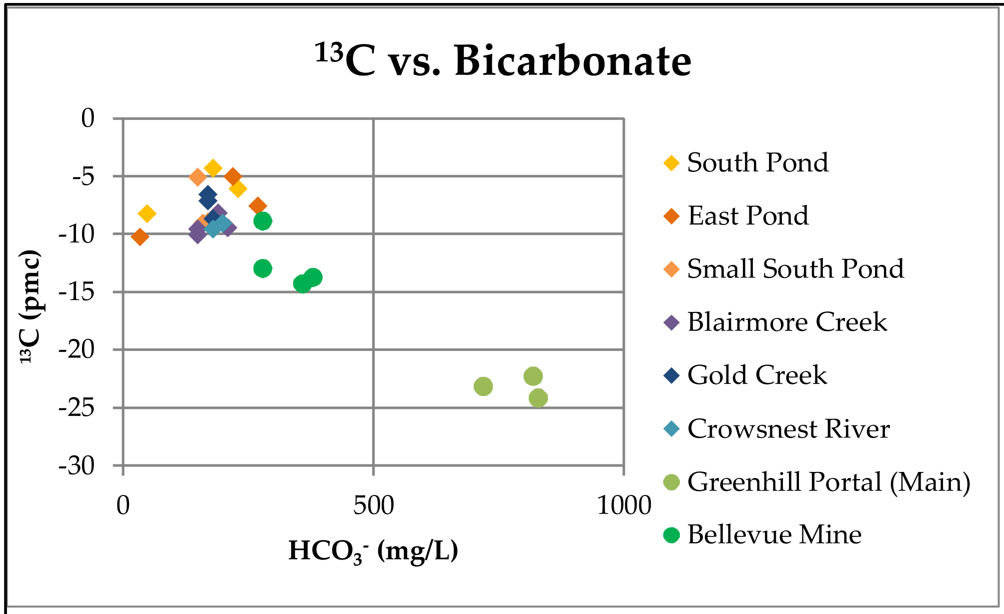
DRAWN BY: JDC

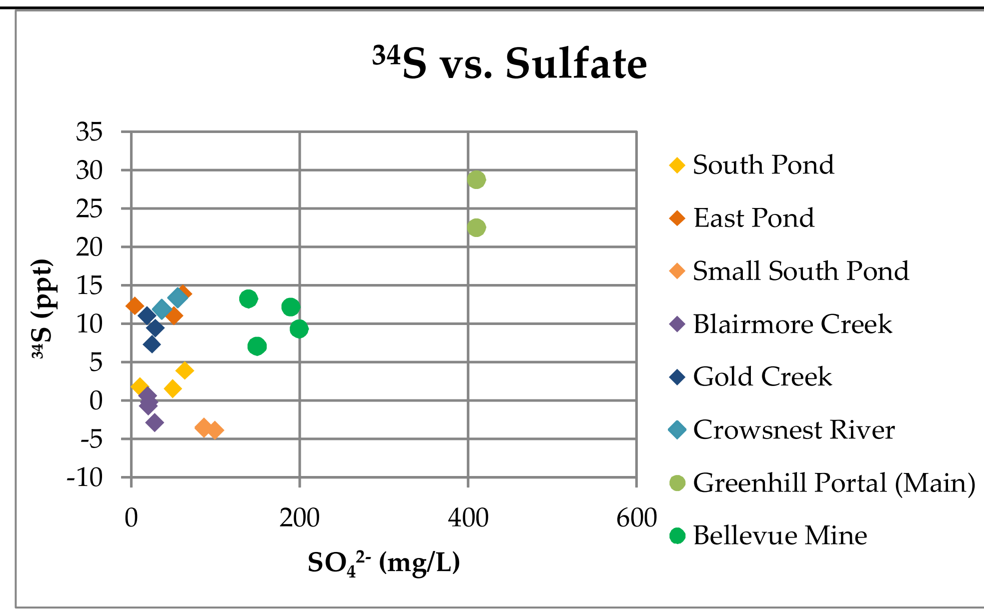
CHECKED BY: AcK

DATE: JULY 29, 2016

FIGURE

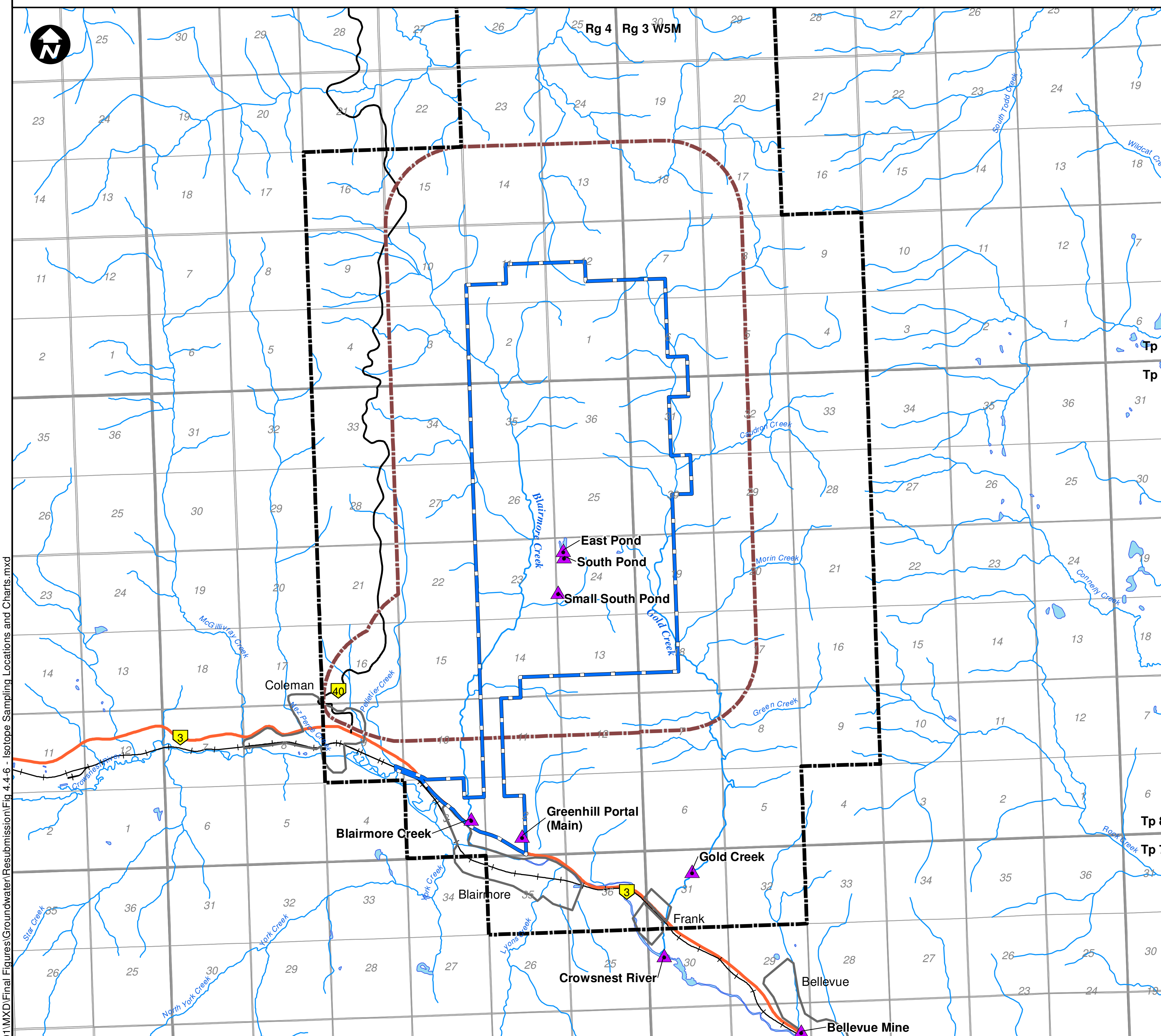
4.4-5





LEGEND

- ◆ Surface Water
- ● Discharge from Portal/Mine



Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 4.4-6 - Isotope Sampling Locations and Charts.mxd

LEGEND

- ▲ Isotope Sampling Location
- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- LSA
- RSA
- Proposed Mine Permit Boundary

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

ISOTOPE SAMPLING LOCATIONS AND CHARTS

NOTES

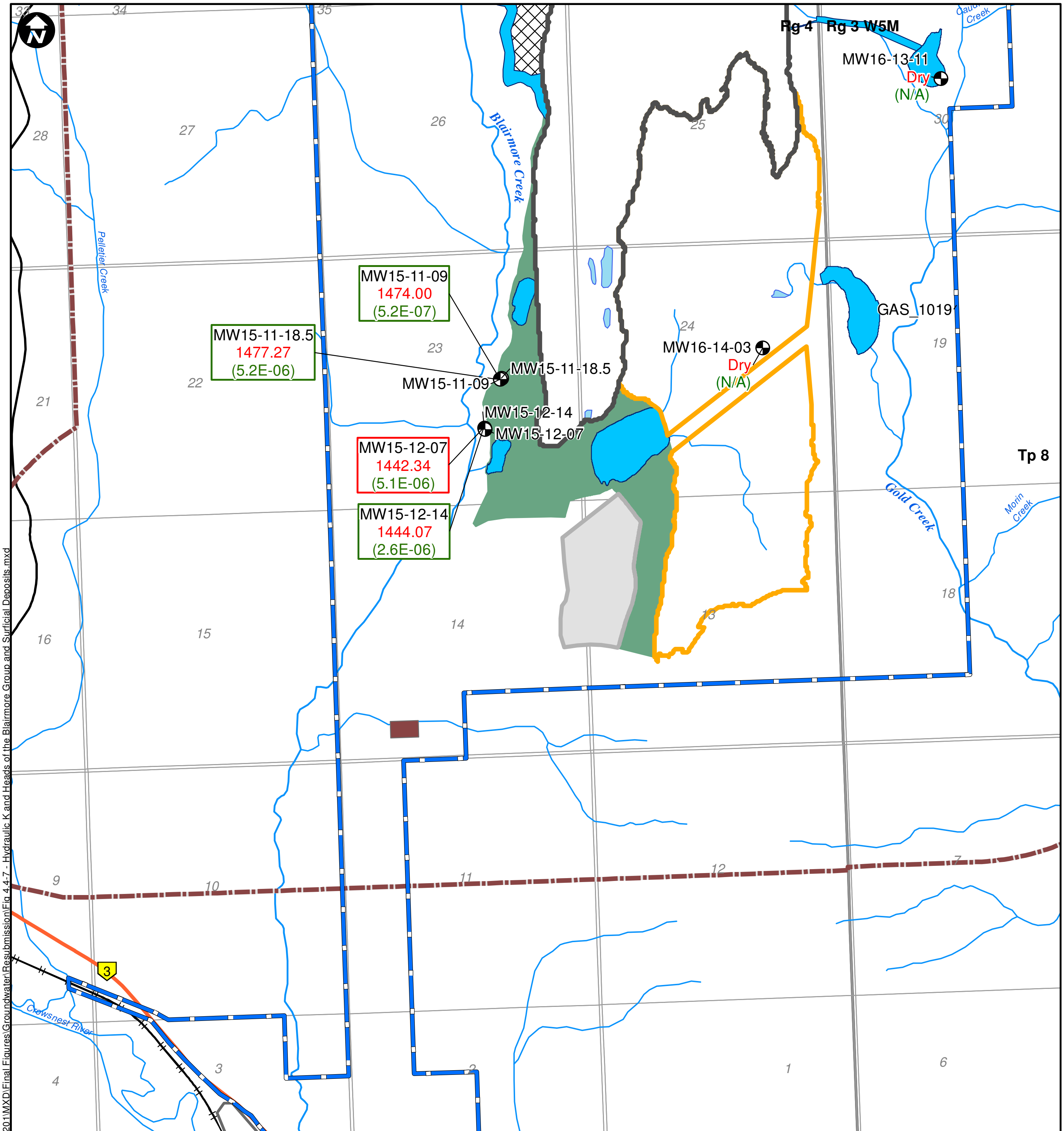
AltaLIS, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2 4 8
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: AcK
DATE: JULY 29, 2016

FIGURE

4.4-6



LEGEND

- Monitoring Well Location
- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- LSA
- Proposed Mine Permit Boundary
- Surficial Deposits
- Blairmore Group
- Ultimate Pit Extent
- Ultimate Rock Disposal Area Extent
- Topsoil Storage
- Construction Camp
- Ponds and Ditches
- Coal Handling Processing Plant and Infrastructure
- Undisturbed Area

(1704.12) Water Level (m asl) Measured in April 2015

(2.3E-06) Hydraulic Conductivity (m/s)

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

HYDRAULIC CONDUCTIVITY AND HYDRAULIC HEADS OF THE BLAIRMORE GROUP AND SURFICIAL DEPOSITS

NOTES

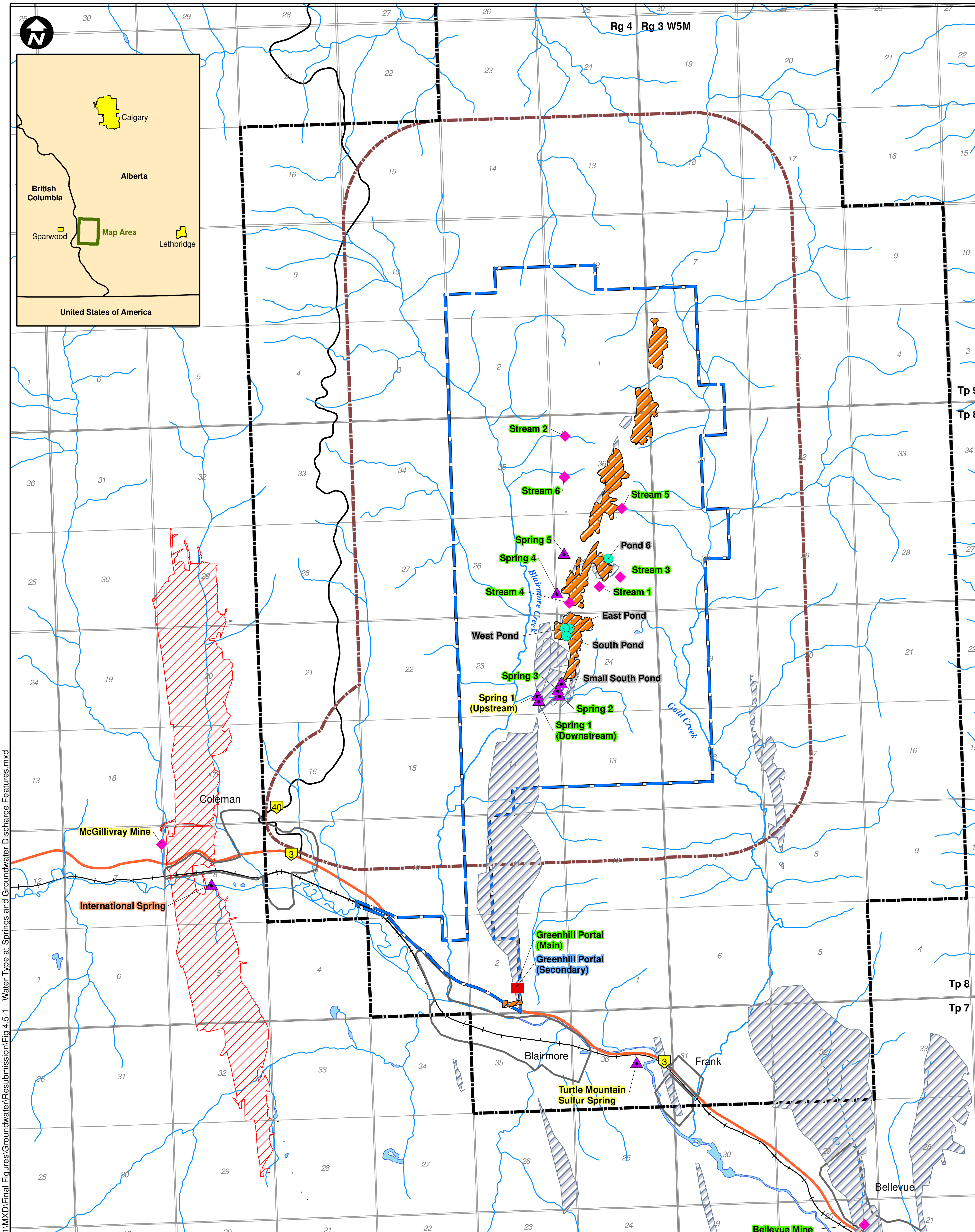
AltaLIS, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 0.5 1 2
Kilometres

PROJECT: 14-00201-01
DRAWN BY: JDC
CHECKED BY: AcK
DATE: JULY 29, 2016

FIGURE
4.4-7

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 4.4-7 - Hydraulic K and Heads of the Blairmore Group and Surficial Deposits.mxd



LEGEND

- Spring
- Creek
- Pond
- Portal
- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- Surface Mine
- Underground Mine
- Abandoned Coal Mine
- LSA
- RSA
- Proposed Mine Permit Boundary

Type Water

Spring 1	Calcium Bicarbonate
Spring 1	Calcium/Magnesium Bicarbonate
Spring 1	Calcium/Magnesium Sulfate
Spring 1	Magnesium Sulfate
Spring 1	Sodium Bicarbonate

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

WATER TYPE AT SPRINGS AND GROUNDWATER DISCHARGE FEATURES

NOTES

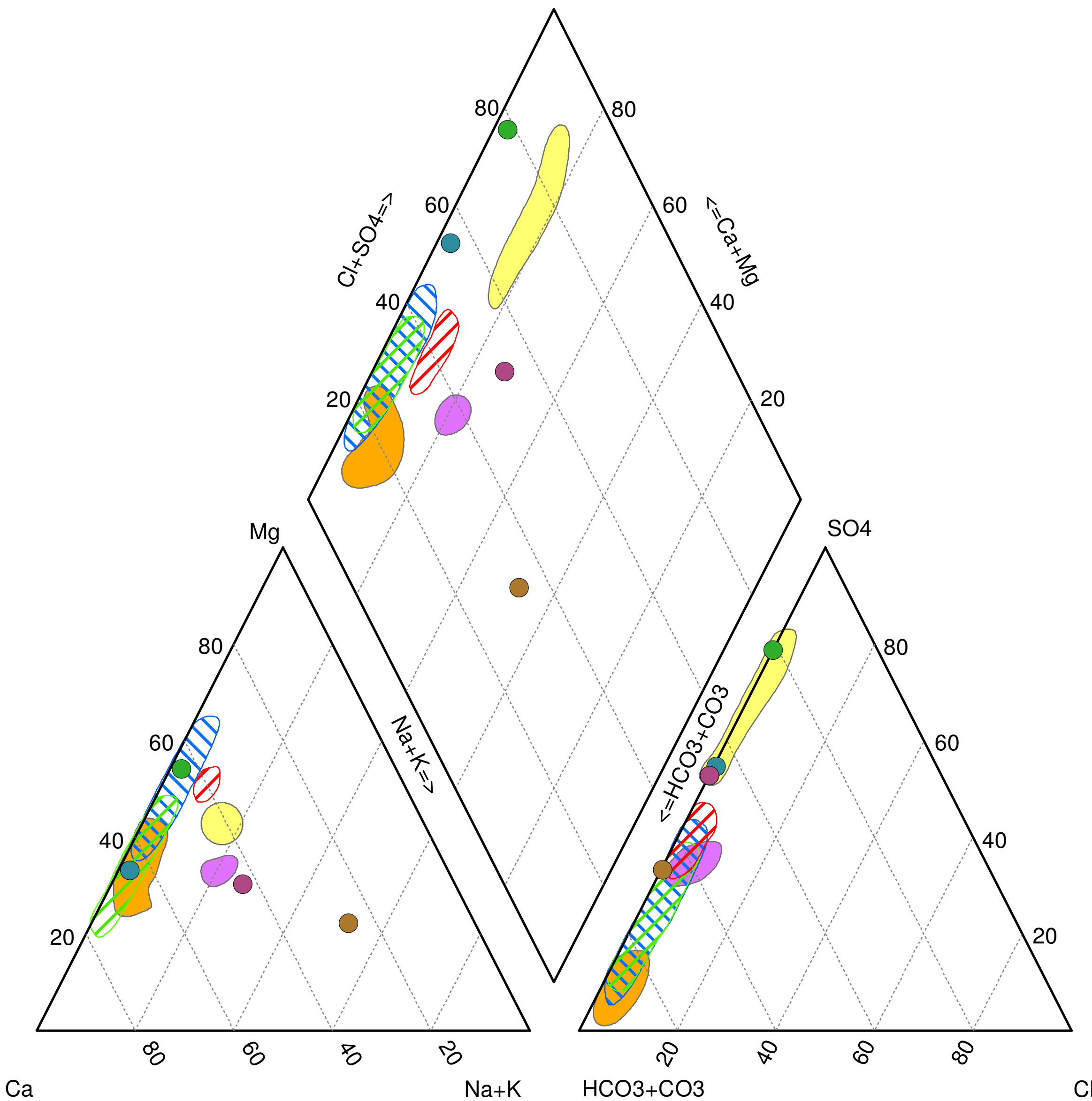
AER, 2016; AGS, 2016; AltaLIS, 2016; ESRD, 2012; Golder, 2016; NRCAN, 2016; Riversdale, 2016; Worthington, 1991
Datum/Projection: UTM NAD 83 Zone 11

0 1 2 4
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: AcK
DATE: JULY 29, 2016

FIGURE
4.5-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 4.5-1 - Water Type at Springs and Groundwater Discharge Features.mxd



LEGEND

- Greenhill Secondary Portal
- International Spring
- McGillivray Mine
- Turtle Mountain Spring
- Bellevue Mine
- Greenhill Main Portal
- Ponds
- Spring 1 (Upstream)
- Toe Springs and Spring 1 (Downstream)
- Streams

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PIPER PLOT – SPRINGS AND GROUNDWATER DISCHARGE FEATURES

NOTES

MEMS, 2016

PROJECT: 14-00201-01

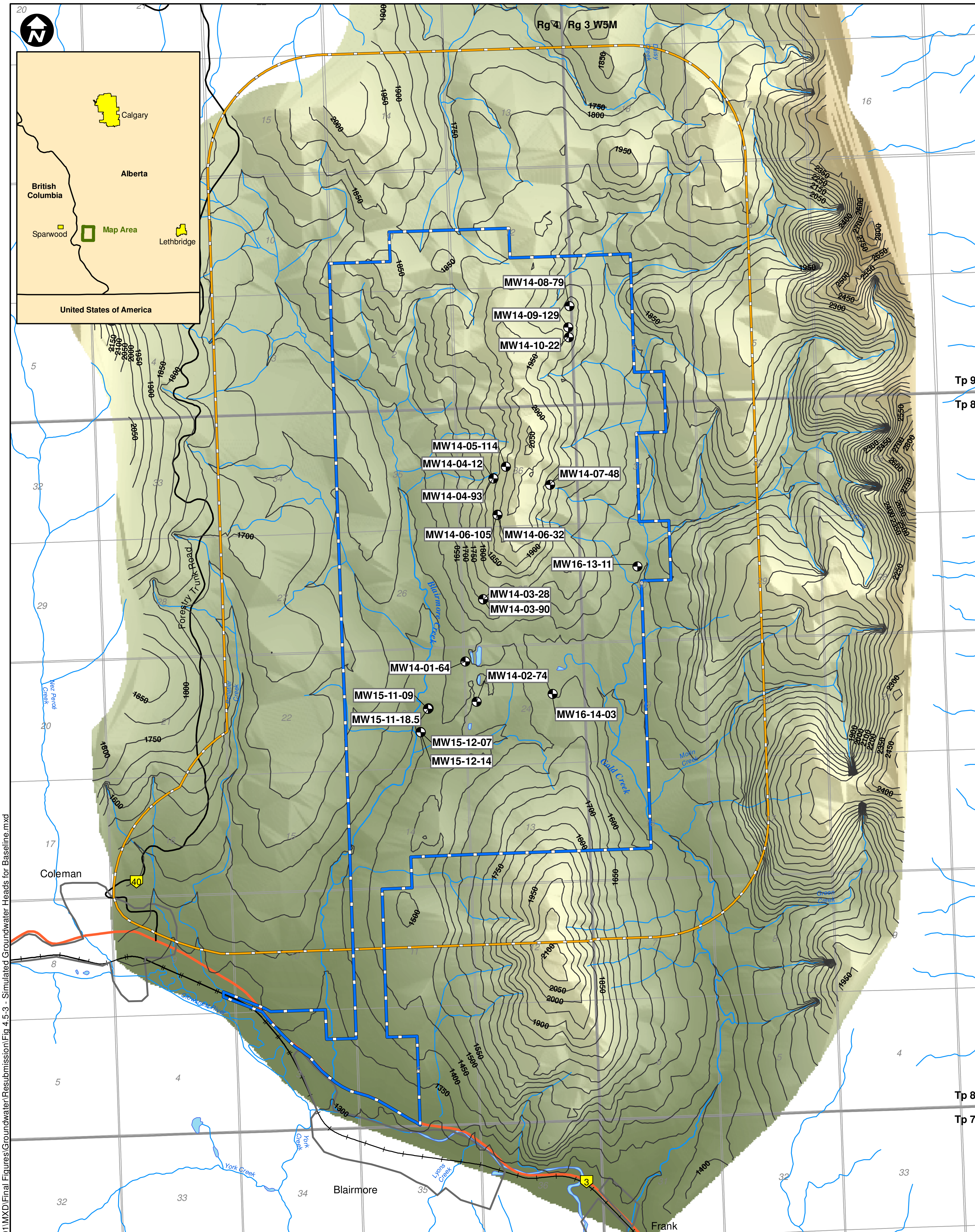
DRAWN BY: JDC

CHECKED BY: AcK

DATE: JULY 29, 2016

FIGURE

4.5-2



LEGEND

- Monitoring Well
- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- Groundwater Head Contours (msal)
- LSA
- Proposed Mine Permit Boundary

Groundwater Heads (msal)

Value

High : 2500

Low : 1200

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

SIMULATED GROUNDWATER HEADS FOR BASELINE

NOTES

AltaLIS, 2016; NRCAN, 2016; Riversdale, 2016; srK, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 1 2 4
Kilometres

PROJECT: 14-00201-01

DRAWN BY: CP/JDC

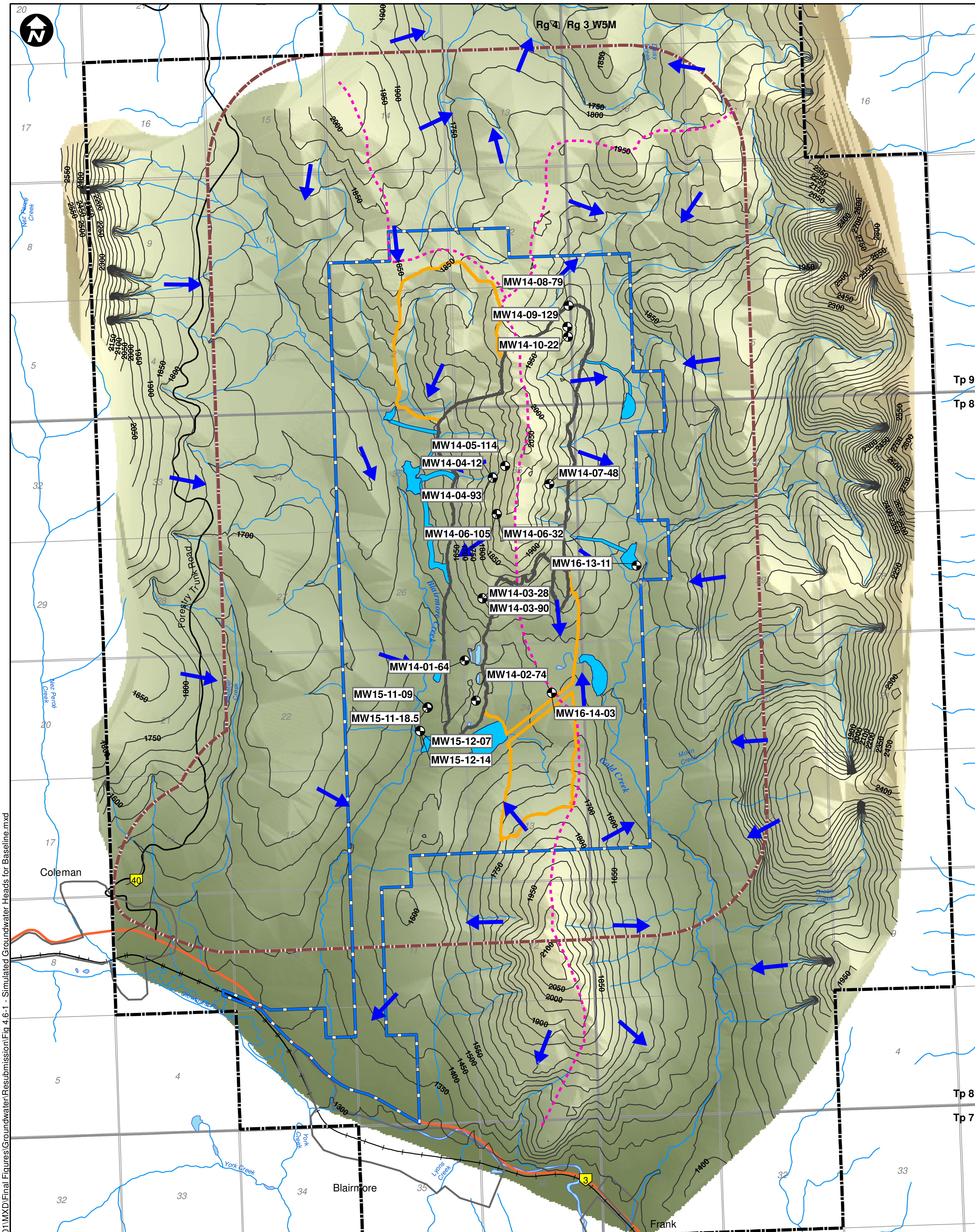
CHECKED BY: AeK

DATE: JUL 27, 2015

FIGURE

4.5-3

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 4.5-3 - Simulated Groundwater Heads for Baseline.mxd



LEGEND

- Monitoring Well
- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- Groundwater Head Contours (msal)
- Groundwater Divide
- Groundwater Flow Direction
- Proposed Mine Permit Boundary
- Ultimate Pit Extent
- Ultimate Rock Disposal Area Extent
- Ponds and Ditches
- LSA
- RSA

Groundwater Heads (msal)

Value

High : 2500

Low : 1200

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

SIMULATED GROUNDWATER HEADS FOR BASELINE

NOTES

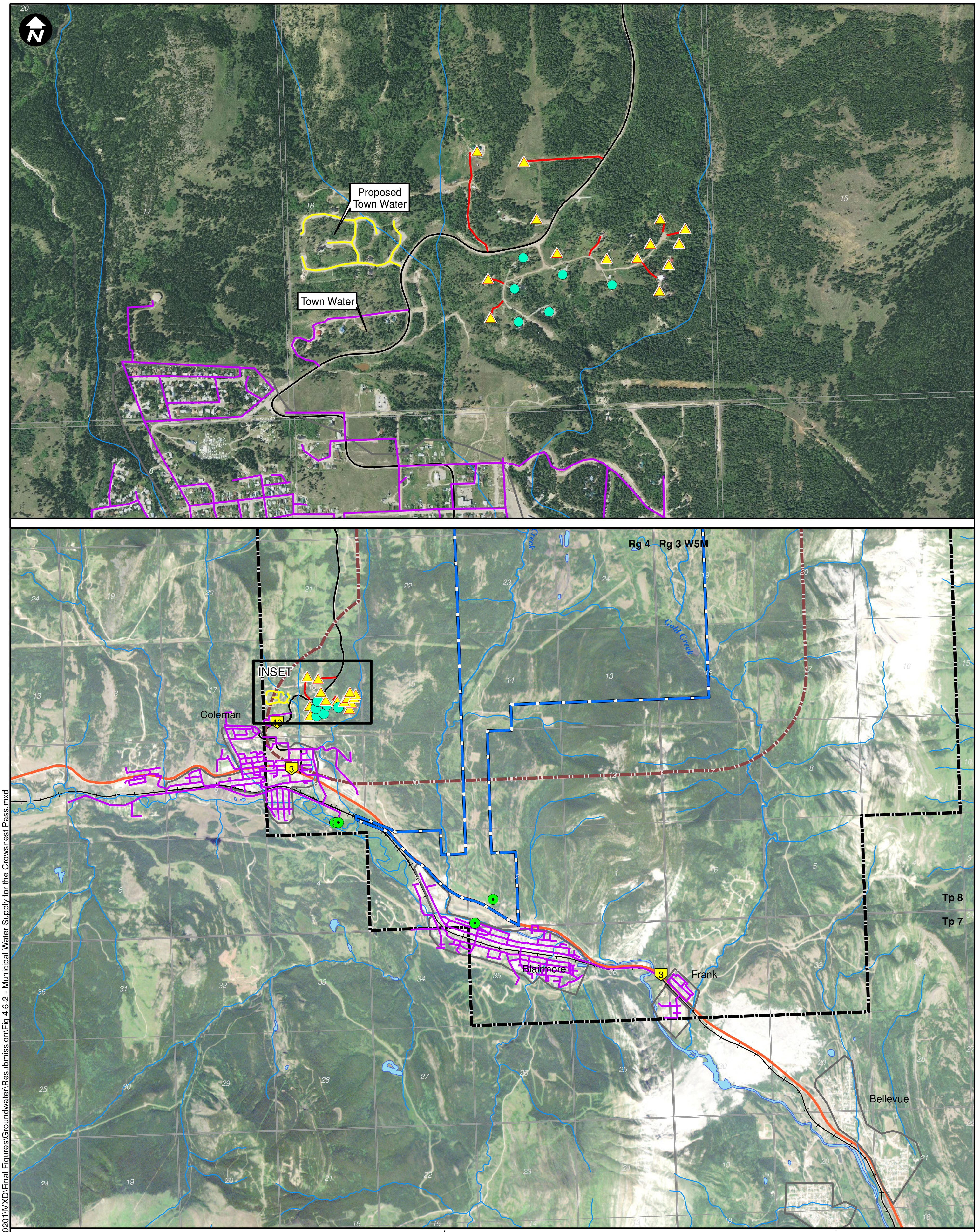
AltaLIS, 2016; NRCAN, 2016; Riversdale, 2016; srK, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 1 2 4
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: AeK
DATE: AUGUST 2, 2016

FIGURE **4.6-1**

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 4.6-1 - Simulated Groundwater Heads for Baseline.mxd



LEGEND

- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- LSA
- RSA
- Proposed Mine Permit Boundary

Water Well

- Municipal Well Location
- Successfully Surveyed and Sampled
- Unsuccessfully Surveyed (Restricted Access /No Contact with Landowner)
- Gated/No Trespassing

Municipal Water Supply

- Municipal Water Supply
- Proposed Town Water/Development in Progress

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

MUNICIPAL WATER SUPPLY FOR THE MUNICIPALITY OF CROWSNEST PASS (EXCLUDING BELLEVUE AND HILLCREST)

NOTES

AltaLIS, 2016; NRCAN, 2016; Riversdale, 2016; Valtus, 2016
(Image Date: Sept 2009-Oct 2010)
Datum/Projection: UTM NAD 83 Zone 11

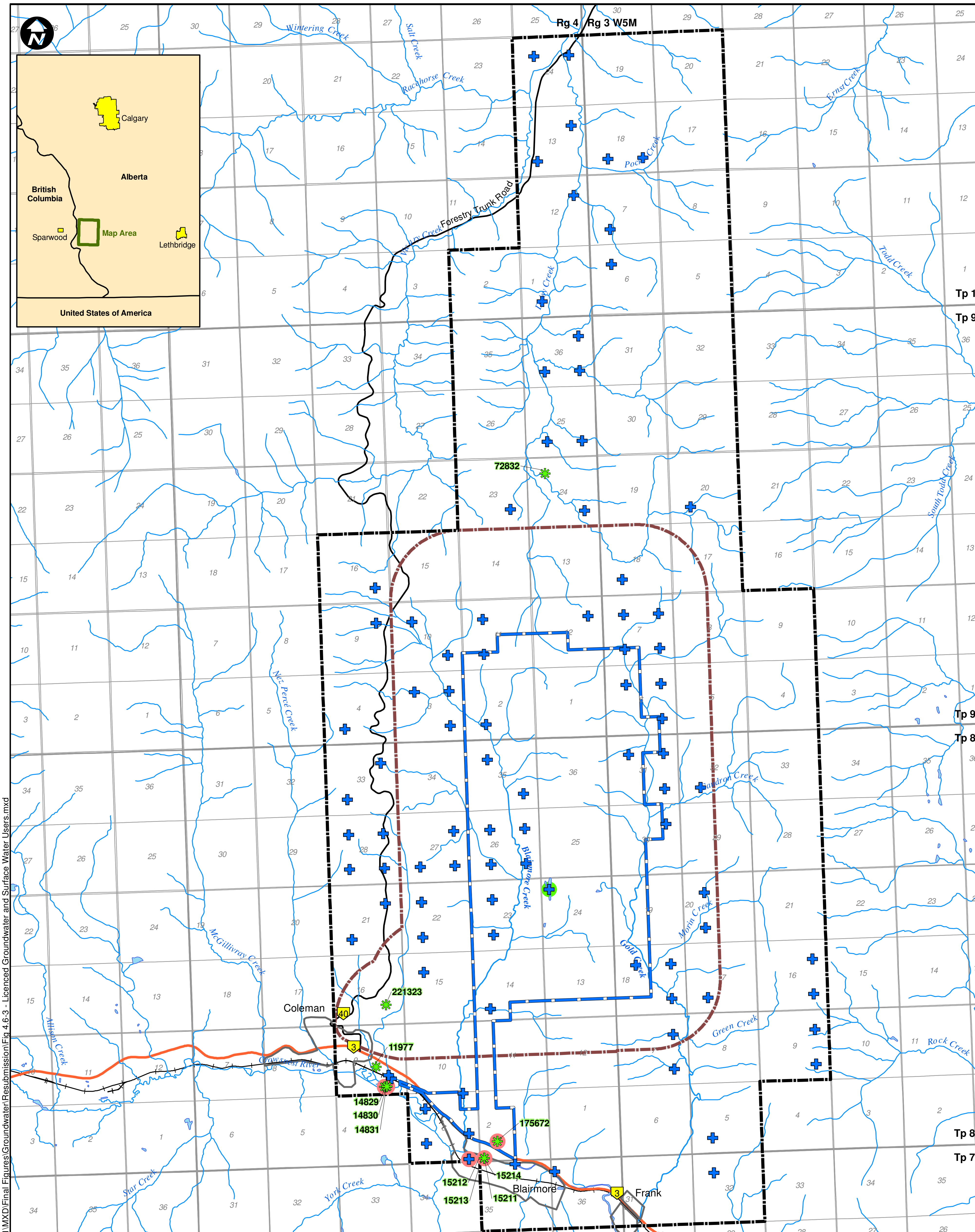
0 1 2 4
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: AcK
DATE: JULY 29, 2016

FIGURE

4.6-2

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 4.6-2 - Municipal Water Supply for the Crowsnest Pass.mxd



LEGEND

Licenced Water Users

- Groundwater User (labelled with water allocation ID)
- Surface Water User
- Licenced to the Municipality of Crowsnest Pass
- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- LSA
- RSA
- Proposed Mine Permit Boundary

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

LICENCED GROUNDWATER AND SURFACE WATER USERS

NOTES

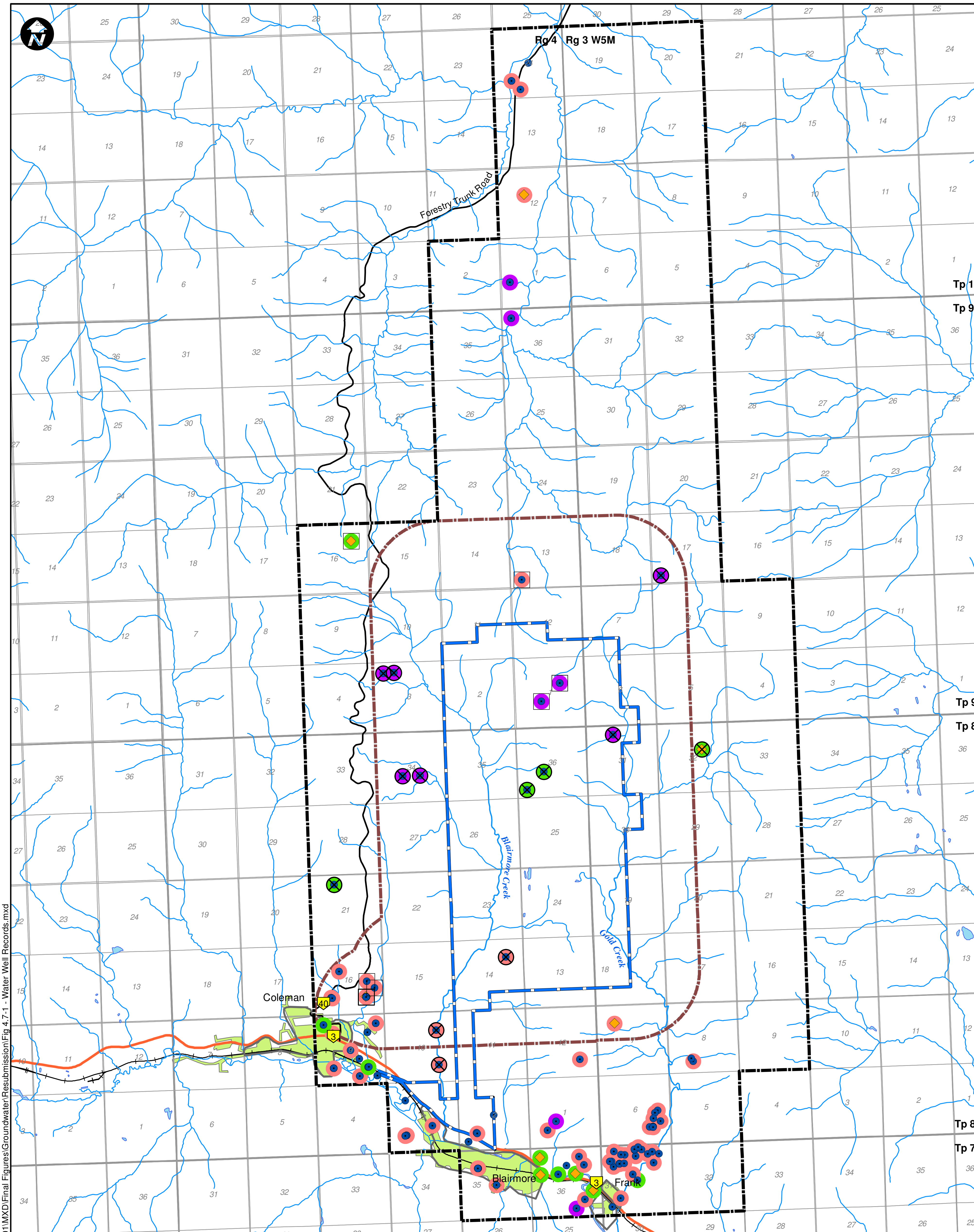
AER, 2016; AltaLIS, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 1.5 3 6
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: AcK
DATE: JULY 29, 2016

FIGURE
4.6-3

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 4.6-3 - Licenced Groundwater and Surface Water Users.mxd



LEGEND

- Water Well Location
- Spring
- Location Visited
- Well Attempted To Be Surveyed
- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- Blairmore Creek; Gold Creek
- LSA
- RSA
- Proposed Mine Permit Boundary
- Approximate Municipal Water Limit

Water Usage

- Domestic
- Industrial
- Unknown

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

WATER WELL RECORDS

NOTES

AER, 2016; AltaLIS, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

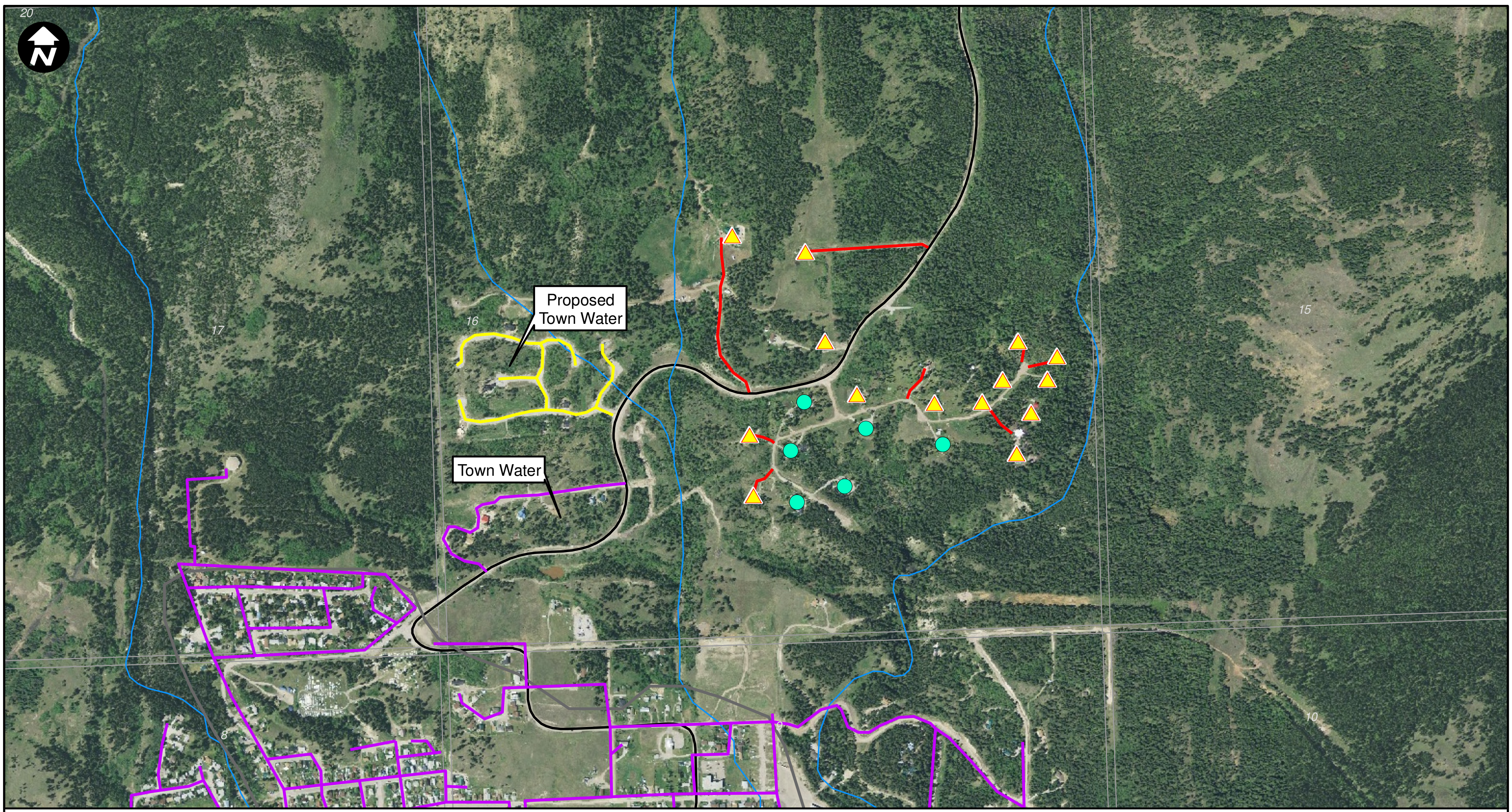
0 1.5 3 6
Kilometres

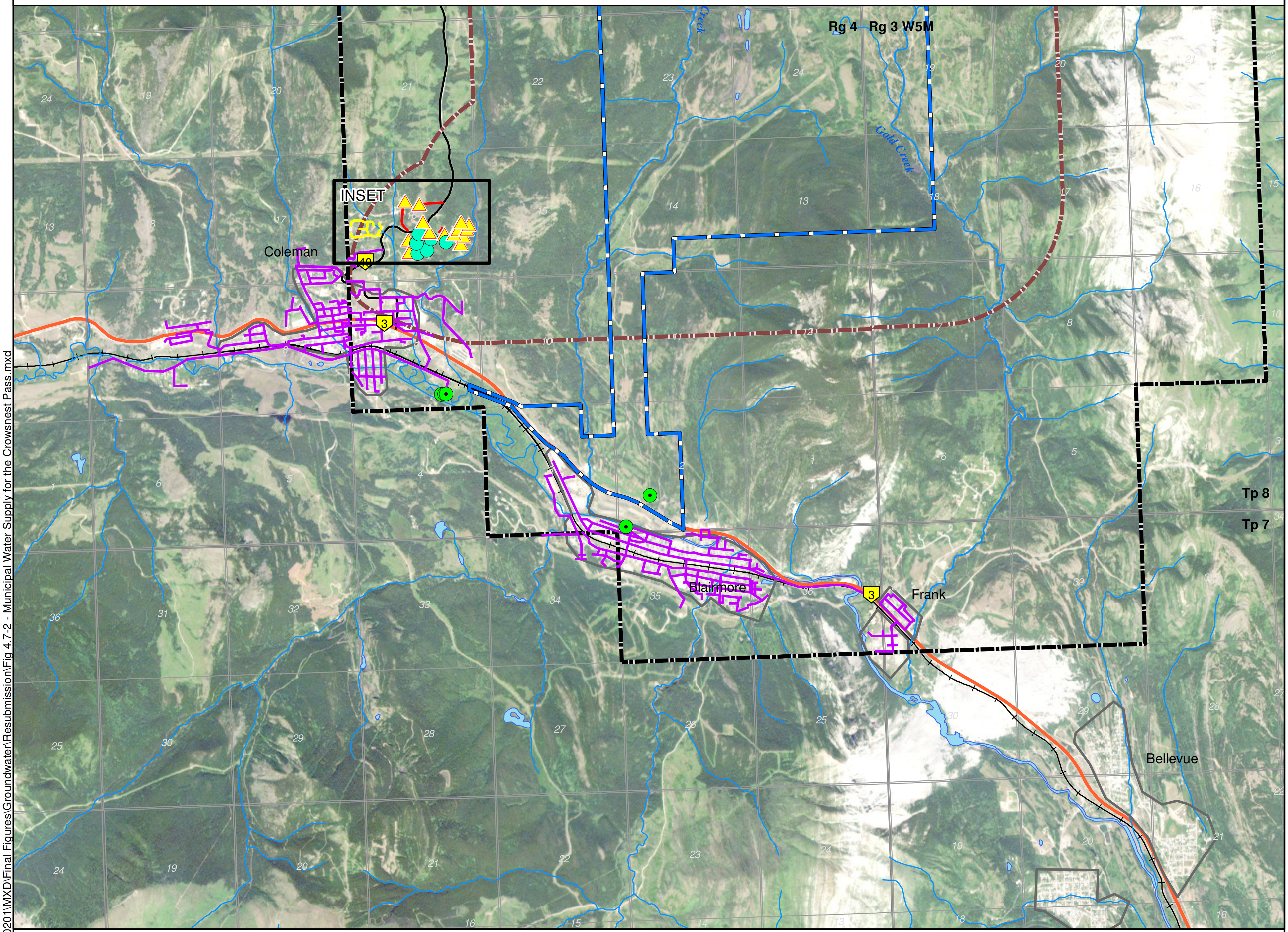
PROJECT: 14-00201-01
DRAWN BY: JL/JDC
CHECKED BY: AcK
DATE: AUGUST 2, 2016

FIGURE

4.7-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 4.7-1 - Water Well Records.mxd





LEGEND

- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- LSA
- RSA
- Proposed Mine Permit Boundary

Water Well

- Municipal Well Location
- Successfully Surveyed and Sampled
- Unsuccessfully Surveyed (Restricted Access /No Contact with Landowner)
- Gated/No Trespassing

Municipal Water Supply

- Municipal Water Supply
- Proposed Town Water/Development in Progress

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

MUNICIPAL WATER SUPPLY FOR THE MUNICIPALITY OF CROWSNEST PASS (EXCLUDING BELLEVUE AND HILLCREST)

NOTES

AltaLIS, 2016; NRCAN, 2016; Riversdale, 2016; Valtus, 2016
(Image Date: Sept 2009-Oct 2010)
Datum/Projection: UTM NAD 83 Zone 11

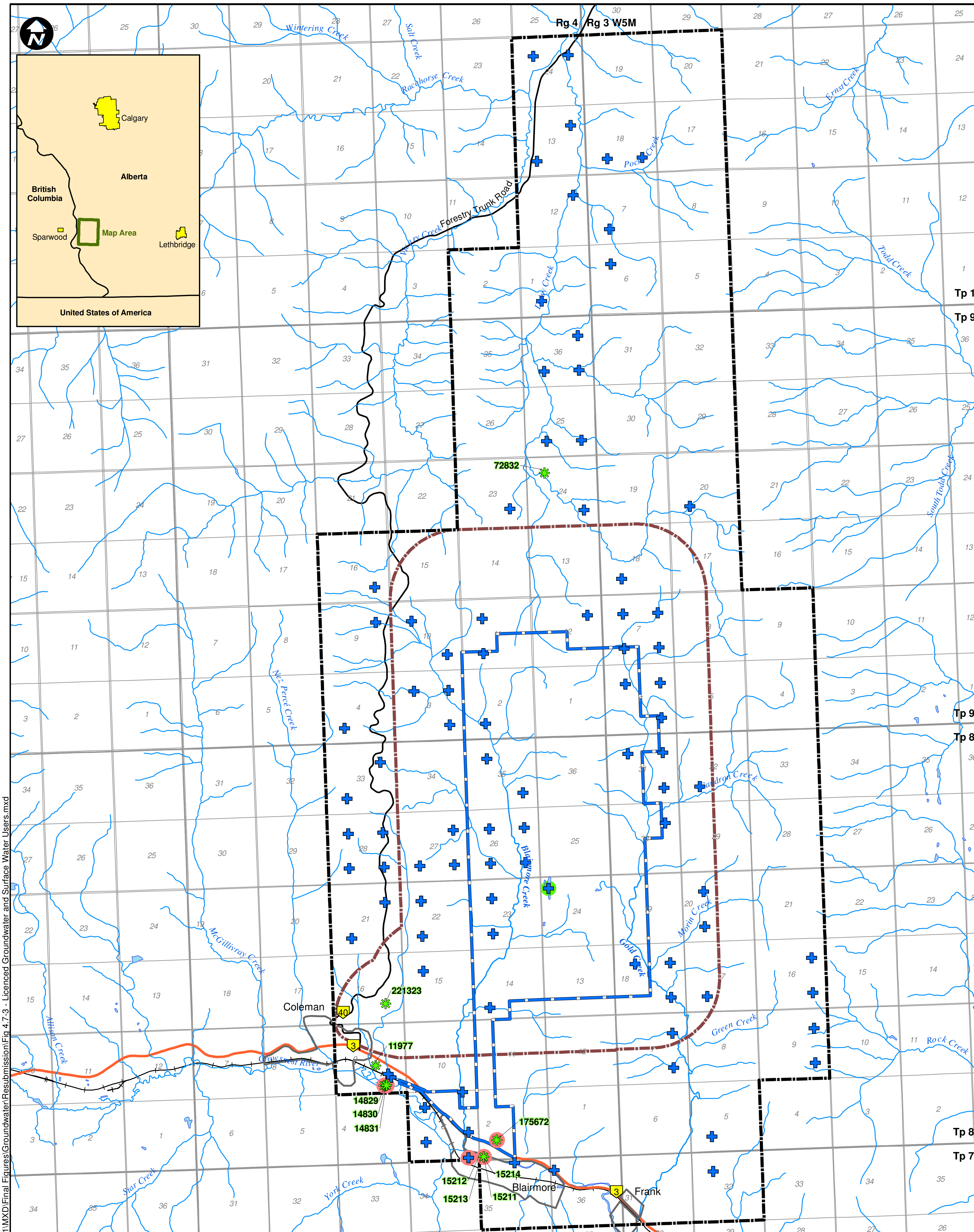
0 1 2 4
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: AcK
DATE: AUGUST 2, 2016

FIGURE

4.7-2

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 4.7-2 - Municipal Water Supply for the Crowsnest Pass.mxd



LEGEND

Licenced Water Users

- Groundwater User (labelled with water allocation ID)
- Surface Water User
- Licenced to the Municipality of Crowsnest Pass
- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- LSA
- RSA
- Proposed Mine Permit Boundary

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 4.7-3 - Licenced Groundwater and Surface Water Users.mxd

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

LICENCED GROUNDWATER AND SURFACE WATER USERS

NOTES

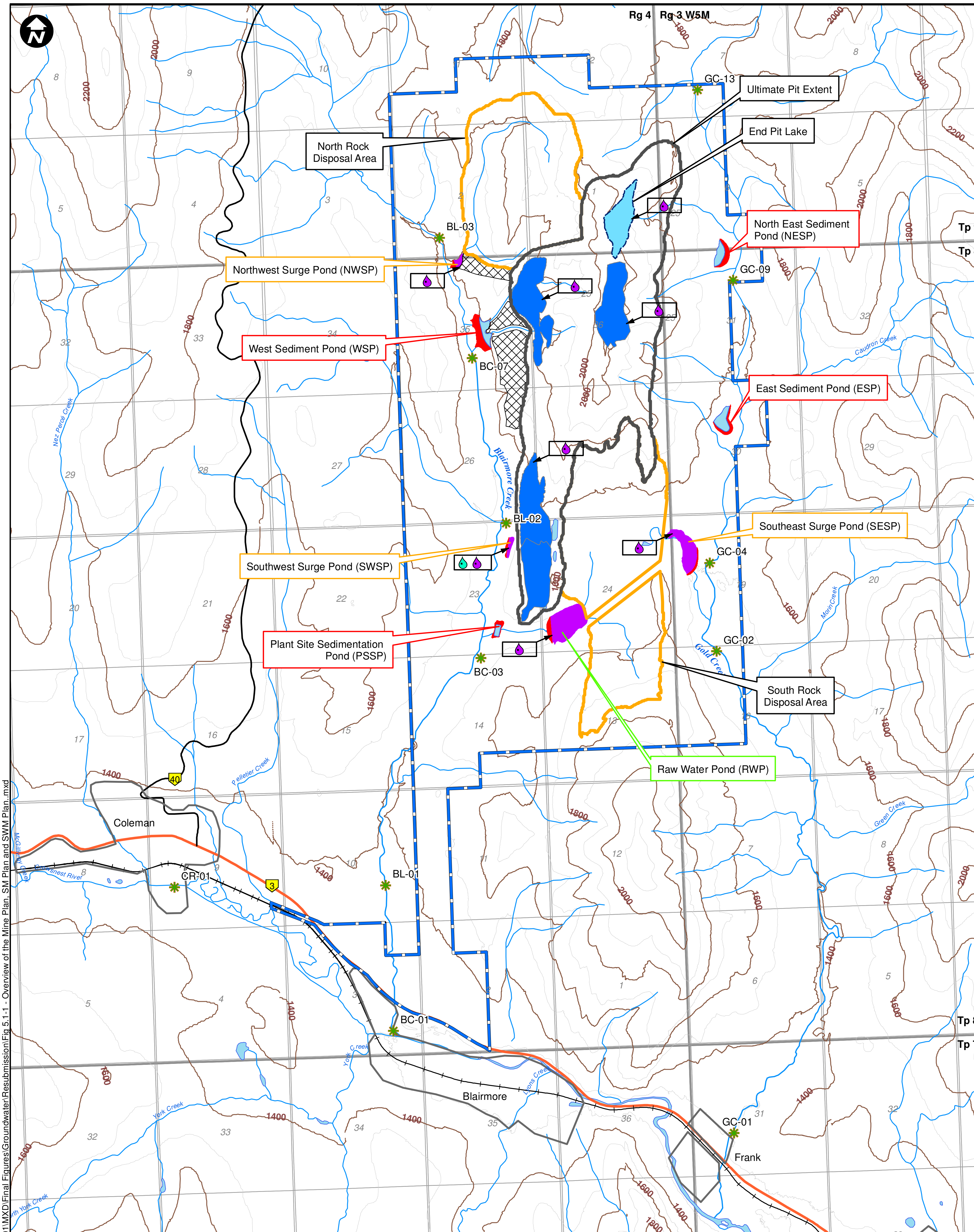
AER, 2016; AltaLIS, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 1.5 3 6
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: AcK
DATE: AUGUST 2, 2016

FIGURE

4.7-3



LEGEND

- Local Gauge Station
- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- Contour - Major (200m Interval)
- Contour - Minor (50m Interval)
- Surge Pond
- Raw Water Pond
- Sedimentation Pond (TSS Treatment and Base Flow Control of Blairmore Creek or Gold Creek)
- Proposed Mine Permit Boundary
- Ultimate Pit Extent
- Ultimate Rock Disposal Area Extent
- Undisturbed Area
- Release Pond
- Dam
- Surge Pond (No Release)
- Saturated Fill Zone
- End-Pit Lake

TSS - Total Suspended Solids

- Potable Water
- Selenium Control

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

OVERVIEW OF THE MINE PLAN, SELENIUM MANAGEMENT PLAN AND SURFACE WATER MANAGEMENT PLAN

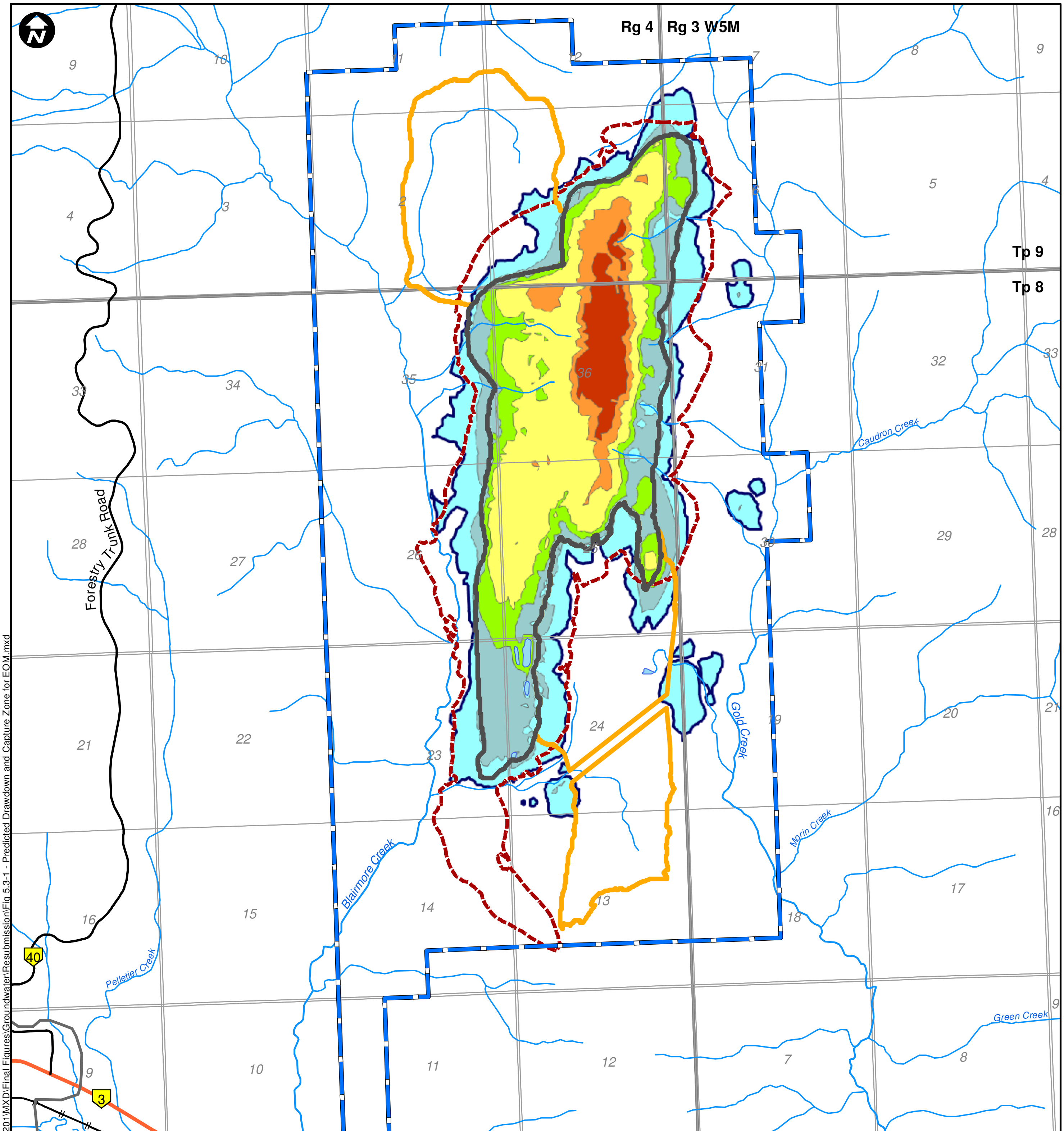
NOTES

AltaLIS, 2016; NRCAN, 2016; Riversdale, 2016; srK, 2016.
Datum/Projection: UTM NAD 83 Zone 11

0 1 2 4
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: AcK
DATE: AUGUST 3, 2016

FIGURE
5.1-1



Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 5.3-1 - Predicted Drawdown and Capture Zone for EOM.mxd

LEGEND

- Proposed Mine Permit Boundary
- Ultimate Pit Extent
- Ultimate Rock Disposal Area Extent
- Capture Zone
- Primary Highway
- Secondary Highway

Drawdown (m)

- 300 - 430
- 220 - 300
- 120 - 220
- 70 - 120
- 30 - 70
- 5 - 30

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED DRAWDOWN AND CAPTURE ZONES FOR EOM

NOTES

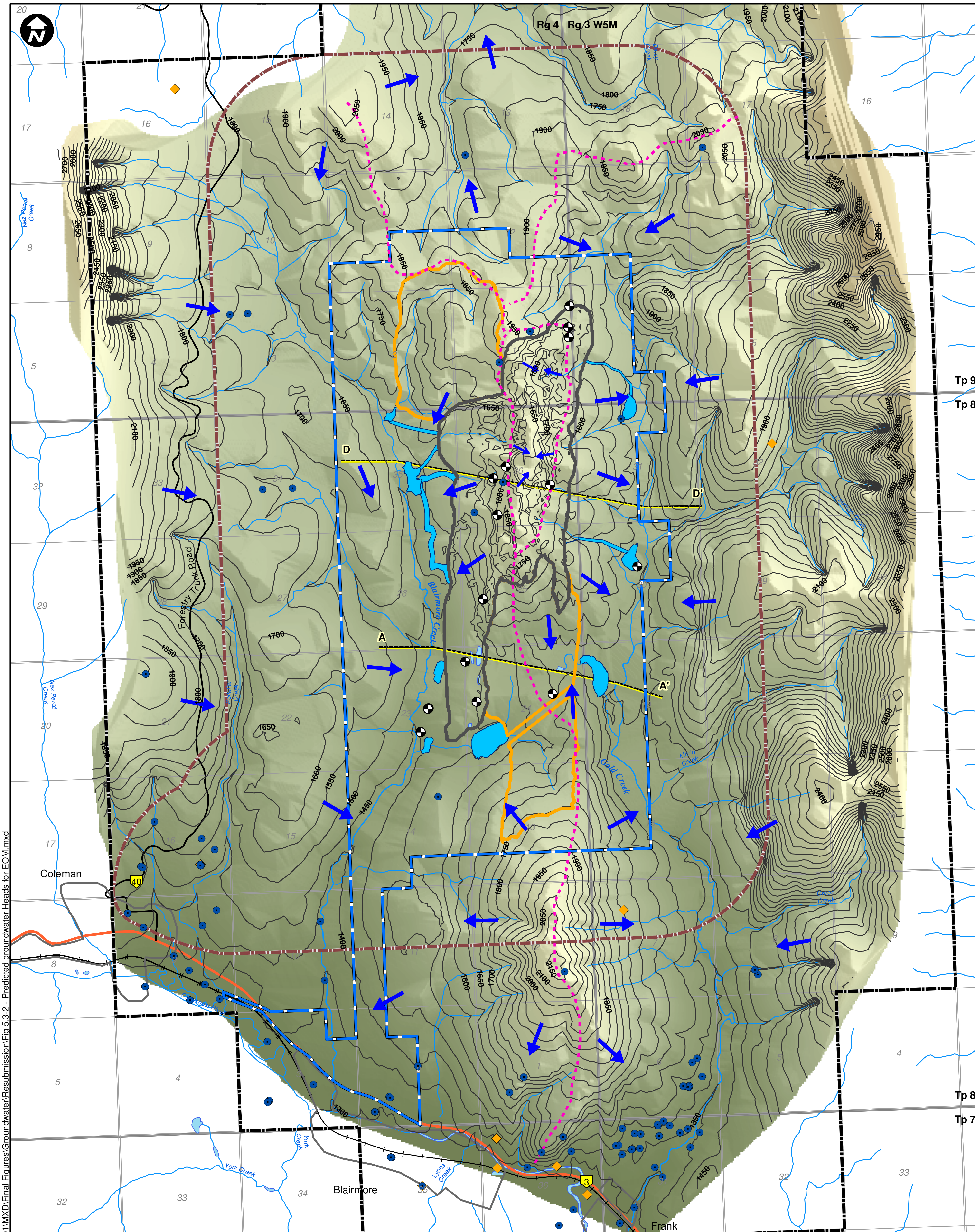
AltaLIS, 2016; NRCAN, 2016; Riversdale, 2016; srK, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 0.75 1.5 3
Kilometres

PROJECT: 14-00201-01
DRAWN BY: JDC
CHECKED BY: AcK
DATE: AUGUST 2, 2016

FIGURE

5.3-1



Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 5.3-2 - Predicted groundwater Heads for EOM.mxd

LEGEND

- Water Well Location
- Spring
- Monitoring Well
- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- Hydrogeological Cross-Section Line
- Predicted Groundwater Head Contours (masl)
- Groundwater Divide
- Groundwater Flow Direction
- Proposed Mine Permit Boundary
- Ultimate Pit Extent
- Ultimate Rock Disposal Area Extent
- Ponds and Ditches
- LSA
- RSA

Predicted Groundwater Heads (msal)

Value

High : 2600

Low : 1200

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED GROUNDWATER HEADS FOR EOM

NOTES

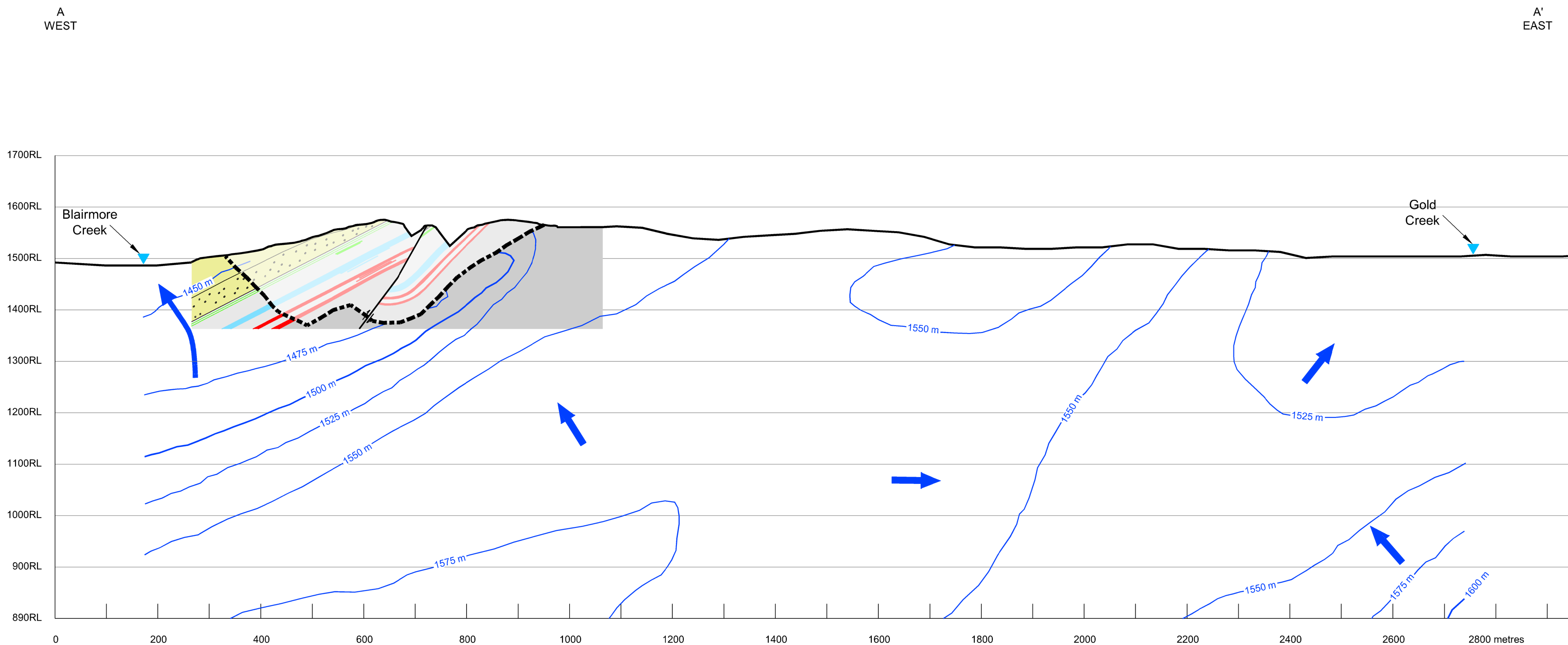
AltaLIS, 2016; NRCAN, 2016; Riversdale, 2016; srK, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 1 2 4
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: AcK
DATE: AUGUST 2, 2016

FIGURE

5.3-2



LEGEND

Geology

- Topography
- Reverse Fault
- Blairmore Group
- Cadomin Formation
- Kootenay Group
- Seam 1
- Seam 2
- Seam 4
- Fernie Group

Mine

- Approximate Ultimate Pit Depth

Hydrogeology / Hydrology

- 1575m — Potentiometric Contour (Modelled Average Baseline from Numerical Model)
- Flow Direction
- Surface Water (Creek)

* - Well is Projected into the Cross-Section Line

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

HYDROGEOLOGICAL CROSS-SECTION AA' - EOM

NOTES

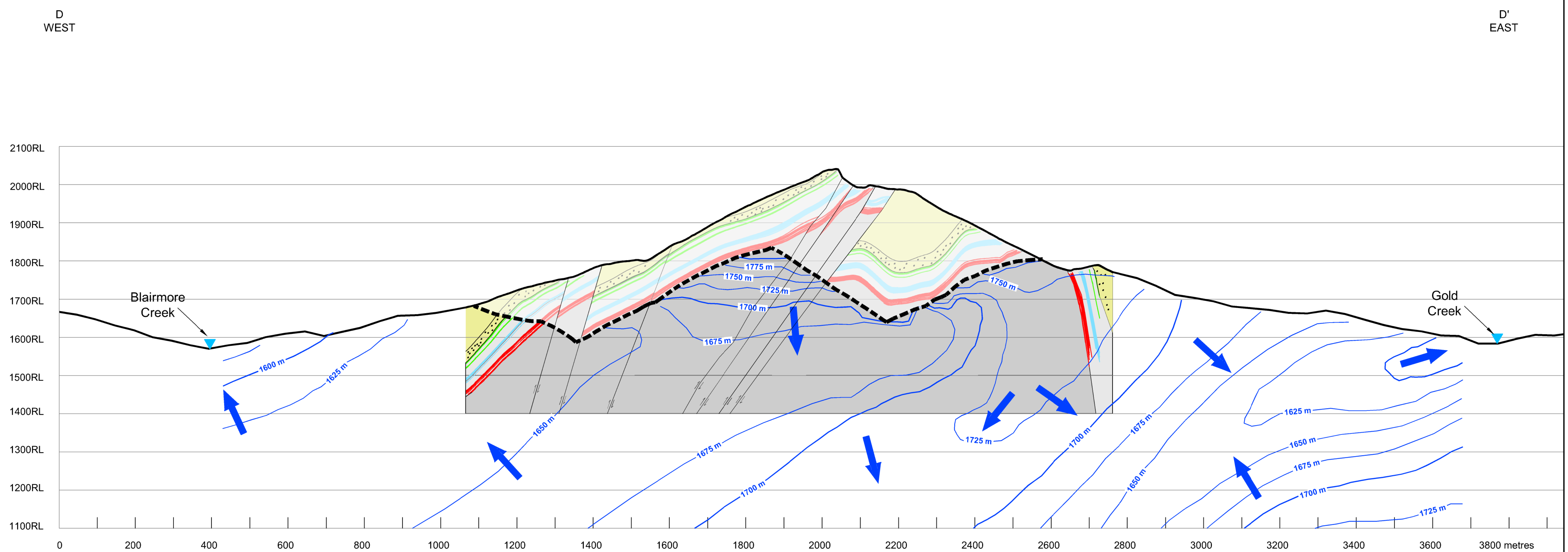
MEMS, 2016; Riversdale, 2016; srK, 2016.

0 100 200 300 400
Metres

PROJECT: 14-00201
DRAWN BY: JDC
CHECKED BY: AcK
DATE: AUGUST 2, 2016

FIGURE

5.3-3



LEGEND

Geology

- Topography
- Reverse Fault
- Blairmore Group
- Cadomin Formation
- Kootenay Group
- Seam 1
- Seam 2
- Seam 4
- Fernie Group

Mine

- Approximate Ultimate Pit Depth

Hydrogeology / Hydrology

- 1575m — Potentiometric Contour (Modelled Average Baseline from Numerical Model)
- Flow Direction
- Surface Water (Creek)

* - Well is Projected into the Cross-Section Line

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

HYDROGEOLOGICAL CROSS-SECTION DD' - EOM

NOTES

MEMS, 2016; Riversdale, 2016; srK, 2016.

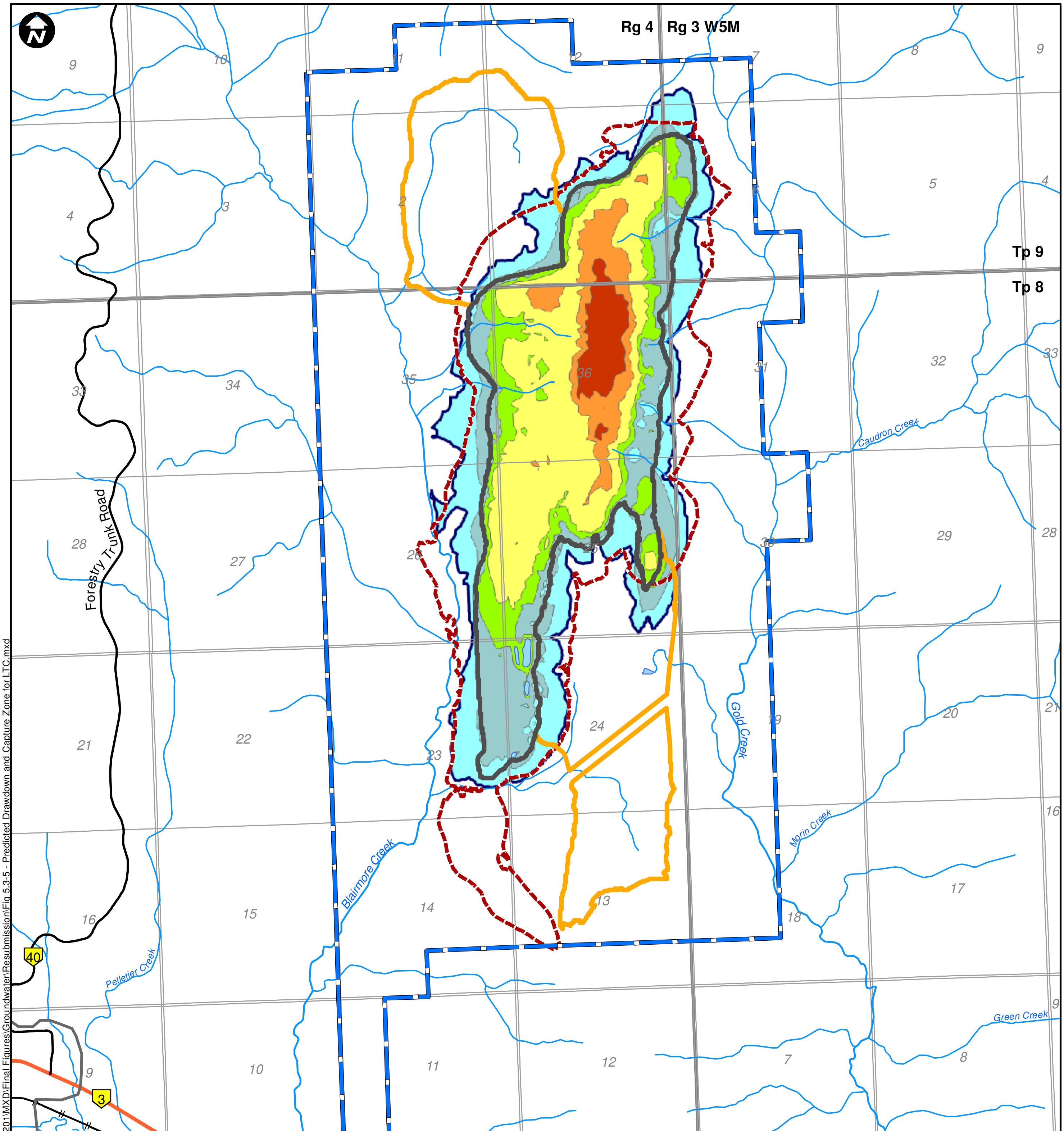
0 100 200 400 600
Metres

PROJECT: 14-00201
DRAWN BY: JDC
CHECKED BY: AcK
DATE: AUGUST 2, 2016

FIGURE

5.3-4

K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Figure 12 - Section DD' 2480.dwg



LEGEND

- Proposed Mine Permit Boundary
- Ultimate Pit Extent
- Ultimate Rock Disposal Area Extent
- Capture Zone
- Primary Highway
- Secondary Highway

Drawdown (m)

- 300 - 388
- 220 - 300
- 120 - 220
- 70 - 120
- 30 - 70
- 5 - 30

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED DRAWDOWN AND CAPTURE ZONES FOR LTC

NOTES

AltaLIS, 2016; NRCAN, 2016; Riversdale, 2016; srK, 2016
Datum/Projection: UTM NAD 83 Zone 11

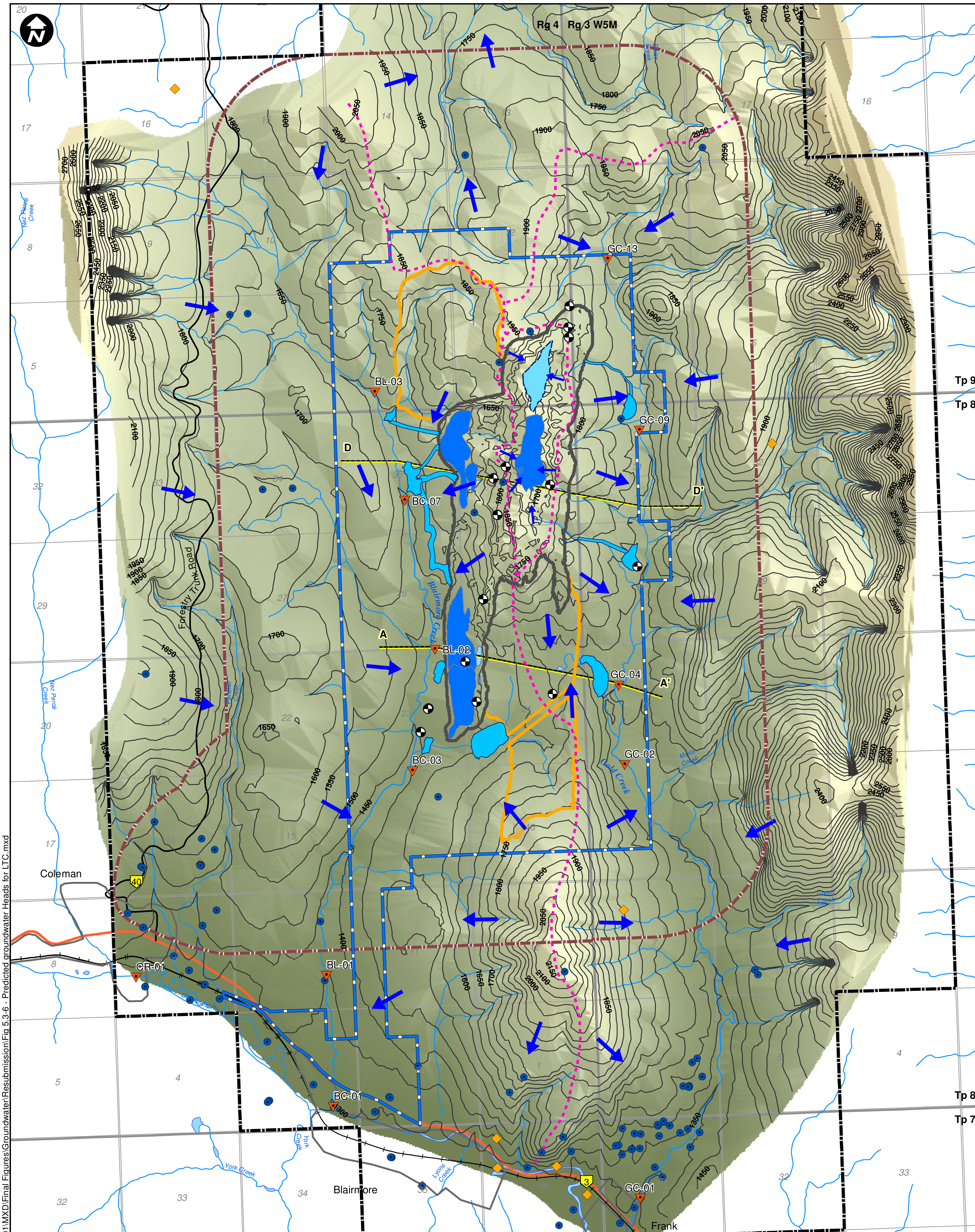
0 0.75 1.5 3
Kilometres

PROJECT: 14-00201-01
DRAWN BY: JDC
CHECKED BY: AcK
DATE: AUGUST 2, 2016

FIGURE

5.3-5

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 5.3-5 - Predicted Drawdown and Capture Zone for LTC.mxd



LEGEND

- Surface Water Gauge Station
- Water Well Location
- Spring
- Monitoring Well
- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- Hydrogeological Cross-Section Line
- Predicted Groundwater Head Contours (masl)
- Groundwater Divide
- Groundwater Flow Direction
- Proposed Mine Permit Boundary
- Ultimate Pit Extent
- Ultimate Dump Extent
- Ponds and Ditches
- Saturated Fill Zone
- End-Pit Lake
- LSA
- RSA

Predicted Groundwater Heads (msal)

Value

High : 2600

Low : 1200

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED GROUNDWATER HEADS FOR LTC

NOTES

AltaLIS, 2016; NRCAN, 2016; Riversdale, 2016; srK, 2016
Datum/Projection: UTM NAD 83 Zone 11

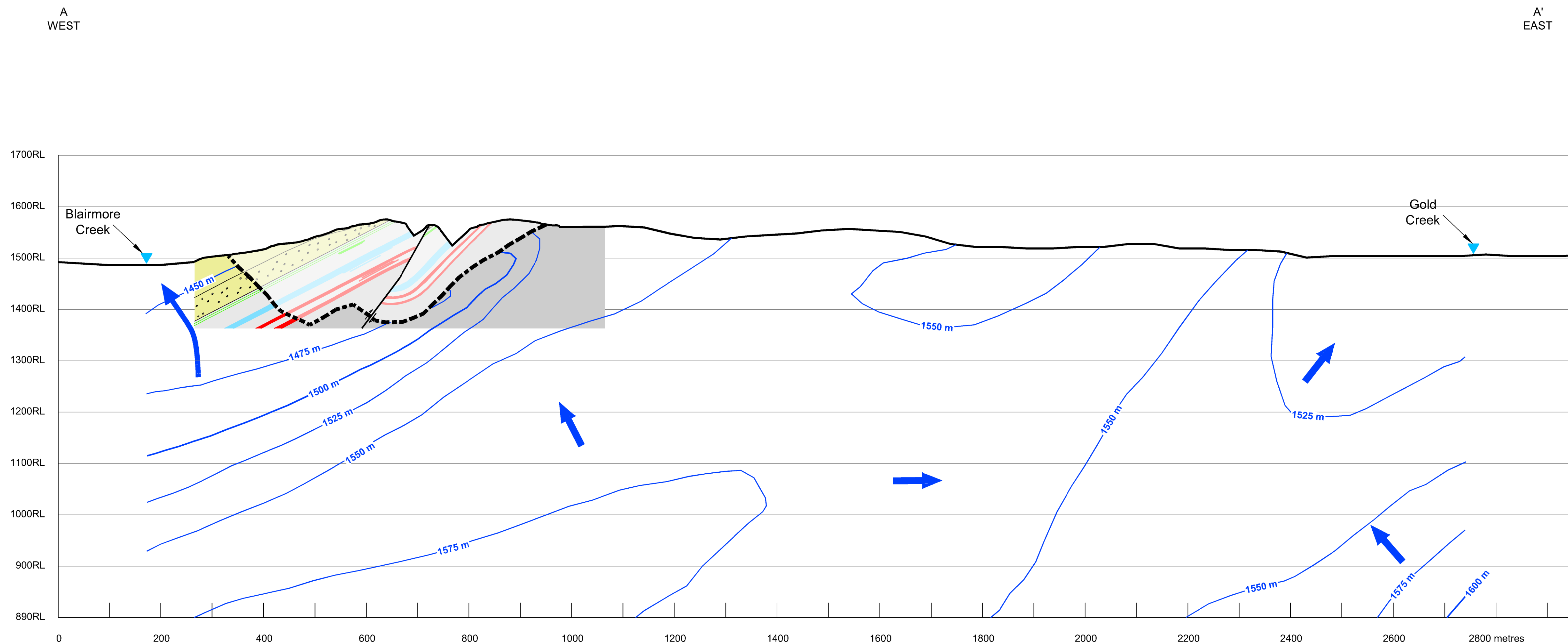
0 1 2 4
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: AcK
DATE: AUGUST 2, 2016

FIGURE

5.3-6

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Resubmission\Fig 5.3-6 - Predicted groundwater Heads for LTC.mxd



LEGEND

Geology

- Topography
- Reverse Fault
- Blairmore Group
- Cadomin Formation
- Kootenay Group
- Seam 1
- Seam 2
- Seam 4
- Fernie Group

Hydrogeology / Hydrology

- 1575m — Potentiometric Contour (Modelled Average Baseline from Numerical Model)
- Flow Direction
- Surface Water (Creek)

Mine

- Approximate Ultimate Pit Depth

* - Well is Projected into the Cross-Section Line

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

HYDROGEOLOGICAL CROSS-SECTION AA' - LTC

NOTES

MEMS, 2016; Riversdale, 2016; srK, 2016.

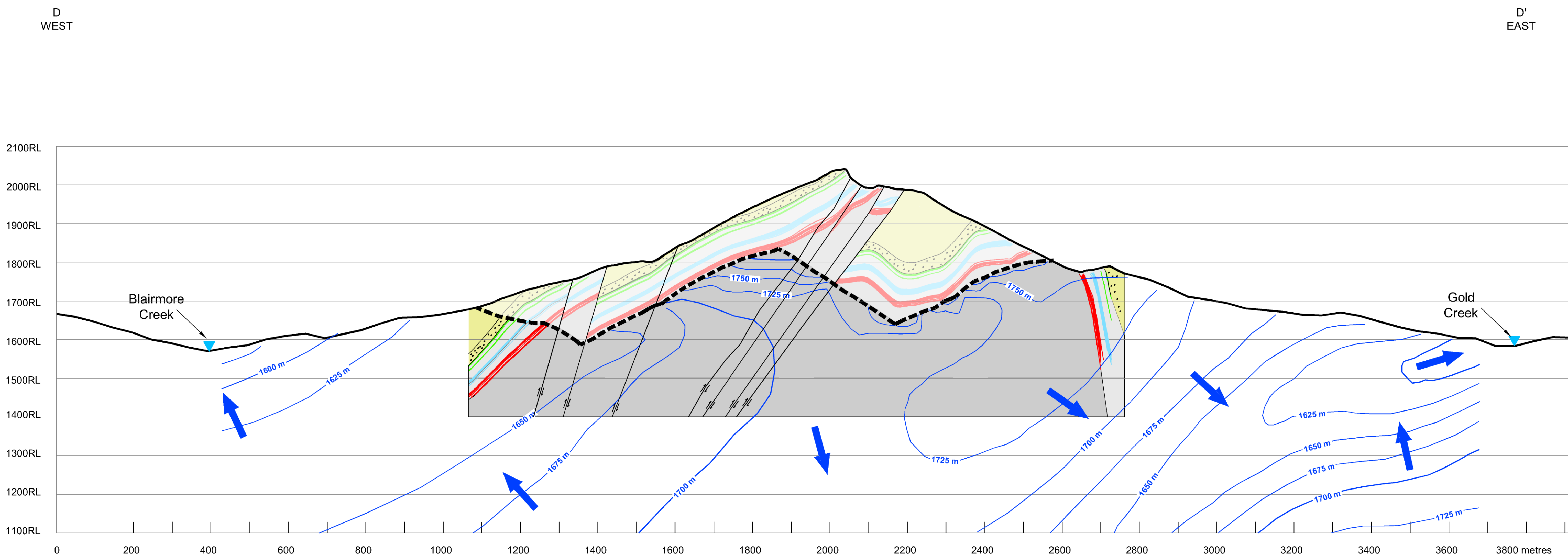
0 100 200 300 400
Metres

PROJECT: 14-00201
DRAWN BY: JDC
CHECKED BY: AcK
DATE: AUGUST 3, 2016

FIGURE

5.3-7

K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Groundwater\Figure 9 - Section AA' 1080.dwg



LEGEND

Geology

- Topography
- Reverse Fault
- Blairmore Group
- Cadomin Formation
- Kootenay Group
- Seam 1
- Seam 2
- Seam 4
- Fernie Group

Mine

- Approximate Ultimate Pit Depth

Hydrogeology / Hydrology

- 1575m — Potentiometric Contour (Modelled Average Baseline from Numerical Model)
- Flow Direction
- Surface Water (Creek)

* - Well is Projected into the Cross-Section Line

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

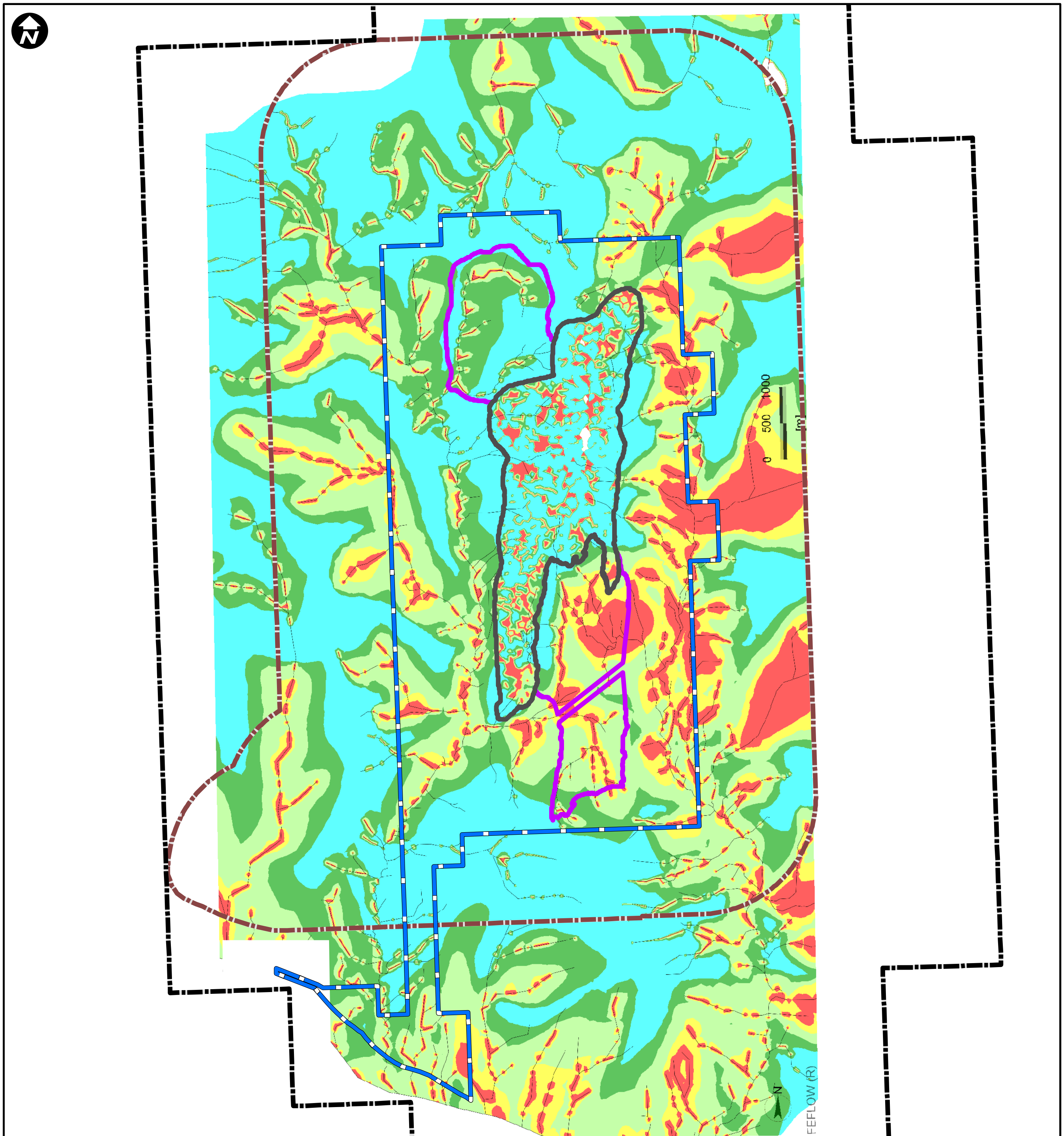
HYDROGEOLOGICAL CROSS-SECTION DD' - LTC

NOTES

MEMS, 2016; Riversdale, 2016; srK, 2016.

0 100 200 400 600
Metres

PROJECT: 14-00201	
DRAWN BY: JDC	
CHECKED BY: AcK	
DATE: AUGUST 3, 2016	
FIGURE	5.3-8



LEGEND

- Proposed Mine Permit Boundary
- Ultimate Pit Extent
- Ultimate Dump Extent
- LSA
- RSA

Mean Life Time Expectancy (Year)

- 10 - 5836.45
- 50 - 100
- 20 - 50
- 10 - 20
- 0 - 10

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED GROUNDWATER TRAVEL TIME TO CREEK DISCHARGE FOR LTC

NOTES

srK, 2016.

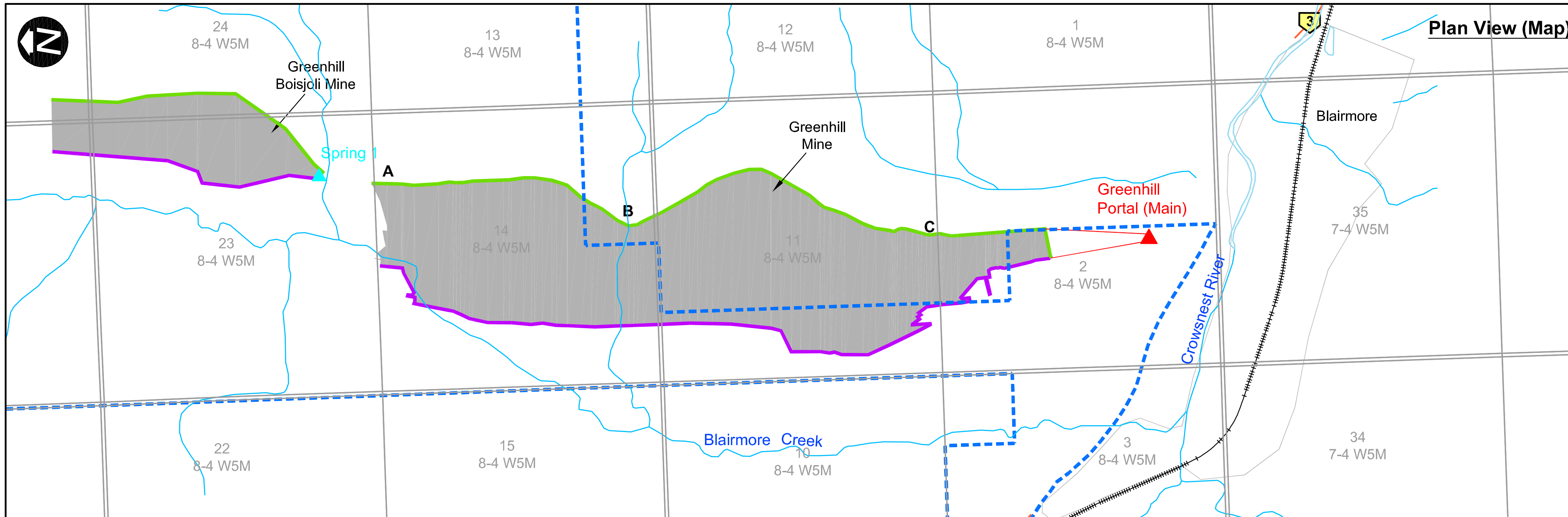
PROJECT: 14-00201-01
DRAWN BY: JDC/JL
CHECKED BY: AcK
DATE: AUGUST 10, 2016

0 1 2 4
Kilometres

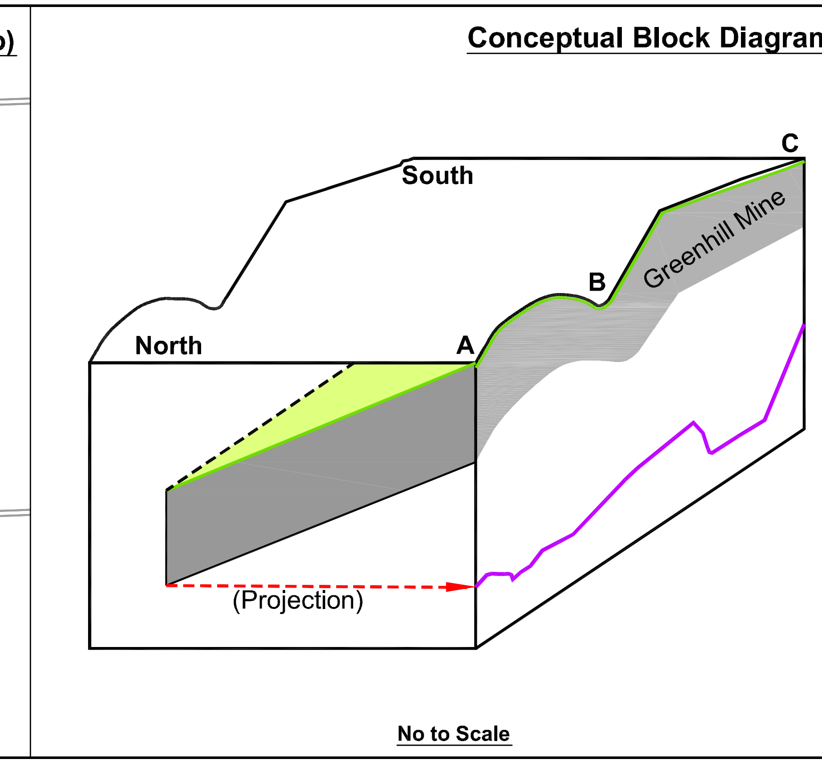
FIGURE

5.3-9

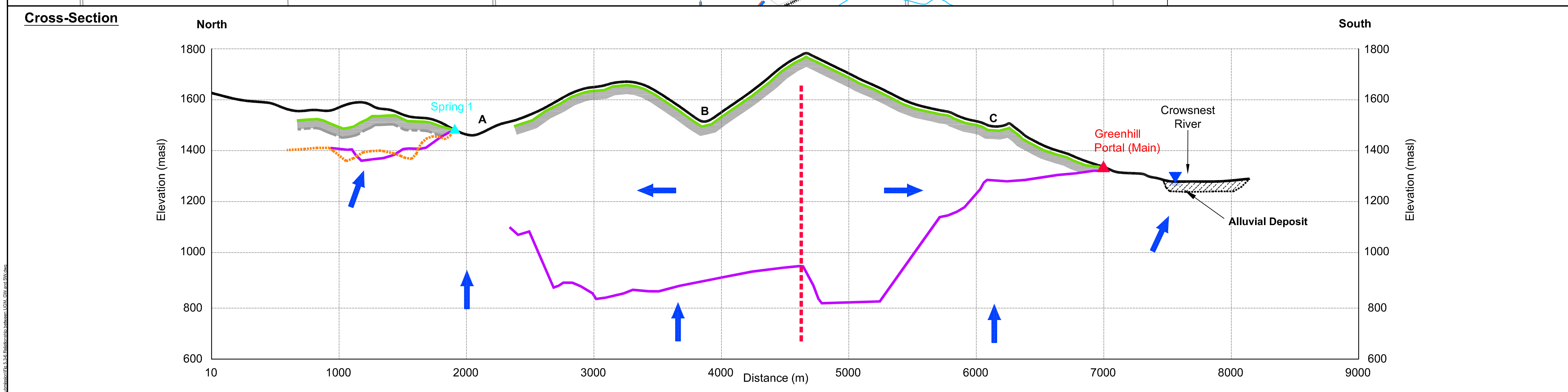
Plan View (Map)



Conceptual Block Diagram



Cross-Section



LEGEND

- ▲ Greenhill Portal (Main)
- ▲ Spring 1 (Greenhill Boisjoli Portal)
- ▼ Crowsnest River
- Watercourse
- Cross Section Alignment
- Top of Underground Mine
- Bottom of Underground Mine
- Bottom of Proposed Pit
- Proposed Mine Permit Boundary
- Groundwater Divide*
- Groundwater Flow Direction*
- Approximate Cumulative Underground Mine Thickness (Seam 1&2)
- * Conceptual Representation of Flow Condition

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

RELATIONSHIP BETWEEN THE UNDERGROUND MINES, GROUNDWATER AND SURFACE WATER

NOTES

MEMS, 2016; Riversdale, 2016; LiDAR, 2015.
Cross Section Vertical Exaggeration: x2

PROJECT: 14-00201-01
DRAWN BY: JDC
CHECKED BY: YL/AcK
DATE: AUGUST 3, 2016

0 0.5 1 2
Kilometres

FIGURE

5.4-1

APPENDIX B: TABLES

Table B1 Concordance Tables, CEAA TOR and AER TOR

Requirements issued by the Canadian Environmental Assessment Agency (CEAA) as per the Guidelines for the Preparation of an Environmental Impact Statement pursuant to the Canadian Environmental Assessment Act, 2012. Prepared for the Grassy Mountain Coal Project. Benga Mining Limited (Riversdale Resources Limited).

6.1.4. Groundwater and Surface Water (CEAA)	MEMS Hydrogeology Assessment
- the characterization of the hydrogeology at the local and regional scales, including:	
✓ the hydrogeological context (e.g., hydrostratigraphy with aquifers and aquitards, major faults, etc.) including the delineation of key stratigraphic and hydrogeologic boundaries;	✓ Sections 4.4, Figures 4.2-1 to 4.2-8 and 4.5-3
✓ the physical properties of the hydrogeological units (e.g., hydraulic conductivity, transmissivity, saturated thickness, storativity, porosity, specific yield);	✓ Section 4.4, Figures 4.4-1 and 4.4-3 , Tables B3a and B3b
✓ the groundwater flow patterns and rates;	✓ Sections 4.4 and 4.6, Figures 4.2-5, 4.2-8 and 4.5-3, Table B5
✓ a discussion of the hydrogeologic, hydrologic, structural, geomorphic, climatic, and anthropogenic controls on groundwater flow;	✓ Sections 4.1, 4.2, 4.3, 4.4, 4.5 and 4.6
✓ temporal changes in groundwater flow (e.g., seasonal and long term changes in water levels);	✓ Sections 4.4 and 4.6, Figure 4.4-2
✓ a delineation and characterization of groundwater surface water interactions, including the locations of groundwater discharge to surface water and surface water recharge to groundwater;	✓ Sections 4.5
- hydrogeological maps and cross-sections for the mine area to outline the extent of aquifers and aquitards, including bedrock fracture and fault zones, locations and depths of wells and strainers, groundwater types springs, surface waters, and project facilities.	– Figures 1.1-2, 3.1-1, 4.2-2, 4.2-3, 4.2-4 to 4.2-8, 4.3-1, 4.3-2, 4.5-1 and 5.1-1
- Groundwater levels, potentiometric contours, flow directions, groundwater divides, and areas of recharge and discharge should be included;	– Figures 4.2-5, 4.2-8 and 4.5-3
- all groundwater monitoring wells, including their location, in respect to the project area, including geologic, hydrostratigraphic, piezometric, and construction data (e.g., depths of surficial and bedrock units, quality, fracture zones, piezometric levels, hydraulic conductivity, diameter and screen depth, and intercepted aquifer unit);	– Figures 3.1-1, 4.2-5 to 4.2-8, Tables B2, B3a, B3b, B4, B6 to B10 and B12
- monitoring protocol for collection of existing groundwater and surface water data;	– Appendix D, items covered in Section 3.1 and Appendix A2 in CR#5 – Water Quality
- a conceptual hydrogeological model that integrates the geological, hydrogeological, and hydrological data to provide the overall conceptual understanding of groundwater flow and chemistry and their controls for the area;	– Section 4.6
- an appropriate numerical hydrogeologic model for the project area, in which quantifies groundwater fluxes, flow path ways, and residence times; the model will be properly calibrated, fully documented and include a sensitivity analysis to test model sensitivity to climatic variations (e.g., recharge) and hydrogeologic parameters (e.g., hydraulic conductivity);	– Appendix C
- graphs or tables indicating the seasonal variations in groundwater levels, flow regime, and quality;	– Figure 4.4-2, Tables B4, B7 to B9
- local and regional potable groundwater supplies, including their current use and potential for future use;	– Section 4.7, Figures 4.7-1 to 4.7-3, Tables B14 and B15
- bedrock fracture sizes and orientations in relation to groundwater flow;	– Sections 4.2 and 4.4, Figure 4.2-2
- the delineation of drainage basins, at appropriate scales (water bodies and watercourses), including intermittent streams, flood risk areas and wetlands, boundaries of the watershed and subwatersheds, overlaid by key project components;	– Items covered in Section 3 in CR#4 – Hydrology, Section 3.2 in CR#5 – Water Quality and Section 3.1 in CR#6 – Aquatic Resources
- hydrological regimes, including monthly, seasonal, and annual water flow (discharge) data;	
- for each affected water body, the total surface area, bathymetry, maximum and mean depths, water level fluctuations, type of substrate (sediments);	
- seasonal water quality field and lab analytical results (e.g., water temperature, turbidity, pH, dissolved oxygen profiles, and contaminants of concern) and interpretation at several representative tributary and water body monitoring stations;	
- any local and regional potable surface water resource;	
- sediment quality analysis for key sites likely to receive mine effluents.	
6.2.2 Changes to Groundwater and Surface Water	**MEMS Hydrogeology Assessment**
- hydrogeological maps and cross-sections for the mine area modified to indicate project facilities and predicted changes in topography, hydrogeology, and groundwater flow;	– Figures 5.1-1 and 5.3-1 to 5.3-9
- changes groundwater flow patterns, fluxes, and divides based on the results of groundwater flow modelling that incorporates changes related to mining;	– Section 5.3, Figures 5.3-2 and 5.3-6
- changes to turbidity, oxygen level, water temperature, ice regime, water quality;	– Items covered in Section 3.0 in CR#6 – Aquatic Resources
- changes to the hydrological and hydrometric conditions including stream base flow conditions;	– Items covered in Section 3.0 CR#4 – Hydrology
- changes to groundwater recharge/discharge areas and groundwater-surface water interactions; and	– Section 5.3
- changes to groundwater and surface water quality attributed to acid or neutral rock drainage and metal leaching associated with the storage of waste rock, coal, tailings, overburden, and potential construction material:	– Items covered in Appendix 10A and CR#5 – Water Quality
✓ short term metal leaching properties;	
✓ longer term rates of acid generation (if any) and metal leaching;	
✓ estimates of the potential for mined materials (including waste rock, reject material, tailings, and coal) to be sources of acid rock drainage or metal leaching;	
✓ estimates of potential time to the onset of acid rock drainage or metal leaching;	
✓ quantity and quality of leachate from samples of reject material, waste rock,	

Table B1 Concordance Tables, CEAA TOR and AER TOR

Requirements issued by the Canadian Environmental Assessment Agency (CEAA) as per the Guidelines for the Preparation of an Environmental Impact Statement pursuant to the Canadian Environmental Assessment Act, 2012. Prepared for the Grassy Mountain Coal Project. Benga Mining Limited (Riversdale Resources Limited).

6.1.4. Groundwater and Surface Water (CEAA)	MEMS Hydrogeology Assessment
tailings, and coal; ✓ quantity and quality of effluent to be released from the site into the receiving waters; ✓ quality of humidity cell or column test liquid from acid rock testing; ✓ sensitivity analysis to assess the effects of imperfect segregation of waste rock; ✓ pit water chemistry during operation and post-closure, and pit closure management measures (e.g., flooding). This will include geochemical modelling of pit water quality in the post-closure period; ✓ surface and seepage water quality from the waste rock dumps, tailings/waste rock impoundment facility, stockpiles, and other infrastructure during operation and post-closure; and ✓ changes in water quality [and sediments] due to contaminants of concern in Elk River and associated tributaries.	

Table B1 (Continued) Concordance Tables, CEAA TOR and AER TOR

Terms of Reference for Environmental Impact Assessment Report issued by the Alberta Energy Regulator (AER) to Benga Mining Limited for the Grassy Mountain Coal Project (about 7 km from Blairmore, Alberta). March 19, 2015.

4.2 Hydrogeology (AER)	MEMS Hydrogeology Assessment
Baseline information	
[A] Provide an overview of the existing geology and hydrogeology from the surface down to, and including, coal zones, and, if applicable, to the base of any deeper strata that would be potentially impacted by mining. Document any new hydrogeological investigations, including methodology and results, undertaken as part of the EIA, and	[A]
a. present regional and project area geology to illustrate depth, thickness and spatial extent of lithology, stratigraphic units and structural features;	a. Section 4.2, Figures 4.2-2, 4.3.2 and 4.2-9
b. present regional and project-area hydrogeology describing	b.
i. the major aquifers, aquitards, and aquicludes (Quaternary and bedrock), their spatial distribution, properties, hydraulic connections between aquifers, hydraulic heads, gradients, groundwater flow directions and velocities. Include maps and cross-sections;	i. Section 4.4, Figures 4.2-1, 4.2-3 to 4.2-8, 4.3-1, 4.3-2, 4.4-1 to 4.4-3, 4.4-7 and 4.5-3, Tables B2, B3a, B3b, B4 and B5
ii. the chemistry of groundwater aquifers, including baseline concentrations of major ions, metals, and hydrocarbons indicators;	ii. Figures 4.4-4 to 4.4-6, 4.5-1 and 4.5-2, Tables B6 to B12
iii. the potential discharge zones, potential recharge zones and sources, areas of groundwater-surface water interaction and areas of Quaternary aquifer-bedrock groundwater interaction;	iii. Sections 4.4 to 4.6, Figures 4.3-1 and 4.5-3
iv. water well development and groundwater use, including an inventory of groundwater users;	iv. Section 4.7, Figures 4.7-1 to 4.7-3, Tables B14 and B15
v. the recharge potential for Quaternary aquifers; and	v. Section 4.5
vi. potential hydraulic connection between coal zones and other aquifers resulting from project operations.	vi. Section 4.5
Impact Assessment	Section 5.0
[A] Describe project components and activities that have the potential to affect groundwater resource quantity and quality at all stages of the project.	[A] Sections 5.1
[B] Describe the nature and significance of the potential project impacts on groundwater with respect to	[B]
a. interrelationship between groundwater and surface water in terms of surface water quantity and quality;	a. Section 5.3, 5.4 and 5.5
b. implications for terrestrial and riparian vegetation, wildlife, and aquatic resources, including wetlands;	b. Items covered under CR#5 – Water Quality
c. changes in groundwater quality and quantity;	c. Sections 5.3, 5.4 and 5.5, Figures 5.3-1 to 5.3-8
d. conflicts with other groundwater users and proposed resolution to these conflicts;	d. Sections 5.3 and 5.4
e. potential implications of seasonal variations; and	e. Section 3.3 and 5.3
f. groundwater withdrawal for project operations, including any expected alterations in the groundwater flow regime during and following operations.	f. Section 5.1 and 5.3, Figures 5.3-1 to 5.3-8
[C] Describe programs to manage and protect groundwater resources, including	[C] Section 7.0
a. the early detection of potential contamination;	
b. groundwater remediation options in the event that adverse effects are detected; and	
c. the monitoring of groundwater production or dewatering impacts.	

Table B2. Groundwater, Springs, Surface Water, Portals and Mines Monitoring and Sampling Locations

Location	Type	Data Source	Easting	Northing	Elevation (masl)	Purpose
MW14-01-64	GW	MEMS	685434	5504891.109	1542.41	Water Level, K and Chemistry
MW14-02-74	GW	MEMS	685588	5504347.037	1583.13	Water Level, K and Chemistry
MW14-03-28	GW	MEMS	685674	5505736.345	1752.44	Water Level, K and Chemistry
MW14-03-90	GW	MEMS	685674	5505739.465	1755.15	Water Level, K and Chemistry
MW14-04-12	GW	MEMS	685809	5507376.615	1856.27	Water Level, K and Chemistry
MW14-04-93	GW	MEMS	685809	5507380.423	1855.86	Water Level, K and Chemistry
MW14-05-114	GW	MEMS	685982	5507539.233	1925.10	Water Level, K and Chemistry
MW14-06-32	GW	MEMS	685864	5506883.554	1928.44	Water Level, K and Chemistry
MW14-06-105	GW	MEMS	685864	5506885.407	1927.03	Water Level, K and Chemistry
MW14-07-48	GW	MEMS	686580	5507292.276	1840.52	Water Level, K and Chemistry
MW14-08-79	GW	MEMS	686844	5509724.695	1847.68	Water Level, K and Chemistry
MW14-09-129	GW	MEMS	686827	5509435.3	1882.73	Water Level, K and Chemistry
MW14-10-22	GW	MEMS	686836	5509301	1926.00	Water Level, K and Chemistry
MW15-11-9	GW	MEMS	684917	5504250	1482.41	Water Level, K and Chemistry
MW15-11-18.5	GW	MEMS	684919	5504250	1482.61	Water Level, K and Chemistry
MW15-12-7	GW	MEMS	684787	5503690	1447.24	Water Level, K and Chemistry
MW15-12-14	GW	MEMS	684790	5503690	1447.07	Water Level, K and Chemistry
MW16-13-11	GW	MEMS/ Terracon	687766	5506182	1573.00	Water Level
MW16-04-03	GW	MEMS/ Terracon	686617	5504451	1564.00	Water Level
RGSC-0004	GW	GOLDER	685490	5506218	1755.00	Packer Test
RGSC-0005	GW	GOLDER	685118	5504574	1508.00	Packer Test and VWP
RGSC-0006	GW	GOLDER	685577	5507161	1826.00	Packer Test and VWP
RGSC-0007	GW	GOLDER	685627	5507655	1912.00	Packer Test
RGSC-0008	GW	GOLDER	686638	5507638	1955.78	Packer Test
RGSC-0009	GW	GOLDER	686742	5509160	1912.39	Packer Test and VWP
RGSC-0010	GW	GOLDER	686807	5510108	1774.33	Packer Test
RGOH-3012	GW	BENGA/ GOLDER	685401	5505479	-	Corehole (Exploration), Water Source Exploration

Table B2. Groundwater, Springs, Surface Water, Portals and Mines Monitoring and Sampling Locations

Location	Type	Data Source	Easting	Northing	Elevation (masl)	Purpose
RGOH-3029	GW	-	-	-	-	Corehole (Exploration), Water Source Exploration
RGOH-3035 (Test Well 1)	GW	GOLDER	-	-	1501.00	Water Source Exploration and VWP
RGOH-3037	GW	GOLDER	-	-	1502.00	Water Source Exploration
RGOH-3039	GW	GOLDER	-	-	1476.14	Water Source Exploration
International Spring	Spring	MEMS	679791	5500683	-	Chemistry, flow rate
Turtle Mountain Sulfur Spring	Spring	MEMS	686707	5497781	-	Chemistry, flow rate
Spring 1 (upstream)	Spring	MEMS	685092	5503772	-	Chemistry, flow rate
Spring 2	Spring	MEMS	685449	5503771	-	Chemistry, flow rate
Spring 3	Spring	MEMS	685423	5503856	-	Chemistry, flow rate
Spring 4	Spring	MEMS	685408	5505435	-	Chemistry, flow rate
Spring 5	Spring	MEMS	685523	5506080	-	Chemistry, flow rate
Blairmore Creek	SW	BENGA	683692	5499327	-	Chemistry
Crowsnest River	SW	BENGA	687648	5496523	-	Chemistry
South Pond	SW	BENGA	685602	5504719	-	Chemistry
		MEMS	685563	5504733	-	Chemistry
Gold Creek	SW	BENGA	688225	5498257	-	Chemistry
East Pond	SW	BENGA	685585	5504847	-	Chemistry
		MEMS	685610	5504848	-	Chemistry
Small South Pond	SW	BENGA	685480	5503984	-	Chemistry
		MEMS	685478	5503975	-	Chemistry
West Pond	SW	MEMS	685537	5504852	-	Chemistry
Pond 6	SW	MEMS	686248	5505991	-	Chemistry
Stream 1	SW	MEMS	686098	5505533	-	Chemistry, flow rate
Stream 2	SW	MEMS	685540	5507994	-	Chemistry, flow rate
Stream 3	SW	MEMS	686440	5505691	-	Chemistry, flow rate

Table B2. Groundwater, Springs, Surface Water, Portals and Mines Monitoring and Sampling Locations

Location	Type	Data Source	Easting	Northing	Elevation (masl)	Purpose
Stream 4	SW	MEMS	685610	5505270	-	Chemistry, fow rate
Stream 5	SW	MEMS	686467	5506816	-	Chemistry, flow rate
Stream 6	SW	MEMS	685531	5507325	-	Chemistry, flow rate
Bellevue Mine	Mine	BENGA	690465	5494963	-	Chemistry
McGillivray Mine	Mine	MEMS	678977	5501333	-	Chemistry, flow rate
Greenhill Portal (Main)	Portal	BENGA	684741	5498981	1324.49	Chemistry, flow rate
		MEMS	684741	5498988		Chemistry
Greenhill Portal (Secondary)	Portal	MEMS	-	-	1324.64	Chemistry
4 m DS from portal	Portal	BENGA	684755	5498960	-	Flow rate
8 m DS from portal	Portal	BENGA	684748	5498962	-	Flow rate
12 m DS from portal	Portal	BENGA	684744	5498966	-	Flow rate
1.2 m DS from confluence	Portal	BENGA	684740	5498953	-	Flow rate
40 m DS from confluence	Portal	BENGA	684719	5498943	-	Flow rate
75 m DS from confluence	Portal	BENGA	684681	5498934	-	Flow rate

Notes:

- : Data is not available

masl: meters above sea level

DS: Downstream

GOLDER: Golder Associates

GW: Groundwater

K: Hydraulic Conductivity

MEMS: Millennium EMS Solutions Ltd.

BENGA: Benga Mining Limited

SW: Surface Water

VWP: Vibrating Wire Piezometer

Table B3a. Monitoring Well Completion and Hydraulic Conductivity Values (MEMS)

Well ID	Easting	Northing	Ground Elevation	Stick up	Well Depth	Top of Completion	Bottom of Completion	K	Lithology
			masl	m	mbgs	mbgs	mbgs	m/s	
MW14-01-64	685434	5504891.1	1542.41	0.94	115.5	62.90	64.40	2.3E-06	Coal Seam 2 (Middle)
MW14-02-74	685588	5504347	1583.13	0.72	99.9	72.30	73.80	9.2E-08	Coal Seam 4 (Deep)
MW14-03-28	685674	5505736.3	1752.44	0.96	28.0	24.52	27.52	-	Coal Seam 1 (Shallow)
MW14-03-90	685674	5505739.5	1755.15	0.90	138.3	88.65	90.15	1.3E-07	Coal Seam 4 (Deep)
MW14-04-12	685809	5507376.6	1856.27	0.90	12.0	9.00	11.50	-*	Coal Seam 1 (Shallow)
MW14-04-93	685809	5507380.4	1855.86	0.89	116.0	90.00	93.00	1.5E-07	Coal Seam 4 (Deep)
MW14-05-114	685982	5507539.2	1925.10	0.92	165.0	110.80	113.80	3.6E-08	Coal Seam 2 (Middle)
MW14-06-32	685864	5506883.6	1928.44	0.96	32.5	30.34	31.84	4.2E-07	Coal Seam 1 (Shallow)
MW14-06-105	685982	5507539.2	1927.03	0.92	152.0	102.02	105.02	4.2E-07	Coal Seam 4 (Deep)
MW14-07-48	686580	5507292.3	1840.52	0.88	66.5	46.55	48.05	1.3E-08	Coal Seam 4 (Deep)
MW14-08-79	686844	5509724.7	1847.68	1.05	145.7	76.87	79.87	<1.0E-10**	Coal Seam 2 (Middle)
MW14-09-129	686827	5509435.3	1882.73	0.89	146.0	127.40	129.00	-	Coal Seam 4 (Deep)
MW14-10-22	686836	5509301	1926.00	0.89	134.0	19.91	21.72	-	Coal Seam 1 (Shallow)
MW15-11-9	684917	5504250	1482.41	0.81	9.18	6.18	9.18	5.2E-07	Mudstone
MW15-11-18.5	684919	5504250	1482.61	0.92	18.48	15.48	18.48	5.2E-06	Mudstone
MW15-12-7	684787	5503690	1447.24	1.04	6.79	3.79	6.79	5.1E-06	Surficial deposits
MW15-12-14	684790	5503690	1447.07	0.98	13.72	10.72	13.72	2.6E-06	Mudstone
MW16-13-11	687766	5506181.9	1573.00	~1.00	10.67	7.31	10.31	-	Surficial deposits/ Sandstone
MW16-14-03	686617	5504450.6	1564.00	~1.00	6.10	1.52	3.00	-	Surficial deposits

Notes:

* not enough water to conduct a slug test

** very slow recovery, well likely completed in claystone/ mudstone instead of coal

m: meters

masl: meters above sea level

mbgs: meters below ground surface

m/s: meters per second

Monitoring wells are numbered so that the first number represents the year drilled, the second number the well location ID and the last number the total well depth. As an example, MW14-01-64 was drilled in 2014, at the first well location, and completed to a maximum depth of 64 metres (m).

Table B3b. Packer Tests and Hydraulic Conductivity Values (GOLDER)

Borehole name	Easting	Northing	Ground Elevation	VWP Installation	WL Prior to Grouting	Packer Test #	Test Depth From	Test Depth To	Total Test Length	Lithology	Avergae Injection Rate	Max. Inj. Pressure	Transmissivity	Hydraulic Conductivity
			masl		masl		masl	masl	m		L/min	psi	m^2/s	m/s
RGOH3012	685401	5505479	-	N	-	Pumping test			~100 m	Coal Seams 1, 2 & 4 and IB	155.6*	NA	4E-05**	4E-07
RGSC-0004	685490	5506218	1755.00	N	-	1	93.74	164.09	70.35	Coal Seams 2 & 4 (34m) and	114.5	5.5	4E-04	5E-06
						2	47.91	164.09	116.18	Coal Seams 1 & 2 & 4 (55m) and IB	110.5	6.5	2E-05	1E-07
RGSC-0005	685118	5504574	1508.00	Y	1507.1	1	57.42	92.00	34.58	Coal Seam 1 (25m) and Interburden	10.0	17	8E-06	2E-07
						2	95.38	140.01	44.63	Coal Seam 1 (7m) and IB	0.9	46	3E-07	6E-09
RGSC-0006	685577	5507161	1826.00	Y	1810.6	1	59.05	91.31	32.26	Coal Seam 1 (21m) and IB	40.1	40	4E-06	1E-07
						2	92.60	145.96	53.36	Coal Seam 1 (53m) and IB	32.6	9	9E-06	2E-07
RGSC-0007	685627	5507655	1912.00	N	-	1	46.60	78.80	32.20	IB	15.4	46	2E-06	7E-08
						2	77.10	124.65	47.55	IB	11.7	46	8E-06	2E-07
						3	125.90	176.70	50.80	Coal Seam 1 (11m) and IB	1.5	46	3E-07	5E-09
RGSC-0008	686638	5507638	1955.78	N	-	1	18.63	93.55	74.92	Coal Seams 2 & 4 (27m) and IB	39.4	30	1E-05	1E-07
RGSC-0009	686742	5509160	1912.39	Y	1798.79	1	54.50	99.06	44.56	IB	81.0	16	2E-06	4E-08
						2	99.01	149.34	50.33	Coal Seam 1 (30m) and IB	67.8	30	3E-06	6E-08
RGSC-0010	686807	5510108	1774.33	N	-	1	36.80	72.30	35.50	Coal Seam 1 (16m) and IB	32.8	8	1E-04	3E-06
						2	76.43	151.57	75.14	Coal Seams 2 & 4 and IB	30.1	12	5E-05	7E-07

Notes:

* Pumping rate (not injection rate). Rate was initially at 144 m^3/d then increased to 224 m^3/d

** Transmissivity from pumping test. Storativity assumed at 1×10^{-4}

IB: Interburden

m: meters; masl: meters above sea level; m^2/s: meter square per second; m/s: meters per second; L/min: liters per minute; psi: pound per square inch (pressure unit).

VWP: Vibrating Wire Piezometer. Completion details available in Golder 2014.

Y: Yes; N: No

Table B4. Groundwater Elevations (masl)

Well ID	Data Source	Ground Elevation	Stick up	Lithology	Date	Water Levels		
		masl	m		mm/dd/yyyy	mbtoc	mbgs	masl
MW14-01-64	MEMS	1542.41	0.94	Coal Seam 2 (Middle)	2/2/2014	35.86	34.92	1507.49
	MEMS				10/16/2014	36.67	35.73	1506.68
	MEMS				4/17/2015	36.19	35.25	1507.16
	MEMS				3/21/2016	37.47	36.53	1505.88
MW14-02-74	MEMS	1583.13	0.72	Coal Seam 4 (Deep)	2/3/2014	72.87	72.15	1510.98
	MEMS				10/16/2014	72.54	71.82	1511.31
	MEMS				4/17/2015	72.22	71.50	1511.63
	MEMS				3/21/2016	72.40	71.68	1511.45
MW14-03-28	MEMS	1752.44	0.96	Coal Seam 1 (Shallow)	10/16/2014	DRY		
	MEMS				4/17/2015	DRY		
	MEMS				3/22/2016	DRY		
MW14-03-90	MEMS	1755.15	0.90	Coal Seam 4 (Deep)	2/1/2014	54.08	53.18	1701.97
	MEMS				10/16/2014	53.83	52.93	1702.22
	MEMS				4/17/2015	53.72	52.82	1702.33
	MEMS				3/22/2016	54.60	53.70	1701.45
MW14-04-12	MEMS	1856.27	0.90	Coal Seam 1 (Shallow)	10/15/2014	12.34	11.44	1844.84
	MEMS				4/17/2015	12.34	11.44	1844.83
	MEMS				3/24/2016	DAMAGED		
MW14-04-93	MEMS	1855.86	0.89	Coal Seam 4 (Deep)	10/14/2014	18.09	17.20	1838.66
	MEMS				4/17/2015	18.17	17.28	1838.58
	MEMS				3/24/2016	DAMAGED		
MW14-05-114	MEMS	1925.10	0.92	Coal Seam 2 (Middle)	10/14/2014	4.07	3.15	1921.95
	MEMS				4/17/2015	5.77	4.85	1920.25
	MEMS				3/24/2016	9.79	8.87	1916.23

Table B4. Groundwater Elevations (masl)

Well ID	Data Source	Ground Elevation	Stick up	Lithology	Date	Water Levels		
		masl	m		mm/dd/yyyy	mbtoc	mbgs	masl
MW14-06-32	MEMS	1928.44	0.96	Coal Seam 1 (Shallow)	9/28/2014	26.10	25.14	1903.30
	MEMS				4/17/2015	26.51	25.55	1902.89
	MEMS				3/23/2016	27.72	26.76	1901.68
MW14-06-105	MEMS	1927.03	0.92	Coal Seam 4 (Deep)	10/14/2014	18.74	17.82	1909.21
	MEMS				4/17/2015	21.31	20.39	1906.64
	MEMS				3/23/2016	22.60	21.68	1905.35
MW14-07-48	MEMS	1840.52	0.88	Coal Seam 4 (Deep)	10/15/2014	17.55	16.67	1823.85
	MEMS				3/22/2016	15.23	14.35	1826.17
MW14-08-79	MEMS	1847.68	1.05	Coal Seam 2 (Middle)	10/15/2014	51.44	50.39	1797.29
	MEMS				4/17/2015	59.01	57.96	1789.72
	MEMS				3/23/2016	58.39	57.34	1790.34
MW14-09-129	MEMS	1882.73	0.89	Coal Seam 4 (Deep)	10/15/2014	112.38	111.49	1771.24
	MEMS				3/23/2016	DAMAGED		
MW14-10-22	MEMS	1926.00	0.89	Coal Seam 1 (Shallow)	10/16/2014	DRY		
	MEMS				3/23/2016	DRY		
MW15-11-9	MEMS	1482.41	0.81	Mudstone	4/17/2015	9.22	8.41	1474.00
	MEMS				3/23/2016	9.08	8.27	1474.14
MW15-11-18.5	MEMS	1482.61	0.92	Mudstone	4/17/2015	6.26	5.34	1477.27
	MEMS				3/23/2016	5.91	4.99	1477.62
MW15-12-7	MEMS	1447.24	1.04	Surficial deposits	4/17/2015	5.94	4.90	1442.34
	MEMS				3/23/2016	4.53	3.49	1443.75
MW15-12-14	MEMS	1447.07	0.98	Mudstone	4/17/2015	3.98	3.00	1444.07
	MEMS				3/21/2016	3.70	2.72	1444.35
RGSC-0004	GOLDER	1755.00	-	Coal Seams 1 & 2 & 4 and IB	-	-	-	-
RGSC-0005	GOLDER	1508.00	-	Coal Seam 1 and IB	8/25/2014	-	0.90	1507.10

Table B4. Groundwater Elevations (masl)

Well ID	Data Source	Ground Elevation	Stick up	Lithology	Date	Water Levels		
		masl	m		mm/dd/yyyy	mbtoc	mbgs	masl
RGSC-0006	GOLDER	1826.00	-	Coal Seam 1 and IB	8/30/2015	-	15.40	1810.60
RGSC-0007	GOLDER	1912.00	-	Coal Seam 1 and IB	-	-	-	-
RGSC-0008	GOLDER	1955.78	-	Coal Seams 2 & 4 and IB	-	-	-	-
RGSC-0009	GOLDER	1912.39	-	Coal Seam 1 and IB	9/16/2014	-	113.60	1798.79
RGSC-0010	GOLDER	1774.33	-	Coal Seams 1 & 2 & 4 and IB	-	-	-	-
RGOH-3012	GOLDER	1600.00	-	Coal Seams 1 & 2 & 4 and IB	-	Artesian Flowing		
RGOH-3029	BENGA	-	-	Coal Seams 1 & 2 & 4 and IB	-	Artesian Flowing		

Notes:

-: Data is Unavailable

BENGA: Benga Mining Limited

GOLDER: Golder Associates

IB: Interburden

m: meters

masl: meters above sea level

mbgs: meters below ground surface

mbtoc: meters below top of casing

MEMS: Millennium EMS Solutions Ltd.

Table B5. Flow Rate Measurements

Location	Data Source	Date	Flow Rate - "Visual Estimate"	Flow Rate - "Bucket Test"	Flow Rate - Weir[1]
			L/s	L/s	L/s
Greenhill Portal (Main)	MEMS	10/1/2013	6.3 - 12.6	-	-
	BENGA	4/22/2014	-	5.0	11.0
	BENGA	5/8/2014	-	9.8	14.4
	BENGA	5/21/2014	-	12.0	17.4
	BENGA	5/28/2014	-	13.0	19.3
	BENGA	6/20/2014	-	20.0	20.0
	BENGA	7/10/2014	-	-	18.1
	BENGA	7/16/2014	-	-	15.8
	BENGA	7/22/2014	-	-	14.0
	BENGA	8/4/2014	-	-	10.2
	BENGA	8/18/2014	-	-	8.9
	BENGA	9/12/2014	-	-	6.5
	BENGA	9/29/2014	-	6.0	5.7
	BENGA	10/10/2014	-	5.7	5.3
	BENGA	10/29/2014	-	4.9	4.4
	BENGA	11/15/2014	-	4.7	4.2
	BENGA	12/15/2014	-	4.3	3.9
	BENGA	1/8/2015	-	3.9	3.7
	BENGA	1/21/2015	-	3.7	3.3
	BENGA	2/3/2015	-	3.8	3.3
	BENGA	2/20/2015	-	3.9	3.4
	BENGA	3/6/2015	-	3.8	3.4
Greenhill Portal (Secondary)	MEMS	10/1/2013	0.13	-	-
Spring 1 (Upstream)	MEMS	10/1/2013	1.9	-	-
Spring 2	MEMS	10/1/2013	-	-	-
Spring 3	MEMS	10/1/2013	0.06	-	-
Spring 4	MEMS	10/1/2013	0.06	-	-
Spring 5	MEMS	10/1/2013	0.6	-	-
Stream 1	MEMS	10/1/2013	-	-	-
Stream 2	MEMS	10/1/2013	6.3	-	-
Stream 3	MEMS	10/1/2013	-	-	-
Stream 4	MEMS	10/1/2013	0.63	-	-
Stream 5	MEMS	10/1/2013	0.6 - 1.2	-	-
Stream 6	MEMS	10/1/2013	0.6 - 1.2	-	-

Notes:

[1]: Water Levels are Monitored at a Weir Using a Level Troll 200 (In-Situ)

BENGA: Benga Mining Limited

L/s: liters per second

MEMS: Millennium EMS Solutions Ltd.

Table B6. Field Measured Parameters.

Location	Type	Data Source	Date	Monitoring Device	Electrical Conductivity	pH	Total Dissolved Solids	Temperature	Dissolved Oxygen
			mm/dd/yyyy		mS/cm	---	mg/L	°C	mg/L
MW14-01-64	GW	MEMS	2/2/2014	Hanna pH/EC/TDS	3.57	7.44	1650	4.1	-
		MEMS	10/16/2014	Hanna pH/EC/TDS	0.70	5.1	340	6.8	-
		MEMS	3/21/2016	YSI	0.6384	6.83	415.35	8.7	2.72
MW14-02-74	GW	MEMS	2/4/2014	Hanna pH/EC/TDS	4.06	8.52	2040	0.9	-
		MEMS	10/17/2014	Hanna pH/EC/TDS	0.33	-	150	8.4	-
		MEMS	3/21/2016	YSI	0.394	6.19	256.11	4.8	3.2
MW14-03-90	GW	MEMS	2/4/2014	Hanna pH/EC/TDS	3.18	12.21	1640	2.6	-
		MEMS	10/17/2014	Hanna pH/EC/TDS	0.22	-	120	3.9	-
		MEMS	3/22/2016	YSI	0.1818	10.09	118.3	5.2	5.75
MW14-04-93	GW	MEMS	10/16/2014	Hanna pH/EC/TDS	0.47	7.38	160	2.4	-
MW14-05-114	GW	MEMS	10/17/2014	Hanna pH/EC/TDS	0.67	-	330	3.5	-
		MEMS	3/24/2016	YSI	0.3135	11.56	204.75	3.7	6.8
MW14-06-32	GW	MEMS	3/23/2016	YSI	0.2544	6.74	165.75	3.3	3.24
MW14-06-105	GW	MEMS	10/16/2014	Hanna pH/EC/TDS	0.25	7.12	260	3.7	-
		MEMS	3/23/2016	YSI	0.3672	6.85	238.55	3.1	5.53
MW14-07-48	GW	MEMS	10/17/2014	Hanna pH/EC/TDS	0.30	-	200	5.6	-
		MEMS	3/22/2016	YSI	2.4271	11.14	1586.5	4.8	6.54
MW14-08-79	GW	MEMS	10/17/2014	Hanna pH/EC/TDS	2.25	-	1120	6.1	-
		MEMS	3/23/2016	YSI	15.445	13.04	10,062	3	7.6
MW15-11-9	GW	MEMS	3/23/2016	YSI	0.6692	8.56	435.5	4.5	9.28
MW15-11-18.5	GW	MEMS	3/23/2016	YSI	0.6544	6.3	425.1	5	2.08
MW15-12-7	GW	MEMS	3/21/2016	YSI	0.5667	7.13	358.55	5.8	11.71
MW15-12-14	GW	MEMS	3/21/2016	YSI	0.5605	7.06	364.65	5.8	6.69
East Pond	SW	BENGA	4/7/2014	YSI	NA	8.24	336	1.1	10.31
		BENGA	4/22/2014	YSI	0.09	7.15	110	1.8	10.31
		BENGA	5/8/2014	YSI	0.04	8.44	47	2.1	7.01
		BENGA	5/13/2014	YSI	0.25	**4.7**	255	6.1	12
		BENGA	5/21/2014	YSI	0.28	7.88	250	11.4	10.71
		BENGA	6/3/2014	YSI	0.34	7.34	285	13.5	9.36
		BENGA	6/18/2014	YSI	0.33	7.72	274	13.5	9.28
		BENGA	7/9/2014	YSI	0.43	8.61	317	19.2	7.2
		BENGA	7/21/2014	YSI	0.43	8.32	318	18.4	8.88
		BENGA	8/14/2014	YSI	0.40	7.42	293	18.9	7.77
East Pond	SW	BENGA	8/24/2014	YSI	0.38	7.19	291	16.5	8.82
		BENGA	9/20/2014	YSI	0.37	8.26	316	12.9	12.41
		BENGA	9/22/2014	YSI	0.39	8.31	329	12.9	13.63
South Pond	SW	BENGA	4/7/2014	YSI	NA	7.81	291	2.7	6.31
		BENGA	4/22/2014	YSI	0.06	8.15	70	1.4	11.2
		BENGA	5/8/2014	YSI	0.16	**3.95**	182	3.2	6.22
		BENGA	5/13/2014	YSI	0.23	**6.04**	240	5.72	8.02

Table B6. Field Measured Parameters.

Location	Type	Data Source	Date	Monitoring Device	Electrical Conductivity	pH	Total Dissolved Solids	Temperature	Dissolved Oxygen
			mm/dd/yyyy		mS/cm	---	mg/L	°C	mg/L
South Pond	SW	BENGA	5/21/2014	YSI	0.24	9.94	223	9.36	9.61
		BENGA	6/3/2014	YSI	0.30	7.24	255	12.38	9.11
		BENGA	6/18/2014	YSI	0.28	7.69	241	12.44	9.18
		BENGA	7/9/2014	YSI	0.38	8.4	282	18.34	7.7
		BENGA	7/21/2014	YSI	0.38	8.03	286	17.6	8.55
		BENGA	8/14/2014	YSI	0.35	7.53	259	18.43	8.05
		BENGA	8/24/2014	YSI	0.33	7.29	257	15.9	8.9
		BENGA	9/20/2014	YSI	0.33	8.25	282	12.49	11.43
		BENGA	9/22/2014	YSI	0.34	8.2	293	11.98	12.96
Small South Pond	SW	BENGA	4/7/2014	YSI	NA	7.42	295	0.51	4.65
		BENGA	4/22/2014	YSI	0.05	7.87	60	1.88	9.49
		BENGA	5/8/2014	YSI	0.26	**4.18**	269	5.71	10.49
		BENGA	5/13/2014	YSI	0.28	**6.5**	268	7.84	10.87
		BENGA	5/21/2014	YSI	0.27	10.05	232	11.96	9.63
Small South Pond	SW	BENGA	6/3/2014	YSI	0.31	7.34	259	13.61	8.62
		BENGA	6/18/2014	YSI	0.30	7.49	252	12.8	7.94
		BENGA	7/9/2014	YSI	0.38	8.4	285	18.45	7.11
		BENGA	7/21/2014	YSI	0.39	7.84	295	17.03	8.34
		BENGA	8/14/2014	YSI	0.38	7.37	283	18.88	7.52
		BENGA	8/24/2014	YSI	0.35	7.15	280	14.99	8.7
		BENGA	9/20/2014	YSI	0.37	8.15	314	12.75	12.21
		BENGA	9/22/2014	YSI	0.38	8.17	324	12.9	12.4
Blairmore Creek	SW	BENGA	4/7/2014	YSI	NA	8.38	239	1.11	16.09
		BENGA	4/22/2014	YSI	0.17	8.11	200	1.42	14.29
		BENGA	5/8/2014	YSI	0.17	**4.41**	175	4.88	13.44
		BENGA	5/13/2014	YSI	0.13	**5.78**	155	1.5	15.17
		BENGA	5/21/2014	YSI	0.01	10.01	98	5.1	13.36
		BENGA	6/3/2014	YSI	0.13	**6.66**	129	5.9	12.64
Blairmore Creek	SW	BENGA	6/18/2014	YSI	0.09	**6.75**	92	6.0	12.43
		BENGA	7/9/2014	YSI	0.28	7.9	245	11.4	10.7
		BENGA	7/21/2014	YSI	0.29	8.25	250	12.1	12.03
		BENGA	8/14/2014	YSI	0.27	7.31	229	13.3	10.82
		BENGA	8/24/2014	YSI	0.25	7.14	250	12.5	11.83
		BENGA	9/20/2014	YSI	0.24	8.3	217	10.7	14.71
		BENGA	9/22/2014	YSI	0.24	8.24	228	8.2	18.72

Table B6. Field Measured Parameters.

Location	Type	Data Source	Date	Monitoring Device	Electrical Conductivity	pH	Total Dissolved Solids	Temperature	Dissolved Oxygen
			mm/dd/yyyy		mS/cm	---	mg/L	°C	mg/L
Crowsnest River	SW	BENGA	4/7/2014	YSI	NA	8.2	280	6.6	9.61
		BENGA	4/22/2014	YSI	0.19	8.63	209	4.0	13.39
		BENGA	5/8/2014	YSI	0.24	**5.2**	233	7.9	12.57
		BENGA	5/13/2014	YSI	0.20	**5.45**	208	4.6	13.96
		BENGA	5/21/2014	YSI	0.15	9.82	159	5.4	12.88
		BENGA	6/3/2014	YSI	0.18	**6.36**	173	7.1	12.07
		BENGA	6/18/2014	YSI	0.16	7.13	160	6.0	10.98
		BENGA	7/9/2014	YSI	0.29	**6.17**	247	12.3	10.42
		BENGA	7/21/2014	YSI	0.28	8.14	235	12.7	11.66
		BENGA	8/14/2014	YSI	0.27	7.38	228	12.6	10.7
		BENGA	8/24/2014	YSI	0.26	7.54	228	10.9	11.25
		BENGA	9/20/2014	YSI	0.27	8.32	235	11.2	14.95
		BENGA	9/22/2014	YSI	0.26	8.31	245	9.0	17.92
Gold Creek	SW	BENGA	4/7/2014	YSI	NA	8.35	203	4.4	11.28
		BENGA	4/22/2014	YSI	0.19	8.75	207	3.4	13.63
		BENGA	5/8/2014	YSI	0.22	**4.31**	219	6.4	12.89
		BENGA	5/13/2014	YSI	0.19	**5.73**	208	3.2	14.39
		BENGA	5/21/2014	YSI	0.14	10.14	151	4.8	13.75
		BENGA	6/3/2014	YSI	0.15	**6.64**	157	6.0	12.9
		BENGA	6/18/2014	YSI	0.13	**6.99**	134	5.2	12.91
		BENGA	7/9/2014	YSI	0.25	**6.55**	240	8.5	11.87
Gold Creek	SW	BENGA	7/21/2014	YSI	0.23	8.33	218	8.9	13.65
		BENGA	8/14/2014	YSI	0.20	7.39	195	8.1	12.74
		BENGA	8/24/2014	YSI	0.20	7.39	199	7.1	13.37
		BENGA	9/20/2014	YSI	0.21	8.28	206	7.9	18.34
		BENGA	9/22/2014	YSI	0.21	8.3	212	6.0	20.32
Greenhill Portal (Main)	Portal	BENGA	4/7/2014	YSI	NA	7.77	1097	8.8	8.38
		BENGA	4/22/2014	YSI	1.09	7.38	1002	9.2	8.59
		BENGA	5/8/2014	YSI	1.15	**3.66**	1059	9.8	8.67
		BENGA	5/13/2014	YSI	1.11	**5.57**	1011	9.9	8.93
		BENGA	5/21/2014	YSI	1.04	10.84	927	10.5	8.04
		BENGA	6/3/2014	YSI	0.96	**6.91**	862	6.8	8.17
		BENGA	6/18/2014	YSI	1.14	**6.96**	1016	10.7	8.19
		BENGA	7/9/2014	YSI	1.32	7.32	1173	10.8	6.92
		BENGA	7/21/2014	YSI	1.17	7.63	1040	10.9	7.98
		BENGA	8/14/2014	YSI	1.15	7.08	1032	10.7	6.99
		BENGA	8/24/2014	YSI	1.22	6.8	1097	10.6	7.45
		BENGA	9/20/2014	YSI	1.29	7.93	1164	10.5	9.82
		BENGA	9/22/2014	YSI	1.32	7.84	1192	10.4	11.71

Table B6. Field Measured Parameters.

Location	Type	Data Source	Date	Monitoring Device	Electrical Conductivity	pH	Total Dissolved Solids	Temperature	Dissolved Oxygen
			mm/dd/yyyy		mS/cm	---	mg/L	°C	mg/L
Bellevue Mine	Mine	BENGA	4/7/2014	YSI	NA	7.71	434	5.9	10.24
		BENGA	4/22/2014	YSI	0.55	**5.49**	541	7.3	12.28
		BENGA	5/8/2014	YSI	0.53	10.41	517	7.5	11.97
		BENGA	5/13/2014	YSI	0.57	**5.64**	557	7.3	12.28
		BENGA	5/21/2014	YSI	0.53	8	522	7.2	11.85
		BENGA	6/3/2014	YSI	0.49	**6.34**	478	7.5	11.71
		BENGA	6/18/2014	YSI	0.43	7.06	415	7.8	11.47
		BENGA	7/9/2014	YSI	0.63	**6.56**	608	7.9	11.51
		BENGA	7/21/2014	YSI	0.52	7.81	501	7.8	13.48
		BENGA	8/14/2014	YSI	0.49	7.27	475	7.9	12.61
		BENGA	8/24/2014	YSI	0.48	7.01	477	7.7	13.4
		BENGA	9/20/2014	YSI	0.51	8.29	496	7.8	17.67
		BENGA	9/22/2014	YSI	0.53	7.42	511	7.8	17.85

Notes:

4.7 pH Artificially Low (low pH solution used for calibration)

BENGA: Benga Mining Limited
°C: Degree Celcius
GW: Groundwater
MEMS: Millennium EMS Solutions
mg/L: milligram per Liter
mS/cm: milliSiemens per centimeter
SW: Surface Water
uS/cm^3: micro Siemens per cubic centimeter

Table B7. Routine Chemistry Results

Location	Type	Data Source	Date	Laboratory	Sample Type	Inorganics																General Chemistry					
						Alkalinity (T) as $CaCO_3$	Bicarbonate	Calcium	Carbonate	Chloride	Fluoride	Hydroxide	Magnesium	Nitrate (as N)	Nitrate + Nitrite-N	Nitrite (as N)	Potassium	Silica as SiO2	Silica as SiO_2 (Filtered)	Sodium	Sulphate	EC (lab)	Ionic Balance	pH (Lab)	Hardness as $CaCO_3$	Total Dissolved Solids	Total organic carbon
			mm/dd/yyyy			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mS/cm	%	pH	mg/L	mg/L	mg/L
CDW (Canadian Drinking Water **MAC** and AO)						-	-	-	-	250	1.5	-	-	**10**	-	**1**	-	-	-	200	500	-	90-110**	6.5-8.5	-	500	-
FWAL (ESRD Aquatic Life 2014)						>20	-	-	-	120	-	-	-	3	-	0.06-0.6*	-	-	-	-	309-429*	-	90-110**	6.5-9	-	-	-
MW14-01-64	GW	MEMS	2/2/2014	ALS	N	361	440	69.8	<5	6.85	-	<5	35.7	<0.05	<0.071	<0.05	4.31	-	-	40.5	24.7	0.7	105	7.8	321	398	-
		MEMS	10/16/2014	ALS	N	384	443	60.4	12.8	0.43	-	<5	19	<0.05	<0.054	<0.02	1.39	6.71	5.6	25.3	<0.5	0.602	74.2	8.45	229	337	-
		MEMS	3/21/2016	ALS	N	397	484	64.9	<5	<0.5	0.428	<5	20.1	<0.02	<0.05	<0.01	1.44	6.88	6.88	66.1	<0.3	0.616	98.1	7.1	245	391	-
MW14-02-74	GW	MEMS	2/4/2014	ALS	N	155	189	46	<5	0.99	-	<5	13	<0.05	<0.071	<0.05	3.78	-	-	2.8	14.5	0.314	105	8.24	168	174	-
		MEMS	10/17/2014	ALS	N	151	185	35.2	<5	0.43	-	<5	9.85	<0.05	<0.054	<0.02	1.34	15.5	11.2	1.2	5.88	0.261	83.8	8.19	128	145	-
		MEMS	3/23/2016	ALS	N	130	159	34.1	<5	<0.5	0.105	<5	10.2	<0.02	<0.05	<0.01	1.25	67	67	1.4	6.66	0.228	95.8	6.4	127	132	-
MW14-03-90	GW	MEMS	2/4/2014	ALS	N	343	<5	99.1	33.1	11.8	-	97.7	0.38	<0.05	<0.071	<0.05	10.8	-	-	28.4	119	1.54	67.2	11.66	249	475	-
		MEMS	10/17/2014	ALS	N	46.5	42.6	15.5	6.9	0.81	-	<5	3.33	<0.05	<0.054	<0.02	5.28	7.87	7.53	9.9	15	0.124	128	9.21	52.4	77.7	-
		MEMS	3/24/2016	ALS	N	88.3	67.1	14.5	20	0.62	0.196	<5	9.85	<0.02	<0.05	<0.01	4.51	11	11	7.3	11.5	0.166	96.7	9.04	76.8	101	-
MW14-04-93	GW	MEMS	10/16/2014	ALS	N	172	202	33.9	<5	1.22	-	<5	17.7	<0.05	<0.054	<0.02	2.75	11.5	12.8	8	22	0.322	93.8	8.43	158	189	-
MW14-05-114	GW	MEMS	10/17/2014	ALS	N	268	<5	118	22.4	1.08	-	78.5	<0.1	<0.05	<0.054	<0.02	7.73	10.7	10	14.6	34.4	1.11	110	11.82	295	337	-
		MEMS	10/17/2014	ALS	FD	252	<5	111	20.2	0.9	-	74.2	<0.1	<0.05	<0.054	<0.02	8.05	-	-	15.2	33.9	1.05	111	11.79	277	320	-
		MEMS	3/24/2016	ALS	N	88.3	<5	35.3	14	<0.5	0.202	22.1	0.12	<0.02	<0.05	<0.01	2.7	15.8	20.8	6.4	24.3	0.333	92.8	11.21	88.6	122	-
MW14-06-32	GW	MEMS	3/24/2016	ALS	N	93.3	114	24.8	<5	<0.5	0.596	<5	13.3	0.081	0.118	0.036	1.43	8.71	4.38	<1	17.7	0.202	104	7.34	117	114	-
MW14-06-105	GW	MEMS	10/16/2014	ALS	N	92.5	95.3	15	8.6	1.78	-	<5	9.77	<0.05	<0.054	<0.02	2.63	19.7	19.6	12.6	26.2	0.215	88.7	8.89	77.7	123	-
		MEMS	3/24/2016	ALS	N	175	214	40.6	<5	1.21	0.2	<5	15.3	0.079	0.079	<0.01	2.58	14.5	19.1	16	18.5	0.312	103	8.17	164	200	-
MW14-07-48	GW	MEMS	10/17/2014	ALS	N	72.4	88.4	29	<5	1.48	-	<5	11.6	<0.05	<0.054	<0.02	8.54	12.8	13	6.8	82.7	0.304	90.8	8.28	120	184	-
		MEMS	3/22/2016	ALS	N	575	<5	223	50	3.94	0.294	167	<0.1	0.037	<0.05	<0.01	3.84	2.71	3.1	44.5	16.6	2.01	110	11.88	557	637	-
MW14-08-79	GW	MEMS	10/17/2014	ALS	N	180	<5	168	17.7	2.01	-	51.1	<0.1	0.143	0.143	<0.02	120	15.5	7.95	44.1	266	1.35	145	11.61	419	709	-
		MEMS	3/23/2016	ALS	N	1890	<5	825	80	16.7	<0.4	598	<1	0.125	0.142	0.017	384	51.6	<1.1	740	548	8.67	167	12.47	2060	3650	-
MW15-11-18.5	GW	MEMS	7/29/2015	Exova	N	329	401	75.1	<6	2.3	-	<5	26.4	0.01	0.01	<0.005	6	-	-	17.3	11.9	0.58	99	7.76	296	336	-
		MEMS	3/23/2016	ALS	N	377	460	86.6	<5	<0.5	0.4	<5	34.3	<0.02	<0.05	<0.01	2.84	20.3	6.51	20.5	21.2	0.626	101	7.42	357	392	-
		MEMS	3/23/2016	ALS	FD	380	464	85.3	<5	<0.5	0.386	<5	34.1	<0.02	<0.05	<0.01	2.7	34.8	34.8	20	21.1	0.618	99.2	7.67	353	392	-
MW15-11-9	GW	MEMS	7/29/2015	Exova	N	332	405	86.6	<6	3.2	-	<5	22.1	0.05	0.06	0.008	6.7	-	-	15.8	12.4	0.599	100	7.94	307	346	-
		MEMS	3/23/2016	ALS	N	367	447	103	<5	1.07	0.182	<5	30.5	0.205	0.205	<0.01	6.04	157	9.35	19.5	10.3	0.592	114	7.54	383	392	-
MW15-12-14	GW	MEMS	7/29/2015	Exova	N	301	367	77.8	<6	2.2	-	<5	27.9	0.62	0.63	0.007	2.9	-	-	8.7	27.1	0.575	99	7.85	309	327	-
		MEMS	3/21/2016	ALS	N	315	384	85.1	<5	1.66	0.172	<5	31	0.811	0.811	<0.01	1.67	11.5	6.07	2.8	20.5	0.549	102	7.18	340	335	-
MW15-12-7	GW	MEMS	7/29/2015	Exova	N	310	377	92.1	<6	10.5	-	<5	25.3	1.13	1.14	0.008	3.1	-	-	2.7	23.5	0.586	98	7.79	334	343	-
		MEMS	3/21/2016	ALS	N	317	386	104	<5	1.45	0.146	<5	26.9	0.745	0.745	<0.01	1.91	33.2	7.09	2.5	18.8	0.525	111	7.2	370	349	-

Table B7. Routine Chemistry Results

						Inorganics																General Chemistry					
Location	Type	Data Source	Date	Laboratory	Sample Type	Alkalinity (T) as $CaCO_3$	Bicarbonate	Calcium	Carbonate	Chloride	Fluoride	Hydroxide	Magnesium	Nitrate (as N)	Nitrate + Nitrite-N	Nitrite (as N)	Potassium	Silica as SiO2	Silica as SiO_2 (Filtered)	Sodium	Sulphate	EC (lab)	Ionic Balance	pH (Lab)	Hardness as $CaCO_3$	Total Dissolved Solids	Total organic carbon
			mm/dd/yyyy			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mS/cm	%	pH	mg/L	mg/L	mg/L
CDW (Canadian Drinking Water **MAC** and AO)						-	-	-	-	250	1.5	-	-	**10**	-	**1**	-	-	-	200	500	-	90-110**	6.5-8.5	-	500	-
FWAL (ESRD Aquatic Life 2014)						>20	-	-	-	120	-	-	-	3	-	0.06-0.6*	-	-	-	-	309-429*	-	90-110**	6.5-9	-	-	-
International Spring	SPG	MEMS	9/30/2013	ALS	N	773	943	110	<5	2.74	-	<5	57.8	<0.05	<0.071	<0.05	4.59	-	-	252	376	1.64	91	7.91	513	1270	-
Turtle Mntn Spring	SPG	MEMS	9/30/2013	ALS	N	162	198	95.1	<5	1.51	-	<5	29.4	<0.05	<0.071	<0.05	1.11	-	-	3.1	200	0.62	98	7.83	359	427	-
Spring 1 (downStm)	SPG	MEMS	11/7/2012	ALS	N	296	361	92.8	<6	1.1	-	<5	28	<0.01	<0.01	<0.005	1.6	-	-	12.1	89.4	0.636	96	8.24	347	402	-
Spring 1 (upstream)	SPG	MEMS	11/7/2012	ALS	N	223	272	80.4	<6	0.6	-	<5	45.9	0.01	0.01	<0.005	1.5	-	-	34	253	0.833	96	7.65	390	550	-
		MEMS	10/1/2013	ALS	N	172	210	85.7	<5	1.08	-	<5	54.7	<0.05	<0.071	<0.05	1.38	-	-	24.8	331	0.849	96	7.2	439	602	-
		MEMS	1/5/2014	ALS	N	75.8	92.4	101	<5	0.34	-		59.9	<0.05	<0.054	<0.02	1.34	-	-	19.9	453	0.949	99	7.09	499	681	-
Spring 2	SPG	MEMS	10/1/2013	ALS	N	321	391	99.2	<5	0.17	-	<5	39.3	<0.05	<0.071	<0.05	0.82	-	-	2.3	112	0.68	95	8.14	410	446	-
Spring 3	SPG	MEMS	10/1/2013	ALS	N	263	320	68.8	<5	0.21	-	<5	40.8	0.077	0.077	<0.05	1.65	-	-	2.2	98.9	0.562	95	8.05	340	371	-
Spring 4	SPG	MEMS	10/1/2013	ALS	N	198	242	41.3	<5	0.15	-	<5	19.9	0.138	0.138	<0.05	1.26	-	-	3.5	22.8	0.335	87	8.11	185	208	-
Spring 5	SPG	MEMS	10/22/2013	ALS	N	156	190	44.4	<5	0.21	-	<5	23.4	0.051	<0.071	<0.05	1.03	-	-	<1	55.9	0.387	97	8	207	219	-
Stream 1	SW	MEMS	9/30/2013	ALS	N	197	237	48.1	<5	0.13	-	<5	25.3	0.337	0.337	<0.05	0.95	-	-	1.7	53.6	0.377	91	8.3	224	249	-
Stream 2	SW	MEMS	10/21/2013	ALS	N	128	156	34.8	<5	0.24	-	<5	10.2	<0.05	<0.071	<0.05	0.92	-	-	1.8	15.5	0.261	93	8.21	129	140	-
Stream 3	SW	MEMS	10/21/2013	ALS	N	149	181	40.8	<5	0.19	-	<5	19.4	<0.05	<0.071	<0.05	1.11	-	-	<1	38.4	0.338	97	8.22	182	189	-
Stream 4	SW	MEMS	10/21/2013	ALS	N	237	290	60.2	<5	0.19	-	<5	35.9	<0.05	<0.071	<0.05	1.16	-	-	<1	59.8	0.521	100	8.24	298	299	-
Stream 5	SW	MEMS	10/22/2013	ALS	N	62.2	75.9	20.3	<5	<0.1	-	<5	9.51	0.476	0.476	<0.05	0.58	-	-	<1	32.1	0.187	93	7.94	89.9	102	-
Stream 6	SW	MEMS	10/22/2013	ALS	N	28.3	34.5	7.87	<5	0.19	-	<5	3.4	0.363	0.363	<0.05	<0.5	-	-	<1	8.81	0.0723	-	7.52	33.7	38.9	-
Blairmore Creek	SW	BENGA	4/7/2014	Maxxam	N	170	210	59	0.89	<1.0	-	<0.50	12	0.039	0.039	<0.010	0.6	-	-	6.5	28	0.39	110	8.32	-	210	1.5
		BENGA	4/22/2014	Maxxam	N	140	170	43	1.4	<1.0	-	<0.50	9.7	0.037	0.037	<0.010	0.51	-	-	4.1	20	0.31	97	8.31	-	160	-
		BENGA	5/8/2014	Maxxam	N	120	150	42	<0.50	1.3	-	<0.50	8.7	0.018	0.018	<0.010	0.6	-	-	3.5	21	0.27	100	8.2	-	150	5.4
		BENGA	5/8/2014	Maxxam	FD	120	150	41	<0.50	1.1	-	<0.50	8.8	0.014	0.014	<0.010	0.7	-	-	3.5	20	0.27	100	8.22	-	150	5.8
		BENGA	5/21/2014	Maxxam	N	76	92	25	<0.50	1.1	-	<0.50	5.2	<0.010	<0.010	<0.010	0.6	-	-	2.2	9.2	0.17	100	7.95	-	89	-
		BENGA	6/3/2014	Maxxam	N	100	120	35	<0.50	1.3	-	<0.50	7.1	<0.010	<0.010	<0.010	0.53	-	-	2.6	12	0.22	110	8.28	-	120	-
		BENGA	6/15/2014	Maxxam	N	120	150	42	<0.50	1.1	-	<0.50	8.7	<0.010	<0.010	<0.010	0.56	-	-	3.4	14	0.27	110	8.17	-	140	-
		BENGA	7/10/2014	Maxxam	N	160	190	58	0.82	ND	-	ND	11	0.015	0.015	ND	0.82	-	-	4.4	22	0.34	110	8.34	190	190	3.1
		BENGA	21/07/2014	Maxxam	N	170	200	61	3.3	<1.0	-	<0.50	13	<0.010	<0.010	<0.010	0.98	-	-	5.5	24	0.36	110	8.44	200	200	-
		BENGA	06/08/2014	Maxxam	N	180	210	66	5.5	ND	-	ND	13	ND	ND	ND	1	-	-	5.6	23	0.39	110	8.53	220	220	-
		BENGA	22/08/2014	Maxxam	N	180	220	66	1.2	2.2	-	ND	13	0.014	0.014	ND	0.81	-	-	5.8	23	0.38	110	8.34	220	220	-
		BENGA	09/09/2014	Maxxam	N	160	190	58	3.0	1.0	-	<0.50	12	0.019	0.019	<0.010	0.70	-	-	5.0	18	0.34	110	8.39	190	190	-
		BENGA	25/09/2014	Maxxam	N	170	200	53	4.5	<1.0	-	<0.50	11	<0.010	<0.010	<0.010	0.79	-	-	5.4	20	0.35	100	8.48	180	190	-

Table B7. Routine Chemistry Results

Location	Type	Data Source	Date	Laboratory	Sample Type	Inorganics																General Chemistry					
						Alkalinity (T) as $CaCO_3$	Bicarbonate	Calcium	Carbonate	Chloride	Fluoride	Hydroxide	Magnesium	Nitrate (as N)	Nitrate + Nitrite-N	Nitrite (as N)	Potassium	Silica as SiO2	Silica as SiO_2 (Filtered)	Sodium	Sulphate	EC (lab)	Ionic Balance	pH (Lab)	Hardness as $CaCO_3$	Total Dissolved Solids	Total organic carbon
			mm/dd/yyyy			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mS/cm	%	pH	mg/L	mg/L	mg/L
CDW (Canadian Drinking Water **MAC** and AO)						-	-	-	-	250	1.5	-	-	**10**	-	**1**	-	-	-	200	500	-	90-110**	6.5-8.5	-	500	-
FWAL (ESRD Aquatic Life 2014)						>20	-	-	-	120	-	-	-	3	-	0.06-0.6*	-	-	-	-	309-429*	-	90-110**	6.5-9	-	-	-
Blairmore Creek	SW	BENGA	24/11/2014	Maxxam	N	180	230	54	<0.50	1.1	-	<0.50	11	0.023	0.023	<0.010	0.56	-	-	5.3	20	0.35	94	8.29	180	200	-
		BENGA	08/12/2014	Maxxam	N	160	200	53	<0.50	1.7	-	<0.50	11	0.055	0.055	<0.010	0.54	-	-	5.2	16	0.35	100	8.33	180	190	-
		BENGA	27/01/2015	Maxxam	N	150	190	54	<0.50	1.9	-	<0.50	12	0.039	0.039	<0.010	0.79	-	-	5.2	18	0.33	110	8.26	180	180	2.3
		BENGA	2/20/2015	Maxxam	N	160	190	50	0.78	<1.0	-	<0.50	11	0.02	0.018	<0.010	0.59	-	-	5	20	0.34	100	8.36	170	180	-
		BENGA	3/6/2015	Maxxam	N	170	200	56	<0.50	1.6	-	<0.50	12	<0.010	0.039	0.039	0.59	-	-	5.5	21	0.36	110	8.3	190	200	-
Crowsnest River	SW	BENGA	4/7/2014	Maxxam	N	160	200	66	<0.50	7.1	-	<0.50	15	0.35	0.35	<0.010	0.87	-	-	7.4	56	0.45	110	8.28	-	250	1.2
		BENGA	4/22/2014	Maxxam	N	150	180	50	<0.50	3.5	-	<0.50	11	0.18	0.18	<0.010	1.5	-	-	5.1	36	0.38	96	8.21	-	200	-
		BENGA	4/22/2014	Maxxam	FD	150	180	49	<0.50	3.1	-	<0.50	11	0.19	0.19	<0.010	0.65	-	-	4.9	36	0.37	94	8.27	-	190	-
		BENGA	5/8/2014	Maxxam	N	150	180	54	1.4	3.4	-	<0.50	12	0.13	0.13	<0.010	0.68	-	-	5.2	37	0.36	100	8.37	-	200	2.7
		BENGA	5/21/2014	Maxxam	N	120	140	39	<0.50	1.9	-	<0.50	9	0.1	0.11	<0.010	0.46	-	-	3	24	0.28	99	8.13	-	150	-
		BENGA	6/3/2014	Maxxam	N	130	160	51	<0.50	2.3	-	<0.50	10	0.13	0.13	<0.010	0.45	-	-	3.1	25	0.31	110	8.28	-	170	-
		BENGA	6/15/2014	Maxxam	N	130	160	49	<0.50	1.9	-	<0.50	11	0.13	0.13	<0.010	0.38	-	-	3.3	27	0.31	110	8.18	-	170	-
		BENGA	7/10/2014	Maxxam	N	150	180	53	ND	1.9	-	ND	11	0.17	0.17	ND	ND	-	-	3.7	30	0.34	100	8.23	180	190	1.2
		BENGA	7/21/2014	Maxxam	N	140	180	56	<0.50	2.1	-	<0.50	12	0.18	0.18	<0.010	0.54	-	-	4.9	34	0.35	110	8.32	190	200	-
		BENGA	06/08/2014	Maxxam	N	150	180	61	2.9	2.6	-	ND	14	0.19	0.19	ND	0.66	-	-	5	39	0.38	110	8.38	210	210	-
		BENGA	22/08/2014	Maxxam	N	150	180	62	ND	3.4	-	ND	14	0.23	0.23	ND	0.43	-	-	5	42	0.38	110	8.16	210	220	-
		BENGA	9/9/2014	Maxxam	N	150	180	60	<0.50	3.2	-	<0.50	13	0.2	0.2	<0.010	0.42	-	-	4.4	39	0.36	110	8.26	200	210	-
		BENGA	9/25/2014	Maxxam	N	150	180	49	<0.50	2.9	-	<0.50	11	0.1	0.1	<0.010	0.48	-	-	4.2	52	0.37	87	8.35	170	210	-
		BENGA	11/15/2014	Maxxam	N	160	200	60	<0.50	3.5	-	<0.50	14	0.32	0.33	<0.010	0.69	-	-	6.1	44	0.42	100	8	210	230	-
		BENGA	11/24/2014	Maxxam	N	160	200	60	<0.50	2.9	-	<0.50	14	0.28	0.28	<0.010	0.51	-	-	5.2	43	0.4	100	8.1	210	220	-
		BENGA	12/8/2014	Maxxam	N	160	190	60	<0.50	3.2	-	<0.50	13	0.23	0.23	<0.010	0.44	-	-	4.8	42	0.4	100	8.27	210	220	-
		BENGA	1/27/2015	Maxxam	N	140	170	59	<0.50	3.9	-	<0.50	14	0.22	0.22	<0.010	0.71	-	-	5.3	40	0.37	110	8.11	200	210	2.1
		BENGA	2/20/2015	Maxxam	N	180	220	59	<0.50	2.9	-	<0.50	14	0.25	0.25	<0.010	0.58	-	-	5.4	44	0.42	95	8.26	210	230	-
		BENGA	3/6/2015	Maxxam	N	160	200	62	<0.50	3.8	-	<0.50	15	<0.010	0.34	0.33	0.68	-	-	6.3	53	0.43	100	8.19	220	240	-
South Pond	SW	BENGA	4/8/2014	Maxxam	N	190	230	45	<0.50	1.8	-	<0.50	26	<0.010	<0.010	<0.010	1.2	-	-	0.91	64	0.49	87	8.24	-	250	1.9
		BENGA	5/8/2014	Maxxam	N	40	48	12	<0.50	<1.0	-	<0.50	5	0.016	0.016	<0.010	0.32	-	-	<0.50	11	0.1	100	7.9	-	52	0.75
		BENGA	7/10/2014	Maxxam	N	160	190	48	2.9	ND	-	ND	27	ND	ND	ND	1	-	-	ND	50	0.41	110	8.38	230	220	1.4

Table B7. Routine Chemistry Results

Location	Type	Data Source	Date	Laboratory	Sample Type	Inorganics																General Chemistry					
						Alkalinity (T) as $CaCO_3$	Bicarbonate	Calcium	Carbonate	Chloride	Fluoride	Hydroxide	Magnesium	Nitrate (as N)	Nitrate + Nitrite-N	Nitrite (as N)	Potassium	Silica as SiO2	Silica as SiO_2 (Filtered)	Sodium	Sulphate	EC (lab)	Ionic Balance	pH (Lab)	Hardness as $CaCO_3$	Total Dissolved Solids	Total organic carbon
			mm/dd/yyyy			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mS/cm	%	pH	mg/L	mg/L	mg/L
CDW (Canadian Drinking Water **MAC** and AO)						-	-	-	-	250	1.5	-	-	**10**	-	**1**	-	-	-	200	500	-	90-110**	6.5-8.5	-	500	-
FWAL (ESRD Aquatic Life 2014)						>20	-	-	-	120	-	-	-	3	-	0.06-0.6*	-	-	-	-	309-429*	-	90-110**	6.5-9	-	-	-
Gold Creek	SW	BENGA	4/7/2014	Maxxam	N	140	170	50	1.2	<1.0	-	<0.50	11	0.067	0.067	<0.010	0.31	-	-	1.8	29	0.33	110	8.35	-	180	0.53
Gold Creek	SW	BENGA	4/22/2014	Maxxam	N	160	190	49	2.7	1.1	-	<0.50	12	0.11	0.11	<0.010	<0.30	-	-	1.9	26	0.36	94	8.4	-	190	-
Gold Creek	SW	BENGA	5/8/2014	Maxxam	N	160	180	53	3.3	1.3	-	<0.50	13	0.062	0.062	<0.010	0.44	-	-	1.9	25	0.34	100	8.45	-	190	1.2
Gold Creek	SW	BENGA	5/21/2014	Maxxam	N	120	150	39	<0.50	1	-	<0.50	9.5	0.057	0.057	<0.010	0.31	-	-	1.2	14	0.27	100	8.31	-	140	-
Gold Creek	SW	BENGA	6/3/2014	Maxxam	N	130	150	47	2.1	1.2	-	<0.50	10	0.042	0.042	<0.010	<0.30	-	-	1.1	14	0.28	110	8.43	-	150	-
Gold Creek	SW	BENGA	6/3/2014	Maxxam	FD	130	150	48	1.9	1.2	-	<0.50	10	0.048	0.048	<0.010	0.33	-	-	1.1	14	0.28	110	8.43	-	150	-
Gold Creek	SW	BENGA	6/15/2014	Maxxam	N	140	170	47	<0.50	<1.0	-	<0.50	11	0.042	0.042	<0.010	<0.30	-	-	1.3	18	0.3	110	8.26	-	160	-
Gold Creek	SW	BENGA	7/10/2014	Maxxam	N	150	170	52	2	ND	-	ND	12	0.053	0.053	ND	ND	-	-	1.2	19	0.32	110	8.37	180	170	1.4
Gold Creek	SW	BENGA	7/21/2014	Maxxam	N	150	180	55	2.8	<1.0	-	<0.50	13	0.044	0.044	<0.010	0.34	-	-	1.5	22	0.33	110	8.45	190	180	-
Gold Creek	SW	BENGA	06/08/2014	Maxxam	N	150	180	57	3.9	ND	-	ND	13	0.025	0.025	ND	0.5	-	-	1.5	24	0.33	110	8.49	190	190	-
Gold Creek	SW	BENGA	22/08/2014	Maxxam	N	150	180	57	ND	1.3	-	ND	13	0.081	0.081	ND	ND	-	-	1.3	25	0.33	110	8.34	190	190	-
Gold Creek	SW	BENGA	9/9/2014	Maxxam	N	140	170	50	2.2	<1.0	-	<0.50	11	0.078	0.078	<0.010	<0.30	-	-	1.6	21	0.32	100	8.37	170	170	-
Gold Creek	SW	BENGA	9/25/2014	Maxxam	N	150	170	49	3.2	<1.0	-	<0.50	11	0.04	0.04	<0.010	0.33	-	-	1.3	22	0.32	100	8.46	170	170	-
Gold Creek	SW	BENGA	11/15/2014	Maxxam	N	140	170	51	0.69	1.3	-	<0.50	12	0.095	0.095	<0.010	0.42	-	-	2.2	26	0.33	100	8.35	180	180	-
Gold Creek	SW	BENGA	11/24/2014	Maxxam	N	140	170	52	1.3	<1.0	-	<0.50	12	0.074	0.074	<0.010	<0.30	-	-	1.4	25	0.32	110	8.36	180	180	-
Gold Creek	SW	BENGA	12/8/2014	Maxxam	N	150	170	52	2.5	1.5	-	<0.50	12	0.13	0.13	<0.010	0.36	-	-	1.4	23	0.33	110	8.4	180	180	-
Gold Creek	SW	BENGA	1/27/2015	Maxxam	N	160	190	56	1.3	1.1	-	<0.50	13	0.12	0.12	<0.010	0.35	-	-	1.6	27	0.33	100	8.37	190	200	0.79
Gold Creek	SW	BENGA	2/20/2015	Maxxam	N	140	170	51	2.3	<1.0	-	<0.50	12	0.09	0.09	<0.010	<0.30	-	-	1.6	27	0.33	110	8.39	180	180	-
Gold Creek	SW	BENGA	3/6/2015	Maxxam	N	140	170	49	0.72	1.3	-	<0.50	12	<0.010	0.11	0.11	0.37	-	-	1.7	26	0.33	100	8.34	170	180	-
East Pond	SW	MEMS	11/7/2012	ALS	N	255	311	47.4	<6	0.7	-	<5	43.9	<0.01	<0.01	<0.005	1.9	-	-	3.7	58	0.52	98	8.28	299	308	-
East Pond	SW	MEMS	9/30/2013	ALS	N	262	304	43.9	7.8	0.55	-	<5	45.3	<0.05	<0.071	<0.05	1.93	-	-	3.5	56.8	0.482	95	8.37	296	309	-
East Pond	SW	BENGA	4/8/2014	Maxxam	N	230	270	42	5	<1.0	-	<0.50	42	<0.010	<0.010	<0.010	1.7	-	-	-	-	0.55	99	8.42	-	290	2.5
East Pond	SW	BENGA	5/8/2014	Maxxam	N	28	34	6.8	<0.50	<1.0	-	<0.50	4.1	<0.010	<0.010	<0.010	0.33	-	-	-	-	0.061	110	7.75	-	33	0.52
East Pond	SW	BENGA	7/10/2014	Maxxam	N	190	220	40	7.3	ND	-	ND	40	ND	ND	ND	1.4	-	-	2.9	51	0.47	110	8.55	260	250	2.4
Small South Pond	SW	MEMS	10/1/2013	ALS	N	172	210	54.9	<5	0.2	-	<5	37.1	<0.05	<0.071	<0.05	1.44	-	-	<1	123	0.491	97	8.15	290	320	-
Small South Pond	SW	BENGA	4/8/2014	Maxxam	N	140	170	45	<0.50	<1.0	-	<0.50	29	0.05	0.05	<0.010	1.1	-	-	-	-	0.46	96	7.97	-	260	2
Small South Pond	SW	BENGA	5/8/2014	Maxxam	N	130	160	43	<0.50	<1.0	-	<0.50	28	<0.010	<0.010	<0.010	1.1	-	-	-	-	0.42	100	8.05	-	240	1.1
Small South Pond	SW	BENGA	7/10/2014	Maxxam	N	130	150	44	ND	ND	-	ND	28	ND	ND	ND	0.83	-	-	0.54	87	0.41	110	8.32	230	240	1.2
Small North Pond	SW	MEMS	11/7/2012	ALS	N	260	318	60.6	<6	0.6	-	<5	32.6	<0.01	<0.01	<0.005	1.4	-	-	0.9	46.7	0.507	94	8.03	286	299	-
South Pond	SW	MEMS	10/1/2013	ALS	N	220	268	52.3	<5	0.51	-	<5	30.7	<0.05	<0.071	<0.05	1.48	-	-	<1	55.5	0.405	93	8.24	257	272	-
West Pond	SW	MEMS	9/30/2013	ALS	N	215	263	34.6	<5	0.41	-	<5	29.5	<0.05	<0.071	<0.05	1.88	-	-	4.8	19	0.353	93.5	8.26	208	219	-

Table B7. Routine Chemistry Results

Location	Type	Data Source	Date	Laboratory	Sample Type	Inorganics																General Chemistry					
						Alkalinity (T) as $CaCO_3$	Bicarbonate	Calcium	Carbonate	Chloride	Fluoride	Hydroxide	Magnesium	Nitrate (as N)	Nitrate + Nitrite-N	Nitrite (as N)	Potassium	Silica as SiO2	Silica as SiO_2 (Filtered)	Sodium	Sulphate	EC (lab)	Ionic Balance	pH (Lab)	Hardness as $CaCO_3$	Total Dissolved Solids	Total organic carbon
			mm/dd/yyyy			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mS/cm	%	pH	mg/L	mg/L	mg/L
CDW (Canadian Drinking Water **MAC** and AO)						-	-	-	-	250	1.5	-	-	**10**	-	**1**	-	-	-	200	500	-	90-110**	6.5-8.5	-	500	-
FWAL (ESRD Aquatic Life 2014)						>20	-	-	-	120	-	-	-	3	-	0.06-0.6*	-	-	-	-	309-429*	-	90-110**	6.5-9	-	-	-
Pond 6	SW	MEMS	10/21/2013	ALS	N	172	210	45.4	<5	0.14	-	<5	23	<0.05	<0.071	<0.05	1.09	-	-	<1	39.5	0.377	98.1	8.26	208	212	-
Greenhill Portal (Main)	Portal	MEMS	9/30/2013	ALS	N	880	1070	179	<5	0.5	-	<5	161	<0.05	<0.071	<0.05	3.83	-	-	50.7	407	1.64	94.1	8.1	1110	1330	-
Greenhill Portal (Main)	Portal	BENGA	4/7/2014	Maxxam	N	680	830	180	<0.50	1.4	-	<0.50	140	<0.010	<0.010	<0.010	3.2	-	-	52	410	1.9	100	8.09	-	1200	2.9
Greenhill Portal (Main)	Portal	MEMS	22/04/2014	Maxxam	N	530	640	150	<0.5	1.1	-		110	0.032	0.055	0.023	2.7	-	-	36	450	1.7	91	7.9	830	1100	-
Greenhill Portal (Main)	Portal	BENGA	4/22/2014	Maxxam	N	530	640	150	<0.50	1.1	-	<0.50	110	0.032	0.055	0.023	2.7	-	-	36	450	1.7	91	7.9	-	1100	-
Greenhill Portal (Main)	Portal	MEMS	1/5/2014	ALS	N	630	769	174	<5	0.43	-		127	<0.05	<0.054	<0.02	3.29	-	-	45.8	458	1.62	95.8	8.06	957	1190	-
Greenhill Portal (Main)	Portal	BENGA	5/8/2014	Maxxam	N	590	720	170	<0.50	1.5	-	<0.50	130	<0.010	<0.010	<0.010	3.3	-	-	49	410	1.7	110	8.1	-	1100	2.8
Greenhill Portal (Main)	Portal	BENGA	5/21/2014	Maxxam	N	660	800	150	<0.50	1.6	-	<0.50	110	0.012	0.012	<0.010	3	-	-	47	390	1.8	87	7.91	-	1100	-
Greenhill Portal (Main)	Portal	BENGA	5/21/2014	Maxxam	FD	660	800	150	<0.50	1.6	-	<0.50	110	0.09	0.09	<0.010	3	-	-	47	390	1.8	87	7.88	-	1100	-
Greenhill Portal (Main)	Portal	BENGA	6/3/2014	Maxxam	N	690	840	190	<0.50	2	-	<0.50	140	0.012	0.012	<0.010	3.5	-	-	53	390	1.8	110	8	-	1200	-
Greenhill Portal (Main)	Portal	BENGA	6/15/2014	Maxxam	N	700	850	160	<0.50	1.5	-	<0.50	120	<0.010	<0.010	<0.010	3.1	-	-	45	380	1.8	91	8.02	-	1100	-
Greenhill Portal (Main)	Portal	BENGA	7/10/2014	Maxxam	N	670	820	180	ND	1.3	-	ND	140	<0.010	<0.010	<0.010	3.1	-	-	50	380	1.8	110	7.91	-	1200	3.3
Greenhill Portal (Main)	Portal	BENGA	7/21/2014	Maxxam	N	680	830	180	<0.50	1.5	-	<0.50	130	<0.010	<0.010	<0.010	3.3	-	-	52	370	1.8	100	8.03	1000	1100	-
Greenhill Portal (Main)	Portal	BENGA	8/6/2014	Maxxam	N	730	890	180	ND	1.6	-	ND	130	<0.010	<0.010	<0.010	3.5	-	-	48	400	1.8	94	7.97	970	1200	-
Greenhill Portal (Main)	Portal	BENGA	8/22/2014	Maxxam	N	720	870	190	ND	2.6	-	ND	150	0.012	0.012	<0.010	3.5	-	-	54	500	1.8	97	7.94	1100	1300	-
Greenhill Portal (Main)	Portal	BENGA	9/9/2014	Maxxam	N	700	850	190	<0.50	2	-	<0.50	150	0.015	0.015	<0.010	3.8	-	-	54	400	1.8	110	8	1100	1200	-
Greenhill Portal (Main)	Portal	BENGA	9/25/2014	Maxxam	N	690	840	160	<0.50	1.5	-	<0.50	120	0.019	0.019	<0.010	3.1	-	-	48	460	1.9	87	7.88	910	1200	-
Greenhill Portal (Main)	Portal	BENGA	11/24/2014	Maxxam	N	710	860	180	<0.50	1.4	-	<0.50	140	0.031	0.031	<0.010	3.3	-	-	51	470	1.9	96	8.03	1000	1300	-
Greenhill Portal (Main)	Portal	BENGA	12/8/2014	Maxxam	N	700	860	180	<0.50	2.1	-	<0.50	140	0.032	0.032	<0.010	3.1	-	-	50	430	1.9	99	8.16	1000	1200	-
Greenhill Portal (Main)	Portal	BENGA	1/27/2015	Maxxam	N	640	790	190	<0.50	2.3	-	<0.50	160	0.029	0.029	<0.010	3.9	-	-	52	490	1.9	110	7.95	1100	1300	3.3
Greenhill Portal (Main)	Portal	BENGA	2/20/2015	Maxxam	N	650	790	170	<0.50	<1.0	-	<0.50	140	0.04	0.04	<0.010	3.3	-	-	47	470	1.9	98	7.99	1000	1200	-
Greenhill Portal (Main)	Portal	BENGA	3/6/2015	Maxxam	N	650	800	160	<0.50	1.4	-	<0.50	130	<0.010	0.036	0.036	3	-	-	44	450	1.9	94	7.98	960	1200	-
Greenhill Portal (Secondary)	Portal	MEMS	10/1/2013	ALS	N	177	216	158	<5	0.35	-	<5	119	0.054	<0.071	<0.05	3.19	-	-	7.5	657	1.28	105	7.85	885	1050	-

Table B7. Routine Chemistry Results

Location	Type	Data Source	Date	Laboratory	Sample Type	Inorganics																General Chemistry					
						Alkalinity (T) as $CaCO_3$	Bicarbonate	Calcium	Carbonate	Chloride	Fluoride	Hydroxide	Magnesium	Nitrate (as N)	Nitrate + Nitrite-N	Nitrite (as N)	Potassium	Silica as SiO2	Silica as SiO_2 (Filtered)	Sodium	Sulphate	EC (lab)	Ionic Balance	pH (Lab)	Hardness as $CaCO_3$	Total Dissolved Solids	Total organic carbon
			mm/dd/yyyy			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mS/cm	%	pH	mg/L	mg/L	mg/L
CDW (Canadian Drinking Water **MAC** and AO)						-	-	-	-	250	1.5	-	-	**10**	-	**1**	-	-	-	200	500	-	90-110**	6.5-8.5	-	500	-
FWAL (ESRD Aquatic Life 2014)						>20	-	-	-	120	-	-	-	3	-	0.06-0.6*	-	-	-	-	309-429*	-	90-110**	6.5-9	-	-	-
McGillivray Mine	Mine	MEMS	9/30/2013	ALS	N	301	367	108	<5	0.67	-	<5	45.9	0.056	<0.071	<0.05	3.52	-	-	74.4	335	1.01	96	7.45	459	748	-
Bellevue Mine	Mine	BENGA	4/8/2014	Maxxam	N	230	280	74	<0.50	1.6	-	<0.50	31	0.12	0.12	<0.010	1	-	-	35	150	0.7	100	8.17	-	430	1.3
		BENGA	4/8/2014	Maxxam	FD	230	280	74	<0.50	1.5	-	<0.50	31	0.12	0.12	<0.010	0.99	-	-	35	140	0.71	100	8.16	-	430	1.2
		BENGA	4/22/2014	Maxxam	N	280	340	74	<0.50	<1.0	-	<0.50	35	0.12	0.13	0.01	1.1	-	-	42	180	0.86	90	8.18	-	500	-
		BENGA	5/8/2014	Maxxam	N	300	360	90	<0.50	<1.0	-	<0.50	42	0.11	0.11	<0.010	1.4	-	-	43	200	0.87	98	8.24	-	550	1.9
		BENGA	5/21/2014	Maxxam	N	300	360	85	<0.50	1.8	-	<0.50	41	0.077	0.077	<0.010	1.3	-	-	47	190	0.93	98	8.08	-	540	-
		BENGA	6/3/2014	Maxxam	N	300	370	94	<0.50	1.9	-	<0.50	41	0.081	0.081	<0.010	1.3	-	-	55	180	0.87	110	8.24	-	550	-
		BENGA	6/15/2014	Maxxam	N	320	390	81	<0.50	1.2	-	<0.50	36	0.062	0.062	<0.010	1.3	-	-	53	170	0.84	95	8.13	-	530	-
		BENGA	6/15/2014	Maxxam	FD	310	370	82	<0.50	<1.0	-	<0.50	36	0.062	0.062	<0.010	1.3	-	-	54	170	0.84	98	8.22	-	520	-
		BENGA	7/10/2014	Maxxam	N	310	380	88	ND	1.4	-	ND	41	0.076	0.076	ND	1.2	-	-	59	190	0.89	100	8.1	390	560	1.8
		BENGA	21/07/2014	Maxxam	N	310	370	85	<0.50	1.1	-	<0.50	38	0.07	0.07	<0.010	1.3	-	-	59	160	0.85	110	8.24	370	530	-
		BENGA	06/08/2014	Maxxam	N	310	380	84	ND	1.4	-	ND	36	0.087	0.087	ND	1.4	-	-	57	140	0.82	110	8.23	360	500	-
		BENGA	22/08/2014	Maxxam	N	280	350	80	ND	2.0	-	ND	34	0.091	0.091	ND	1.2	-	-	53	120	0.75	110	8.15	340	470	-
		BENGA	09/09/2014	Maxxam	N	290	350	80	<0.50	2.0	-	<0.50	34	0.061	0.061	<0.010	1.3	-	-	54	130	0.77	110	8.19	340	470	-
		BENGA	25/09/2014	Maxxam	N	290	360	67	<0.50	1.4	-	<0.50	29	0.059	0.059	<0.010	1.1	-	-	47	140	0.79	89	8.1	290	460	-
		BENGA	15/11/2014	Maxxam	N	270	330	71	<0.50	1.6	-	<0.50	31	0.1	0.11	<0.010	1.2	-	-	48	130	0.75	99	8.23	300	450	-
		BENGA	24/11/2014	Maxxam	N	250	300	70	<0.50	1.4	-	<0.50	30	0.13	0.13	<0.010	1	-	-	38	120	0.68	100	8.13	300	410	-
		BENGA	08/12/2014	Maxxam	N	240	290	65	<0.50	1.4	-	<0.50	28	0.15	0.15	<0.010	0.83	-	-	34	110	0.67	99	8.31	280	380	-
		BENGA	27/01/2015	Maxxam	N	240	290	78	<0.50	2.3	-	<0.50	35	0.13	0.13	<0.010	1.2	-	-	38	130	0.71	110	8.08	340	430	1.2
		BENGA	2/20/2015	Maxxam	N	230	280	73	<0.50	<1.0	-	<0.50	33	0.14	0.14	<0.010	1.1	-	-	35	140	0.7	110	8.15	320	420	-
		BENGA	3/6/2015	Maxxam	N	260	310	72	<0.50	1.6	-	<0.50	34	<0.010	0.14	0.14	1.1	-	-	34	140	0.73	97	8.2	320	440	-

Notes:

Value exceeds freshwater aquatic life and drinking water guidelines
Value exceeds freshwater aquatic life guidelines
Value exceeds drinking water guidelines
Value is outside acceptable QC limits
*Hardness or Chloride Dependant Value
** QA/QC (not Guideline Values)
- : Parameter not Analysed; Not Applicable (for Guidelines Only)
Data considered unreliable (ion balance indicates unreliable concentrations or pH is outside guidelines)
Data with ion balance outside acceptable QA/QC limit but considered reliable after further review

AO: Aesthetic Objective
BENGA: Benga Mining Limited
FD: Field Duplicate
FWAL: Fresh Water Aquatic Life
GW: Groundwater
N: Normal Sample

ND: Non Detect
MEMS: Millennium EMS Solutions Ltd.
MAC: Maximum Acceptable Concentration
SPG: Spring
SW: Surface Water

Table B8. Dissolved Metals Results

Location	Type	Data Source	Date	Laboratory	Sample Type	Dissolved Metals																
						Aluminium	Antimony	Arsenic	Barium	Boron	Cadmium	Chromium (III+VI)	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Silver	Uranium	Zinc
			mm/dd/yyyy			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CDW (Canadian Drinking Water **MAC** and AO)						0.1	**0.006**	**0.01**	**1**	**5**	**0.005**	**0.05**	1	0.3	**0.01**	0.05	**0.001**		**0.05**	-	**0.02**	5
FWAL (ESRD Aquatic Life 2014)						0.05*	-	0.005	-	1.5	0.00025-0.00037*	-	0.007	0.3	0.0063-0.007*	-	0.000005	0.082-0.170*	0.001	0.0001	0.015	0.03
MW14-01-64	GW	MEMS	2/2/2014	ALS	N	0.0212	0.00179	0.00103	0.539	0.142	<0.0001	<0.005	0.0027	0.497	0.0001	1.71	<0.00002	0.0104	<0.0004	<0.0001	0.00617	0.0222
		MEMS	10/16/2014	ALS	N	0.0053	<0.0001	0.00015	2.16	0.121	<0.00001	0.0001	0.00029	1.35	<0.00005	0.075	0.0000309	0.00194	0.00022	<0.00001	0.000078	<0.005
		MEMS	3/21/2016	ALS	N	0.0184	<0.0001	0.00018	1.6	0.162	<0.000005	0.00092	0.00024	1.41	0.000053	0.0554	<0.000005	0.00138	0.00081	<0.00001	0.000045	0.0041
MW14-02-74	GW	MEMS	2/4/2014	ALS	N	0.288	0.00105	0.00113	0.243	0.05	<0.0001	<0.005	0.0027	0.217	0.00037	0.141	<0.00002	0.0069	<0.0004	<0.0001	0.00081	0.0061
		MEMS	10/17/2014	ALS	N	0.017	<0.0001	<0.0001	0.583	0.056	<0.00001	0.00014	0.00023	3.39	<0.00005	0.256	0.0000357	0.00385	0.00016	<0.00001	0.000083	<0.005
		MEMS	3/23/2016	ALS	N	0.0362	<0.0001	0.0001	0.496	0.06	<0.000005	0.00019	0.00039	1.31	0.000055	0.212	<0.000005	0.00123	0.00267	<0.00001	0.000043	0.0033
MW14-03-90	GW	MEMS	2/4/2014	ALS	N	0.0591	0.00053	<0.0004	0.261	<0.05	<0.0001	0.0592	0.0029	<0.02	<0.0001	<0.002	<0.00002	<0.002	0.00149	<0.0001	<0.0001	0.004
		MEMS	10/17/2014	ALS	N	0.0023	0.00038	<0.0001	0.129	0.018	<0.00001	0.00226	0.00096	<0.03	0.000052	<0.005	0.0000333	0.00195	0.00012	<0.00001	<0.00001	<0.005
		MEMS	3/24/2016	ALS	N	0.0277	0.00125	0.00069	0.283	0.03	<0.000005	0.00038	0.00043	0.041	<0.00005	0.0054	<0.000005	0.00068	0.000175	<0.00001	0.000178	0.0013
MW14-04-93	GW	MEMS	10/16/2014	ALS	N	0.0067	0.00074	0.00087	0.983	0.06	<0.00001	0.00046	0.0026	<0.03	<0.00005	0.0076	<0.000005	0.00215	0.00017	<0.00001	0.000967	<0.005
MW14-05-114	GW	MEMS	10/17/2014	ALS	N	0.135	0.00276	0.00076	0.322	<0.01	<0.00001	0.023	0.00099	<0.03	0.000051	<0.005	0.0000269	0.00027	0.00115	<0.00001	<0.00001	<0.005
		MEMS	10/17/2014	ALS	FD	0.138	0.00284	0.00074	0.322	<0.01	<0.00001	0.0224	0.00176	<0.03	0.000112	<0.005	0.0000275	0.00064	0.00117	<0.00001	<0.00001	<0.005
		MEMS	3/24/2016	ALS	N	0.0602	0.00928	0.0012	0.172	0.048	<0.000005	0.00776	0.00146	<0.03	0.000069	<0.005	<0.000005	0.00115	0.000392	<0.00001	<0.00001	0.0026
MW14-06-32	GW	MEMS	3/24/2016	ALS	N	0.139	<0.0001	0.00041	0.146	0.013	0.0000794	0.00031	0.00575	0.036	0.000468	0.0977	<0.000005	0.0018	0.000065	<0.00001	0.000094	0.0106
MW14-06-105	GW	MEMS	10/16/2014	ALS	N	0.012	0.00294	0.00127	0.413	0.041	<0.00001	0.00053	0.00169	<0.03	<0.00005	<0.005	<0.000005	0.00089	0.00042	<0.00001	0.000232	<0.005
		MEMS	3/24/2016	ALS	N	0.220	0.00322	0.00237	1.37	0.06	0.0000165	0.00446	0.00597	0.242	0.000489	0.0157	<0.000005	0.00309	0.000348	<0.00001	0.000211	0.0158
MW14-07-48	GW	MEMS	10/17/2014	ALS	N	0.039	0.00165	0.0007	0.0813	0.035	<0.00001	0.0102	0.00404	<0.03	<0.00005	<0.005	0.000011	0.00147	0.00252	<0.00001	0.000382	<0.005
		MEMS	3/22/2016	ALS	N	0.718	0.0026	<0.0005	0.692	<0.05	<0.000025	0.00753	0.0051	<0.03	<0.00025	<0.005	<0.000005	<0.0025	0.00096	<0.00005	<0.00005	<0.005
MW14-08-79	GW	MEMS	10/17/2014	ALS	N	0.124	0.00051	0.00079	0.177	<0.05	0.000054	0.258	0.0105	0.06	<0.00025	<0.005	0.000032	0.0013	0.017	<0.00005	<0.00005	<0.02
		MEMS	3/23/2016	ALS	N	0.021	<0.002	<0.002	0.125	<0.2	0.00021	0.443	0.0328	<0.3	0.0013	<0.05	<0.000005	<0.01	0.0257	<0.0002	<0.0002	<0.02
MW15-11-18.5	GW	MEMS	7/29/2015	Exova	N	0.007	0.0004	0.0029	3.42	0.08	0.00001	<0.0005	0.002	0.27	<0.0001	0.325	<0.000005	0.0022	0.0005	0.00004	0.0012	0.004
		MEMS	3/23/2016	ALS	N	0.0218	<0.0005	0.00076	2.47	0.1	<0.000025	<0.0005	<0.001	0.856	<0.00025	0.368	<0.000005	<0.0025	0.00135	<0.00005	0.00027	<0.005
		MEMS	3/23/2016	ALS	FD	0.0285	<0.0005	0.00091	2.5	0.101	<0.000025	<0.0005	<0.001	0.86	<0.00025	0.363	<0.000005	<0.0025	0.00122	<0.00005	0.000265	<0.005
MW15-11-9	GW	MEMS	7/29/2015	Exova	N	0.218	0.0003	0.0002	0.154	0.072	0.00002	0.0006	0.002	0.14	0.0002	0.141	<0.000005	0.0022	0.0004	<0.00001	0.0009	0.004
		MEMS	3/23/2016	ALS	N	0.596	<0.0005	0.00061	0.258	0.079	0.000071	0.00189	0.0019	<0.03	0.00165	0.129	<0.000005	0.0032	0.00064	<0.00005	0.00255	0.0064
MW15-12-14	GW	MEMS	7/29/2015	Exova	N	0.008	0.0005	0.0002	0.096	0.053	0.00009	<0.0005	0.003	0.01	<0.0001	0.026	<0.000005	0.0012	0.0038	<0.00001	0.0013	0.003
		MEMS	3/21/2016	ALS	N	0.0164	<0.0005	<0.0005	0.103	<0.05	<0.000025	<0.0005	<0.001	0.047	<0.00025	0.0093	<0.000005	<0.0025	0.00508	<0.00005	0.00107	<0.005
MW15-12-7	GW	MEMS	7/29/2015	Exova	N	0.094	<0.0002	<0.0002	0.119	0.031	0.00009	<0.0005	0.001	0.12	<0.0001	0.207	<0.000005	0.0014	0.00530	<0.00001	0.0012	0.003
		MEMS	3/21/2016	ALS	N	8.83	<0.0005	0.00064	0.455	<0.05	0.0004	0.0203	0.0106	<0.03	0.0044	<0.005	<0.000005	0.013	0.00358	0.000289	0.00188	0.0552

Table B8. Dissolved Metals Results

Location	Type	Data Source	Date	Laboratory	Sample Type	Dissolved Metals																
						Aluminium	Antimony	Arsenic	Barium	Boron	Cadmium	Chromium (III+VI)	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Silver	Uranium	Zinc
			mm/dd/yyyy			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CDW (Canadian Drinking Water **MAC** and AO)						0.1	**0.006**	**0.01**	1	5	**0.005**	**0.05**	1	0.3	**0.01**	0.05	**0.001**		**0.05**	-	**0.02**	5
FWAL (ESRD Aquatic Life 2014)						0.05*	-	0.005	-	1.5	0.00025-0.00037*	-	0.007	0.3	0.0063-0.007*	-	0.000005	0.082-0.170*	0.001	0.0001	0.015	0.03
International Spring	SPG	MEMS	9/30/2013	ALS	N	0.0064	<0.0001	0.00063	0.024	0.191	<0.00001	<0.0001	0.00031	2.35	<0.00005	0.287	<0.00005	0.00725	<0.0001	<0.00001	0.000532	<0.005
Turtle Mntn Spring	SPG	MEMS	9/30/2013	ALS	N	0.0108	<0.0001	0.00026	0.0298	0.022	<0.00001	<0.0001	<0.0001	<0.03	<0.00005	<0.005	<0.00005	0.00102	0.00102	<0.00001	0.000854	<0.005
Spring 1 (upstream)	SPG	MEMS	10/1/2013	ALS	N	0.116	<0.0001	0.00013	0.662	0.111	0.000402	<0.0001	0.00113	15.6	<0.00005	2.11	<0.00005	0.177	0.00038	<0.00001	0.000915	0.324
		MEMS	1/5/2014	ALS	N	0.14	<0.0001	0.00019	0.545	0.078	0.000176	<0.0001	0.00103	21.4	<0.00005	2.69	<0.00005	0.262	0.00082	<0.00001	0.0000006	0.406
Spring 2	SPG	MEMS	10/1/2013	ALS	N	0.0031	<0.0001	0.00017	0.125	0.046	<0.00001	<0.0001	0.00074	<0.03	<0.00005	0.034	<0.00005	0.00403	0.00031	<0.00001	0.000261	<0.005
Spring 3	SPG	MEMS	10/1/2013	ALS	N	<0.001	0.00022	<0.0001	0.2	0.064	0.000038	<0.0001	0.00102	<0.03	<0.00005	<0.005	<0.00005	0.00414	0.00264	<0.00001	0.00037	0.0093
Spring 4	SPG	MEMS	10/1/2013	ALS	N	0.0023	<0.0001	0.00036	0.759	0.039	<0.00001	<0.0001	0.00045	<0.03	<0.00005	0.0686	<0.00005	0.00186	0.00046	<0.00001	0.000022	<0.005
Spring 5	SPG	MEMS	10/22/2013	ALS	N	0.0022	<0.0001	0.00155	0.0455	0.02	<0.00001	0.00011	0.00053	1.18	<0.00005	0.0909	<0.00005	0.00406	<0.0001	<0.00001	0.000072	<0.005
Stream 1	SW	MEMS	9/30/2013	ALS	N	0.003	<0.0001	<0.0001	0.151	0.031	0.000015	<0.0001	0.00089	<0.03	<0.00005	<0.005	<0.00005	0.00197	0.0073	<0.00001	0.0002	<0.005
Stream 2	SW	MEMS	10/21/2013	ALS	N	0.0022	<0.0001	0.00012	0.146	0.034	<0.00001	<0.0001	0.00108	<0.03	<0.00005	<0.005	<0.00005	0.00404	0.00245	<0.00001	0.000651	<0.005
Stream 3	SW	MEMS	10/21/2013	ALS	N	0.002	0.0001	0.00014	0.114	0.015	0.000015	<0.0001	0.00081	<0.03	<0.00005	<0.005	<0.00005	0.00145	0.0011	<0.00001	0.000298	<0.005
Stream 4	SW	MEMS	10/21/2013	ALS	N	<0.001	0.00017	<0.0001	0.184	0.022	0.000028	<0.0001	0.00069	<0.03	<0.00005	<0.005	<0.00005	0.00163	0.00368	<0.00001	0.000522	<0.005
Stream 5	SW	MEMS	10/22/2013	ALS	N	0.006	<0.0001	0.00013	0.0815	<0.01	0.000026	<0.0001	0.00116	<0.03	<0.00005	0.0097	<0.00005	0.00457	0.00336	<0.00001	0.000052	<0.005
Stream 6	SW	MEMS	10/22/2013	ALS	N	0.0017	<0.0001	0.0002	0.0452	<0.01	0.000014	<0.0001	0.00065	<0.03	<0.00005	<0.005	<0.00005	0.00058	0.00071	<0.00001	-	<0.005
Blairmore Creek	SW	BENGA	4/7/2014	Maxxam	N	<0.0030	<0.0006	<0.0002	0.11	<0.020	0.000013	<0.0010	0.00066	<0.060	<0.00020	<0.0040	-	0.00058	0.00079	<0.00010	0.0000008	<0.0030
		BENGA	4/22/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	0.0046	-	-	-	-	-	-
		BENGA	5/8/2014	Maxxam	N	0.024	<0.0006	<0.0002	0.081	<0.020	0.000018	<0.0010	0.0015	<0.060	<0.00020	0.013	-	0.0017	0.00061	<0.00010	0.0000004	0.005
		BENGA	5/8/2014	Maxxam	FD	0.024	<0.00060	<0.00020	0.079	<0.020	0.00002	<0.0010	0.0013	<0.060	<0.00020	0.013	-	0.0016	0.00061	<0.00010	0.0000004	0.0052
		BENGA	5/21/2014	Maxxam	N	-	-	-	-	-	-	-	-	0.25	-	0.0056	-	-	-	-	-	-
		BENGA	6/3/2014	Maxxam	N	-	-	-	-	-	-	-	-	0.082	-	0.0055	-	-	-	-	-	-
		BENGA	6/15/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	0.0059	-	-	-	-	-	-
		BENGA	7/10/2014	Maxxam	N	0.041	ND	ND	0.11	ND	-	ND	0.00098	ND	ND	0.0097	-	0.0015	0.00053	ND	0.0006	ND
		BENGA	7/21/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	0.0041	-	-	-	-	-	-
		BENGA	8/6/2014	Maxxam	N	-	-	-	-	-	-	-	-	ND	-	ND	-	-	-	-	-	-
		BENGA	8/22/2014	Maxxam	N	-	-	-	-	-	-	-	-	ND	-	ND	-	-	-	-	-	-
		BENGA	9/9/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	<0.0040	-	-	-	-	-	-
		BENGA	9/25/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	<0.0040	-	-	-	-	-	-
		BENGA	10/23/2014	Maxxam	N	0.0043	<0.00060	0.00031	0.12	<0.020	<0.020	<0.0010	0.00058	<0.060	<0.00020	<0.0040	-	0.00061	0.00045	<0.00010	0.00069	<0.0030

Table B8. Dissolved Metals Results

Location	Type	Data Source	Date	Laboratory	Sample Type	Aluminium	Antimony	Arsenic	Barium	Boron	Cadmium	Chromium (III+VI)	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Silver	Uranium	Zinc
			mm/dd/yyyy			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CDW (Canadian Drinking Water **MAC** and AO)						0.1	**0.006**	**0.01**	1	5	**0.005**	**0.05**	1	0.3	**0.01**	0.05	**0.001**		**0.05**	-	**0.02**	5
FWAL (ESRD Aquatic Life 2014)						0.05*	-	0.005	-	1.5	0.00025-0.00037*	-	0.007	0.3	0.0063-0.007*	-	0.000005	0.082-0.170*	0.001	0.0001	0.015	0.03
Blairmore Creek	SW	BENGA	11/24/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	<0.0040	-	-	-	-	-	-
		BENGA	12/8/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	<0.0040	-	-	-	-	-	-
		BENGA	1/27/2015	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	<0.0040	-	-	-	-	-	-
		BENGA	2/20/2015	Maxxam	N	0.016	<0.00060	<0.00020	0.097	<0.020	<0.00002	<0.0010	0.0006	<0.060	<0.00020	<0.0040	-	0.00079	0.00066	<0.00010	0.00063	<0.0030
Crowsnest River	SW	BENGA	4/7/2014	Maxxam	N	<0.0030	<0.0006	0.00024	0.074	<0.020	0.0000095	<0.0010	0.00058	<0.060	<0.00020	0.011	-	<0.00050	0.0011	<0.00010	0.00000056	<0.0030
		BENGA	4/22/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	<0.0040	-	-	-	-	-	-
		BENGA	4/22/2014	Maxxam	FD	-	-	-	-	-	-	-	-	<0.060	-	0.0063	-	-	-	-	-	-
		BENGA	5/8/2014	Maxxam	N	0.0075	<0.00060	<0.00020	0.07	<0.020	0.0000074	<0.0010	0.00097	<0.060	<0.00020	0.0067	-	0.00053	0.00074	<0.00010	0.0000004	<0.0030
		BENGA	5/21/2014	Maxxam	N	-	-	-	-	-	-	-	-	0.072	-	<0.0040	-	-	-	-	-	-
		BENGA	6/3/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	<0.0040	-	-	-	-	-	-
		BENGA	6/15/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	<0.0040	-	-	-	-	-	-
		BENGA	7/10/2014	Maxxam	N	0.0052	ND	ND	0.059	ND	-	ND	0.0012	ND	ND	0.0047	-	0.00053	0.0015	ND	0.00041	0.0038
		BENGA	7/21/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	<0.0040	-	-	-	-	-	-
		BENGA	8/6/2014	Maxxam	N	-	-	-	-	-	-	-	-	ND	-	ND	-	-	-	-	-	-
		BENGA	8/22/2014	Maxxam	N	-	-	-	-	-	-	-	-	ND	-	ND	-	-	-	-	-	-
		BENGA	9/9/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	<0.0040	-	-	-	-	-	-
		BENGA	9/25/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	0.006	-	-	-	-	-	-
		BENGA	10/23/2014	Maxxam	N	0.0036	<0.0006	<0.0002	0.063	<0.020	<0.020	<0.0010	0.00043	<0.060	<0.00020	<0.0040	-	<0.00050	0.0012	<0.00010	0.00048	<0.0030
		BENGA	11/15/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	0.017	-	-	-	-	-	-
		BENGA	11/24/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	0.032	-	-	-	-	-	-
		BENGA	12/8/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	0.0061	-	-	-	-	-	-
		BENGA	1/27/2015	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	0.0046	-	-	-	-	-	-
		BENGA	2/20/2015	Maxxam	N	0.008	<0.00060	<0.00020	0.068	<0.020	<0.00002	<0.0010	0.0003	<0.060	<0.00020	<0.0040	-	<0.00050	0.00087	<0.00010	0.00045	<0.0030
Gold Creek	SW	BENGA	4/7/2014	Maxxam	N	<0.0030	<0.0006	<0.0002	0.051	<0.020	0.0000098	<0.0010	0.00045	<0.060	<0.00020	<0.0040	-	0.00056	0.00091	<0.00010	0.0000005	<0.0030
		BENGA	4/22/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	<0.0040	-	-	-	-	-	-
		BENGA	5/8/2014	Maxxam	N	<0.0030	<0.00060	<0.00020	0.058	<0.020	0.000012	<0.0010	0.0007	<0.060	<0.00020	<0.0040	-	<0.00050	0.00093	<0.00010	0.0000005	<0.0030
		BENGA	5/21/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	<0.0040	-	-	-	-	-	-
		BENGA	6/3/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	<0.0040	-	-	-	-	-	-
		BENGA	6/3/2014	Maxxam	FD	-	-	-	-	-	-	-	-	<0.060	-	<0.0040	-	-	-	-	-	-
		BENGA	6/15/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	<0.0040	-	-	-	-	-	-
		BENGA	7/10/2014	Maxxam	N	0.0089	ND	ND	0.057	ND	-	ND	0.00098	ND	ND	ND	-	ND	0.00065	ND	0.00045	0.64

Table B8. Dissolved Metals Results

Location	Type	Data Source	Date	Laboratory	Sample Type	Dissolved Metals																	
						Aluminium	Antimony	Arsenic	Barium	Boron	Cadmium	Chromium (III+VI)	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Silver	Uranium	Zinc
			mm/dd/yyyy			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CDW (Canadian Drinking Water MAC and AO)						0.1	0.006	0.01	1	5	0.005	0.05	1	0.3	0.01	0.05	0.001		0.05	-	0.02	5
FWAL (ESRD Aquatic Life 2014)						0.05*	-	0.005	-	1.5	0.00025-0.00037*	-	0.007	0.3	0.0063-0.007*	-	0.000005	0.082-0.170*	0.001	0.0001	0.015	0.03
Gold Creek	SW	BENGA	7/21/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	<0.0040	-	-	-	-	-	-
		BENGA	8/6/2014	Maxxam	N	-	-	-	-	-	-	-	-	ND	-	ND	-	-	-	-	-	-
		BENGA	8/22/2014	Maxxam	N	-	-	-	-	-	-	-	-	ND	-	ND	-	-	-	-	-	-
		BENGA	9/9/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	<0.0040	-	-	-	-	-	-
		BENGA	9/25/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	<0.0040	-	-	-	-	-	-
		BENGA	10/23/2014	Maxxam	N	<0.0030	<0.00060	<0.00020	0.052	<0.020	<0.020	<0.0010	0.00027	<0.060	<0.00020	<0.0040	-	<0.00050	0.00064	<0.00010	0.00038	<0.0030
		BENGA	11/15/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	0.025	-	-	-	-	-	-
		BENGA	11/24/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	0.0056	-	-	-	-	-	-
		BENGA	12/8/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	<0.0040	-	-	-	-	-	-
		BENGA	1/27/2015	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	<0.0040	-	-	-	-	-	-
		BENGA	2/20/2015	Maxxam	N	<0.0030	<0.00060	<0.00020	0.053	<0.020	<0.00002	<0.0010	0.0003	<0.060	<0.00020	<0.0040	-	<0.00050	0.00081	<0.00010	0.00039	<0.0030
East Pond	SW	MEMS	9/30/2013	ALS	N	0.0016	0.00023	0.00034	0.141	0.071	0.000013	<0.0001	0.00102	<0.03	<0.00005	<0.005	<0.00005	0.00484	0.00058	<0.00001	0.000849	<0.005
		BENGA	4/8/2014	Maxxam	N	<0.0030	<0.0006	0.0003	0.13	0.077		<0.0010	0.0012	0.073	<0.00020	<0.0040	-	0.0011	0.00047	<0.00010	0.0000009	0.0044
		BENGA	5/8/2014	Maxxam	N	0.0044	<0.00060	<0.00020	0.022	<0.020		<0.0010	0.00067	<0.060	<0.00020	<0.0040	-	<0.00050	<0.00020	<0.00010	-	0.0046
		BENGA	4/8/2014	Maxxam	N	<0.0030	<0.0006	<0.0002	0.066	0.023		<0.0010	0.0013	<0.060	<0.00020	0.098	-	0.0026	0.0042	<0.00010	0.0000003	0.012
		BENGA	5/8/2014	Maxxam	N	0.0036	<0.00060	<0.00020	0.069	0.02		<0.0010	0.00073	<0.060	<0.00020	0.031	-	0.0021	0.0037	<0.00010	0.0000002	0.0064
		BENGA	7/10/2014	Maxxam	N	0.028	ND	0.00026	0.13	0.07	-	ND	0.00097	ND	ND	0.017	-	0.0019	0.00051	ND	0.00094	ND
		BENGA	10/23/2014	Maxxam	N	0.0044	<0.00060	0.00024	0.14	0.072	<0.020	<0.0010	0.00052	0.066	<0.00020	<0.0040	-	0.001	0.00041	<0.00010	0.00092	<0.0030
		BENGA	1/27/2015	Maxxam	N	0.028	<0.00060	0.00029	0.11	0.062	<0.020	<0.0010	0.00043	<0.060	<0.00020	<0.0040	-	0.00089	0.00033	<0.00010	0.00069	<0.0030
South Pond	SW	MEMS	10/1/2013	ALS	N	0.0049	0.00017	0.00047	0.155	0.024	0.000034	<0.0001	0.00099	<0.03	<0.00005	0.0507	<0.00005	0.00227	0.00212	<0.00001	0.000638	<0.005
		BENGA	4/8/2014	Maxxam	N	<0.0030	<0.00060	0.00031	0.12	<0.020	0.000024	<0.0010	0.0011	<0.060	<0.00020	0.04	-	0.0012	0.0014	<0.00010	0.0000006	0.0066
		BENGA	5/8/2014	Maxxam	N	0.0036	<0.00060	<0.00020	0.04	<0.020	0.000026	<0.0010	0.00079	<0.060	<0.00020	0.024	-	0.00056	0.00044	<0.00010	0.0000001	0.0044
		BENGA	7/10/2014	Maxxam	N	0.0033	ND	0.00029	0.13	ND	-	ND	0.00053	ND	ND	ND	-	0.0012	0.0027	ND	0.00065	ND
		BENGA	10/23/2014	Maxxam	N	0.0069	<0.00060	0.00036	0.14	0.025	<0.020	<0.0010	0.00074	<0.060	<0.00020	<0.0040	-	0.0015	0.0017	<0.00010	0.00066	<0.0030
		BENGA	1/27/2015	Maxxam	N	0.012	<0.00060	0.00029	0.081	<0.020	<0.020	<0.0010	0.00043	<0.060	<0.00020	<0.0040	-	0.0015	0.0012	<0.00010	0.0004	<0.0030
Small South Pond	SW	MEMS	10/1/2013	ALS	N	0.0028	<0.0001	0.00012	0.0826	0.031	0.000019	<0.0001	0.00079	<0.03	<0.00005	0.0068	<0.00005	0.00374	0.00411	<0.00001	0.000238	<0.005
		BENGA	7/10/2014	Maxxam	N	<0.0030	<0.00060	<0.00020	0.076	0.033	0.02	<0.0010	0.00048	0.062	<0.00020	0.019	-	0.0017	0.0031	<0.00010	0.00025	<0.0030
		BENGA	10/23/2014	Maxxam	N	0.015	<0.00060	<0.00020	0.074	<0.020	0.025	<0.0010	0.0011	<0.060	<0.00020	0.007	-	0.0011	0.002	<0.00010	0.00012	0.0043
		BENGA	1/27/2015	Maxxam	N	0.017	ND	ND	0.074	0.026	-	ND	0.00052	ND	ND	ND	-	0.0024	0.0059	ND	0.00027	ND

Table B8. Dissolved Metals Results

Location	Type	Data Source	Date	Laboratory	Sample Type	Dissolved Metals																
						Aluminium	Antimony	Arsenic	Barium	Boron	Cadmium	Chromium (III+VI)	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Silver	Uranium	Zinc
			mm/dd/yyyy			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CDW (Canadian Drinking Water **MAC** and AO)						0.1	**0.006**	**0.01**	1	5	**0.005**	**0.05**	1	0.3	**0.01**	0.05	**0.001**		**0.05**	-	**0.02**	5
FWAL (ESRD Aquatic Life 2014)						0.05*	-	0.005	-	1.5	0.00025-0.00037*	-	0.007	0.3	0.0063-0.007*	-	0.000005	0.082-0.170*	0.001	0.0001	0.015	0.03
West Pond	SW	MEMS	9/30/2013	ALS	N	0.0038	0.00015	0.00063	0.202	0.044	0.000011	<0.0001	0.00104	<0.03	<0.00005	<0.005	<0.00005	0.00128	0.00039	<0.00001	0.000439	<0.005
Pond 6	SW	MEMS	10/21/2013	ALS	N	0.0011	0.00019	0.00018	0.113	0.027	0.000033	<0.0001	0.00099	<0.03	<0.00005	0.0121	<0.00005	0.00443	0.00282	<0.00001	0.000551	0.0052
Greenhill Portal (Main)	Portal	MEMS	9/30/2013	ALS	N	0.0298	<0.0001	0.00054	0.12	0.187	<0.00001	0.0001	0.00011	0.953	<0.00005	0.444	<0.00005	0.0037	0.00049	<0.00001	0.000793	<0.005
		MEMS	22/04/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.06	-	0.45	-	-	-	-	-	-
		MEMS	1/5/2014	ALS	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		BENGA	4/7/2014	Maxxam	N	0.021	<0.0006	0.00036	0.11	0.19	0.0000096	<0.0010	0.00037	1.3	<0.00020	0.42	-	0.0038	0.00023	<0.00010	0.0000008	0.0048
		BENGA	4/22/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	0.45	-	-	-	-	-	-
		BENGA	5/8/2014	Maxxam	N	0.02	<0.00060	0.00039	0.1	0.17	<0.0000050	<0.0010	0.00029	1.8	<0.00020	0.44	-	0.0092	0.0019	<0.00010	0.0000008	0.0041
		BENGA	5/21/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	0.39	-	-	-	-	-	-
		BENGA	5/21/2014	Maxxam	FD	-	-	-	-	-	-	-	-	<0.060	-	0.39	-	-	-	-	-	-
		BENGA	6/3/2014	Maxxam	N	-	-	-	-	-	-	-	-	0.25	-	0.44	-	-	-	-	-	-
		BENGA	6/15/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	0.38	-	-	-	-	-	-
		BENGA	7/10/2014	Maxxam	N	0.036	<0.00060	0.00042	0.11	0.19		<0.0010	<0.0002	0.26	<0.0002	0.41	-	0.0044	0.0022	<0.0001	0.0000009	<0.003
		BENGA	7/21/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	0.43	-	-	-	-	-	-
		BENGA	8/6/2014	Maxxam	N	-	-	-	-	-	-	-	-	ND	-	0.43	-	-	-	-	-	-
		BENGA	8/22/2014	Maxxam	N	-	-	-	-	-	-	-	-	0.31	-	0.48	-	-	-	-	-	-
		BENGA	9/9/2014	Maxxam	N	-	-	-	-	-	-	-	-	0.24	-	0.5	-	-	-	-	-	-
		BENGA	9/25/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	0.44	-	-	-	-	-	-
		BENGA	10/23/2014	Maxxam	N	0.019	<0.00060	0.00037	0.099	0.19	<0.020	<0.0010	0.00024	0.41	<0.00020	0.54	-	0.0023	<0.00020	<0.00010	0.00075	<0.0030
		BENGA	11/24/2014	Maxxam	N	-	-	-	-	-	-	-	-	0.26	-	0.46	-	-	-	-	-	-
		BENGA	12/8/2014	Maxxam	N	-	-	-	-	-	-	-	-	0.26	-	0.45	-	-	-	-	-	-
		BENGA	1/27/2015	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	0.48	-	-	-	-	-	-
		BENGA	2/20/2015	Maxxam	N	0.019	<0.00060	0.0004	0.086	0.2	0.000073	<0.0010	<0.00020	0.23	0.0003	0.41	-	0.0019	<0.00020	<0.00010	0.00069	0.0081
Greenhill Portal (Secondary)	Portal	MEMS	10/1/2013	ALS	N	0.0087	<0.0001	<0.0001	0.046	0.086	0.000174	<0.0001	0.00091	0.246	<0.00005	0.102	<0.00005	0.0126	0.00041	<0.00001	0.000285	0.0334
McGillivray Mine	Mine	MEMS	9/30/2013	ALS	N	0.0127	<0.0001	0.00016	0.024	0.083	<0.00001	<0.0001	0.00043	3.71	<0.00005	0.788	<0.00005	0.00079	<0.0001	<0.00001	0.000202	<0.005

Table B8. Dissolved Metals Results

Location	Type	Data Source	Date	Laboratory	Sample Type	Dissolved Metals																
						Aluminium	Antimony	Arsenic	Barium	Boron	Cadmium	Chromium (III+VI)	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Silver	Uranium	Zinc
			mm/dd/yyyy			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CDW (Canadian Drinking Water **MAC** and AO)						0.1	**0.006**	**0.01**	**1**	**5**	**0.005**	**0.05**	1	0.3	**0.01**	0.05	**0.001**		**0.05**	-	**0.02**	5
FWAL (ESRD Aquatic Life 2014)						0.05*	-	0.005	-	1.5	0.00025-0.00037*	-	0.007	0.3	0.0063-0.007*	-	0.000005	0.082-0.170*	0.001	0.0001	0.015	0.03
Bellevue Mine	Mine	BENGA	4/8/2014	Maxxam	N	0.088	<0.0006	<0.0002	0.088	0.05	0.000081	<0.0010	0.00095	0.25	<0.00020	0.037	-	0.051	0.0016	<0.00010	0.0000013	0.092
Bellevue Mine	Mine	BENGA	4/8/2014	Maxxam	FD	0.086	<0.0006	<0.0002	0.088	0.05	0.000069	<0.0010	0.00047	0.25	<0.00020	0.037	-	0.046	0.0015	<0.00010	0.0000011	0.089
Bellevue Mine	Mine	BENGA	4/22/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	0.041	-	-	-	-	-	-
Bellevue Mine	Mine	BENGA	5/8/2014	Maxxam	N	0.046	<0.00060	0.00022	0.086	0.064	0.000015	<0.0010	0.00062	0.1	<0.00020	0.043	-	0.033	0.0013	<0.00010	0.0000012	0.03
Bellevue Mine	Mine	BENGA	5/21/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	0.041	-	-	-	-	-	-
Bellevue Mine	Mine	BENGA	6/3/2014	Maxxam	N	-	-	-	-	-	-	-	-	0.098	-	0.046	-	-	-	-	-	-
Bellevue Mine	Mine	BENGA	6/15/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	0.046	-	-	-	-	-	-
Bellevue Mine	Mine	BENGA	6/15/2014	Maxxam	FD	-	-	-	-	-	-	-	-	<0.060	-	0.046	-	-	-	-	-	-
Bellevue Mine	Mine	BENGA	7/10/2014	Maxxam	N	0.044	ND	ND	0.096	0.078	-	ND	0.00066	0.21	ND	0.053	-	0.032	0.0011	ND	0.0015	0.012
Bellevue Mine	Mine	BENGA	7/21/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	0.048	-	-	-	-	-	-
Bellevue Mine	Mine	BENGA	8/6/2014	Maxxam	N	-	-	-	-	-	-	-	-	ND	-	0.045	-	-	-	-	-	-
Bellevue Mine	Mine	BENGA	8/22/2014	Maxxam	N	-	-	-	-	-	-	-	-	0.08	-	0.039	-	-	-	-	-	-
Bellevue Mine	Mine	BENGA	9/9/2014	Maxxam	N	-	-	-	-	-	-	-	-	0.09	-	0.046	-	-	-	-	-	-
Bellevue Mine	Mine	BENGA	9/25/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	0.035	-	-	-	-	-	-
Bellevue Mine	Mine	BENGA	11/15/2014	Maxxam	N	0.053	<0.0006	0.0002	0.094	0.063	0.13	<0.0010	0.00071	0.25	<0.00020	0.039	-	0.026	0.00098	<0.00010	0.0013	0.034
Bellevue Mine	Mine	BENGA	11/24/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	0.037	-	-	-	-	-	-
Bellevue Mine	Mine	BENGA	12/8/2014	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	0.031	-	-	-	-	-	-
Bellevue Mine	Mine	BENGA	1/27/2015	Maxxam	N	-	-	-	-	-	-	-	-	<0.060	-	0.023	-	-	-	-	-	-
Bellevue Mine	Mine	BENGA	2/20/2015	Maxxam	N	0.06	<0.0006	0.0003	0.079	0.054	0.00038	<0.0010	0.0004	0.17	<0.00020	0.025	-	0.021	0.0018	<0.00010	0.0011	0.04

Notes:

Value exceeds freshwater aquatic life and drinking water guidelines

Value exceeds freshwater aquatic life guidelines

Value exceeds drinking water guidelines

Data Considered Unreliable (ion balance is <90% or >110% or pH is outside guidelines)

- : Parameter not Analysed; Not Applicable (for Guidelines Only)

*Hardness or pH dependant value

AO: Aesthetic Objective

BENGA: Benga Mining Limited

FD: Field Duplicate

FWAL: Fresh Water Aquatic Life

GW: Groundwater

N: Normal Sample

ND: Non Detect

MAC: Maximum Acceptable Concentration

MEMS: Millennium EMS Solutions Ltd.

SPG: Spring

SW: Surface Water

Table B9. Total Metals Results

Location	Type	Data Source	Date (mm/dd/yyyy)	Laboratory	Sample Type	Aluminium (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (III+VI) (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Silver (mg/L)	Uranium (mg/L)	Zinc (mg/L)
						Total Metals																
CDW (Canadian Drinking Water **MAC** and AO)						0.1	**0.006**	**0.01**	1	5	**0.005**	**0.05**	1	0.3	**0.01**	0.05	**0.001**	-	**0.05**	-	**0.02**	5
FWAL (ESRD Aquatic Life 2014)						0.05*	-	0.005	-	1.5	0.00025*	-	0.007	0.3	0.0063*	-	0.000005	0.082*	0.001	0.0001	0.015	0.03
MW14-01-64	GW	MEMS	10/16/2014	ALS	N	0.0293	<0.0001	0.00021	2.35	0.141	<0.00001	0.00026	0.00033	1.4	0.000058	0.0773	0.0000222	0.00057	<0.0001	0.000028	0.000091	<0.005
		MEMS	3/21/2016	ALS	N	0.008	<0.0001	0.00011	1.47	0.209	<0.000005	0.00123	<0.0005	1.15	<0.00005	0.0488	<0.000005	0.00105	0.000053	<0.00001	0.000037	<0.003
MW14-02-74	GW	MEMS	10/17/2014	ALS	N	1.25	0.00021	0.00061	0.688	0.064	0.000037	0.00152	0.00378	4.55	0.00151	0.279	0.0000269	0.00225	<0.0001	0.000022	0.000336	0.0148
		MEMS	3/23/2016	ALS	N	13.4	0.00083	0.0116	0.965	0.057	0.000526	0.0133	0.0457	17.3	0.0233	0.323	<0.000005	0.0182	0.000493	0.000132	0.0034	0.253
MW14-03-90	GW	MEMS	10/17/2014	ALS	N	0.0561	0.00041	0.00019	0.16	0.02	<0.00001	0.00283	0.00098	0.056	0.000071	<0.005	0.0000306	0.0008	0.00012	<0.00001	0.000018	<0.005
		MEMS	3/24/2016	ALS	N	0.662	0.00234	0.00108	0.273	0.029	0.0000832	0.00583	0.00734	0.927	0.0011	0.0293	<0.000025	0.00267	0.000143	0.000029	0.000242	0.0121
MW14-04-93	GW	MEMS	10/16/2014	ALS	N	0.33	0.00079	0.00099	1.1	0.069	0.000027	0.00209	0.00363	0.289	0.000445	0.0119	<0.000005	0.00146	0.00019	0.000076	0.00108	0.0057
MW14-05-114	GW	MEMS	10/17/2014	ALS	N	0.384	0.00285	0.00094	0.335	<0.01	0.000024	0.0246	0.00561	0.318	0.000432	0.0084	0.0000278	0.00143	0.00112	0.000019	0.000031	0.0065
		MEMS	10/17/2014	ALS	FD	0.456	0.00285	0.001	0.353	<0.01	0.00003	0.0254	0.00642	0.385	0.000518	0.0093	0.0000274	0.00153	0.00117	0.000024	0.000033	0.0071
		MEMS	3/24/2016	ALS	N	0.148	0.0103	0.00182	0.207	0.049	0.0000091	0.00896	0.00166	0.09	0.000205	<0.005	<0.000005	0.00082	0.000354	0.000015	0.000032	0.0031
MW14-06-32	GW	MEMS	3/24/2016	ALS	N	1.64	0.00043	0.00168	0.212	0.016	0.000446	0.00322	0.0341	6.21	0.00372	0.147	<0.000025	0.00881	0.000261	0.000099	0.000333	0.0409
MW14-06-105	GW	MEMS	10/16/2014	ALS	N	0.115	0.00307	0.00138	0.523	0.045	0.000014	0.00206	0.00249	0.175	0.000194	<0.005	<0.000005	0.00055	0.00035	0.000045	0.000244	<0.005
		MEMS	3/24/2016	ALS	N	0.227	0.00368	0.00238	1.42	0.059	0.0000171	0.00627	0.00503	0.27	0.000539	0.0139	<0.000005	0.00335	0.000152	0.000029	0.000214	0.0162
MW14-07-48	GW	MEMS	10/17/2014	ALS	N	0.504	0.00191	0.00131	0.123	0.036	0.000086	0.0146	0.0167	0.798	0.000922	0.035	0.0000078	0.0056	0.00235	0.000224	0.000501	0.017
		MEMS	3/22/2016	ALS	N	0.728	0.00176	0.00062	0.417	<0.05	0.00015	0.00517	0.0101	1.41	0.00129	0.0726	<0.000005	0.0059	0.00049	<0.00005	0.000153	<0.015
MW14-08-79	GW	MEMS	10/17/2014	ALS	N	0.869	0.00229	0.00201	0.203	0.013	0.000091	0.26	0.0208	1.03	0.00126	0.0327	0.0000335	0.00319	0.0169	0.000059	0.000121	0.033
		MEMS	3/23/2016	ALS	N	3.84	0.0083	0.0055	0.613	<0.2	0.00014	0.455	0.073	5.56	0.0081	0.22	<0.000025	0.015	0.0231	0.00026	0.00081	0.146
MW15-11-18.5	GW	MEMS	3/23/2016	ALS	N	3.29	<0.0005	0.00244	3.3	0.107	0.000171	0.00528	0.0044	2.73	0.00232	0.346	<0.000005	0.0046	0.0003	0.000083	0.000485	0.02
		MEMS	3/23/2016	ALS	FD	5.15	<0.0005	0.00226	2.97	0.101	0.000157	0.00769	0.0041	3.29	0.00228	0.395	<0.000005	0.0048	0.00028	0.000078	0.000509	0.02
MW15-11-9	GW	MEMS	3/23/2016	ALS	N	77.9	0.00061	0.0217	3.38	0.12	0.00363	0.206	0.193	108	0.0923	2.65	0.000211	0.27	0.00129	0.00225	0.00842	0.639
MW15-12-14	GW	MEMS	3/21/2016	ALS	N	1.56	0.00016	0.00046	0.185	0.044	0.000113	0.00164	0.00267	2.28	0.00299	0.0566	<0.000005	0.00279	0.00399	0.000086	0.0015	0.0101
MW15-12-7	GW	MEMS	3/21/2016	ALS	N	9.54	<0.0005	0.00108	0.586	<0.05	0.00035	0.0188	0.0144	11.8	0.00436	0.337	<0.000025	0.0146	0.00348	0.000577	0.00188	0.063
Spring 1 (downstream)	SPG	MEMS	11/7/2012	ALS	N	0.04	<0.0002	0.0002	0.168	0.059	0.00011	<0.0005	0.008	1.07	<0.0001	0.269	<0.0001	0.0151	0.0005	0.00006	0.6	0.021
Spring 1 (upstream)	SPG	MEMS	11/7/2012	ALS	N	0.36	<0.0002	0.0005	0.489	0.146	0.00124	<0.0005	0.001	10.6	<0.0001	1.67	<0.0001	0.118	0.001	0.00006	0.6	0.215
Small North Pond	SW	MEMS	11/7/2012	ALS	N	0.1	<0.0002	<0.0002	0.166	0.03	<0.00001	<0.0005	<0.001	0.2	<0.0001	0.022	<0.0001	0.0006	0.0011	0.00005	<0.5	0.008

Notes:

Value exceeds freshwater aquatic life and drinking wate

Value exceeds freshwater aquatic life guidelines

Value exceeds drinking water guidelines

Data Considered Unreliable (ion balance is <90% or >110% or pH is outside guidelines)

- : Parameter not Analysed; Not Applicable (for Guidelines Only)

*Hardness or pH dependant value

AO: Aesthetic Objective

FD: Field Duplicate

FWAL: Fresh Water Aquatic Life

GW: Groundwater

N: Normal Sample

MAC: Maximum Acceptable Concentration

MEMS: Millennium EMS Solutions Ltd.

SPG: Spring

SW: Surface Water

Table B10. Petroleum Hydrocarbon Results

Well ID	Type	Data Source	Date	Laboratory	Sample Type	Petroleum Hydrocarbons					
						Benzene	Toluene	Ethylbenzene	Xylenes Total	F1-BTEX	F2
			mm/dd/yyyy			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CDW (Canadian Drinking Water MAC)						0.005	0.06	0.14	0.09	-	-
FWAL (ESRD Aquatic Life 2014)						0.04	0.0005	0.09	0.03	-	-
MW14-01-64	GW	MEMS	10/16/2014	ALS	N	<0.0005	<0.0005	<0.0005	<0.00071	<0.1	<0.25
		MEMS	3/21/2016	ALS	N	<0.0005	<0.0005	<0.0005	<0.00071	<0.1	<0.1
MW14-02-74	GW	MEMS	10/17/2014	ALS	N	<0.0005	<0.0005	<0.0005	<0.00071	<0.1	<0.25
			3/23/2016	ALS	N	<0.0005	<0.0005	<0.0005	<0.00071	<0.1	<0.1
MW14-03-90	GW	MEMS	10/17/2014	ALS	N	<0.0005	<0.0005	<0.0005	<0.00071	<0.1	<0.25
		MEMS	3/24/2016	ALS	N	<0.0005	<0.0005	<0.0005	<0.00071	<0.1	<0.1
MW14-04-93	GW	MEMS	10/16/2014	ALS	N	<0.0005	<0.0005	<0.0005	<0.00071	<0.1	<0.25
MW14-05-114	GW	MEMS	10/17/2014	ALS	N	<0.0005	<0.0005	<0.0005	<0.00071	<0.1	<0.25
		MEMS	10/17/2014	ALS	FD	<0.0005	<0.0005	<0.0005	<0.00071	<0.1	<0.25
		MEMS	3/24/2016	ALS	N	<0.0005	<0.0005	<0.0005	<0.00071	<0.1	<0.1
MW14-06-32	GW	MEMS	3/24/2016	ALS	N	<0.0005	<0.0005	<0.0005	<0.00071	<0.1	<0.1
MW14-06-105	GW	MEMS	10/16/2014	ALS	N	<0.0005	<0.0005	<0.0005	<0.00071	<0.1	<0.25
		MEMS	3/24/2016	ALS	N	0.0006	<0.0005	<0.0005	<0.00071	<0.1	<0.1
MW14-07-48	GW	MEMS	10/17/2014	ALS	N	0.00837	0.00103	<0.0005	0.00096	<0.1	<0.25
		MEMS	3/22/2016	ALS	N	<0.0005	0.00073	<0.0005	<0.00071	<0.1	<0.1
MW14-08-79	GW	MEMS	10/17/2014	ALS	N	<0.0005	0.00056	<0.0005	<0.00071	<0.1	<0.25
	GW	MEMS	3/23/2016	ALS	N	<0.0005	<0.0005	<0.0005	<0.00071	<0.1	<0.1
MW15-11-18.5	GW	MEMS	3/23/2016	ALS	N	<0.0005	<0.0005	<0.0005	<0.00071	<0.1	<0.1
	GW	MEMS	3/23/2016	ALS	FD	<0.0005	<0.0005	<0.0005	<0.00071	<0.1	<0.1

Table B10. Petroleum Hydrocarbon Results

Well ID	Type	Data Source	Date	Laboratory	Sample Type	Petroleum Hydrocarbons					
						Benzene	Toluene	Ethylbenzene	Xylenes Total	F1-BTEX	F2
			mm/dd/yyyy			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CDW (Canadian Drinking Water MAC)						0.005	0.06	0.14	0.09	-	-
FWAL (ESRD Aquatic Life 2014)						0.04	0.0005	0.09	0.03	-	-
MW15-11-9	GW	MEMS	3/23/2016	ALS	N	<0.0005	<0.0005	<0.0005	<0.00071	<0.1	<0.1
MW15-12-14	GW	MEMS	3/21/2016	ALS	N	<0.0005	<0.0005	<0.0005	<0.00071	<0.1	<0.1
MW15-12-7	GW	MEMS	3/21/2016	ALS	N	<0.0005	<0.0005	<0.0005	<0.00071	<0.1	<0.1

Notes:

Value exceeds freshwater aquatic life and drinking water guidelines
Value exceeds freshwater aquatic life guidelines
Value exceeds drinking water guidelines

*Hardness or pH dependant value
- : Parameter not Analysed; Not Applicable (for Guidelines Only)
FD: Field Duplicate
FWAL: Fresh Water Aquatic Life
GW: Groundwater
N: Normal Sample
MAC: Maximum Acceptable Concentration
MEMS: Millennium EMS Solutions Ltd.

Table B11. Total Petroleum Hydrocarbons, Phenols and Polycyclic Aromatic Hydrocarbons (PAHs)

Location	Type	Data Source	Date	Laboratory	Sample Type	Total Petroleum Hydrocarbons	Phenols (4AAP)	Acenaphthene	Acenaphthylene	Acridine	Anthracene	Benz[a]anthracene	Benzo[a]pyrene	Benzo[b]fluoranthene + Benzo[j]fluoranthene	Benzo[c]phenanthrene	Benzo[e]pyrene	Benzo[g,h,i]perylene	Benzo[k]fluoranthene	Chrysene
			mm/dd/yyyy			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CDW (Canadian Drinking Water MAC)						-	-	-	-	-	-	-	0.00001	-	-	-	-	-	-
FWAL (ESRD Aquatic Life 2014)						-	0.004	0.0058	-	0.0044	0.000012	0.000018	0.000015	-	-	-	-	-	-
Blairmore Creek	SW	BENGA	4/7/2014	Maxxam	N	<2.0	<0.0020	<0.00010	<0.00010	<0.00020	<0.000010	<0.0000085	<0.0000075	<0.0000085	<0.000050	<0.000050	<0.0000085	<0.0000085	<0.0000085
		BENGA	5/8/2014	Maxxam	N	<2.0	0.0021	<0.00010	<0.00010	<0.00020	<0.000010	<0.0000085	<0.0000075	<0.0000085	<0.000050	<0.000050	<0.0000085	<0.0000085	<0.0000085
		BENGA	5/8/2014	Maxxam	FD	<2.0	0.0028	<0.00010	<0.00010	<0.00020	<0.000010	<0.0000085	<0.0000075	<0.0000085	<0.000050	<0.000050	<0.0000085	<0.0000085	<0.0000085
		BENGA	10/7/2014	Maxxam	N	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		BENGA	10/23/2014	Maxxam	N	<2.0	<0.0020	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0075	<0.0085	<0.050	<0.050	<0.0085	<0.0085	<0.0085
		BENGA	1/27/2015	Maxxam	N	<2.0	<0.0020	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0075	<0.0085	<0.050	<0.050	<0.0085	<0.0085	<0.0085
Crowsnest River	SW	BENGA	4/7/2014	Maxxam	N	<2.0	<0.0020	<0.00010	<0.00010	<0.00020	<0.000010	<0.0000085	<0.0000075	<0.0000085	<0.000050	<0.000050	<0.0000085	<0.0000085	<0.0000085
		BENGA	5/8/2014	Maxxam	N	<2.0	<0.0020	<0.00010	<0.00010	<0.00020	<0.000010	<0.0000085	<0.0000075	<0.0000085	<0.000050	<0.000050	<0.0000085	<0.0000085	<0.0000085
		BENGA	10/7/2014	Maxxam	N	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		BENGA	10/23/2014	Maxxam	N	<2.0	<0.0020	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0075	<0.0085	<0.050	<0.050	<0.0085	<0.0085	<0.0085
		BENGA	1/27/2015	Maxxam	N	<2.0	<0.0020	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0075	<0.0085	<0.050	<0.050	<0.0085	<0.0085	<0.0085
South Pond	SW	BENGA	4/8/2014	Maxxam	N	<2.0	<0.0020	<0.00010	<0.00010	<0.00020	<0.000010	<0.0000085	<0.0000075	<0.0000085	<0.000050	<0.000050	<0.0000085	<0.0000085	<0.0000085
		BENGA	5/8/2014	Maxxam	N	<2.0	0.003	<0.00010	<0.00010	<0.00020	<0.000010	<0.0000085	<0.0000075	<0.0000085	<0.000050	<0.000050	<0.0000085	<0.0000085	<0.0000085
		BENGA	10/7/2010	Maxxam	N	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		BENGA	10/23/2014	Maxxam	N	<2.0	<0.0020	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0075	<0.0085	<0.050	<0.050	<0.0085	<0.0085	<0.0085
		BENGA	1/27/2015	Maxxam	N	<2.0	<0.0020	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0075	<0.0085	<0.050	<0.050	<0.0085	<0.0085	<0.0085
Gold Creek	SW	BENGA	4/7/2014	Maxxam	N	<2.0	0.0037	<0.00010	<0.00010	<0.00020	<0.000010	<0.0000085	<0.0000075	<0.0000085	<0.000050	<0.000050	<0.0000085	<0.0000085	<0.0000085
		BENGA	5/8/2014	Maxxam	N	<2.0	<0.0020	<0.00010	<0.00010	<0.00020	<0.000010	<0.0000085	<0.0000075	<0.0000085	<0.000050	<0.000050	<0.0000085	<0.0000085	<0.0000085
		BENGA	10/7/2014	Maxxam	N	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		BENGA	10/23/2014	Maxxam	N	<2.0	<0.0020	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0075	<0.0085	<0.050	<0.050	<0.0085	<0.0085	<0.0085
		BENGA	1/27/2015	Maxxam	N	<2.0	<0.0020	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0075	<0.0085	<0.050	<0.050	<0.0085	<0.0085	<0.0085
East Pond	SW	BENGA	4/8/2014	Maxxam	N	<2.0	<0.0020	<0.00010	<0.00010	<0.00020	<0.000010	<0.0000085	<0.0000075	<0.0000085	<0.000050	<0.000050	<0.0000085	<0.0000085	<0.0000085
		BENGA	5/8/2014	Maxxam	N	<2.0	0.0026	<0.00010	<0.00010	<0.00020	<0.000010	<0.0000085	<0.0000075	<0.0000085	<0.000050	<0.000050	<0.0000085	<0.0000085	<0.0000085
		BENGA	10/7/2014	Maxxam	N	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		BENGA	10/23/2014	Maxxam	N	<2.0	<0.0020	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0075	<0.0085	<0.050	<0.050	<0.0085	<0.0085	<0.0085
		BENGA	1/27/2015	Maxxam	N	<2.0	<0.0020	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0075	<0.0085	<0.050	<0.050	<0.0085	<0.0085	<0.0085

Table B11. Total Petroleum Hydrocarbons, Phenols and Polycyclic Aromatic Hydrocarbons (PAHs)

Location	Type	Data Source	Date	Laboratory	Sample Type	Total Petroleum Hydrocarbons	Phenols (4AAP)	Acenaphthene	Acenaphthylene	Acridine	Anthracene	Benz[a]anthracene	Benzo[a]pyrene	Benzo[b]fluoranthene + Benzo[j]fluoranthene	Benzo[c]phenanthrene	Benzo[e]pyrene	Benzo[g,h,i]perylene	Benzo[k]fluoranthene	Chrysene
			mm/dd/yyyy			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CDW (Canadian Drinking Water MAC)						-	-	-	-	-	-	-	0.00001	-	-	-	-	-	-
FWAL (ESRD Aquatic Life 2014)						-	0.004	0.0058	-	0.0044	0.000012	0.000018	0.000015	-	-	-	-	-	-
Small South Pond	SW	BENGA	4/8/2014	Maxxam	N	<2.0	0.0024	<0.00010	<0.00010	<0.00020	<0.000010	<0.0000085	<0.0000075	<0.0000085	<0.000050	<0.000050	<0.0000085	<0.0000085	<0.0000085
		BENGA	5/8/2014	Maxxam	N	<2.0	0.0024	<0.00010	<0.00010	<0.00020	<0.000010	<0.0000085	<0.0000075	<0.0000085	<0.000050	<0.000050	<0.0000085	<0.0000085	<0.0000085
		BENGA	10/7/2014	Maxxam	N	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		BENGA	10/23/2014	Maxxam	N	<2.0	<0.0020	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0075	<0.0085	<0.050	<0.050	<0.0085	<0.0085	<0.0085
		BENGA	1/27/2015	Maxxam	N	<2.0	<0.0020	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0075	<0.0085	<0.050	<0.050	<0.0085	<0.0085	<0.0085
Greenhill Portal (Main)	Portal	BENGA	4/7/2014	Maxxam	N	<2.0	<0.0020	<0.00010	<0.00010	<0.00020	<0.000010	<0.0000085	<0.0000075	<0.0000085	<0.000050	<0.000050	<0.0000085	<0.0000085	<0.0000085
		BENGA	5/8/2014	Maxxam	N	<2.0	0.0024	<0.00010	<0.00010	<0.00020	<0.000010	<0.0000085	<0.0000075	<0.0000085	<0.000050	<0.000050	<0.0000085	<0.0000085	<0.0000085
		BENGA	7/10/2014	Maxxam	N	<2.0	0.0035	<0.00010	<0.00010	<0.00020	<0.000010	<0.0000085	<0.0000075	<0.0000085	<0.000050	<0.000050	<0.0000085	<0.0000085	<0.0000085
		BENGA	10/7/2014	Maxxam	N	ND	0.0035	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		BENGA	10/23/2014	Maxxam	N	<2.0	<0.0020	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0075	<0.0085	<0.050	<0.050	<0.0085	<0.0085	<0.0085
		BENGA	1/27/2015	Maxxam	N	<2.0	<0.0020	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0075	<0.0085	<0.050	<0.050	<0.0085	<0.0085	<0.0085
Bellevue Mine	Mine	BENGA	4/8/2014	Maxxam	N	<2.0	0.0024	<0.00010	<0.00010	<0.00020	<0.000010	<0.0000085	<0.0000075	<0.0000085	<0.000050	<0.000050	<0.0000085	<0.0000085	<0.0000085
		BENGA	4/8/2014	Maxxam	FD	<2.0	<0.0020	<0.00010	<0.00010	<0.00020	<0.000010	<0.0000085	<0.0000075	<0.0000085	<0.000050	<0.000050	<0.0000085	<0.0000085	<0.0000085
		BENGA	5/8/2014	Maxxam	N	<2.0	0.0022	<0.00010	<0.00010	<0.00020	<0.000010	<0.0000085	<0.0000075	<0.0000085	<0.000050	<0.000050	<0.0000085	<0.0000085	<0.0000085
		BENGA	10/7/2014	Maxxam	N	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		BENGA	10/23/2014	Maxxam	N	<2.0	<0.0020	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0075	<0.0085	<0.050	<0.050	<0.0085	<0.0085	<0.0085
		BENGA	1/27/2015	Maxxam	N	<2.0	<0.0020	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0075	<0.0085	<0.050	<0.050	<0.0085	<0.0085	<0.0085

Location	Type	Data Source	Date	Laboratory	Sample Type	Dibenz[a,h]anthracene	Fluoranthene	Fluorene	Indeno[1,2,3-cd]pyrene	2-Methylnaphthalene	Naphthalene	Carcinogenic PAHs (as B(a)P TPE)	Perylene	Phenanthrene	Pyrene	Quinoline
			mm/dd/yyyy			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CDW (Canadian Drinking Water MAC)						-	-	-	-	-	-	-	-	-	-	-
FWAL (ESRD Aquatic Life 2014)						-	0.00004	0.003	-	-	0.001	-	-	0.0004	0.000025	0.0034
Blairmore Creek	SW	BENGA	4/7/2014	Maxxam	N	<0.0000075	<0.000010	<0.000050	<0.0000085	<0.00010	<0.00010	<0.000010	<0.000050	<0.000050	<0.000020	<0.00020
		BENGA	5/8/2014	Maxxam	N	<0.0000075	<0.000010	<0.000050	<0.0000085	<0.00010	<0.00010	<0.000010	<0.000050	<0.000050	<0.000020	<0.00020
		BENGA	5/8/2014	Maxxam	FD	<0.0000075	<0.000010	<0.000050	<0.0000085	<0.00010	<0.00010	<0.000010	<0.000050	<0.000050	<0.000020	<0.00020
		BENGA	10/7/2014	Maxxam	N	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		BENGA	10/23/2014	Maxxam	N	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.010	<0.050	<0.050	<0.020	<0.20
		BENGA	1/27/2015	Maxxam	N	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.010	<0.050	<0.050	<0.020	<0.20
Crowsnest River	SW	BENGA	4/7/2014	Maxxam	N	<0.0000075	<0.000010	<0.000050	<0.0000085	<0.00010	<0.00010	<0.000010	<0.000050	<0.000050	<0.000020	<0.00020
		BENGA	5/8/2014	Maxxam	N	<0.0000075	<0.000010	<0.000050	<0.0000085	<0.00010	<0.00010	<0.000010	<0.000050	<0.000050	<0.000020	<0.00020
		BENGA	10/7/2014	Maxxam	N	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		BENGA	10/23/2014	Maxxam	N	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.010	<0.050	<0.050	<0.020	<0.20
		BENGA	1/27/2015	Maxxam	N	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.010	<0.050	<0.050	<0.020	<0.20
South Pond	SW	BENGA	4/8/2014	Maxxam	N	<0.0000075	<0.000010	<0.000050	<0.0000085	<0.00010	<0.00010	<0.000010	<0.000050	<0.000050	<0.000020	<0.00020
		BENGA	5/8/2014	Maxxam	N	<0.0000075	<0.000010	<0.000050	<0.0000085	<0.00010	<0.00010	<0.000010	<0.000050	<0.000050	<0.000020	<0.00020
		BENGA	10/7/2010	Maxxam	N	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		BENGA	10/23/2014	Maxxam	N	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.010	<0.050	<0.050	<0.020	<0.20
		BENGA	1/27/2015	Maxxam	N	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.010	<0.050	<0.050	<0.020	<0.20
Gold Creek	SW	BENGA	4/7/2014	Maxxam	N	<0.0000075	<0.000010	<0.000050	<0.0000085	<0.00010	<0.00010	<0.000010	<0.000050	<0.000050	<0.000020	<0.00020
		BENGA	5/8/2014	Maxxam	N	<0.0000075	<0.000010	<0.000050	<0.0000085	<0.00010	<0.00010	<0.000010	<0.000050	<0.000050	<0.000020	<0.00020
		BENGA	10/7/2014	Maxxam	N	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		BENGA	10/23/2014	Maxxam	N	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.010	<0.050	<0.050	<0.020	<0.20
		BENGA	1/27/2015	Maxxam	N	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.010	<0.050	<0.050	<0.020	<0.20
East Pond	SW	BENGA	4/8/2014	Maxxam	N	<0.0000075	<0.000010	<0.000050	<0.0000085	<0.00010	<0.00010	<0.000010	<0.000050	<0.000050	<0.000020	<0.00020
		BENGA	5/8/2014	Maxxam	N	<0.0000075	<0.000010	<0.000050	<0.0000085	<0.00010	<0.00010	<0.000010	<0.000050	<0.000050	<0.000020	<0.00020
		BENGA	10/7/2014	Maxxam	N	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		BENGA	10/23/2014	Maxxam	N	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.010	<0.050	<0.050	<0.020	<0.20
		BENGA	1/27/2015	Maxxam	N	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.010	<0.050	<0.050	<0.020	<0.20

Location	Type	Data Source	Date	Laboratory	Sample Type	Dibenz[a,h]anthracene	Fluoranthene	Fluorene	Indeno[1,2,3-cd]pyrene	2-Methylnaphthalene	Naphthalene	Carcinogenic PAHs (as B(a)P TPE)	Perylene	Phenanthrene	Pyrene	Quinoline
			mm/dd/yyyy			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CDW (Canadian Drinking Water MAC)						-	-	-	-	-	-	-	-	-	-	-
FWAL (ESRD Aquatic Life 2014)						-	0.00004	0.003	-	-	0.001	-	-	0.0004	0.000025	0.0034
Small South Pond	SW	BENGA	4/8/2014	Maxxam	N	<0.0000075	<0.000010	<0.000050	<0.0000085	<0.00010	<0.00010	<0.000010	<0.000050	<0.000050	<0.000020	<0.00020
		BENGA	5/8/2014	Maxxam	N	<0.0000075	<0.000010	<0.000050	<0.0000085	<0.00010	<0.00010	<0.000010	<0.000050	<0.000050	<0.000020	<0.00020
		BENGA	10/7/2014	Maxxam	N	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		BENGA	10/23/2014	Maxxam	N	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.010	<0.050	<0.050	<0.020	<0.20
		BENGA	1/27/2015	Maxxam	N	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.010	<0.050	<0.050	<0.020	<0.20
Greenhill Portal (Main)	Portal	BENGA	4/7/2014	Maxxam	N	<0.0000075	<0.000010	<0.000050	<0.0000085	<0.00010	<0.00010	<0.000010	<0.000050	<0.000050	<0.000020	<0.00020
		BENGA	5/8/2014	Maxxam	N	<0.0000075	<0.000010	<0.000050	<0.0000085	<0.00010	<0.00010	<0.000010	<0.000050	<0.000050	<0.000020	<0.00020
		BENGA	7/10/2014	Maxxam	N	<0.0000075	<0.000010	<0.000050	<0.0000085	<0.00010	<0.00010	<0.000010	<0.000050	<0.000050	<0.000020	<0.00020
		BENGA	10/7/2014	Maxxam	N	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		BENGA	10/23/2014	Maxxam	N	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.010	<0.050	<0.050	<0.020	<0.20
		BENGA	1/27/2015	Maxxam	N	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.010	<0.050	<0.050	<0.020	<0.20
Bellevue Mine	Mine	BENGA	4/8/2014	Maxxam	N	<0.0000075	<0.000010	<0.000050	<0.0000085	<0.00010	<0.00010	<0.000010	<0.000050	<0.000050	<0.000020	<0.00020
		BENGA	4/8/2014	Maxxam	FD	<0.0000075	<0.000010	<0.000050	<0.0000085	<0.00010	<0.00010	<0.000010	<0.000050	<0.000050	<0.000020	<0.00020
		BENGA	5/8/2014	Maxxam	N	<0.0000075	<0.000010	<0.000050	<0.0000085	<0.00010	<0.00010	<0.000010	<0.000050	<0.000050	<0.000020	<0.00020
		BENGA	10/7/2014	Maxxam	N	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		BENGA	10/23/2014	Maxxam	N	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.010	<0.050	<0.050	<0.020	<0.20
		BENGA	1/27/2015	Maxxam	N	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.010	<0.050	<0.050	<0.020	<0.20

Notes:

- : Parameter not Analysed; Not Applicable (for Guidelines Only)
AO: Aesthetic Objective
BENGA: Benga Mining Limited
FD: Field Duplicate
FWAL: Fresh Water Aquatic Life
GW: Groundwater
N: Normal Sample
ND: Non Detect
MEMS: Millennium EMS Solutions Ltd.
MAC: Maximum Acceptable Concentration
SPG: Spring
SW: Surface Water

Table B12. Isotope Analyses

Location	Type	Data Source	Date	Laboratory	Type	Alkalinity ($CaCO_3$)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Chloride	Sulphate	E^3H		^{14}C (DIC)		$\delta^{18}O$		$\delta^{13}C$ (DOC)		$\delta^{34}S$ (SO_4)	
											Result	± 1σ	Fraction of Modern	± 1σ	Result	Repeat	Result	Repeat	Result	Repeat
													DIC		VSMOW		PDB		VCDT	
			mm/dd/yyyy			mg/L	mg/L	mg/L	mg/L	mg/L	TU		pmC		‰		‰		ppt	
Blairmore Creek	SW	BENGA	7-Apr-14	Maxxam	N	170	210	0.89	<1.0	28	-	-	-	-	7.8	-	-9.5	-	-2.9	-
		BENGA	8-May-14	Maxxam	N	120	150	<0.50	1.3	21	-	-	-	-	-3.6	-	-10.1	-	-0.7	-
		BENGA	8-May-14	Maxxam	FD	120	150	<0.50	1.1	20	-	-	-	-	-5	-	-9.6	-	0.6	-
		BENGA	10-Jul-14	Maxxam	N	-	190	-	-	22	-	-	-	-	-5.6	-5.13	-8.21	-8.07	-0.22	-0.23
		BENGA	23-Oct-14	Maxxam	N	-	-	-	-	-	-	-	-	-	-3.99	-3.61	-7.77	-	2.22	-
		BENGA	27-Jan-15	Maxxam	N	-	-	-	-	-	-	-	-	-	-2.96	-	-8.56	-	-0.01	-
Crowsnest River	SW	BENGA	7-Apr-14	Maxxam	N	160	200	<0.50	7.1	56	-	-	-	-	7	-	-9.1	-	13.4	-
		BENGA	8-May-14	Maxxam	N	150	180	1.4	3.4	37	-	-	-	-	5.1	-	-9.6	-	11.9	-
		BENGA	23-Oct-14	Maxxam	N	-	-	-	-	-	-	-	-	-	4.22	-	-7.59	-	13.32	-
		BENGA	27-Jan-15	Maxxam	N	-	-	-	-	-	-	-	-	-	4.04	4.2	-8.29	-8	14.14	14.6
South Pond	SW	BENGA	8-Apr-14	Maxxam	N	190	230	<0.50	1.8	64	-	-	-	-	0.5	-	-6.1	-	3.9	-
		BENGA	8-May-14	Maxxam	N	40	48	<0.50	<1.0	11	-	-	-	-	-2.1	-	-8.3	-	1.8	-
		BENGA	10-Jul-14	Maxxam	N	-	180	-	-	50	-	-	-	-	-2.59	-	-4.36	-	1.53	-
		BENGA	23-Oct-14	Maxxam	N	-	-	-	-	-	-	-	-	-	-2.97	-2.92	-5.23	-	1.97	-
		BENGA	27-Jan-15	Maxxam	N	-	-	-	-	-	-	-	-	-	-1.54	-	-4.32	-	1.22	-
Gold Creek	SW	BENGA	7-Apr-14	Maxxam	N	140	170	1.2	<1.0	29	-	-	-	-	9.5	-	-7.2	-	9.4	-
		BENGA	8-May-14	Maxxam	N	160	180	3.3	1.3	25	-	-	-	-	3.7	-	-8.7	-	7.3	-
		BENGA	10-Jul-14	Maxxam	N	-	170	-	-	19	-	-	-	-	6.77	-	-6.6	-	11.02	-
		BENGA	23-Oct-14	Maxxam	N	-	-	-	-	-	-	-	-	-	8.77	-	-6.02	-	12.86	13.1
		BENGA	27-Jan-15	Maxxam	N	-	-	-	-	-	-	-	-	-	9.48	-	-6.38	-	11.63	-
East Pond	SW	BENGA	8-Apr-14	Maxxam	N	230	270	5	<1.0	62	-	-	-	-	7	-	-7.6	-	13.9	-
		BENGA	8-May-14	Maxxam	N	28	34	<0.50	<1.0	4.5	-	-	-	-	7.7	-	-10.3	-	12.3	-
		BENGA	10-Jul-14	Maxxam	N	-	220	-	-	51	-	-	-	-	9.3	9.17	-5.08	-5.28	11.04	-
		BENGA	23-Oct-14	Maxxam	N	-	-	-	-	-	-	-	-	-	2.69	-	-6.43	-6.42	10.89	-
		BENGA	27-Jan-15	Maxxam	N	-	-	-	-	-	-	-	-	-	3.43	-	-7.09	-	11.03	-
Small South Pond	SW	BENGA	8-Apr-14	Maxxam	N	140	170	<0.50	<1.0	100	-	-	-	-	-2.6	-	-9	-	-3.9	-
		BENGA	8-May-14	Maxxam	N	130	160	<0.50	<1.0	87	-	-	-	-	-5.8	-	-9.1	-	-3.6	-
		BENGA	10-Jul-14	Maxxam	N	-	150	-	-	87	-	-	-	-	-6.68	-	-5.1	-	-3.46	-
		BENGA	23-Oct-14	Maxxam	N	-	-	-	-	-	-	-	-	-	-6.67	-	-6.14	-	-4.35	-4.47
		BENGA	27-Jan-15	Maxxam	N	-	-	-	-	-	-	-	-	-	-7.07	-	-6.57	-6.59	-4.02	-

Table B12. Isotope Analyses

Location	Type	Data Source	Date (mm/dd/yyyy)	Laboratory	Type	Alkalinity ($CaCO_3$) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Carbonate (CO_3) (mg/L)	Chloride (mg/L)	Sulphate (mg/L)	E^3H Result (TU)	E^3H ± 1σ (TU)	^{14}C (DIC) Fraction of Modern (DIC, pmC)	^{14}C (DIC) ± 1σ (DIC, pmC)	$\delta^{18}O$ Result (VSMOW, ‰)	$\delta^{18}O$ Repeat (VSMOW, ‰)	$\delta^{13}C$ (DOC) Result (PDB, ‰)	$\delta^{13}C$ (DOC) Repeat (PDB, ‰)	$\delta^{34}S$ (SO_4) Result (VCDT, ppt)	$\delta^{34}S$ (SO_4) Repeat (VCDT, ppt)
Greenhill Portal (Main)	Portal	BENGA	7-Apr-14	Maxxam	N	680	830	<0.50	1.4	410	-	-	-	-	6.3	-	-24.2	-	28.7	-
		BENGA	8-May-14	Maxxam	N	590	720	<0.50	1.5	410	-	-	-	-	-1	-	-23.2	-	22.5	-
		BENGA	10-Jul-14	Maxxam	N	-	820	-	-	380	-	-	-	-	-1.81	-1.49	-22.32	-22.12	27.2	-
		BENGA	23-Oct-14	Maxxam	N	-	-	-	-	-	-	-	-	-	-1.69	-1.3	-21.92	-22.07	27.25	27.58
		BENGA	13-Nov-14	Maxxam	N	-	-	-	-	-	9.9	1.1	40.19	0.20	-	-	-23.36	-23.26	24.8	-
		BENGA	27-Jan-15	Maxxam	N	-	-	-	-	-	-	-	-	-	0.7	-	-22.16	-22.3	25.73	-
Bellevue Mine	Mine	BENGA	8-Apr-14	Maxxam	N	230	280	<0.50	1.6	150	-	-	-	-	2.9	-	-8.9	-	7	-
		BENGA	8-Apr-14	Maxxam	FD	230	280	<0.50	1.5	140	-	-	-	-	5.2	-	-13	-	13.2	-
		BENGA	8-May-14	Maxxam	N	300	360	<0.50	<1.0	200	-	-	-	-	-3.2	-	-14.3	-	9.3	-
		BENGA	10-Jul-14	Maxxam	N	-	380	-	-	190	-	-	-	-	-2.27	-2.4	-13.76	-	12.14	-
		BENGA	23-Oct-14	Maxxam	N	-	-	-	-	-	-	-	-	-	0.7	-	-13.23	-	12.96	-
		BENGA	27-Jan-15	Maxxam	N	-	-	-	-	-	-	-	-	-	1.08	0.85	-12.36	-	12.85	13.06

Notes:

Tritium is reported in Tritium Units. 1TU = 3.221 Picocurries/L per IAEA, 2000 Report. 1TU = 0.11919 Becquerels/L per IAEA, 2000 Report.

- : Parameter not Analysed; Not Applicable (for Guidelines Only)

BENGA: Benga Mining Limited

DIC: Dissolved Inorganic Carbon

FD: Field Duplicate

N: Normal Sample

PDB: Pee Dee Belemnite (Standard for Carbon-13 work)

SW: Surface Wtaer

VCDT: Vienna Canyon Diablo Troilote (Standard for Sulphur)

VSMOW: Vienna Standard Mean Ocean Water (Standard for Fresh Water)

Table B13. Landowner Routine Chemistry Results

Location	Date	Laboratory	Inorganics													General Chemistry				
			Alkalinity (T) as CaCO3	Bicarbonate	Calcium	Carbonate	Chloride	Hydroxide	Magnesium	Nitrate (as N)	Nitrate + Nitrite-N	Nitrite (as N)	Potassium	Sodium	Sulphate	Electrical Conductivity (lab)	Ionic Balance	pH (Lab)	Hardness as CaCO3	Total Dissolved Solids
	mm/dd/yyyyy		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mS/cm	%	pH	mg/L	mg/L
CDW (Canadian Drinking Water **MAC** and AO)				-	-	-	250	-	-	**10**	-	**1**	-	200	500	-	90-110	6.5-8.5	-	500
FWAL (ESRD Aquatic Life 2014)			>20	-	-	-	120	-	-	3	-	0.06-0.6*	-	-	429*	-	90-110	6.5-9	-	-
A	9/27/2014	ALS	382	466	85.1	<5	28.1	<5	39.0	<0.05	<0.054	<0.02	1.03	20.8	38.2	0.781	90.9	8.13	373	441
B	9/28/2014	ALS	442	539	75.7	<5	49.0	<5	36.5	<0.05	<0.054	<0.02	0.97	80.2	39.2	0.947	93.3	8.20	339	547
C	9/27/2014	ALS	345	420	101	<5	36.9	<5	24.0	1.59	1.59	<0.02	1.16	10.0	23.6	0.740	87.7	8.05	351	411
D	9/28/2014	ALS	385	470	100	<5	57.0	<5	37.1	0.868	0.868	<0.02	1.28	38.0	55.9	0.910	92.3	8.18	402	524
E	9/27/2014	ALS	376	458	54.0	<5	62.1	<5	18.2	0.096	0.096	<0.02	1.32	114	14.7	0.841	96.0	8.22	210	490
F	10/16/2014	ALS	255	306	73.9	<5	0.89	<5	14.7	0.129	0.129	<0.02	0.94	4.2	15.4	0.444	95.1	8.32	245	264
G	9/28/2014	ALS	405	494	76.2	<5	125	<5	35.6	0.084	0.084	<0.02	2.06	118	50.6	1.16	94.0	8.01	337	651
H	9/27/2014	ALS	427	520	75.3	<5	50.0	<5	36.6	1.08	1.11	0.027	0.95	85.4	29.6	0.930	98.9	8.09	339	539

Notes:

Value exceeds freshwater aquatic life guidelines

Value exceeds drinking water guidelines

Value is outside acceptable QC limits

*Hardness or chloride dependant value

- : Not Applicable (for Guidelines Only)

Table B14. Water Well Records within the Regional Study Area

	Well ID	Easting	Northing	LSD	SEC	TWP	RGE	M	DrillingCompany	Date Completed	Depth (m)	Type of Work	Use	Well Owner	Static Level (m)	Pumping Method	Test Rate (L/min)
LSA	188146	683464	5501362	NE	10	008	04	5	CAMFIELD DRILLING SERVICES LTD.	11/15/84	12.19	New Well	Domestic	LESLIE, KIETH	4.57	Air	5
	341561	681840	5502123	SE	16	008	04	5	DOLLMAN'S WATER WELL DRILLING INC.	07/19/02	32.92	New Well	Domestic	AUFFRAY, ANNI/MIKE	24.41	Pump	4
	354743	681062	5501280	NW	09	008	04	5	UNKNOWN DRILLER	-	0	Chemistry	Domestic	VARE, JOAN	-	-	-
	356307	685064	5503054	NE	14	008	04	5	UNKNOWN DRILLER	-	7.62	Chemistry	Domestic	NEWMAN, SHIRLEY	-	-	-
	359116	681840	5502132	SE	16	008	04	5	CAMFIELD DRILLING SERVICES LTD.	09/16/96	60.05	Deepened	Domestic	CAPPRON, FRANK	13.72	Air	1
	363437	681840	5502132	SE	16	008	04	5	CAMFIELD DRILLING SERVICES LTD.	03/27/92	13.72	New Well	Domestic	SUDWORTH, ELAINE/CAPPRON, F.	4.6	Air	19.7
	365998	681840	5502132	SE	16	008	04	5	UNKNOWN DRILLER	-	0	Spring	Domestic	CAPPRON, FRANK	-	-	-
	366020	681840	5502132	SE	16	008	04	5	UNKNOWN DRILLER	-	13.72	Chemistry	Domestic	FISHER, GORDON W	-	-	-
	369184	681840	5502132	SE	16	008	04	5	CAMFIELD DRILLING SERVICES LTD.	09/29/92	42.67	New Well	Domestic	CAMPBELL, BILL	7.62	Air	3
	372430	681840	5502132	SE	16	008	04	5	CAMFIELD DRILLING SERVICES LTD.	05/05/93	46.02	New Well	Domestic	HERBERT, GUNTHER	6.1	Pump	3
	402136	687580	5501512	NW	07	008	03	5	UNKNOWN DRILLER	-	0	Spring	Domestic	KANTOS, RICHARD	-	-	-
	402146	687544	5508189	14	31	008	03	5	UNKNOWN DRILLER	-	170.69	FSH	Industrial	SCURRY RAINBOW OIL#SP 36	170.69	-	-
	402354	681062	5501280	NW	09	008	04	5	UNKNOWN DRILLER	-	0	Chemistry	Domestic	COLEMAN COLLIERIES	0.03	-	-
	402357	681062	5501280	NW	09	008	04	5	UNKNOWN DRILLER	-	9.14	Chemistry	Domestic	FINN, MICHAEL	1.52	-	-
	402360	680855	5501475	13	09	008	04	5	CAMFIELD DRILLING SERVICES LTD.	08/22/81	30.48	Unknown	Unknown	FAIRBROTHER, BRUCE	-	-	-
	402361	680855	5501475	13	09	008	04	5	CAMFIELD DRILLING SERVICES LTD.	08/22/81	27.43	Unknown	Unknown	FAIRBOTHER, BRUCE	-	-	-
	402363	682061	5501515	16	09	008	04	5	CAMFIELD DRILLING SERVICES LTD.	06/04/82	14.63	New Well	Domestic	FINN, MICHAEL#1	5.79	-	0.5
	402366	682061	5501515	16	09	008	04	5	CAMFIELD DRILLING SERVICES LTD.	06/04/82	9.14	New Well	Domestic	FINN, MICHAEL#2	5.79	P & A	30
	402383	682034	5502340	08	16	008	04	5	ALLAN BROS	07/01/74	62.48	New Well	Domestic	CAPRON, FRANK	21.95	Pump	10
	402388	681840	5502132	SE	16	008	04	5	UNKNOWN DRILLER	-	45.72	Chemistry	Domestic	SHARP, ALLAN	12.19	-	-
	402394	681840	5502132	SE	16	008	04	5	CAMFIELD DRILLING SERVICES LTD.	07/26/85	73.15	New Well	Domestic	SHARP, AL	12.19	Unknown	1
	402397	681035	5502106	SW	16	008	04	5	UNKNOWN DRILLER	-	3.05	Chemistry	Domestic	COPRON, FRANK	0.3	-	-
	402398	681216	5502715	11	16	008	04	5	UNKNOWN DRILLER	-	0	Chemistry	Domestic	TROTZ, LORI	-	-	-
	402414	683089	5507245	07	34	008	04	5	UNKNOWN DRILLER	11/26/78	22.86	FSH	Industrial	CHEVRON STANDARD#SP 26	-	-	-
	402417	682686	5507231	06	34	008	04	5	UNKNOWN DRILLER	11/26/78	22.86	FSH	Industrial	CHEVRON STANDARD#SP 27	-	-	-
	402418	685555	5506916	04	36	008	04	5	UNKNOWN DRILLER	-	0	FSH	Industrial	SCURRY RAINBOW#SP 12	-	-	-
	402419	685944	5507332	06	36	008	04	5	UNKNOWN DRILLER	-	0	FSH	Industrial	SCURRY RAINBOW#SP 23	-	-	-
	404153	688649	5511878	04	17	009	03	5	UNKNOWN DRILLER	-	0	FSH	Industrial	TEXACO EXPL	-	-	-
	404164	685889	5508959	06	01	009	04	5	UNKNOWN DRILLER	-	121.92	FSH	Industrial	SCURRY RAINBOW#26	-	-	-
	404165	682240	5509607	13	03	009	04	5	OTHER	08/16/72	30.48	FSH	Industrial	GULF OIL CAN#26	-	-	-
	404166	682484	5509621	14	03	009	04	5	OTHER	08/16/72	30.48	FSH	Industrial	GULF OIL CAN#25	-	-	-
	468463	681840	5502132	SE	16	008	04	5	DOLLMAN'S WATER WELL DRILLING INC.	09/15/97	35.05	New Well	Domestic	KOWALSKI, LONNY	0.61	Pump	3.5
	469022	681840	5502132	SE	16	008	04	5	CAMFIELD DRILLING SERVICES LTD.	09/11/96	60.96	New Well	Domestic	BARNARD, ANDY	22.86	P & A	2
	469023	681840	5502132	SE	16	008	04	5	DOLLMAN'S WATER WELL DRILLING INC.	12/09/97	67.06	New Well	Domestic	HAMAR, JOE	3.17	Pump	3

Table B14. Water Well Records within the Regional Study Area

	Well ID	Easting	Northing	LSD	SEC	TWP	RGE	M	DrillingCompany	Date Completed	Depth (m)	Type of Work	Use	Well Owner	Static Level (m)	Pumping Method	Test Rate (L/min)
LSA	469024	681035	5502106	SW	16	008	04	5	DOLLMAN'S WATER WELL DRILLING INC.	04/17/98	36.58	New Well	Domestic	OLIVERIE, FLORE	18.2	Pump	10
	469025	681035	5502106	SW	16	008	4	5	DOLLMAN'S WATER WELL DRILLING INC.	04/09/98	45.72	New Well	Domestic	FEAVER, M.	9.85	Pump	4
	492886	681840	5502132	SE	16	008	04	5	DOLLMAN'S WATER WELL DRILLING INC.	08/27/99	32.31	New Well	Domestic	HAMILTON, RICK	16.15	Pump	9
	492889	681840	5502132	SE	16	008	04	5	DOLLMAN'S WATER WELL DRILLING INC.	05/10/99	48.77	New Well	Domestic	MARITZ, JACOB J.	4.85	Pump	5
	499264	681035	5502106	SW	16	008	04	5	DOLLMAN'S WATER WELL DRILLING INC.	10/18/01	60.96	New Well	Domestic	MACLEOD, IAN	-	-	-
	1064235	686310	5509381	10	01	009	04	5	ALKEN BASIN DRILLING LTD.	04/29/05	109.73	New Well	Industrial	DEVON (PD 425)	54.86	P & A	27
	1064236	686310	5509381	10	01	009	04	5	ALKEN BASIN DRILLING LTD.	04/30/05	103.63	New Well	Industrial	DEVON (PD 426)	70.1	P & A	23
	1250064	681055	5502093	SW	16	008	04	5	DOLLMAN'S WATER WELL DRILLING INC.	09/15/04	62.48	New Well	Domestic	APPLEBY, ROBERT	10.78	Air	1.5
	1250139	681849	5502120	SE	16	008	04	5	DOLLMAN'S WATER WELL DRILLING INC.	03/01/04	34.75	New Well	Domestic	EWEN, STACY & MICHELLE	0.79	Pump	5
	1250246	681849	5502120	SE	16	008	04	5	DOLLMAN'S WATER WELL DRILLING INC.	11/14/06	50.29	New Well	Domestic	JMH INDUSTRIES LTD.	9.09	Air	3.5
	1250444	685434	5511777	04	13	009	4	5	DOLLMAN'S WATER WELL DRILLING INC.	08/28/09	62.48	New Well	Domestic	DEVON CANADA	22.74	Air	6
	1250498	681840	5502122	SE	16	008	4	5	DOLLMAN'S WATER WELL DRILLING INC.	09/22/10	42.67	New Well	Domestic	CAPRON, FRANK	10.68	Air	3.75
	1250499	681857	5502486	8	16	008	4	5	DOLLMAN'S WATER WELL DRILLING INC.	09/28/10	23.16	New Well	Domestic	CAPRON, FRANK	14.32	Air	8
	1250500	681840	5502122	SE	16	008	4	5	DOLLMAN'S WATER WELL DRILLING INC.	10/01/10	54.86	New Well	Domestic	FRIEDAY, LLOYD	18.75	Air	4
RSA	341023	688470	5499127	SE	06	008	03	5	CAMFIELD DRILLING SERVICES LTD.	07/21/00	103.63	New Well	Domestic	CLARK, JUDY	59.44	Pump	4
	341024	681894	5500504	SE	09	008	04	5	CAMFIELD DRILLING SERVICES LTD.	09/25/00	38.1	New Well	Municipal	CROWSNEST PASS, MUNICIPAL OF	12.16	Pump	1697.6
	341559	688470	5499115	SE	06	008	03	5	CAMFIELD DRILLING SERVICES LTD.	08/11/99	48.77	New Well	Domestic	VALLEY RIDGE COUNTRY EST	4.57	Air	16
	351916	682775	5498925	SW	03	008	04	5	STAVELY WATER WELLS	07/23/90	73.15	New Well	Domestic	KROSKEY, SPENCER	24.69	Bailer	20
	356302	682775	5498925	SW	03	008	04	5	UNKNOWN DRILLER		16.76	Chemistry	Domestic	HAY, MARGARET	-	-	-
	357732	684435	5498157	NW	35	007	04	5	CAMFIELD DRILLING SERVICES LTD.	03/15/90	18.29	New Well	Domestic	HAY, TREVOR	3.05	Air	6
	357733	684435	5498157	NW	35	007	04	5	CAMFIELD DRILLING SERVICES LTD.	09/12/90	12.19	New Well	Domestic	CHOMYN, JOHN	3.66	Unknown	5
	374110	684435	5498157	NW	35	007	04	5	UNKNOWN DRILLER	01/25/84	4.27	Chemistry	Unknown	ALTA GOVT	-	-	-
	374111	686702	5497231	02	36	007	04	5	KINSELLA DRILLING LTD.	05/22/85	36.58	New Well	Industrial	DEKALB PETRO	2.74	Bailer & Pump	10
	374115	684400	5498982	SW	02	008	04	5	CAMFIELD DRILLING SERVICES LTD.	04/13/85	36.58	New Well	Municipal	CROSWNEST PASS, MD OF	-	-	-
	395327	684206	5498774	04	02	008	04	5	CAMFIELD DRILLING SERVICES LTD.	04/13/85	34.14	New Well	Municipal	CROWSNEST PASS, MUN OF	10.49	Pump	1413

Table B14. Water Well Records within the Regional Study Area

	Well ID	Easting	Northing	LSD	SEC	TWP	RGE	M	DrillingCompany	Date Completed	Depth (m)	Type of Work	Use	Well Owner	Static Level (m)	Pumping Method	Test Rate (L/min)
RSA	395350	684789	5499397	SE	02	008	04	5	CAMFIELD DRILLING SERVICES LTD.	05/21/85	11.28	Old Well-Test	Municipal	ALTA ENV #OBS WELL	10.61	NA	
	401892	687723	5497469	SW	31	007	03	5	UNKNOWN DRILLER	-	6.1	Chemistry	Domestic	FRIESEN, GREY	1.52		
	401893	687528	5497261	04	31	007	03	5	BEAGRIE KARL J	07/27/78	15.54	New Well	Municipal	FRANK, VILLAGE OF	8.29	Pump	240
	401894	687528	5497261	04	31	007	03	5	BEAGRIE KARL J	07/14/78	13.72	New Well	Municipal	FRANK, VILLAGE OF	8.29	Pump	75
	401895	687695	5498273	NW	31	007	03	5	UNKNOWN DRILLER	-	0	Chemistry	Domestic	KOENTGES, R.	-	-	-
	401934	684435	5498157	NW	35	007	04	5	UNKNOWN DRILLER	-	0	Chemistry	Municipal	EDL, E.	-	-	-
	401935	684435	5498157	NW	35	007	04	5	UNKNOWN DRILLER	-	36.58	Chemistry	Municipal	FRANK	-	-	-
	401936	684850	5497768	SE	35	007	04	5	UNKNOWN DRILLER	-	0	Spring	Unknown	KROPINAK, ANNA	0	-	-
	401937	684850	5497768	SE	35	007	04	5	UNKNOWN DRILLER	-	60.96	Chemistry	Domestic	CROWSNEST PASS, MUN OF	6.1	-	-
	401938	686897	5497439	SE	36	007	04	5	UNKNOWN DRILLER	-	3.05	Chemistry	Domestic	SCOTT, M.	1.52	-	-
	401939	687091	5497647	08	36	007	04	5	UNKNOWN DRILLER	-	0	Spring	Unknown	#TURTLE MOUNTAIN	-	-	-
	401940	686675	5498035	10	36	007	04	5	UNKNOWN DRILLER	-	0	Spring	Unknown	TURTLE MTN#FRANK SPRING	-	-	-
	401941	686273	5498021	11	36	007	04	5	UNKNOWN DRILLER	-	0	Chemistry	Unknown	RESEARCH COUNCIL OF ALTA	-	-	-
	401942	685870	5498007	12	36	007	04	5	UNKNOWN DRILLER	-	0	Spring	Unknown	-	-	-	-
	401943	685857	5498409	13	36	007	04	5	UNKNOWN DRILLER	-	0	Spring	Unknown	-	-	-	-
	401944	686467	5498229	NH	36	007	04	5	UNKNOWN DRILLER	-	0	Chemistry	Municipal	CROWSNEST PASS, MUN OF	-	-	-
	401945	686869	5498243	NE	36	007	04	5	UNKNOWN DRILLER	-	2.74	Chemistry	Domestic	KAYWOLT, ULASTE	2.13	-	-
	402147	689594	5507855	10	32	008	03	5	UNKNOWN DRILLER	-	0	Spring	Unknown		-	-	-
	402149	686033	5499042	SW	01	008	04	5	UNKNOWN DRILLER	-	0	Chemistry	Domestic	FRANK SLIDE INTERPRETIVE CENTR	-	-	-
	402151	686227	5499250	06	01	008	04	5	UNKNOWN DRILLER	-	121.92	FSH	Industrial	SCURRY RAINBOW OIL#SP 26	109.73	-	-
	402152	684206	5498774	04	02	008	04	5	UNKNOWN DRILLER	04/10/75	12.19	Old Well-Test	Observation	#OBSERVATION WELL 1	12.04	Other	260
	402205	684206	5498774	04	02	008	04	5	UNKNOWN DRILLER	04/10/75	12.19	Old Well-Test	Observation	CROWSNEST PASS, MUN OF#OW 2	11.86	Pump	260
	402206	684206	5498774	04	02	008	04	5	UNKNOWN DRILLER	04/10/75	13.41	Old Well-Test	Municipal	BLAIRMORE, TOWN OF#PRODUCTION	12.89	Pump	260
	402207	683372	5499146	07	03	008	04	5	WATSON DRLG	11/30/70	25.91	New Well	Domestic	TEXACO OIL	18.59	Pump	2
	402208	682748	5499729	NW	03	008	04	5	OTHER	05/05/64	13.72	New Well	Municipal	CLINIC, CROWSNEST PASS	2.44	Pump	9
	402308	681894	5500504	SE	09	008	04	5	UNKNOWN DRILLER	-	28.96	Chemistry	Unknown	CROWSNEST PASS, MUN OF	1.83	-	-
	402309	681894	5500504	SE	09	008	04	5	UNKNOWN DRILLER	-	4.27	Chemistry	Domestic	MICHALSKY, TERRY	3.05	-	-
	402310	681894	5500504	SE	09	008	04	5	UNKNOWN DRILLER	-	6.1	Chemistry	Unknown	MICHALSKY, T.	3.05	-	-
	402311	681894	5500504	SE	09	008	04	5	VANDRIESTEN WM	11/01/72	6.71	New Well	Domestic	PYTLARY, J.	1.52	Pump	7
	402312	681894	5500504	SE	09	008	04	5	UNKNOWN DRILLER	-	15.85	Chemistry	Domestic	NATAL FOREST PRODUCTS	10.67	-	-
	402313	681894	5500504	SE	09	008	04	5	VANDRIESTEN WM	04/23/76	28.65	New Well	Domestic	SNYDER, P.	15.24	Unknown	3
	402314	682102	5500309	01	09	008	04	5	CAMFIELD DRILLING SERVICES LTD.	06/15/82	11.58	Test Hole	Investigation	NATAL FOREST PRODUCTS		-	-
	402316	681699	5500296	02	09	008	04	5	CAMFIELD DRILLING SERVICES LTD.	06/14/82	23.16	New Well	Domestic	MICHALSKI, TED	2.59	P & A	15
	402317	681894	5500504	SE	09	008	04	5	UNKNOWN DRILLER	-	22.86	Chemistry	Domestic	NATAL FOREST PRODUCTS	2.29	-	-
	402319	681894	5500504	SE	09	008	04	5	UNKNOWN DRILLER	-	15.24	Chemistry	Domestic	KNIGHT, GEORGE		-	-

Table B14. Water Well Records within the Regional Study Area

	Well ID	Easting	Northing	LSD	SEC	TWP	RGE	M	DrillingCompany	Date Completed	Depth (m)	Type of Work	Use	Well Owner	Static Level (m)	Pumping Method	Test Rate (L/min)
RSA	402320	681894	5500504	SE	09	008	04	5	CAMFIELD DRILLING SERVICES LTD.	02/01/83	22.86	Test Hole	Observation	CROWSNEST PASS, MUN OF	2.07	Pump	-
	402321	681699	5500296	02	09	008	04	5	CAMFIELD DRILLING SERVICES LTD.	01/26/83	24.38	Test Hole	Observation	CROWSNEST PASS, MUN OF	2.01	Pump	-
	402322	681894	5500504	SE	09	008	04	5	CAMFIELD DRILLING SERVICES LTD.	03/12/82	35.05	New Well	Unknown	CROWSNEST PASS, MUN OF	1.74	Pump	500
	402323	681686	5500698	07	09	008	04	5	CAMFIELD DRILLING SERVICES LTD.	01/05/84	24.38	New Well	Municipal	CROWSNEST PASS, MUN OF	1.71	-	-
	402324	681894	5500504	SE	09	008	04	5	UNKNOWN DRILLER	-	21.03	Chemistry	Municipal	CROWSNEST PASS, MUN OF		-	-
	402330	681686	5500698	07	09	008	04	5	CAMFIELD DRILLING SERVICES LTD.	04/25/85	9.75	New Well	Domestic & Stock	MICHALSKI, TERRY	4.88	Air	40
	402332	681089	5500477	SW	09	008	04	5	UNKNOWN DRILLER	-	7.62	Chemistry	Domestic	SKRZYZALA, L.	1.83	-	-
	402334	681089	5500477	SW	09	008	04	5	VANDRIESTEN WM	11/01/72	6.71	New Well	Domestic	BELLAK, R.	1.83	Pump	8
	402338	681089	5500477	SW	09	008	04	5	VANDRIESTEN WM	11/29/76	46.33	New Well	Domestic	SHARP, A.	0	Bailer	2
	402341	681089	5500477	SW	09	008	04	5	UNKNOWN DRILLER	-	24.38	Chemistry	Domestic	CROWSNEST PASS, MUN OF	0.91	-	-
	402343	681089	5500477	SW	09	008	04	5	UNKNOWN DRILLER	-	23.77	Chemistry	Domestic	MICHALSKY	1.83	-	-
	402346	681089	5500477	SW	09	008	04	5	UNKNOWN DRILLER	-	4.57	Chemistry	Domestic	ZUR, WALTER	-	-	-
	402350	681089	5500477	SW	09	008	04	5	UNKNOWN DRILLER	-	0	Chemistry	Domestic	REMUS, BARRY	-	-	-
	402351	681089	5500477	SW	09	008	04	5	UNKNOWN DRILLER	-	7.01	Chemistry	Domestic	SANYSHYN, JOHN	-	-	-
	402378	681478	5500892	00	09	008	04	5	UNKNOWN DRILLER	-	3.96	Chemistry	Domestic	WATT, GEORGE	-	-	-
	402381	683524	5500561	SE	10	008	04	5	UNKNOWN DRILLER	-	12.19	Chemistry	Domestic	OLD CLINIC BLDG	6.1	-	-
	402382	686778	5500681	SE	12	008	04	5	UNKNOWN DRILLER	-	36.58	Chemistry	Domestic	PINSENT, WESLEY	-	-	-
	403164	685158	5518655	05	01	010	04	5	MID-WEST WATER WELLS LTD.	08/30/83	91.44	New Well	Industrial	HOME OIL/MONTGOMERY 49	10.67	Pump	30
	403165	685158	5518655	05	01	010	04	5	MID-WEST WATER WELLS LTD.	08/31/83	30.48	New Well	Domestic	HOME OIL/MONTGOMERY 49 #CAMP	9.14	Pump	10
	403166	685158	5518655	05	01	010	04	5	MID-WEST WATER WELLS LTD.	08/31/83	36.58	New Well	Industrial	HOME OIL/MONTGOMERY 49 #RIG2	10.67	Pump	30
	403175	685489	5520680	11	12	010	04	5	UNKNOWN DRILLER	08/12/70	0	Spring	Domestic	RCA	-	-	-
	403180	685194	5523310	SW	24	010	04	5	UNKNOWN DRILLER	07/04/67	27.43	Chemistry	Domestic	RACEHORSE REC AREA	23.77	-	-
	403181	685582	5523725		24	010	04	5	SOUTHERN ALBERTA DRILLING & SERVICING CO. LTD.	09/07/68	27.43	New Well	Municipal	RACEHORSE REC AREA	10.67	Bailer	10
	403182	685194	5523310	SW	24	010	04	5	UNKNOWN DRILLER	-	18.9	Chemistry	Domestic	RACEHORSE REC AREA	6.1	-	-
	403183	685194	5523310	SW	24	010	04	5	CAMFIELD DRILLING SERVICES LTD.	10/03/81	9.14	New Well	Domestic	ALTA FOREST SVC	4.24	Pump	2.5
	403184	685402	5523116	03	24	010	04	5	OTHER	09/16/65	8.53	New Well	Domestic	RACEHORSE CAMPGROUND	3.35	Unknown	8
	404169	685187	5517829	13	36	009	04	5	OTHER	-	0	FSH	Industrial	-	-	-	-
	404170	685187	5517829	13	36	009	04	5	OTHER	-	0	FSH	Industrial	-	-	-	-
	404171	681495	5512669	16	16	9	4	5	UNKNOWN DRILLER	-	0	Spring	Unknown	WAKALUK, ALEX	-	-	-
	412714	682775	5498925	SW	03	008	04	5	CAMFIELD DRILLING SERVICES LTD.	08/25/94	77.11	New Well	Domestic	NEWSOM C/O REIMER CONSTR	20.97	Pump	5
	412729	682775	5498925	SW	03	008	04	5	CAMFIELD DRILLING SERVICES LTD.	08/16/94	30.48	New Well	Domestic	MOHAMED, SALIM SHAH #SITE 1	5.18	Pump	10
	412730	682775	5498925	SW	03	008	04	5	CAMFIELD DRILLING SERVICES LTD.	08/29/94	79.25	New Well	Domestic	DUDLEY, THOMAS	6.1	Pump	5
	466009	682775	5498925	SW	03	008	04	5	DOLLMAN'S WATER WELL DRILLING INC.	06/15/96	16.76	New Well	Domestic	ANCTIL, GARRY	2.44	Pump	12

Table B14. Water Well Records within the Regional Study Area

	Well ID	Easting	Northing	LSD	SEC	TWP	RGE	M	DrillingCompany	Date Completed	Depth (m)	Type of Work	Use	Well Owner	Static Level (m)	Pumping Method	Test Rate (L/min)
RSA	467012	682775	5498925	SW	03	008	04	5	DOLLMAN'S WATER WELL DRILLING INC.	02/14/97	21.34	New Well	Domestic	BIGCHARLES, DON	7.92	Pump	5
	467013	682775	5498925	SW	03	008	04	5	DOLLMAN'S WATER WELL DRILLING INC.	02/20/97	20.73	New Well	Domestic	BIGCHARLES, DON	7.77	Pump	4.5
	467014	682775	5498925	SW	03	008	04	5	DOLLMAN'S WATER WELL DRILLING INC.	03/19/97	22.25	New Well	Domestic	BIGCHARLES, DON	0.61	Pump	4.5
	467017	682775	5498925	SW	03	008	04	5	DOLLMAN'S WATER WELL DRILLING INC.	04/14/97	57.91	New Well	Domestic	BIGCHARLES, DON	9.45	Pump	4.75
	468780	682775	5498925	SW	03	008	04	5	DOLLMAN'S WATER WELL DRILLING INC.	03/27/97	36.88	New Well	Domestic	BIGCHARLES, DON	10.42	Pump	5
	492888	682775	5498925	SW	03	008	04	5	DOLLMAN'S WATER WELL DRILLING INC.	05/12/99	42.67	New Well	Domestic	STAHL, KEN	11.37	Pump	5.27
	495497	688470	5499127	SE	6	8	3	5	DOLLMAN'S WATER WELL DRILLING INC.	10/21/10	60.96	Reconstructed	Domestic	POZZI, JOE	-	-	-
	495498	688470	5499127	SE	06	008	03	5	CAMFIELD DRILLING SERVICES LTD.	10/09/97	10.67	New Well	Domestic	KOENTGES SUBDIV#SITE 2	2.35	Pump	6.5
	495499	688470	5499127	SE	06	008	03	5	CAMFIELD DRILLING SERVICES LTD.	02/09/98	79.25	New Well	Domestic	KOENTGES SUBDIV	21.34	Pump	5.2
	499176	688470	5499127	SE	06	008	03	5	CAMFIELD DRILLING SERVICES LTD.	10/16/97	71.63	New Well	Domestic	KOENTGES SUBDIV#SITE 3	20.97	Pump	8.79
	1170093	688641	5499256	8	6	8	3	5	DOLLMAN'S WATER WELL DRILLING INC.	05/25/10	91.44	Reconstructed	Domestic	CIONI, TONY	-	-	-
	1170095	688457	5499118	SE	06	008	03	5	CAMFIELD DRILLING SERVICES LTD.	02/06/03	67.06	New Well	Domestic	VALLEY RIDGE ESTATE	21	Air	0.33
	1170096	688457	5499118	SE	06	008	03	5	CAMFIELD DRILLING SERVICES LTD.	10/07/03	42.67	New Well	Domestic	VALLEY RIDGE ESTATES	12.19	Air	15
	1170101	688457	5499118	SE	6	8	3	5	CAMFIELD DRILLING SERVICES LTD.	10/15/02	89.92	New Well	Domestic	VALLEY RIDGE ESTATES	59.45	Air	5.94
	1170103	688457	5499118	SE	6	8	3	5	CAMFIELD DRILLING SERVICES LTD.	10/04/03	88.39	New Well	Domestic	VALLEY RIDGE ESTATES	24.99	Air	4.5
	1170105	688457	5499118	SE	06	008	03	5	CAMFIELD DRILLING SERVICES LTD.	07/07/00	48.77	New Well	Domestic	PASKUSKI, ALBERT	15.24	Pump	8.91
	1170109	688457	5499118	SE	06	008	03	5	CAMFIELD DRILLING SERVICES LTD.	10/04/03	73.15	New Well	Domestic	VALLEY RIDGE ESTATES	24.99	Air	4.5
	1170129	686759	5498437	15	36	007	04	5	CAMFIELD DRILLING SERVICES LTD.	03/06/07	55.78	New Well	Domestic	VALLEY RIDGE EST	3.1	Unknown	5
	1170132	684413	5498968	SW	02	008	04	5	CAMFIELD DRILLING SERVICES LTD.	05/04/07	48.77	New Well	Domestic	HAY, TREVOR	17.37	Air	20
	1170149	687815	5498473	14	31	007	03	5	CAMFIELD DRILLING SERVICES LTD.	07/26/07	32	New Well	Domestic	VALLEY RIDGE COUNTRY EST	1.52	Air	10
	1170150	688348	5498492	15	31	007	03	5	CAMFIELD DRILLING SERVICES LTD.	07/31/07	30.48	New Well	Domestic	VALLEY RIDGE COUNTRY EST	12.8	Pump	20
	1170151	688486	5498295	NE	31	007	03	5	CAMFIELD DRILLING SERVICES LTD.	08/08/07	32	New Well	Domestic	VALLEY RIDGE COUNTRY ESTATES	12.5	Air	7
	1170151	688486	5498295	NE	31	007	03	5	CAMFIELD DRILLING SERVICES LTD.	08/08/07	32	New Well	Domestic	VALLEY RIDGE COUNTRY ESTATES	12.5	Pump	7
	1170152	687557	5498199	NW	31	007	03	5	CAMFIELD DRILLING SERVICES LTD.	03/03/07	67.06	New Well	Domestic	VALLEY RIDGE COUNTRY ESTATES	16.76	Air	7
	1170153	687691	5498268	NW	31	007	03	5	CAMFIELD DRILLING SERVICES LTD.	08/09/07	32	New Well	Domestic	VALLEY RIDGE COUNTRY ESTATES	7.62	Air	7

Table B14. Water Well Records within the Regional Study Area

	Well ID	Easting	Northing	LSD	SEC	TWP	RGE	M	DrillingCompany	Date Completed	Depth (m)	Type of Work	Use	Well Owner	Static Level (m)	Pumping Method	Test Rate (L/min)
RSA	1170153	687691	5498268	NW	31	007	03	5	CAMFIELD DRILLING SERVICES LTD.	08/09/07	32	New Well	Domestic	VALLEY RIDGE COUNTRY ESTATES	7.62	Air	7
	1170156	688457	5499118	SE	06	008	03	5	CAMFIELD DRILLING SERVICES LTD.	11/18/99	42.67	New Well	Domestic	VALLEY RIDGE ESTATES	18.29	Air	6.93
	1170181	687691	5498268	NW	31	007	03	5	CAMFIELD DRILLING SERVICES LTD.	09/04/07	152.4	New Well	Domestic	VALLEY RIDGE COUNTRY ESTATES	9.14	Air	3
	1170182	687691	5498268	NW	31	007	03	5	CAMFIELD DRILLING SERVICES LTD.	09/14/07	109.73	New Well	Domestic	VALLEY RIDGE COUNTRY ESTATES	12.19	Air	3.5
	1170183	687691	5498268	NW	31	007	03	5	CAMFIELD DRILLING SERVICES LTD.	03/18/07	67.06	New Well	Domestic	VALLEY RIDGE COUNTRY ESTATES	4.57	Air	7
	1170185	688609	5498501	16	31	007	03	5	CAMFIELD DRILLING SERVICES LTD.	03/09/07	109.73	New Well	Observation	VALLEY RIDGE COUNTRY EST	14.02	Pump	0
	1170189	687512	5498321	NW	31	007	03	5	CAMFIELD DRILLING SERVICES LTD.	10/02/07	115.82	New Well	Domestic	VALLEY RIDGE COUNTRY ESTATES	28.96	Air	3
	1170190	687472	5498319	NW	31	007	03	5	CAMFIELD DRILLING SERVICES LTD.	10/08/07	140.21	New Well	Domestic	VALLEY RIDGE COUNTRY ESTATES	35.05	Air	3
	1170192	687691	5498268	NW	31	007	03	5	CAMFIELD DRILLING SERVICES LTD.	10/22/07	121.92	New Well	Domestic	VALLEY RIDGE COUNTRY ESTATES	24.38	Air	15
	1170193	687691	5498268	NW	31	007	03	5	CAMFIELD DRILLING SERVICES LTD.	10/29/07	140.21	New Well	Domestic	VALLEY RIDGE COUNTRY ESTATES	6.1	Air	5
	1170195	687691	5498268	NW	31	007	03	5	CAMFIELD DRILLING SERVICES LTD.	11/05/07	36.58	New Well	Domestic	VALLEY RIDGE COUNTRY ESTATES	9.45	Air	20
	1170196	688064	5498448	14	31	7	3	5	CAMFIELD DRILLING SERVICES LTD.	11/29/07	152.4	New Well	Domestic	VALLEY RIDGE COUNTRY ESTATES	6.71	Air	2
	1170230	687562	5498549	13	31	7	3	5	CAMFIELD DRILLING SERVICES LTD.	07/14/08	48.77	New Well	Domestic	VALLEY RIDGE ESTATES	6.4	Air	10
	1170243	689400	5500643	03	8	8	3	5	CAMFIELD DRILLING SERVICES LTD.	07/24/08	42.67	New Well	Domestic	LIVINGSTONE VENTURES LTD.	0	Pump	10
	1170244	689358	5500703	03	8	8	3	5	CAMFIELD DRILLING SERVICES LTD.	08/05/08	48.77	New Well	Observation	LIVINGSTONE VENTURES LTD.	0	Water Levels Only	-
	1170250	687728	5498483	14	31	7	3	4	CAMFIELD DRILLING SERVICES LTD.	08/22/08	42.67	New Well	Domestic	VALLEY RIDGE ESTATES	7.62	Air	10
	1170251	687798	5498279	14	31	7	3	5	CAMFIELD DRILLING SERVICES LTD.	08/29/08	91.44	New Well	Domestic	VALLEY RIDGE ESTATES	11.58	Air	4.5
	1170252	688576	5499501	8	6	8	3	5	CAMFIELD DRILLING SERVICES LTD.	09/02/08	42.67	New Well	Domestic	MURRAY, DAN	6.71	Air	5
	1170253	688512	5499448	8	6	8	3	5	CAMFIELD DRILLING SERVICES LTD.	09/02/08	42.67	New Well	Domestic	MURRAY, DAN	6.71	Air	5
	1170282	688206	5498594	15	31	7	3	5	DOLLMAN'S WATER WELL DRILLING INC.	08/23/11	71.63	Reconstructed	Domestic	AMOS, LANNY	31.52	Pump	12
	1170283	688046	5498587	NW	31	007	03	5	CAMFIELD DRILLING SERVICES LTD.	03/24/09	36.58	New Well	Domestic	VALLEY RIDGE COUNTRY ESTATES	0	Unknown	8
	1170285	688041	5498605	14	31	7	3	5	CAMFIELD DRILLING SERVICES LTD.	03/24/09	36.58	New Well	Domestic	VALLEY RIDGE COUNTRY ESTATES	0	Air	8
	1170286	688452	5498545	15	31	7	3	5	CAMFIELD DRILLING SERVICES LTD.	06/06/09	42.67	New Well	Domestic	VALLEY RIDGE COUNTRY ESTATES	27.43	Air	9
	1170327	688389	5499124	7	6	8	3	5	CAMFIELD DRILLING SERVICES LTD.	10/06/10	64.01	New Well	Domestic	GALAXY HOMES	15.85	Air	10

Table B14. Water Well Records within the Regional Study Area

	Well ID	Easting	Northing	LSD	SEC	TWP	RGE	M	DrillingCompany	Date Completed	Depth (m)	Type of Work	Use	Well Owner	Static Level (m)	Pumping Method	Test Rate (L/min)
RSA	1170352	688124	5498651	14	31	7	3	5	CAMFIELD DRILLING SERVICES LTD.	09/06/11	65.53	New Well	Domestic	VALLEY RIDGE COUNTRY ESTATES	18.29	Air	8
	1170353	688002	5498023	11	31	7	3	5	CAMFIELD DRILLING SERVICES LTD.	08/19/11	66.14	New Well	Domestic	VALLEY RIDGE COUNTRY ESTATES	36.58	Air	20
	1250061	682752	5498912	SW	03	008	04	5	DOLLMAN'S WATER WELL DRILLING INC.	09/25/03	68.58	New Well	Domestic	BEREZNIUK, ROD	19.79	Air	12
	1250137	681903	5500508	SE	09	008	04	5	DOLLMAN'S WATER WELL DRILLING INC.	07/22/04	10.36	New Well	Dewatering	NATAL FOREST PRODUCTS	4.21	Bailer	18
	1250455	682752	5498912	SW	3	8	4	5	DOLLMAN'S WATER WELL DRILLING INC.	11/04/09	62.48	New Well	Domestic	DOERKSEN, JAMES	5.46	Air	15
	1250621	684422	5498159	NW	35	7	4	5	DOLLMAN'S WATER WELL DRILLING INC.	10/09/13	25.91	New Well	Domestic	HAY, TREVOR	7.05	Pump	11
	1250622	684422	5498159	NW	35	7	4	5	DOLLMAN'S WATER WELL DRILLING INC.	10/11/13	25.91	New Well	Domestic	HAY, TREVOR	4.35	Pump	4
	1250623	684422	5498159	NW	35	7	4	5	DOLLMAN'S WATER WELL DRILLING INC.	10/24/13	86.87	New Well	Domestic	HAY, TREVOR	20.72	Pump	1.5
	1250624	684422	5498159	NW	35	7	4	5	DOLLMAN'S WATER WELL DRILLING INC.	10/26/13	99.06	New Well	Domestic	HAY, TREVOR	9.42	Pump	4
	1250700	688469	5499115	SE	6	8	3	5	DOLLMAN'S WATER WELL DRILLING INC.	01/23/15	99.06	New Well	Domestic	SHACKLETON, WAYNE & EDIE	24.54	Air	100.1
	9731006	688475	5499314	8	6	8	3	5	CAMFIELD DRILLING SERVICES LTD.	08/21/03	42.67	New Well	Domestic	GERRY GRIGG	24.69	Pump	22.75

Notes:
-: Information not Available
P & A: Pump and Air
FSH: Flowing Shot Hole

Table B15: Licensed Groundwater and Surface Water Users within the Regional Study Area

	Water Allocation ID	Approval ID	Priority	LSD	SEC	TWP	RGE	M	Applicant	Type	Source	Quantity (m^3)	Pumping Rate*	Consumptive Use (m^3)	Losses (m^3)	Return Flow (m^3)	Specific Purpose	Licence Type	Licenced Date	Expiry Date	Upper Production Interval (mbgs)	Lower Production Interval (mbgs)
LSA	150091	258569	19001227391	NE	7	8	3	5	PUBLIC LAND MANAGEMENT	SW	Gold Creek	104	0	104	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	148565	258631	19001229863	SE	7	8	3	5	PUBLIC LAND MANAGEMENT	SW	Gold Creek	211	0	211	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	148567	258631	19001229865	SE	18	8	3	5	PUBLIC LAND MANAGEMENT	SW	Gold Creek	211	0	211	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	148568	258631	19001229866	NW	18	8	3	5	PUBLIC LAND MANAGEMENT	SW	Gold Creek	211	0	211	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	148569	258631	19001229867	NE	18	8	3	5	PUBLIC LAND MANAGEMENT	SW	Morin Creek	211	0	211	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	148962	258566	19001228261	SW	20	8	3	5	PUBLIC LAND MANAGEMENT	SW	Morin Creek	183	0	183	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	148963	258566	19001228262	NW	20	8	3	5	PUBLIC LAND MANAGEMENT	SW	Morin Creek	183	0	183	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	149025	258616	19001228324	NE	30	8	3	5	PUBLIC LAND MANAGEMENT	SW	Gold Creek	173	0	173	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	148961	258566	19001228260	NE	31	8	3	5	PUBLIC LAND MANAGEMENT	SW	Gold Creek	183	0	183	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	149026	258616	19001228325	SE	31	8	3	5	PUBLIC LAND MANAGEMENT	SW	Gold Creek	173	0	173	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	149027	258616	19001228326	NW	31	8	3	5	PUBLIC LAND MANAGEMENT	SW	Gold Creek	173	0	173	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	148972	258566	19001228271	SW	32	8	3	5	PUBLIC LAND MANAGEMENT	SW	Caudron Creek	183	0	183	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	1667	23668	19880223001	SW	14	8	4	5	SUSTAINABLE RESOURCE	SW	Carbondale River	0	0	0	0	0	FLOODCNT	WRLIC	7-Jun-89	-	-	-
	147479	258580	19001230776	NW	15	8	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	342	0	342	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	221323	308538	20031105016	SE	16	8	4	5	DALE & LETICIA BODOR	GW	Unnamed Aquifer - UC	1250	39.3	1250	0	0	SUBDIVD	WALIC	12-Jun-13	11-Jun-38	-	-
	198160	164944	19191231190	NW	22	8	4	5	PUBLIC LAND MANAGEMENT	SW	Pelletier Creek	14	0	14	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198161	164944	19191231191	NW	22	8	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	14	0	14	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198162	164944	19191231192	SW	22	8	4	5	PUBLIC LAND MANAGEMENT	SW	Pelletier Creek	14	0	14	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	149682	258631	19001228981	NW	23	8	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	121	0	121	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	149683	258631	19001228982	SW	23	8	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	121	0	121	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	149680	258631	19001228979	NW	26	8	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	121	0	121	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	149681	258631	19001228980	SW	26	8	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	121	0	121	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	148561	258631	19001229859	NE	26	8	4	5	PUBLIC LAND MANAGEMENT	SW	Blairmore Creek	211	0	211	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	148562	258631	19001229860	SE	26	8	4	5	PUBLIC LAND MANAGEMENT	SW	Blairmore Creek	211	0	211	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198163	164944	19191231193	NE	27	8	4	5	PUBLIC LAND MANAGEMENT	SW	Pelletier Creek	25	0	25	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198164	164944	19191231194	SE	27	8	4	5	PUBLIC LAND MANAGEMENT	SW	Pelletier Creek	25	0	25	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198165	164944	19191231195	SW	27	8	4	5	PUBLIC LAND MANAGEMENT	SW	Pelletier Creek	14	0	14	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	190923	164944	19191231128	SE	35	8	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	14	0	14	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198171	164944	19191231200	NW	35	8	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	14	0	14	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	190927	261387	19191231132	NE	6	9	3	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	12	0	12	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198180	261387	19191231209	NW	6	9	3	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	12	0	12	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198181	261387	19191231210	SE	6	9	3	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	12	0	12	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	190928	261387	19191231133	NE	7	9	3	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	12	0	12	0	0	REGISTRY	WAREG	29-May-09	-	-	-

Table B15: Licensed Groundwater and Surface Water Users within the Regional Study Area

	Water Allocation ID	Approval ID	Priority	LSD	SEC	TWP	RGE	M	Applicant	Type	Source	Quantity (m³)	Pumping Rate*	Consumptive Use (m³)	Losses (m³)	Return Flow (m³)	Specific Purpose	Licence Type	Licenced Date	Expiry Date	Upper Production Interval (mbgs)	Lower Production Interval (mbgs)
LSA	190944	261387	19191231135	SE	7	9	3	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	12	0	12	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198158	261387	19191231188	SW	7	9	3	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	12	0	12	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198182	261387	19191231211	NW	7	9	3	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	12	0	12	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	190558	166095	18941231922	SW	18	9	3	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	32	0	32	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198172	164944	19191231201	SW	2	9	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	6	0	6	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	190924	164944	19191231129	NW	3	9	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	6	0	6	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198173	164944	19191231202	NE	3	9	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	6	0	6	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198174	164944	19191231203	SE	3	9	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	6	0	6	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	190654	261388	19191231124	SW	4	9	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	5	0	5	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198176	164944	19191231205	NW	10	9	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	19	0	19	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198177	164944	19191231206	SE	10	9	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	6	0	6	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	190926	164944	19191231131	NW	11	9	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	6	0	6	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198178	164944	19191231207	SW	11	9	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	6	0	6	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	190890	261375	18941230112	NE	12	9	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	10	0	10	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	278980	371912		NW	24	8	4	5	BENGA MINING LIMITED	SW	Unnamed Lake - UC	500	0.01	500	0	0	SOTHERA	WATDL	16-Sep-15	15-Sep-16		
RSA	149687	258627	19001228986	NW	32	7	3	5	PUBLIC LAND MANAGEMENT	SW	Surface Runoff	120	0	120	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	26442	45622	19100919001	NW	34	7	4	5	MUNICIPALITY OF CROWSNEST PASS	SW	York Creek	308380	0.105	30840	2470	275070	URBAN	WRLIC	16-Aug-83	-	-	-
	26440	45620	19101025001	NW	35	7	4	5	DEVON CANADA CORPORATION	SW	Crowsnest River	0	0	0	0	0	FLOODCNT	WRLIC	7-Mar-84	-	-	-
	1736	23737	19820706001	NW	36	7	4	5	ALBERTA TRANSPORTATION	SW	Crowsnest River	0	0	0	0	0	FLOODCNT	WRLIC	22-Aug-85	-	-	-
	148564	258631	19001229862	SW	5	8	3	5	PUBLIC LAND MANAGEMENT	SW	Gold Creek	211	0	211	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	194767	261442	18941229921	NE	9	8	3	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	42	0	42	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	192349	261442	18941230684	SE	9	8	3	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	42	0	42	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	194725	261442	18941229902	SE	16	8	3	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	42	0	42	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	192328	261442	18941230673	NE	16	8	3	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	42	0	42	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	148566	258631	19001229864	SW	17	8	3	5	PUBLIC LAND MANAGEMENT	SW	Gold Creek	211	0	211	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	15214	34622	19750522002	4	2	8	4	5	MUNICIPALITY OF CROWSNEST PASS	GW	Unnamed Aquifer - UC	123350	3273.19	24670	0	98680	URBAN	WRLIC	1-Feb-88	-	28.6	31.7
	11835	31853	19790720015	SW	2	8	4	5	CROWSNEST PASS GOLF	SW	Blairmore Creek	1230	0.025	1230	0	0	PRK	WRLIC	7-Jul-89	-	-	-
	15212	34621	19850826003	4	2	8	4	5	MUNICIPALITY OF CROWSNEST PASS	GW	Unnamed Aquifer - UC	1234720	9164.92	246944	0	987776	URBAN	WRLIC	1-Feb-88	-	28	34.1
	15213	34621	19850826007	4	2	8	4	5	MUNICIPALITY OF CROWSNEST PASS	GW	Unnamed Aquifer - UC	0	11587.1	0	0	0	URBAN	WRLIC	1-Feb-88	-	27.4	33.5
	15211	34620	19940217001	4	2	8	4	5	MUNICIPALITY OF CROWSNEST PASS	GW	Unnamed Aquifer - UC	444050	9164.92	88810	0	355240	URBAN	WRLIC	5-May-94	-	28	34.1
	175672	140020	20051102002	SW	2	8	4	5	MUNICIPALITY OF CROWSNEST PASS	GW	Unnamed Aquifer - UC	710000	5616	710000	0	0	URBAN	WALIC	30-May-06	30-May-31	30.8	37.5
	79491	173072	19000601005	NW	3	8	4	5	ROCKY MOUNTAIN ELK F. CANADA	SW	Crowsnest River	77	0	77	0	0	REGISTRY	WAREG	22-Mar-02	-	-	-
	79495	173072	19000601006	SW	3	8	4	5	ROCKY MOUNTAIN ELK F. CANADA	SW	Crowsnest River	78	0	78	0	0	REGISTRY	WAREG	22-Mar-02	-	-	-

Table B15: Licensed Groundwater and Surface Water Users within the Regional Study Area

	Water Allocation ID	Approval ID	Priority	LSD	SEC	TWP	RGE	M	Applicant	Type	Source	Quantity (m^3)	Pumping Rate*	Consumptive Use (m^3)	Losses (m^3)	Return Flow (m^3)	Specific Purpose	Licence Type	Licenced Date	Expiry Date	Upper Production Interval (mbgs)	Lower Production Interval (mbgs)
RSA	1687	23688	19850422003	SE	3	8	4	5	MUNICIPALITY OF CROWSNEST PASS	SW	Blairmore Creek	0	0	0	0	0	FLOODCNT	WRLIC	12-Mar-90	-	-	-
	11834	31852	19940527002	NE	3	8	4	5	CROWSNEST PASS GOLF	SW	Blairmore Creek	111000	0.023	108540	2460	0	PRK	WRINL	9-Aug-95	9-Aug-98	-	-
	198183	164944	19191231212	SE	9	8	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	14	0	14	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198184	164944	19191231213	SE	9	8	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	14	0	14	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	11977	31948	19620630001	7	9	8	4	5	NATAL FOREST PRODUCTS LTD	GW	Unnamed Aquifer - UC	1230	3.73	1230	0	0	OTHR	WRLIC	6-Feb-80	-	0.1	15.2
	14829	34274	19830513002	2	9	8	4	5	MUNICIPALITY OF CROWSNEST PASS	GW	Unnamed Aquifer - UC	1230	4582.45	246	0	984	URBAN	WRLIC	2-Feb-88	-	15.2	22.8
	14830	34274	19830513003	2	9	8	4	5	MUNICIPALITY OF CROWSNEST PASS	GW	Unnamed Aquifer - UC	1230	4582.45	246	0	984	URBAN	WRLIC	2-Feb-88	-	16.1	24.3
	14831	34274	19830513004	2	9	8	4	5	MUNICIPALITY OF CROWSNEST PASS	GW	Unnamed Aquifer - UC	1230	4582.45	246	0	984	URBAN	WRLIC	2-Feb-88	-	18.2	24.3
	44	22044	19960209002	SE	9	8	4	5	NATAL FOREST PRODUCTS LTD	SW	Crowsnest River	0	0	0	0	0	FLOODCNT	WRINL	15-Feb-96		-	-
	190655	164944	19191231125	SW	21	8	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	14	0	14	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	190930	164944	19191231134	NE	21	8	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	14	0	14	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198185	164944	19191231214	SW	21	8	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	14	0	14	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198166	164944	19191231122	NE	28	8	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	14	0	14	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	190921	164944	19191231126	NW	28	8	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	14	0	14	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198134	261388	19191231178	NW	28	8	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	5	0	5	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198135	261388	19191231179	SW	28	8	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	5	0	5	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198167	164944	19191231196	NE	28	8	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	14	0	14	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198168	164944	19191231197	SE	28	8	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	14	0	14	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	190922	164944	19191231127	NE	33	8	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	14	0	14	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198140	261388	19191231184	SW	33	8	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	5	0	5	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198169	164944	19191231198	NE	33	8	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	14	0	14	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198170	164944	19191231199	SW	33	8	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	14	0	14	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	196969	166095	18941227067	SW	20	9	3	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	32	0	32	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	190925	164944	19191231130	NE	9	9	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	19	0	19	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198175	164944	19191231204	NE	9	9	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	19	0	19	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	198179	164944	19191231208	SE	16	9	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	19	0	19	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	76331	158870	19320601005	SE	23	9	4	5	LEONARD & ARDA KLAN	SW	Unnamed Lake - UC	778	0	778	0	0	REGISTRY	WAREG	20-Mar-02	-	-	-
	196973	166095	18941227071	SE	24	9	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	32	0	32	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	72832	178099	19601231646	NW	24	9	4	5	CAMERON, EVELYN	GW	Unnamed Aquifer - UC	3270	0	3270	0	0	REGISTRY	WAREG	18-Mar-02	-	-	27.4
	196974	166095	18941227072	SE	25	9	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	32	0	32	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	191423	166095	18941230224	SW	25	9	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	32	0	32	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	196977	166095	18941227075	SE	36	9	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	32	0	32	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	196978	166095	18941227076	SW	36	9	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	32	0	32	0	0	REGISTRY	WAREG	29-May-09	-	-	-

Table B15: Licensed Groundwater and Surface Water Users within the Regional Study Area

	Water Allocation ID	Approval ID	Priority	LSD	SEC	TWP	RGE	M	Applicant	Type	Source	Quantity (m³)	Pumping Rate*	Consumptive Use (m³)	Losses (m³)	Return Flow (m³)	Specific Purpose	Licence Type	Licenced Date	Expiry Date	Upper Production Interval (mbgs)	Lower Production Interval (mbgs)
RSA	191424	166095	18941230225	NE	36	9	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	32	0	32	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	196979	166095	18941227077	NW	6	10	3	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	32	0	32	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	191425	166095	18941230226	NW	6	10	3	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	32	0	32	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	196980	166095	18941227078	SW	7	10	3	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	32	0	32	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	196981	166095	18941227079	SW	18	10	3	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	32	0	32	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	191426	166095	18941230227	SE	18	10	3	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	32	0	32	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	196982	166095	18941227080	SW	1	10	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	32	0	32	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	196987	166095	18941227084	NE	12	10	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	32	0	32	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	196988	166095	18941227085	NE	13	10	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	32	0	32	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	191430	166095	18941230231	SW	13	10	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	32	0	32	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	196906	261510	18941227045	NE	24	10	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	47	0	47	0	0	REGISTRY	WAREG	29-May-09	-	-	-
	191447	261510	18941230237	NW	24	10	4	5	PUBLIC LAND MANAGEMENT	SW	Unnamed Stream - UC	47	0	47	0	0	REGISTRY	WAREG	29-May-09	-	-	-

Notes:

*Pumping Rate: Surface Water - m³/sec; Groundwater - m³/day

GW: Groundwater

SW: Surface Water

- : information not available

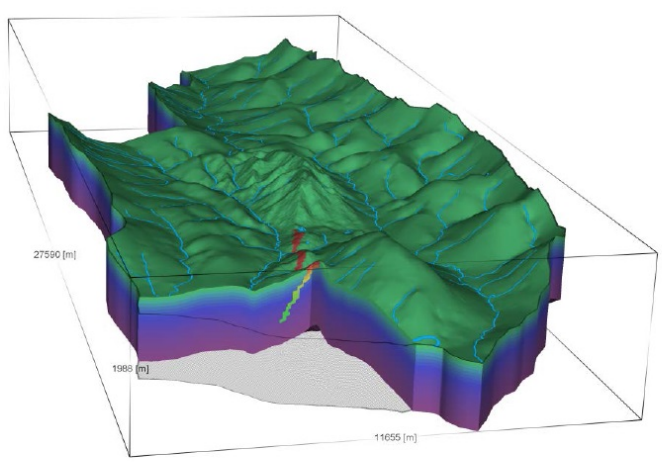
APPENDIX C: GROUNDWATER NUMERICAL MODEL

MILLENNIUM
EMS Solutions Ltd.

Grassy Mountain Coal Project Groundwater Numerical Model 2016

Prepared for

Millennium EMS Solutions Ltd.



Prepared by

srk consulting

SRK Consulting (Canada) Inc.
1CM029.011
August 2016

Grassy Mountain Coal Project
Groundwater Numerical Model 2016

August 2016

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Project No: 1CM029.011

File Name: Grassy_1CM029 011_2016_GW_Model_Update_JM_GF_KTH_20160810_FNL.docx

srk consulting

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List of Abbreviations

AGS	Alberta Geological Survey
AEP	Alberta Environment and Parks
CEAA	Canadian Environmental Agency of Alberta
AER	Alberta Energy Regulator
EIA	Environmental Impact Assessment
EPM	Equivalent Porous Media
EOM	End of Mine
LTC	Long-term Closure
MAP	Mean Annual Precipitation
RPD	Relative Percent Difference

1 Introduction

1.1 Background

The Grassy Mountain Project (The Project) is a proposed coal mine of Benga Mining Limited (Benga), a wholly owned subsidiary of Riversdale Resources (Riversdale), and is located in Southern Alberta, 150 km south of Calgary and about 7 km north of the community of Blairmore. The Project will include the recovery and processing of raw coal and is planned to produce 4.5 million tonnes of clean metallurgical coal annually over 24 years of active mining. The mining development will consist of a series of pits located along the center of the north-northeast-trending “hogsback” ridge of Grassy Mountain, in-pit and ex-pit rock disposal areas, a coal preparation plant and infrastructure including a coal conveyor system, a rail load-out facility, an access corridor, maintenance shops, environmental management systems, and other necessary facilities.

SRK Consulting (SRK) has reviewed and compiled the available hydrogeological data for the Project and constructed a three-dimensional numerical groundwater model on the basis of this information. The model was calibrated to available piezometric head and creek base flow data and, with incorporation of the mine plan, subsequently used to predict the Project’s effects on piezometric levels and creek base flows during the life of the mine and beyond mine closure, as well as assessing the likely quantities of precipitation which would contact mine waste and eventually be discharged as creek base flow.

This information serves as an important data source used to assess the effect of the Project on the groundwater environment and is used as an input to the updated Project site-wide water and load balance (SRK, 2016b).

1.2 Scope of Work

This report presents the results of the 2016 groundwater numerical modelling. The modeling objectives were to estimate:

- The groundwater inflows to the pit during mining operations and following closure;
- The extent of the Project influence on the groundwater system at the end-of-mine (EOM) and for the long-term closure[1] (LTC) phase;
- How the Project will affect the quantity of groundwater discharging into the nearby creeks as base flow; and
- The quantities of precipitation entering the groundwater system following contact with waste rock and travel time to discharge points.

[1] Condition when all closure activities have ceased and groundwater system is at a steady-state, apart for seasonal fluctuations.

1.3 Report Layout

The layout of the report is as follows:

- Section 2 presents a description of the physical environment, the hydrogeological conceptual model and the current mine plan;
- Section 3 describes the numerical model, model calibration and simulation results, model sensitivity and uncertainty; and
- Section 4 presents the study conclusions.

2 Physical Environment and Conceptual Hydrogeological Model

This section presents the data which were used to define the groundwater conceptual model and construct the numerical model. Complete reference information of published documents is provided in the reference list for this report; some unpublished data are also provided in the appendices. The data presentation is followed by a description of the conceptual model of the groundwater system for the pre-mining (baseline) and future conditions, including mining period, end-of-mine (EOM) and long-term closure (LTC).

2.1 Physical Environment

2.1.1 Topography

The Project is located in the Foreland Ranges of the Rocky Mountains, between the High Rock Range and the Livingstone Range. Figure 2-1 shows a satellite view of the Project area, including the mine permit boundary.

The geomorphology of the site is characterized by high rounded hills with moderate to extremely steep slopes at higher elevations grading to more gentle slopes at lower elevations. The elevations vary between a minimum of 1,250 metres above sea level (masl) in the alluvial plain of the Crowsnest River, south of the Project, to a maximum of about 2,514 masl at Caudron Peak, east of the Project. The proposed pit rim elevations range from about 1,525 to 2,070 masl.

One metre LIDAR contours were provided by MEMS and used to define the baseline elevations of the model nodes, with a strong focus on the elevations at the creeks and their tributaries.

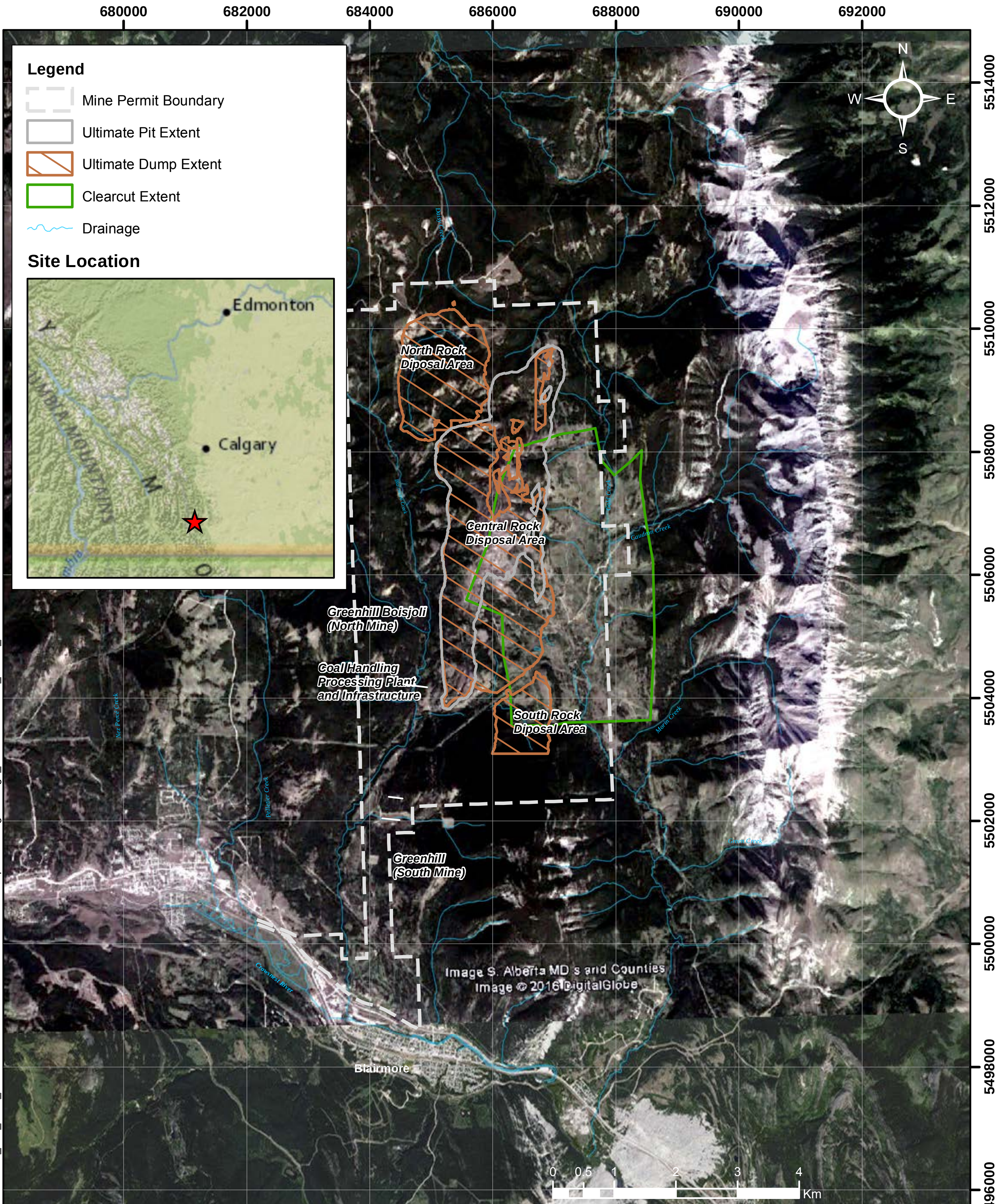
2.1.2 Geology

2.1.2.1 Unconsolidated Geology

The surficial geology consists of pre-glacial, glacial, and recent colluvial and alluvial deposits (Figure 2-2). Mountainous and steeply sloping terrains are mapped as having thin colluvium and till horizons, less than 2 m thick. The Crowsnest River valley and sub-valleys are mapped as containing silty sandy till generally less than three meters in thickness, and coarse grained alluvium, kames, kame terraces and glacial moraines (Waterline, 2013). Figure 2-3 shows the available information on depth to bedrock, which is limited outside of the proposed mining area.

2.1.2.2 Bedrock Geology

The major coal-bearing formation is the Jurassic to Lower Cretaceous Mist Mountain Formation (MMF) of the Kootenay Group. A typical stratigraphic column for the Project area is shown in Figure 2-4. The MMF is underlain by the Morrissey and Fernie formations, and overlain by a conglomerate of the Cadomin Formation.



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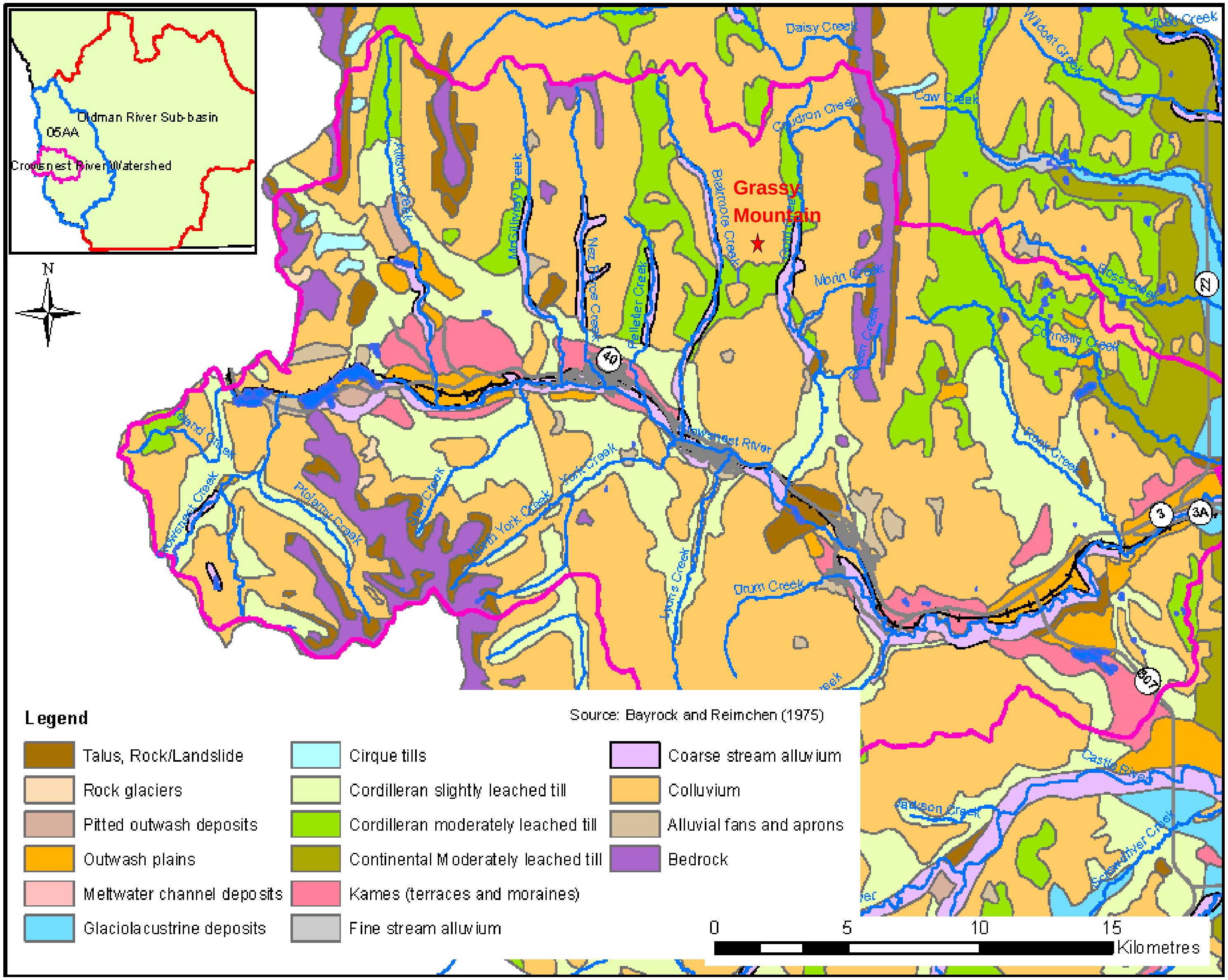
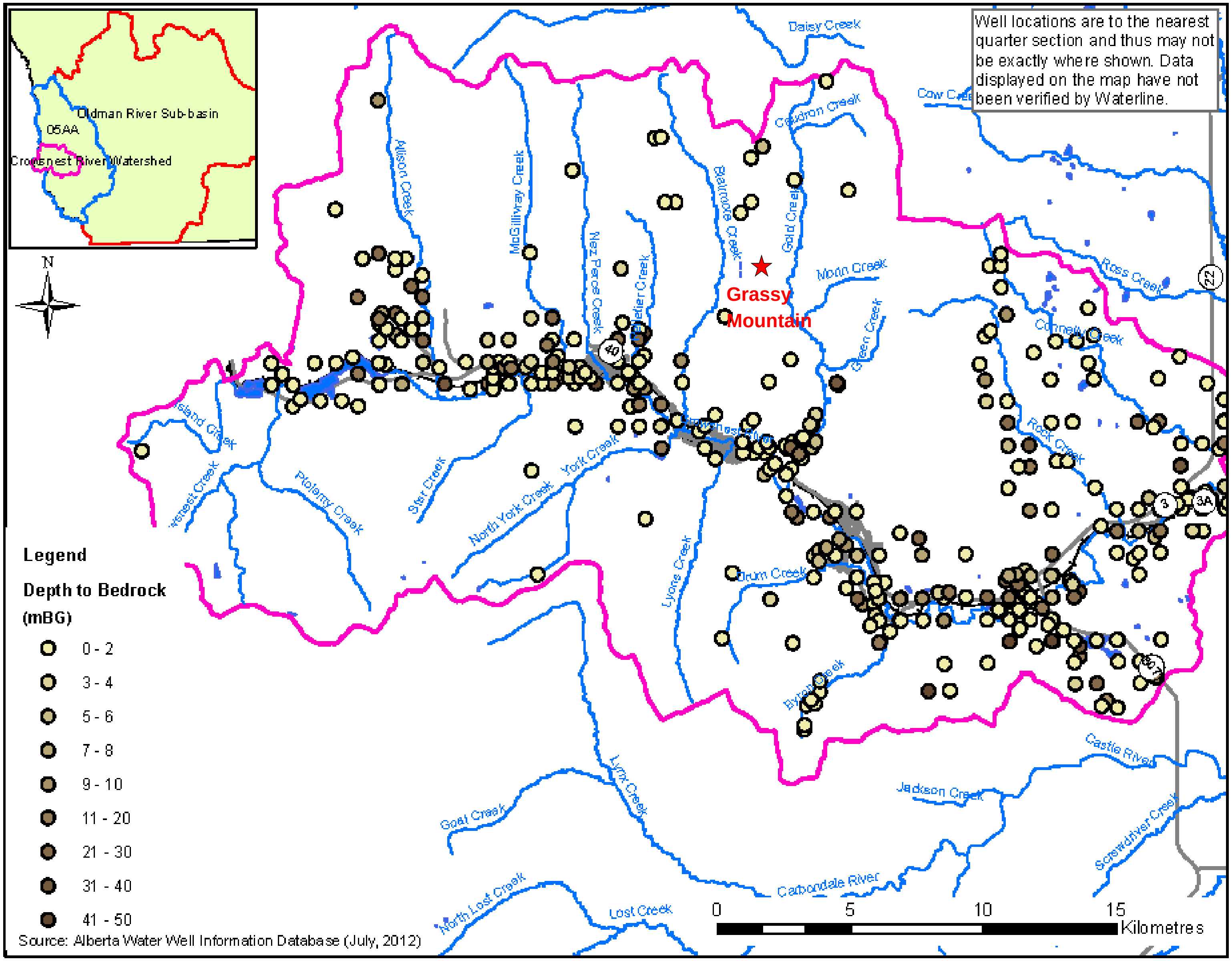
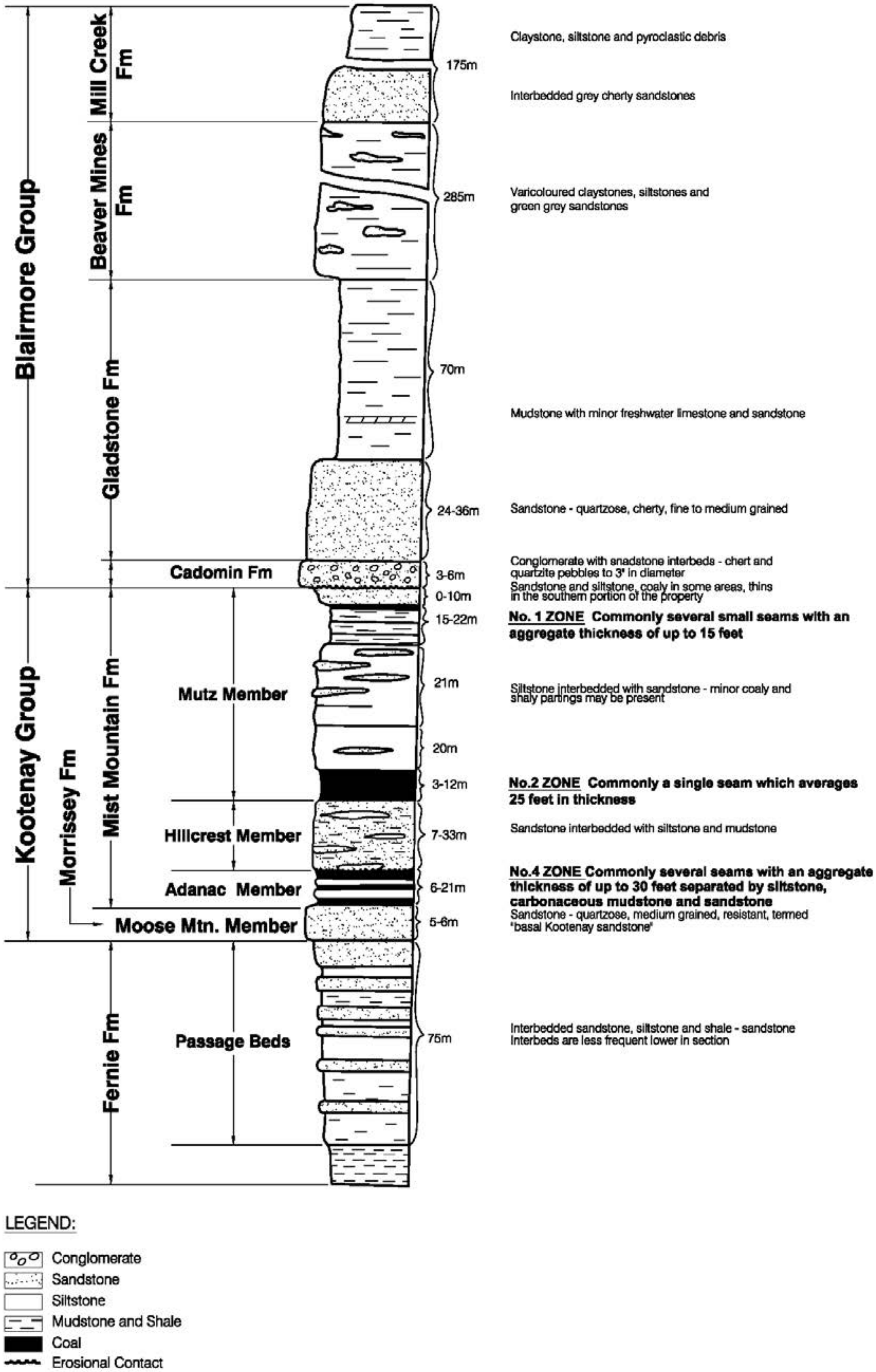
srk consulting	RIVERSDALE RESOURCES	Groundwater Update
		Satellite View of Project
Job No: 1CM029.011 Filename: Fig1_SatelliteOverview_Rev02_JR	Grassy Mountain Coal Project	Date: July 2016 | Approved: GF | Figure: 2-1



srk consulting	RIVERSDALE RESOURCES	Grassy Groundwater Model
		Surficial Geology Map (Waterline, 2013)
Job No: 1CM029.011	Grassy Mountain Coal Project	Date: July 2016 · Approved: GF · Figure: **2-2**



srk consulting	RIVERSDALE RESOURCES	Grassy Groundwater Model
		Depth to Bedrock (Waterline, 2013)
Job No: 1CM029.011	Grassy Mountain Coal Project	Date: July 2016 / Approved: GF / Figure: 2-3



srk consulting

RIVERSDALE RESOURCES

Grassy Groundwater Model

Typical Stratigraphic Column
(Norwest, May 2013)

Job No: 1CM029.011
Filename: Fig6_Stratigraphic Column.pptx

Grassy Mountain Coal Project

Date:	Approved:	Figure:
June 2015	GF	2-4

The Grassy Mountain seams of the MMF in the Kootenay Group outcrop on the Property in a general north-south direction for a strike length of 7 km. The MMF includes 66 to 194 m of cyclic carbonaceous sandstone, mudstone, siltstone, and some conglomerate containing medium volatile bituminous coal seams and is overlain by prominent, erosion-resistant Blairmore conglomerate, sandstones and mudstones (Norwest, 2013). The formation conformably overlies about 210 m of Fernie formation shales. The strata has been strongly folded and faulted, resulting in repetition of coal beds. Bedding dips, on average, 30° towards the west, subject to folding and fault displacement.

A geological map of the Project area and a cross-section are provided in Figure 2-5 and Figure 2-6, respectively.

2.1.2.3 Structural Geology

The Project is located in the Rocky Mountain Foreland Thrust and Fold Belt, and lies between two generally west-dipping thrust faults, in an area of somewhat lesser disturbance.

The strata have been strongly folded and faulted, resulting in sediments and coal zones repeated in parallel bands. Coal deposits of this type are characterized by tight folds, some with steeply inclined or overturned limbs. Fault offsets are common, but fault-bounded plates generally retain normal stratigraphic thickness. Known faults are mapped in Figure 2-5.

The stress regime imposed on bedrock formations in this area has resulted in various fracture patterns. Some fractures are oriented along bedding planes, which are sometimes folded, and secondary vertical to sub-vertical fractures related to thrust faulting.

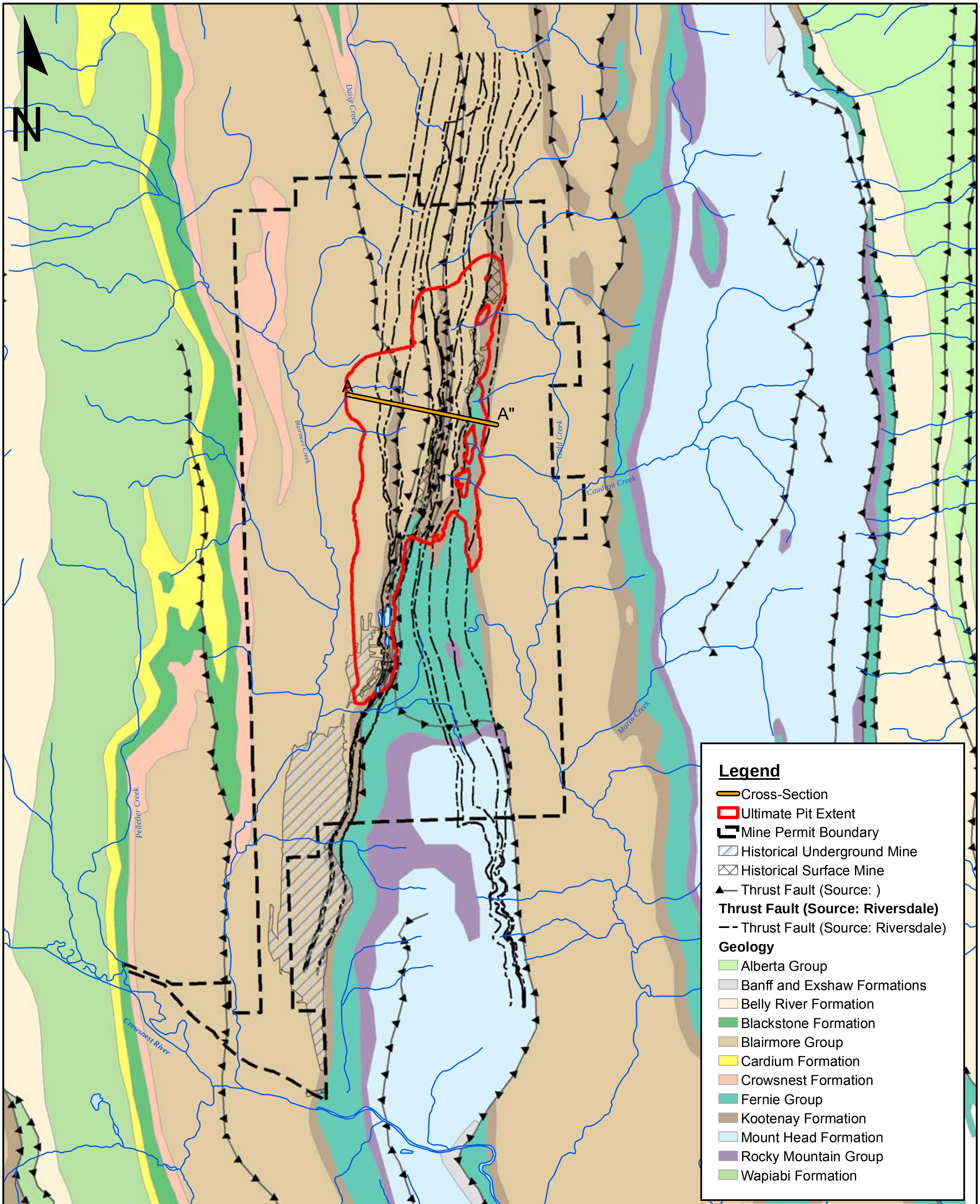
2.1.3 Climate

The Project area is described as having humid continental climate with mild to warm summers and having at least four months with average temperatures greater than 10ºC (Peel, Finlayson, & McMahon, 2007). According to regional analyses (SRK, 2015c), the Mean Annual Precipitation (MAP) at the Property was determined to range from 611 to 992 mm, with a positive linear correlation between precipitation and elevation, resulting in an increase in precipitation at higher elevations, as shown in Figure 2-7. Average monthly precipitation is generally low, between 20 and 32 mm, in the fall and winter (October to February) and peaks at about 88 mm around June. Average lake evaporation and actual evapotranspiration for the Project are 738 mm/year and 262 mm/yr, respectively (SRK, 2015c).

The regional precipitation analyses (SRK, 2015c) concluded that a positive linear correlation exists between precipitation and elevation, with increased precipitation observed at higher elevations, with some spatial variability, as shown in Figure 2-7. This trend is defined by:

$$MAP \approx 0.33 * z + 154$$

Where: z = surface elevation in meters above mean sea level.



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0 750 1,500 Meters

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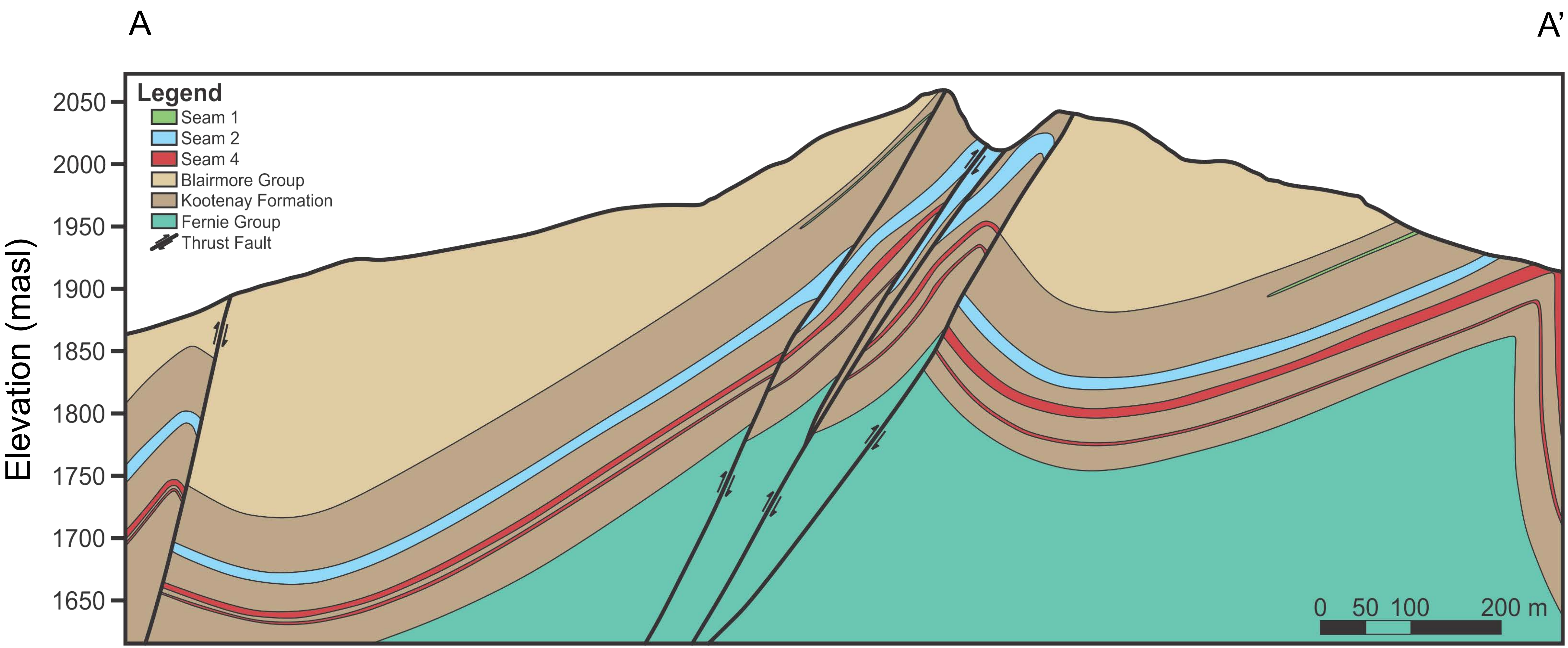
RIVERSDALE RESOURCES

Bedrock Subcrop and Structural Geology Map

Job No: 1CM029.011
Filename: Fig6_Geology_jm_rev02

Grassy Mountain Coal Project

Date: July 2016
Approved: JM
Figure: 2-5



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RIVERSDALE RESOURCES

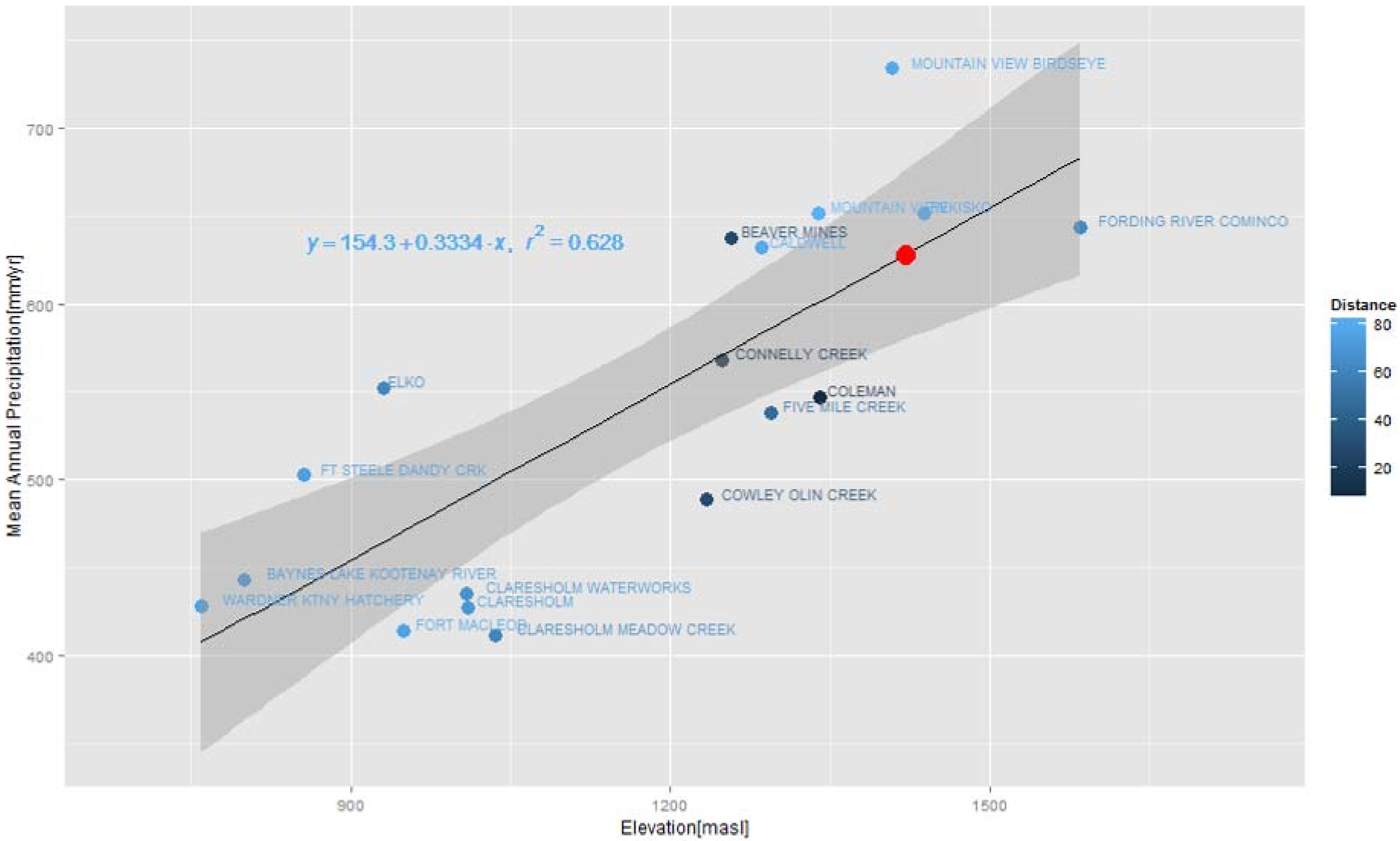
Grassy Mountain Numerical Model

Geological Cross-Section A-A’

Job No: 1CM029.011
Filename: Fig7_Geology_Cross_Section.pptx

Grassy Mountain Coal Project

Date: 6/18/15 | Approved: JM | Figure: **2-6**



Source: 01_SITES\Grassy Mountain\1CM029.007_Hydrotechnical_Engineering\Hydrology\Precipitation\ MAP.jpg

srk consulting	RIVERSDALE RESOURCES	Grassy Groundwater Model
		Mean Annual Precipitation vs. Elevation
Job No: 1CM029.011	Grassy Mountain Coal Project	Date: July 2016 · Approved: GF · Figure: **2-7**

2.1.4 Hydrology

The Project site is located within the Blairmore Creek, Gold Creek and Daisy Creek watersheds (Figure 2-8). The hydrologic characteristics of these watersheds were estimated using data from 18 regional climate stations and 12 regional flow gauging stations located within a 90 km radius from the site, and nine local flow gauging stations located along Crowsnest Creek, Blairmore Creek and Gold Creek (Figure 2-8) (SRK, 2015c). Four of the local flow gauging stations are located along Blairmore Creek, including BL-01, BL-02, BL-03 and BL-04. Two stations, UNC-01 and UNC-02, are located along tributaries of Blairmore Creek. One station is located along Gold Creek, above Morin Creek (GC-01), and one station is located along the Crowsnest River, CR-01. Table 2-1 provides a summary of streamflow data collected to date.

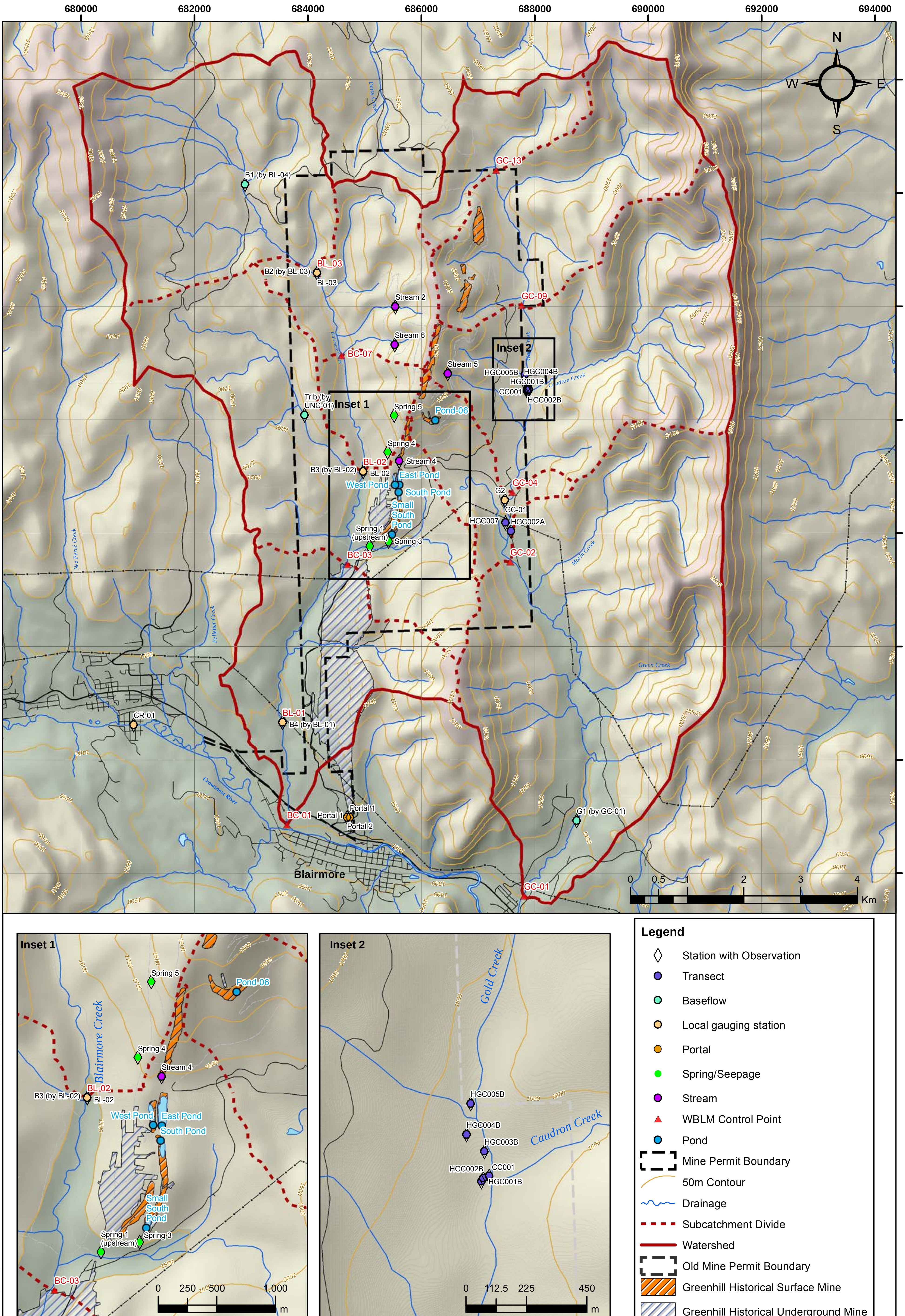
Table 2-1: Summary of Local Streamflow Data Collection

Gauge Station ID	Watershed	Easting[1] [m]	Northing[1] [m]	Watershed Size [km²]	Is Continuous Stage Data Available?	Number of Manual Flow Gauging Measurements	Starting Records	Available Records
BL-01	Blairmore Creek	683555	5500661	48.1	Yes	9	20-Sep-13	23-Dec-16
BL-02	Blairmore Creek	684976	5505089	24.2	Yes	6	18-Oct-13	19-Aug-14
BL-03	Blairmore Creek	684163	5508587	15.4	Yes	7	17-Sep-13	20-Aug-16
BL-04	Blairmore Creek	682891	5510151	8.8	No	3	11-Jun-14	20-Aug-14
CR-01	Crowsnest River	680925	5500619	236.5	Yes	7	21-Sep-13	21-Aug-15
GC-01	Gold Creek	687472	5504582	32.5	Yes	9	19-Sep-13	14-May-16
UNC-01	Unnamed Creek	683939	5506085	6.9	No	4	29-May-14	19-Aug-14
UNC-02	Unnamed Creek	682179	5511085	1.5	No	1	29-May-14	29-May-14

Source: file:///Z:\01_SITES\Grassy Mountain\1CM029.007_Hydrotechnical_Engineering\Hydrology\Hatfield_Data\ProvisionalFlowData_20160602

[1] UTM Coordinate system NAD 83 Zone 11U.

Blairmore Creek is a relatively steep, 50 km^2 catchment, with an average slope of 22%, and elevations ranging between about 1,300 and 2,320 masl, a mean elevation of 1693 masl, flowing from north to south through the valley west of the proposed Project. Gold Creek has similar geomorphological characteristics to Blairmore, with an average slope of 19% and elevations ranging from about 1,300 to 2,514 masl, a mean elevation of 1868 masl, draining an area of 63 km^2 to the east of the proposed Project, discharging into the Crowsnest River approximately 4.5 km downstream of the Blairmore confluence. MAP for the entire Blairmore catchment is estimated at 719 mm and Gold Creek 777 mm. Daisy Creek flows from south to north and drains the north side of the Grassy Mountain. Daisy Creek has an average slope of 7% and elevations ranging from 1,970 to 1,730 masl. It collects runoff from an upstream area of 60 km^2 and discharges into the Oldman River.



D1 is the location used to report baseflow estimates of the groundwater model.

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RIVERSDALE RESOURCES

Watersheds and Surface Water Monitoring Network

Job No: 1CM029.11

Filename: Fig2_Watersheds & HydroStations_Rev01_AD

Grassy Mountain Coal Project

Date:	Approved:	Figure:
July 2016	GF	2-8

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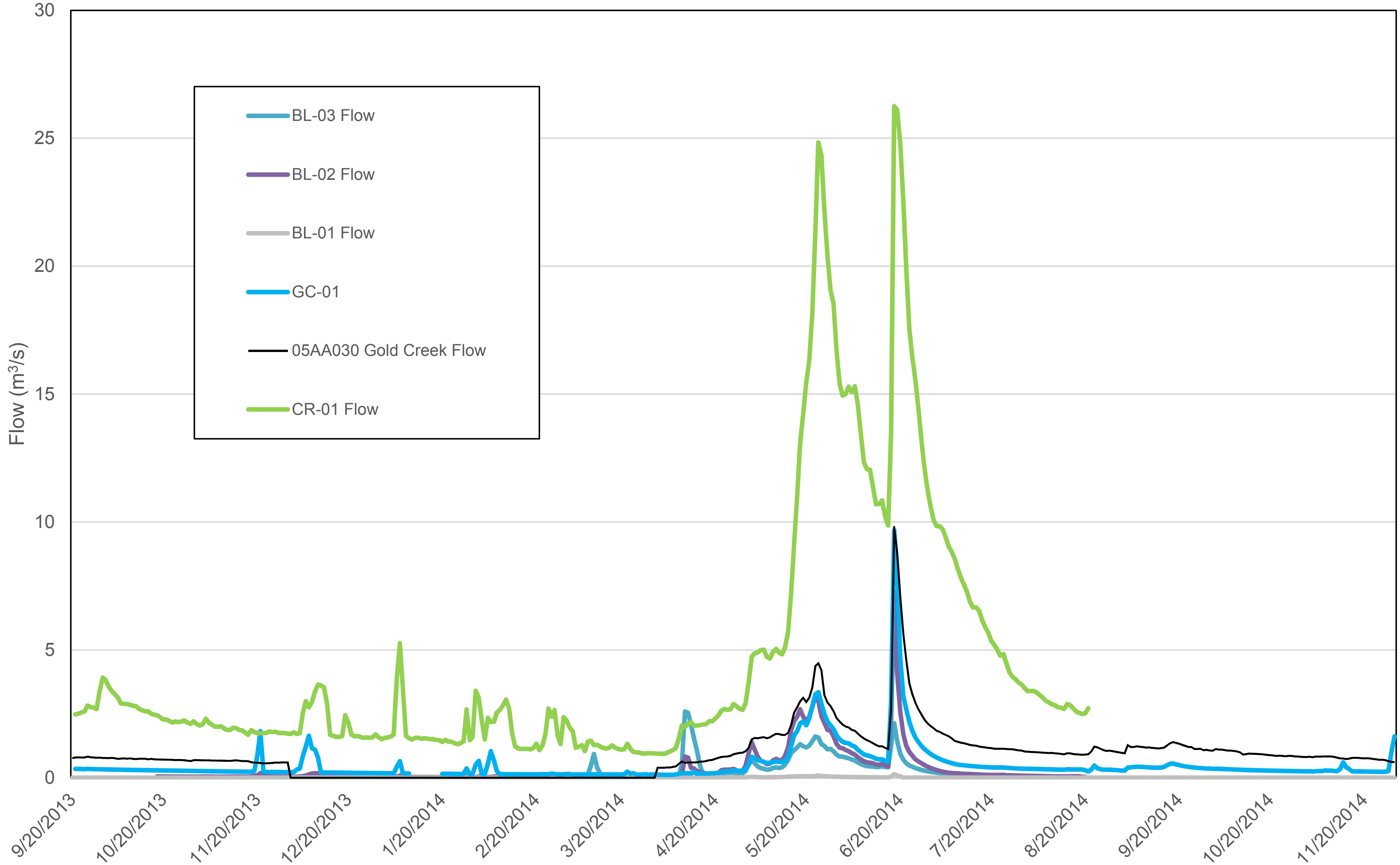
In 2015, SRK (SRK, 2015c) completed a base flow separation analysis on the long-term Crowsnest River data using the Nathan and McMahon (1990) technique to estimate the proportion of groundwater contributing to the creek flows. Surface runoff was separated in two components, defined as quick flow: the portion of stream flow that comes from either surface runoff or interflow; and base flow: the portion of stream flow that includes deep subsurface flow and delayed shallow subsurface flow. At the time of this analysis, the public records from the Crowsnest River station at Frank contained 105 years of flow data. By comparison, the local flow gauging stations on Blairmore and Gold Creeks had only eight months of flow data measured over a period of about one year. A brief analysis of the data available suggested that Gold Creek had higher unit base flows (annual base flow/ catchment area) than Blairmore Creek. However, given the short period of record for the local stations, the base flow analysis undertaken for the Crowsnest River was used as the basis for estimating base flow in Blairmore and Gold Creeks in the 2015 numerical model.

In 2016, SRK updated the analysis, using the method of Nathan and McMahon. Additional “spot”, or manual flow gauging, measurements and continuous stage measurements were provided by Hatfield Consultants (2016), providing for a period of record of up to three years, three months for key stations, with some data gaps. Additional public records from the Crowsnest River station, up to August 2015, were also obtained. This allowed the local datasets to be “patched” based on their relationship with the Crowsnest river flow data, and also to conduct a more complete seasonal evaluation of flow response within the different catchments. Blairmore Creek data were treated differently to Gold Creek due to differences in measured flows within these two watersheds and due to the more detailed data available for Blairmore Creek. Blairmore Creek base flow calculations were more detailed, utilising catchment area relations for each station. At Gold Creek a single expression was applied for the entire catchment since data was available for only a single gauging station.

Figure 2-9 and Figure 2-10 show the total flows and unit flows, respectively, calculated at those stations for which there are continuous measurements of stream stage available. These flows were calculated by Hatfield Consultants using preliminary rating curves. Field surveys and continuous stage measurement are ongoing and these rating curves are expected to be updated at a later date.

Figure 2-11 and Table 2-2 show SRK’s base flow estimates. Note that only the estimates for stations BL-01, BL-02, BL-03 and GC-01 are based on review of continuous stage data. A more comprehensive description of the base flow separation process is provided in SRK (2016a).



Source: U:\01_SITES\Grassy Mountain\1CM029.007_Hydrotechnical_Engineering\Hydrology\Update_2016\Regional_Local_Comparison_v2_FS.xlsx

Data sourced from Hatfield Consultants

srk consulting

RIVERSDALE RESOURCES

Grassy Groundwater Model

Inferred Flow in Blairmore and Gold Creeks, 2013-2014

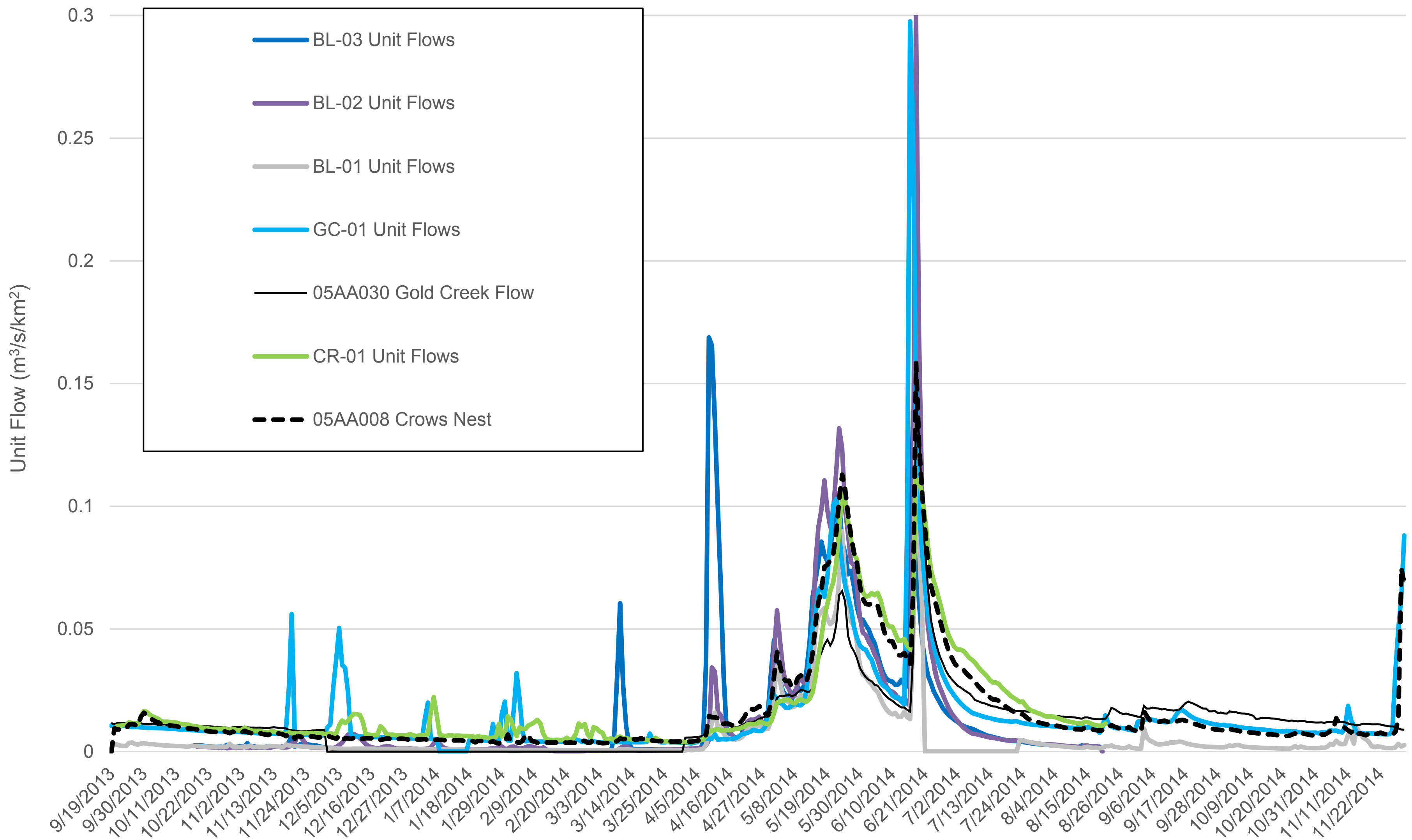
Job No: 1CM029.011

Grassy Mountain Coal Project

Date: July 2016

Approved: GF

Figure: **2-9**



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Data sourced from Hatfield Consultants

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RIVERSDALE RESOURCES

Grassy Groundwater Model

Inferred Unit Flow in Blairmore and Gold Creeks, 2013-2014

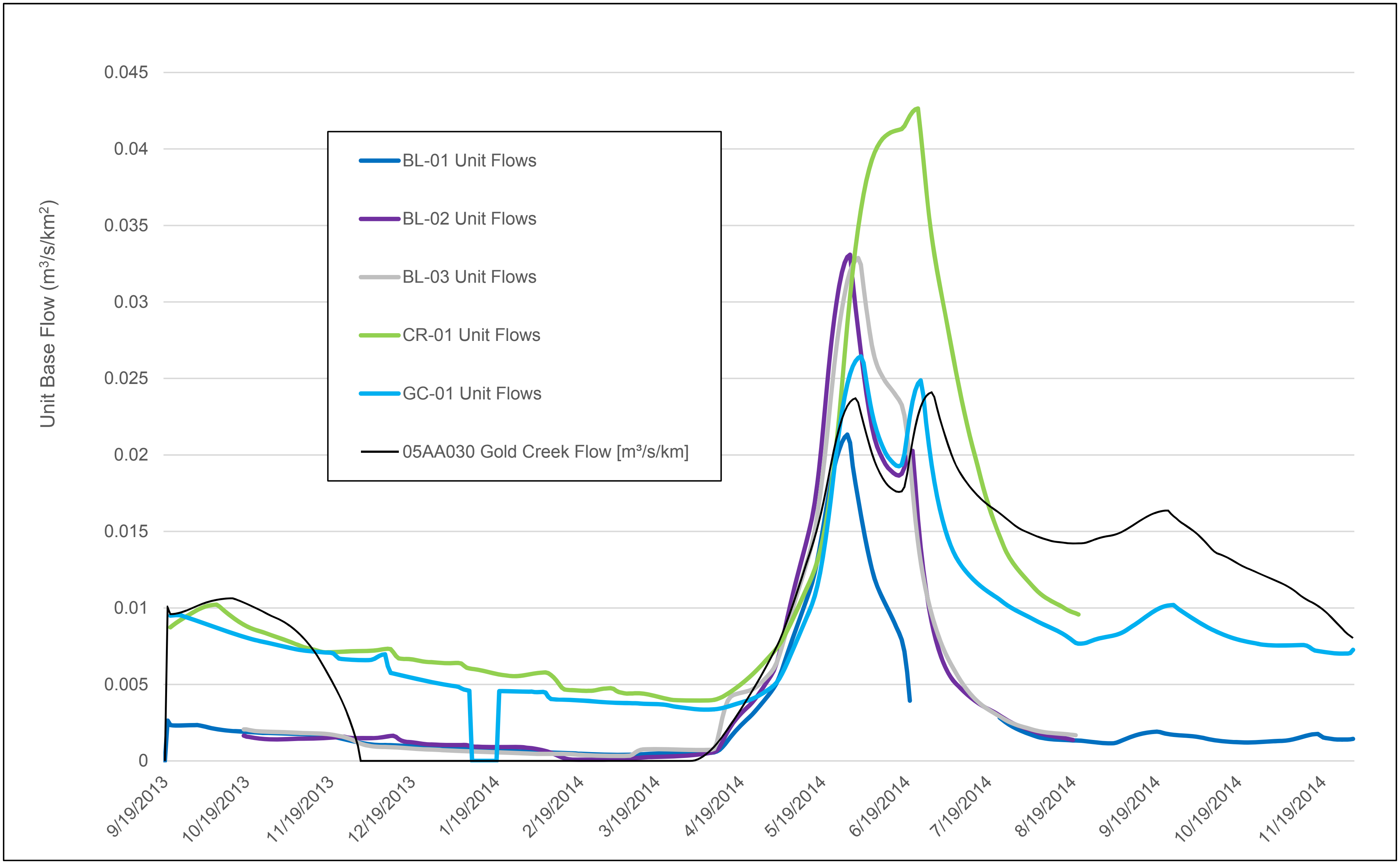
Job No: 1CM029.011

Grassy Mountain Coal Project

Date: July 2016

Approved: GF

Figure: **2-10**



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Data sourced from Hatfield Consultants

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RIVERSDALE RESOURCES

Grassy Groundwater Model

Inferred Unit Base Flow in Blairmore and Gold Creeks, 2013-2014

Job No: 1CM029.011

Grassy Mountain Coal Project

Date: July 2016

Approved: GF

Figure: **2-11**

Table 2-2: Base Flow Estimates

Creek Name	Station	Catchment Area (km^2)	Estimated Base flow (m^3/day)	Estimated Unit Base flow (L/s/km^2)
Blairmore Creek	BL-03	15.4	7,917	6.0
	BC-07	20.6	9,906	5.6
	BL-02	24.2	11,085	5.3
	BC-03	40.5	14,206	4.1
	BC-01	49.8	14,424	3.4
Gold Creek	GC-13	3.9	2,969	8.8
	GC-09	15.1	11,467	8.8
	GC-04	32.4	24,587	8.8
	GC-02	36.1	27,366	8.8
	GC-01	63.1	47,843	8.8
Daisy Creek	D1*	64.6	23,662	4.24

Source: Base flows_Targets_GW_Model_1CM029.005_vm_20150923.xlsx

BC-01, BC-07, D1,and all GC stations are control points used to report base flow estimates of the groundwater model; it is not a gauging station.

Flows for BC-07 inferred on the basis of data from other stations.

Flows for GC-01, GC-02, GC-04, GC-09 and GC-13 control stations inferred on the basis of data from GC-01 gauge station.

The base flow data suggests the following:

- The measurements within the Blairmore Creek watershed show highest unit base flows in the upper catchment; base flow appears to decrease progressively downstream. Base flow in the reach between BL-02 and BL-01 is about 25% of that above BL-03.
- The 2016 flow rate measurements and base flow separation analysis indicate that the total unit flow rate for the Gold Creek catchment at GC-01 gauging station is about 2/3 higher than for Blairmore Creek at BC-02 gauging station.

The physical differences between the Blairmore and Gold Creek watersheds include:

- A higher catchment elevation in Gold Creek, hence higher precipitation and increased snow pack/ snowmelt (see Figure 2-1) component from the Livingston Range; and
- Land cover – a 12.5 km^2 clear cut area within the Gold Creek catchment. The clear cut section, as seen in Figure 2-1, is inferred to increase the groundwater recharge rate due to decreased evapotranspiration. Vegetative cover and roots provide an interface that increases retention time of water in the surface substrate while also actively absorbing water. The

foliage canopy creates an "umbrella" effect shielding the ground surface and stores a portion of the precipitation on the plants that either evaporates or slowly travels to the ground.

These two effects are likely to contribute to the differences in base flow observed between the two watersheds. An estimate of monthly base flow for the overall Blairmore Creek at station BL-02 and Gold Creek at GC-01, and the Crowsnest River at Frank is provided in Table 2-3. Base flow is interpreted to increase by a factor of almost 5 between low base flow and high base flow periods.

Table 2-3: Monthly Unit Base Flow Estimates

Location	Base Flow [l/s/km²]											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Blairmore Creek at BL-02 gauging station	2.0	1.8	1.9	2.9	10.9	18.5	7.8	4.5	3.8	3.5	3.2	2.5
Gold Creek at GC-01 gauging station	5.5	5.4	5.5	6.4	14.3	21.7	11.3	8.0	7.3	7.1	6.8	6.0
Crowsnest River at CR-01 (Frank)	2.8	2.7	2.7	3.3	6.9	13.2	9.1	6.2	5.1	4.3	3.4	3.0

Source: file:///Z:\01_SITES\Grassy%20Mountain\1CM029.007_Hydrotechnical_Engineering\Hydrology\Update_2016\RunoffDistribution_v1_FS.xlsx

The full set of calculated base flows are provided for all stations and all months in Tables A-1 and A-2, Appendix A.

In addition to the creeks/rivers, five ponds and ten surface discharge locations were identified in various areas of the Project. Among the surface discharge locations, two correspond to the old mine portals of the Greenhill underground mine and four seeps (Springs 1 to 4) are assumed to be related to historical mining activities because they are located at the toe of historical spoils. Table 2-4 presents the information collected at each location.

Discharge from Portal-01 (Greenhill mine portal) occurs at an approximate elevation of 1,300 masl and flows to the Crowsnest River. Flows were measured continuously between July 2014 and January 2015. During the monitoring period, flow rate decreased steadily from 1,555 to 260 m^3/d.

Table 2-4: Spring Flow Measurements

Label	Type	Easting (UTM)	Northing (UTM)	Estimated Flow Rate (m^3/d)	Field Comments
West Pond	Pond	685,537	5,504,852	na	Pond corresponding to the mining of the west coal seam.
East Pond	Pond	685,610	5,504,848	na	Pond corresponding to the mining of the east coal seam.
South Pond 1	Pond	685,563	5,504,733	na	-
South Pond 2	Pond	685,478	5,503,975	na	-
Pond-06	Pond	686,248	5,505,991	na	Small shallow pond, water discharges to the south.
Portal-01	Portal	684,741	5,498,988	650-1,300	Greenhill portal (Main). Rotten egg smell and black precipitate.
Portal-02	Portal	684,691	5,498,988	13	Greenhill portal (Secondary).
Spring-1	Spring/seepage	685,092	5,503,772	195	Spring flowing in a meadow, below spoil, likely related to portal of Boisjoli Greenhill underground mine.
Spring-2	Spring/seepage	685,449	5,503,771	na	Seepage area. 100 m downslope from spoil, about 300 m down from Spring 3.
Spring-3	Spring/seepage	685,423	5,503,856	7	Likely related to spoil.
Spring-4	Spring/seepage	685,408	5,505,435	7	Seep from spoil, trickling at surface and flowing downslope.
Spring-5	Spring/seepage	685,523	5,506,080	70	Red staining at bottom of spring bed.
Spring Int	Spring/seepage	679,791	5,500,683	na	International Spring located in Coleman by old decommissioned mine. Red staining at bottom of creek/ spring.
Spring McG	Spring/seepage	678,977	5,501,333	na	Located at McGillivray Mine. Red staining and deposits at mine portal. Discharge to creek downslope.
Spring TM	Spring/seepage	686,707	5,497,781	na	Turtle Mountain Sulfur Spring. White deposits, strong sulfur odor.

Source: Spring and creek LOC_MEMS_12-00328-01.xlsx

2.2 Hydrogeology

The following description of the hydrogeological system in the Project area is based on compiled site observations, regional data and fundamental hydrogeological principles. It is also guided by the results of the numerical model calibration.

2.2.1 Work Undertaken to Date

Relevant hydrogeological investigation work documented to date includes:

- Barnes (1978) – Regional study of the Brazeau-Canoe river area, which included documentation of Blairmore Group and Fernie Group hydrogeological characteristics;
- Waterline (2013) – Watershed aquifer mapping and groundwater management planning;
- Norwest Corporation (2014) – Preliminary water balance for mining operation;
- Golder (2014a) – Test pumping of a reverse-flood borehole within the MMF, which had encountered higher than average flows;
- Golder (2014b) – Documentation of packer-based hydraulic testing and vibrating wire piezometer installation; and
- SRK (2015) – Compilation of site data and construction of a site-wide numerical groundwater model.

2.2.2 Hydrogeological Units

2.2.2.1 Unconsolidated Deposits

Based on the testing conducted to date, the only high yielding aquifer documented close to the Project is the unconfined fluvial sand and gravel associated with the Crowsnest River, which lies hydraulically downgradient of the Project.

On the flanks of the proposed pits, soil cover is thin and expected to be largely unsaturated. Deposits include colluvium, till, kame and kame terrace deposits, glaciofluvial deposits and recent alluvium in the creek valleys. The deposits are expected to be largely of low to moderate hydraulic conductivity (K), with local high permeability layers[2]. Monitoring well MW15-12-7 was installed in the mine area in 2015 and hydraulically-tested, yielding a moderate K of 5.1×10^{-6}m/s.

The unconfined fluvial aquifer associated with the Crowsnest River is expected to be of high permeability.

2.2.2.2 Blairmore Group

Three monitoring wells (MW15-11-18.5, MW15-11-9 and MW15-12-14) were installed in the incompetent, highly fractured conglomerates, sandstones and mudstones of the Cadomin Formation (Blairmore Group), which overlie the Kootenay Group rocks. These wells yielded moderate K values ranging from 5.2×10^{-7} to 5.2×10^{-6} m/s. According to Barnes (1978), this

[2] Low K: 10^{-9} to 10^{-7} m/s; Moderate K: 10^{-7} to 10^{-5} m/s; High K: 10^{-5} to 10^{-3} m/s.

formation has water supply potential, particularly where thick sandstone sequences and interbedded coal seams occur on valley floors, where yields of about 25 to 100 imperial gallons per minute (igpm) (1.9 to 7.6 L/s) may be obtained, suggesting this group may be of overall moderate permeability. Waterline (2013) indicates that the basal Cadomin formation pebbly conglomerate presents the highest yield potential for this group.

2.2.2.3 Kootenay Group

Hydraulic testing to date has focused on rocks of the MMF, with the Kootenay Group, consisting of coal seams and interbedded carbonaceous sandstone, claystone, mudstone and siltstone.

In 2014, 24 K tests were completed by Golder and MEMS using either slug testing, packer-based slug and constant injection/recovery testing; or constant-rate test pumping techniques (Golder, 2014a and 2014b; MEMS, 2015). Testing was conducted largely on intervals perpendicular to bedding, hence test results should be representative of K parallel to bedding. Table 2-5 presents the results of the tests. Figure 2-12 shows the interpreted K distribution with depth; Figure 2-13 shows the distribution with elevation.

The packer tests targeted coal seams and interburden, while slug tests were conducted on monitoring wells largely installed within coal seams. The test interval midpoint depths ranged from 30 and 151 m below ground surface (mbgs), with an average of 91 mbgs. Results for coal-seam-dominated bedrock K ranged from 1×10^{-10} to 5×10^{-6} m/s. Arithmetic mean K is 6×10^{-7} m/s, with a standard deviation of 208% of the arithmetic mean, while geometric mean is 1×10^{-7} m/s. On this basis, the formation appears to be of low to moderate permeability, with a moderately low range of variability.

2.2.2.4 Fernie Group

No testing data were obtained for the shales of the Fernie Group, which underlie the Kootenay Group rocks. These rocks are expected to be of low permeability, based on their lithology, and on the limited well yield database (Nielsen, 2009).

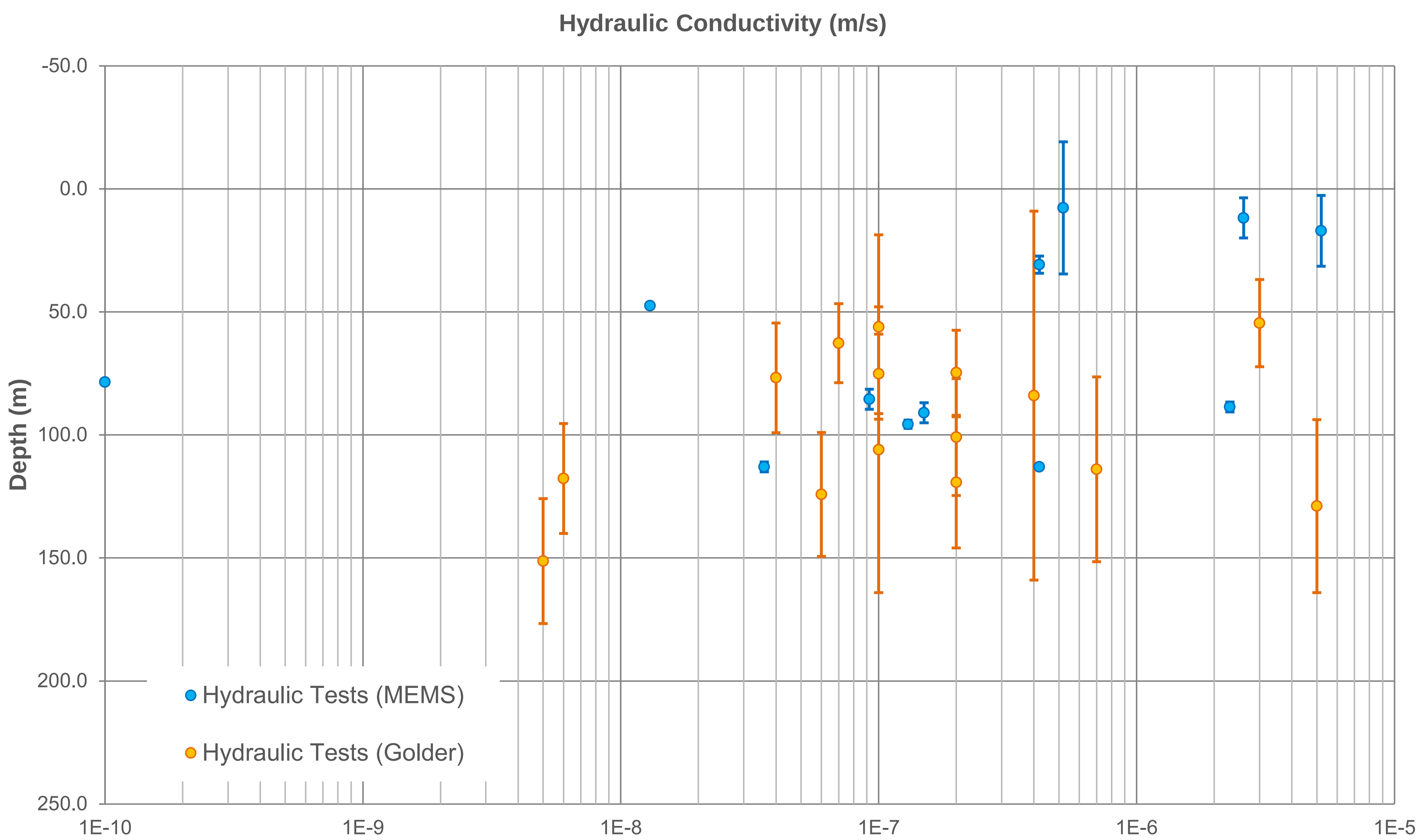
2.2.2.5 Thrust Faults

While no testing data exists for the thrust faults in the area of the Project, it is likely that these faults, which strike parallel to the hogsback ridge, likely present a hydraulic barrier to flow perpendicular to them, given the cataclastic nature of these faults and a tendency to form low-permeability fault gouge.

Table 2-5: Summary of K Tests

Well ID	Easting	Northing	Screened Interval (mbgs)		K (m/s)	Test Type	Geology
			From	To			
Surficial Deposits							
MW15-12-7	684787	5503690	3.8	6.8	5.1×10^{-6}	Slug	Surficial deposits
Cadomin Formation							
MW15-11-9	684917	5504250	6.2	9.2	5.2×10^{-7}	Slug	Mudstone
MW15-11-18.5	684919	5504250	15.5	18.5	5.2×10^{-6}	Slug	Mudstone
MW15-12-14	684790	5503690	9.9	13.7	2.6×10^{-6}	Slug	Mudstone
Mist Mountain Formation							
MW14-01-64	685,434	5,504,891	61.7	115.5	2.3×10^{-6}	Slug	Coal seam 2, claystone, siltstone
MW14-02-74	685,588	5,504,347	71.1	99.9	9.2×10^{-8}	Slug	Coal seam 4, siltstone, mudstone
MW14-03-90	685,674	5,505,739	87.5	103.8	1.3×10^{-7}	Slug	Coal seam 4, carbonaceous mudstone/ claystone
MW14-04-93	685,809	5,507,380	89.0	93.0	1.5×10^{-7}	Slug	Siltstone, coal seam 4
MW14-05-114	685,982	5,507,539	108.9	117.0	3.6×10^{-8}	Slug	Coal seam 2
MW14-06-32	685,864	5,506,884	29.1	32.5	4.2×10^{-7}	Slug	Coal seam 1
MW14-06-105	685,982	5,507,539	108.9	117.0	4.2×10^{-7}	Slug	Coal seam 4, claystone
MW14-07-48	686,580	5,507,292	45.5	49.5	1.3×10^{-8}	Slug	Shale/claystone, coal seam 4
MW14-08-79	686,844	5,509,725	75.0	82.0	1.0×10^{-10}	Slug	Coal seam 2
RGSC-0004	685,490	5,506,218	93.7	164.1	5.0×10^{-6}	Packer	Coal seams 2 & 4 (34m) and interburden
RGSC-0004	685,490	5,506,218	47.9	164.1	1.0×10^{-7}	Packer	Coal seams 1 & 2 & 4 (55m) and interburden
RGSC-0005	685,118	5,504,574	57.4	92.0	2.0×10^{-7}	Packer	Coal seam 1 (25m) and interburden
RGSC-0005	685,118	5,504,574	95.4	140.0	6.0×10^{-9}	Packer	Coal seam 1 (7m) and interburden
RGSC-0006	685,577	5,507,161	59.1	91.3	1.0×10^{-7}	Packer	Coal seam 1 (21m) and interburden
RGSC-0006	685,577	5,507,161	92.6	146.0	2.0×10^{-7}	Packer	Coal seam 1 (53m) and interburden
RGSC-0007	685,627	5,507,655	46.6	78.8	7.0×10^{-8}	Packer	Interburden
RGSC-0007	685,627	5,507,655	77.1	124.7	2.0×10^{-7}	Packer	Interburden
RGSC-0007	685,627	5,507,655	125.9	176.7	5.0×10^{-9}	Packer	Coal seam 1 (11m) and interburden
RGSC-0008	686,638	5,507,638	18.6	93.6	1.0×10^{-7}	Packer	Coal seams 2 & 4 (27m) and interburden
RGSC-0009	686,742	5,509,160	54.5	99.1	4.0×10^{-8}	Packer	Interburden
RGSC-0009	686,742	5,509,160	99.0	149.3	6.0×10^{-8}	Packer	Coal seam 1 (30m) and interburden
RGSC-0010	686,807	5,510,108	36.8	72.3	3.0×10^{-6}	Packer	Coal seam 1 (16m) and interburden
RGSC-0010	686,807	5,510,108	76.4	151.6	7.0×10^{-7}	Packer	Coal seams 2 & 4 and interburden
RGOH3012	685,401	5,505,479	9.0	159.0	4.0×10^{-7}	Pump	Cadomin, seam 1, 2 and 4, MMF

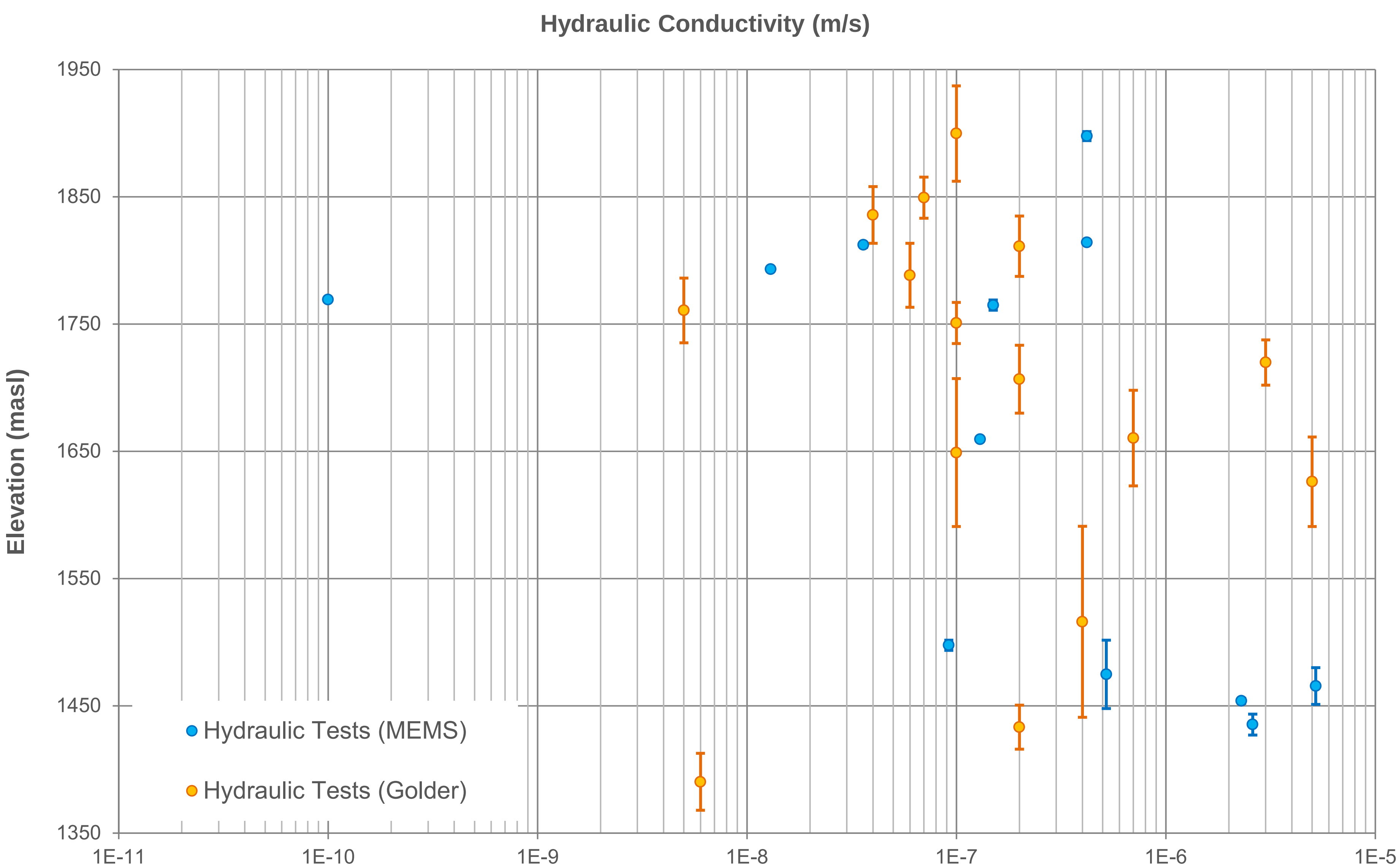
Source: Hydraulic_conductivity_1CM029.005_gf_20150615.xlsx



Note: Vertical error bars indicate test intervals. Circles indicate estimated K value at mid- interval.

Source:
Hydraulic_conductivity_1CM029.005_gf_20150615.xlsx

srk consulting	RIVERSDALE RESOURCES	Grassy Groundwater Model
		K vs. Depth
Job No: 1CM029.011	Grassy Mountain Coal Project	Date: July 2016 — Approved: GF — Figure: **2-12**



Note: Vertical error bars indicate test intervals. Circles indicate estimated K value at mid- interval.

Source:
Hydraulic_conductivity_1CM029.005_gf_20150615.xlsx

srk consulting	RIVERSDALE RESOURCES	Grassy Groundwater Model **K vs. Elevation**
Job No: 1CM029.011	Grassy Mountain Coal Project	Date: July 2016 | Approved: GF | Figure: **2-13**

2.2.3 Groundwater Head Distribution and Flow Regime

2.2.3.1 Piezometric Monitoring

Groundwater levels were measured manually in 17 monitoring wells and three nested Vibrating Wire Piezometers (VWPs); four levels were also measured opportunistically in packed-off sections of geotechnical drill holes (RGSC-0004, -0007, -0008 and - 0010) during packer testing. Two additional wells were drilled and installed in 2016, however water level recovery was very slow in these wells due to low permeability, hence water level data has not been utilized from these wells.

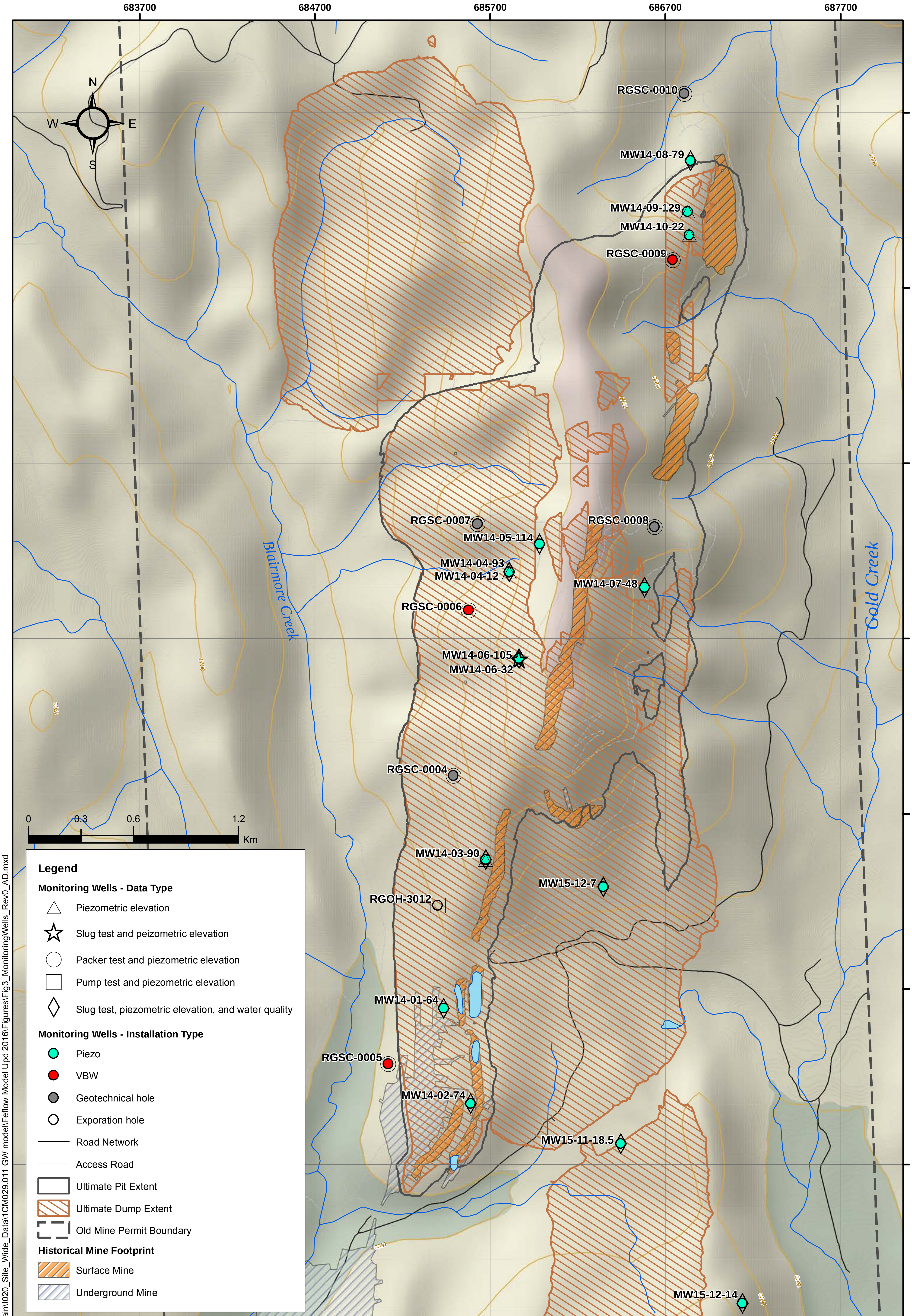
Figure 2-14 shows the locations of groundwater level monitoring points. The following information was obtained.

- Continuous measurements of water levels from the monitoring wells MW14-01-64, MW14-02-74, MW14-05-114, MW14-06-32, MW14-06-105 between October 2014 and March 2016;
- Manual measurements of water levels from the monitoring wells MW14-03-28, MW14-03-90, MW14-04-11.5, MW14-04-93, MW14-07-48, MW14-09-129, MW14-10-22, MW15-11-18.5, MW15-11-9, MW15-12-14, MW15-12-7 to March 2016; and
- Continuous measurements of pore water pressure from three vibrating wire piezometers RGSC-005, -006, and -009 between September 2014 and April 2016.

General observations from groundwater head measurements are as follows:

- Groundwater flow is strongly controlled by topography, together with low overall K, dominantly recharging at high elevations, where dipping strata are exposed, and discharging in valley bottoms;
- Groundwater flows eastward and westward away from the hogsback ridge and towards the creeks, with downward hydraulic gradients; and
- The relatively high water table under Grassy Mountain results from:
  - The surface topography;
  - Groundwater recharge occurring predominantly at higher elevations[3] and moving towards low lying areas;
  - The overall low to moderate permeability of the Mist Mountain Formation and underlying Fernie Group;
  - The expected reduction of K with depth;
  - A strong bedding-aligned anisotropy, with K transverse to bedding (Kz) expected to be much lower than permeability parallel to bedding (Kx, Ky); and
  - The potential role of thrust faults as hydraulic barriers.

[3] Due to increasing precipitation and decreasing potential evapotranspiration with increasing elevation and due to exposure of bedrock/ dipping beds along ridges.



Z:\01_SITES\Grassy Mountain\!020_Site_Wide_Data\1CM029.011 GW model\Feflow Model Upd 2016\Figures\Fig3_MonitoringWells_Rev0_AD.mxd

Coordinate System: NAD 1983 UTM Zone 11N	srk consulting	RIVERSDALE RESOURCES	Groundwater Monitoring Network
	Job No: 1CM029.011 Filename: Fig3_MonitoringWells_Rev0_AD	Grassy Mountain Coal Project	Date: July 2016 / Approved: AD / Figure: 2-14

The water table is moderately deep (35 to 110 mbgs) along the ridge and near ground surface at topographic lows and in the valleys. Based on limited piezometric data, the water table may lie further below ground surface on the Gold Creek slope than under the Blairmore Creek slope.

Monitored wells show seasonal variation in response to precipitation, with the exception of MW14-02-73, which is likely dry. Wells show two significant recharge responses per year, associated with precipitation in October and another associated with the freshet in April. Water level fluctuations range from one to five meters. Responses to the infiltration of precipitation are seen at depths of up to 120 mbgs, implying that there is a degree of connectivity with depth.

In the higher elevation areas, the shallow groundwater pathways are short and are expected to contribute to interflow or high elevation, low-order streams and tributaries. The deep groundwater pathways are expected to be long and slow and contribute to the creeks in the valley or to the deep regional groundwater flow. The upper sections of mountain streams are likely ephemeral, perched above the water table. The relative lack of surficial overburden deposits, particularly in the middle and upper valley slopes of Blairmore and Gold creeks, implies that the creeks receive a base flow largely controlled by the secondary K of the fractured rock in these areas. The flows into the creeks are believed to be dominated by surface runoff and quick flow generated by the precipitation and snowmelt.

Head measurements suggest that the anisotropy induced by bedding planes, coal seams and geological structures is influencing the distribution of heads:

- Between monitoring wells MW14-06-105 and MW14-06-32, installed adjacent to each other and are screened across Coal Seams 4 and 1 respectively, there is a slight upwards gradient of 0.08 m/m. However a downward gradient would rather be expected considering these wells are located at a relatively high elevation (1,927 masl);
- Artesian conditions were observed at exploration hole RGOH-3012 (1,600 masl), which confirms confined conditions for the permeable layer supplying this borehole; and
- There is a downward gradient in RGSC-0005 although it is located at low elevation (1,507 masl) and expected therefore to show an upward gradient instead. This could be an indication of compartmentalization.

Gentzis (2005) observed that geologic history exerted a profound effect in reducing the permeability of coals in the Canadian Foothills and Mountains, through burial and uplift, followed by episodes of intense thrusting and folding. Exposures of Mist Mountain coal beds in existing pit walls suggested that coal seams act sometimes as barriers to groundwater flow and that discharges occurs at the coal-interburden contact. SRK has made the same observations in other coal mines in British Columbia (e.g. Trend Roman Coal Mine), where coal seams or units immediately adjacent to coal acted as aquitards. These observations imply that groundwater moves preferentially parallel to the bedding planes and coal seams because of the anisotropy perpendicular to bedding orientation. Depth of burial exerts a control on the capacity of joints and fractures to convey flow. As lithostatic load increases with depth, the apertures of the joints and fractures decrease and the bulk K is lowered. While the hydraulic testing data presented in Figure 2-12 does not suggest a strong reduction in K with depth, and has a bias towards testing conducted within coal seams, testing depth has been relatively modest to date, and it is expected that deeper testing would show reduced permeability associated with a given formation.

At the regional scale, deep groundwater flows from west to east underneath the Foreland Ranges, paralleling the Crowsnest River (Waterline, 2013). The flow is driven by the differences in elevation between the Rocky Mountains to the west and the Great Plains to the east. Springs such as the Turtle Mountain Sulfur Spring indicate that groundwater can cross formational boundaries via faults and fractures, approximately perpendicular to the axis of the Crowsnest River. At the Project scale; however, other than the influence of bedding planes, coal seams and depth, there is no data that clearly suggests such a geological conduit exists.

The groundwater flow system is expected to vary locally from this model:

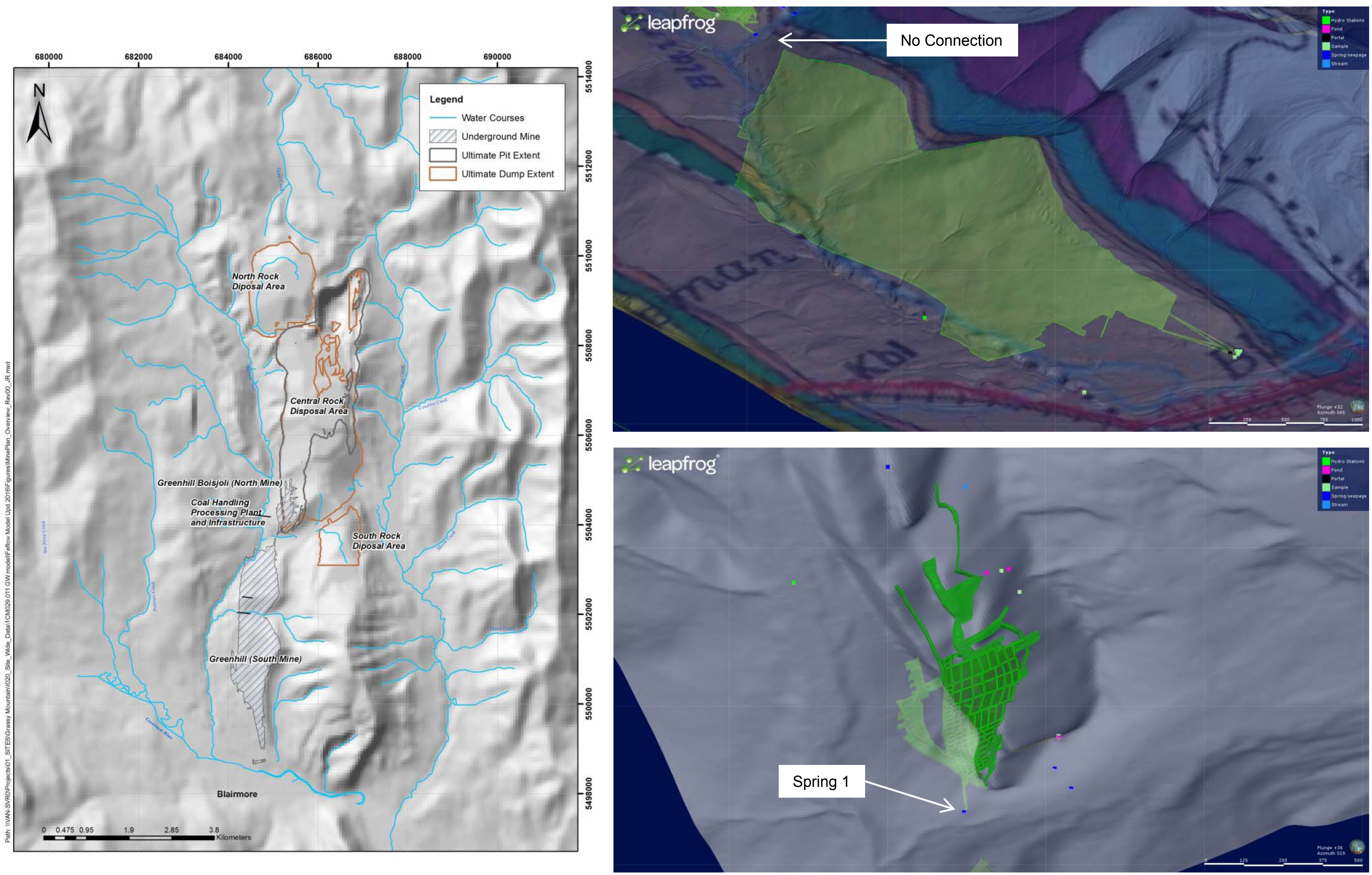
- At the south end of the Project, the rock in, or at proximity to, the old underground mines is likely disturbed due to the presence of voids in collapsed underground workings and characterized by higher bulk K. The underground mines drain and discharge water at the portals and likely lower the water table, particularly to the north; and
- Spring #5 on the slope of Grassy Mountain may indicate the presence of a local geological structure acting as a flow conduit; the spring does not seem to be associated with historical mine workings, although the potential presence of workings cannot be ruled out with the existing data.

2.2.4 Greenhill Historical Underground Mine

The Property has undergone surface and underground coal mining in the past as well as additional coal exploration. Two historic underground mines are located with the Project boundary:

- The Greenhill Underground Mine (South Mine) is located to the south-southwest of the Grassy Mountain pits and rock disposal areas and extends approximately 6 km north-south; and
- The Greenhill Boisjoli Underground Mine (north Mine), which is adjacent to the southwest edge of the planned pits, and extends approximately 1 km north-south.

Both were developed on several levels below Grassy Mountain, and focused on the exploitation of Coal Seams 1 and 2, the two shallowest seams planned for exploitation at Grassy Mountain. There is no record of the mines being backfilled. Underground mining ceased and was eventually replaced by a surface mine along the crest of Grassy Mountain an additional 5 km or so to the north of the Greenhill Boisjoli mine. The footprints and 3D views of the historical underground mines are shown in Figure 2-15.



srk consulting	RIVERSDALE RESOURCES	Groundwater Model Update
		Greenhill Boisjoli and Greenhill Mines 3D Views
Job No: 1CM029.011 Filename: Greenhill_3DViews.pptx	Grassy Mountain Coal Project	Date: July 2016 · Approved: GF · Figure: **2-15**

Available maps of the Greenhill Boisjoli and the Greenhill mine workings show that the two mines are not directly connected. The entrance portal of the Greenhill Boisjoli mine has been covered by fill, but matches the location of Spring 1, located on the southern slope of Grassy Mountain, and on the northern slope of a roughly east-west trending tributary valley. The Greenhill mine workings lie underneath the southern slope, at a distance of about 90 m horizontally from the Greenhill Boisjoli portal. The two entrance portals of the Greenhill mine, i.e. the Greenhill Portal (Main) and Greenhill Portal (Secondary), are still present, located approximately 4.5 km south of Spring 1, at an elevation of about 1,324 masl.

SRK updated the 3D geometry of the two mines by projecting the georeferenced maps on the 3D solids representing the coal seams in the 2016 Benga's geological model, as shown in Figure 2-15.

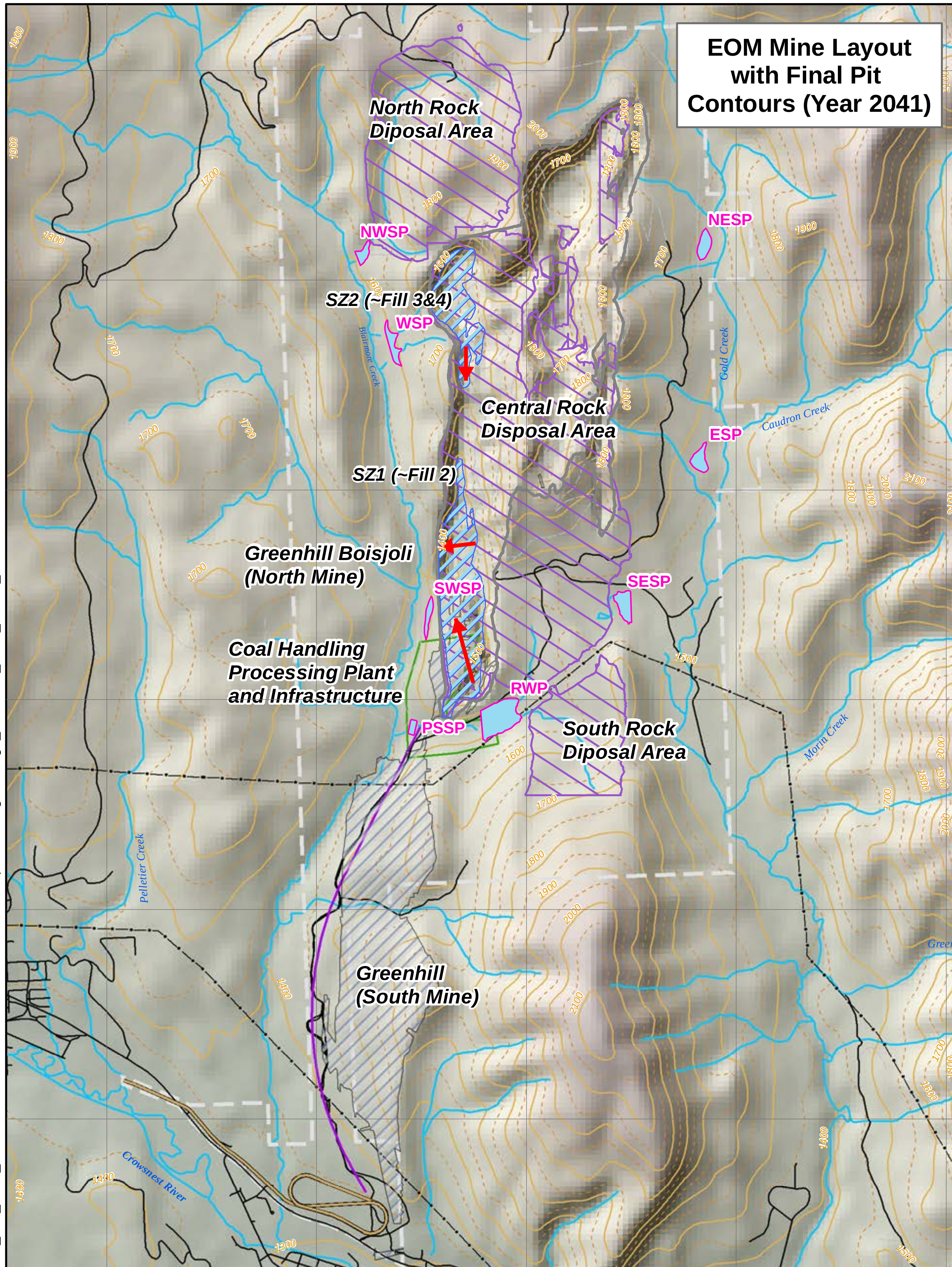
2.2.5 Mine Plan

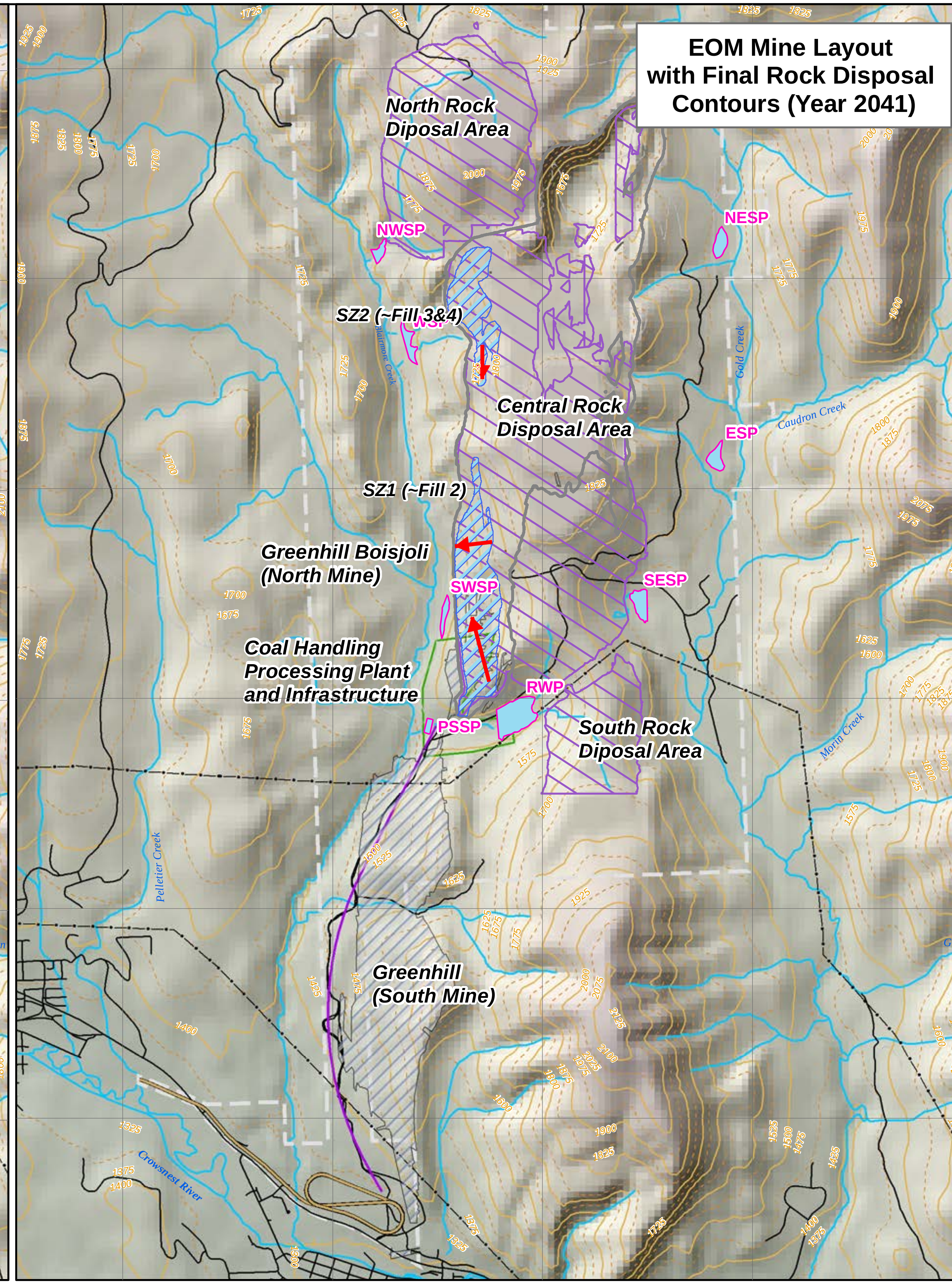
The pit shells and water management system were provided by Benga on April 7, 2016. Table 2-6 summarizes the mine plan components, where relevant for modeling groundwater. Figure 2-16 and Figure 2-17 show the mine layouts at EOM and for LTC, respectively.

In general terms, mining progresses from the lower elevation southern portion of the ridge northwards, hence minimum pit base elevation is established early in the mine life (two years after start of mining), while maximum depth below water table increases through the mine life.

Table 2-6: 2016 Mine Plan

Component	Mine Plan, April 7, 2016
Mine life	23 years - Commissioning & Operation: Late 2018 – 2041
Disturbance area	1387 ha
Total pit footprint	6.2 km^2
Pit shell	1-2 pits
Maximum depth of the pits	• About 430 mbgs, to a base elevation of 1,590 masl. • Base of the pits will extend, in some places, up to approximately 110 m below Blairmore Creek, 40 m below Gold Creek, and up to 430 m below the estimated water table.
Waste Rock	• Placed in both ex-pit (South, Central and North Rock Disposal Area) and in-pit rock disposal areas. • In-pit rock disposal area will fill about 73% of the pit footprint and leave a large EOM void in the north east corner of the pit, which will be allowed to form a pit lake.
Surface water management system	• Geometry and sequencing of the excavation and in-pit rock disposal areas will accommodate a passive treatment strategy for selenium. • 3 saturated fill zones, 1 pit lake - water in the pit lake and in the saturated rock fill will be allowed to flow from one backfilled zone to another in order for the selenium to drop out before it is discharged to the environment
Pit lake and Saturated Zones	Water levels at LTC *(SZ, Saturated Zone)*: • SZ #1: 1465 m • SZ #2: 1636 m • SZ #3, Pit Lake: 1700 m
Surface water management structures	• Structures constructed around the perimeter of the rock disposal areas to maximize the separation of contact and non-contact water, and to manage the discharge of contact water, to avoid, or minimize, environmental impacts. • Structures: o Three surge ponds, o Four sedimentation ponds, o One raw water pond, o A series of surface water ditches designed to collect the runoff and seeps at the toes of the rock disposals.





Legend

- Road
- Existing Powerline
- Proposed Rail Loop
- Overland Conveyor
- Ponds
- EOM Fill Flow Directions
- Ultimate Pit Extent
- Ultimate Dump Extent
- Coal Processing Plant Extent
- Mine Permit Boundary
- Greenhills Underground Mine

Sediment Pond Details

Sediment Pond Name	Label	Water Level (masl)
Northwest Surge Pond	NWSP	1602
West Sediment Pond	WSP	1592
Southwest Surge Pond	SWSP	1490
Plant Site Sediment Pond	PSSP	1460
Raw Water Pond	RWP	1497
Southeast Surge Pond	SESP	1508
East Sediment Pond	ESP	1579
Northeast Sediment Pond	NESP	1364
Saturated Zone #1	SZ1	1465
Saturated Zone #2	SZ2	1636

Site Location

N W E S

0 0.5 1 2 3 4 Km

NOTES:
1. Map coordinate system NAD 83 UTM Zone 11N.
2. Mine plan from Riversdale Resources (Apr 2016)
3. Labels of the ponds, ditches and saturated rock fills were abbreviated for the purpose of the groundwater model.

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Job No: 1CM029.011

Fig5_MinePlan_EOM_Rev01_AD

Grassy Mountain Coal Project

Mine Plan at End of Mining

Date: July 2016 | Approved: GF | Figure: 2-16

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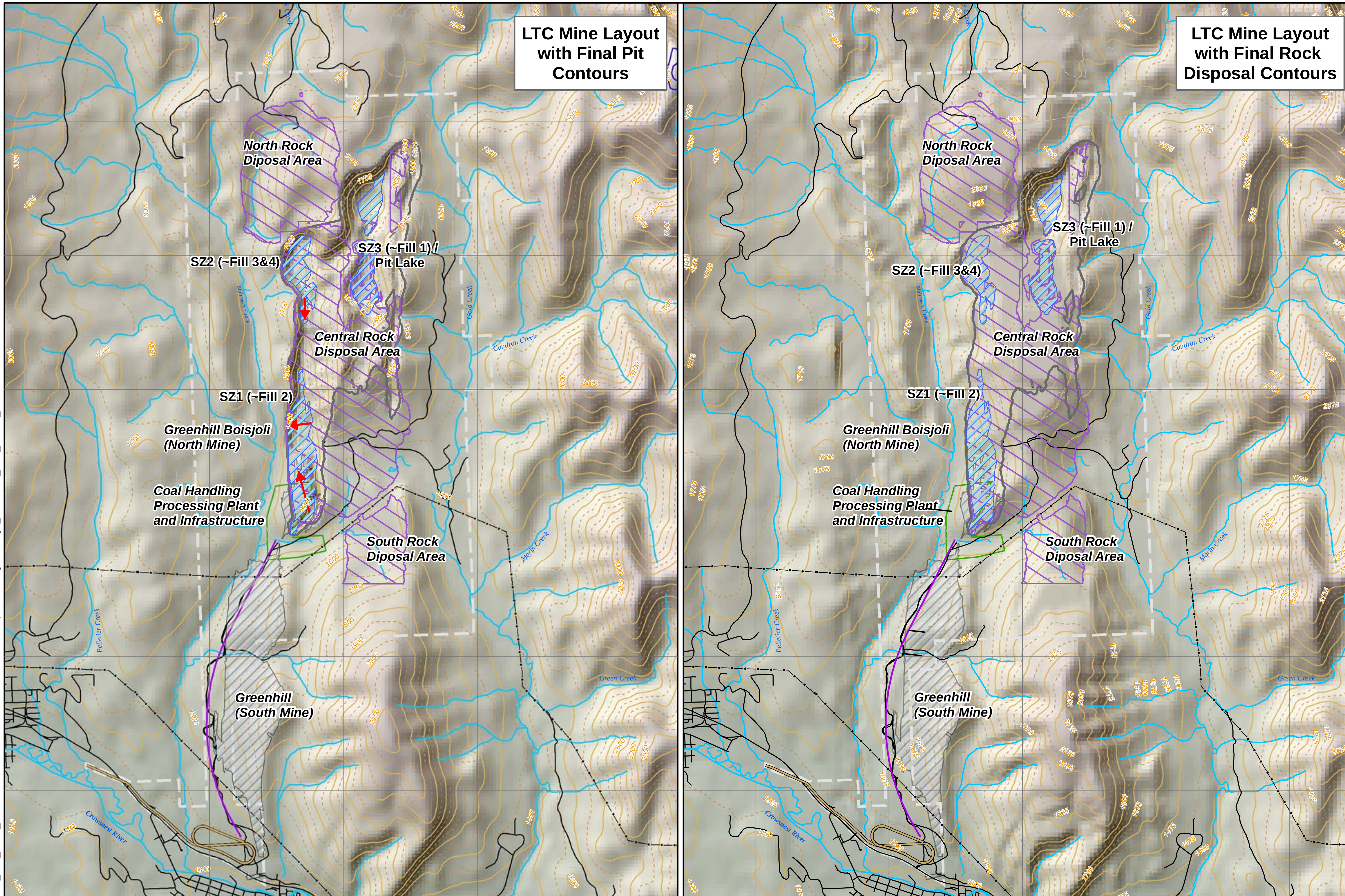

Legend

- Road
- Existing Powerline
- Proposed Rail Loop
- Overland Conveyor
- EOM Fill Flow Directions
- Ultimate Dump Extent
- Ultimate Pit Extent
- Coal Processing Plant Extent
- Greenhills Underground Mine
- Mine Permit Boundary
- Saturation Zone

Saturation Zone Details

Saturation Zone Name	Label	Water Level (masl)
Saturation Zone #1	SZ1	1465
Saturation Zone #2	SZ2	1636
Saturation Zone #3	SZ3	1700

Site Location

N
W E
S

0 0.5 1 2 3 4 Km

NOTES:
1. Map coordinate system NAD 83 UTM Zone 11N.
2. Mine plan from Riversdale Resources (Apr 2016)
3. Labels of the ponds, ditches and saturated rock fills were abbreviated for the purpose of the groundwater model.

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Mine Plan at Long-term Closure

Job No: 1CM029.011
Fig6_MinePlan_LTC_Rev01_AD

Grassy Mountain Coal Project

Date: July 2016 | Approved: GF | Figure: 2-17

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3 Groundwater Numerical Model

3.1 Model Updates

The following summarizes updates made to the 2015 numerical groundwater model (SRK, 2015a):

- The model mesh was revised. One metre LIDAR contours were used to define the baseline ground elevation and to assign head boundary conditions at the creek and tributaries. Increased accuracy of the elevations for the creeks and tributaries improved the modeling of creek base flows;
- The number of nodes and layers were adjusted to optimize computing time and allow calibration and simulation of transient runs;
- The geometry of the Greenhill underground mines were updated based on a review of all the documentation. This update corrected the relationship between the Greenhill Boisjoli Mine and the Greenhill Mine;
- The simplified hydraulic conductivity (K) anisotropy trend that represented the influence of bedding and thrust faults was replaced by a 3D distribution of the K anisotropy, which was based on the beds orientation (synclines/anticlines) at the regional scale;
- The model was calibrated under steady-state and transient conditions. The calibration targets were updated with continuous and manual water level measurements collected in 2016, and calculated monthly base flows inferred from measurements of flow rates at the local surface water stations;
- Two models were calibrated to baseline conditions. The first, base, model was calibrated to a linear recharge-elevation distribution, corresponding to the direct linear relationship between precipitation and elevation. A second calibration was used as an alternative calibration case, and included a direct exponential recharge-elevation distribution. This provides a range of potential solutions and helps to quantify uncertainty associated with model predictions; and
- The predictive models were ran under steady-state and transient conditions. The latter allowed the assessment of Project effects to seasonal base flows.

3.2 Model Software

The numerical groundwater modeling was completed using the software FEFLOW v6.2 (P11) (DHI, September 2015). FEFLOW is a professional software package for modeling fluid flow and transport of dissolved constituents and/or heat transport processes in the subsurface. This program is used extensively for groundwater mining projects around the world. The code is based on a finite element solution of the partial differential equations for flow and transport.

3.3 Model Assumptions

The model assumptions are as follows:

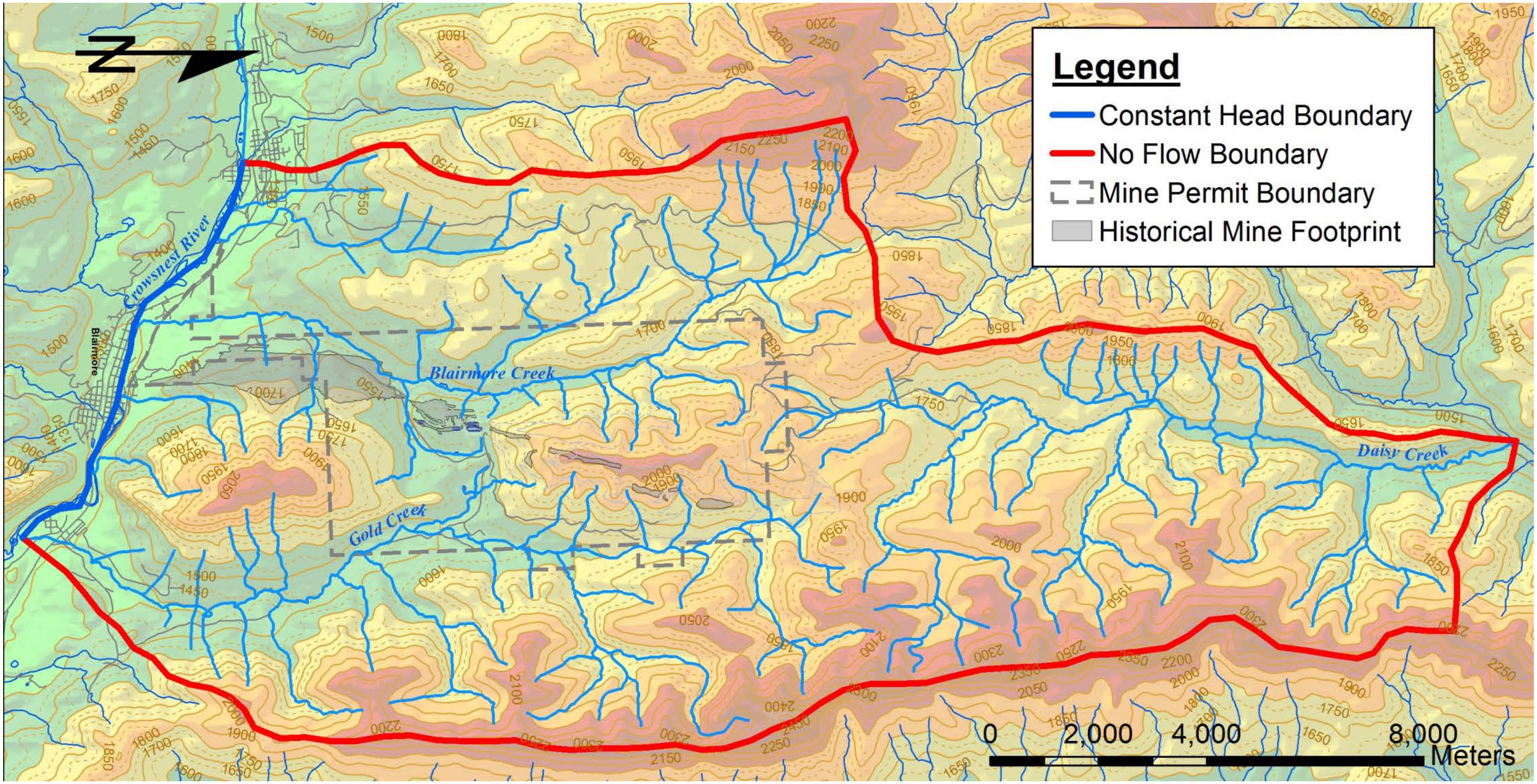
- For the purposes of the assessment, the entire rock/ sediment package may be treated effectively as a homogeneous, anisotropic medium;
- The system will largely behave as an confined aquifer, although it can effectively represent unconfined conditions where these occur;
- On the scale of the assessment, groundwater system flow, which is expected to occur dominantly via fracture flow, can be approximated by an Equivalent Porous Media (EPM) model;
- K is largely anisotropic, with highest K parallel to bedding planes/ coal seams and to thrust fault strike with lowest K perpendicular to bedding. In general terms, K, in all orientations, decreases with depth, according to the model proposed by Wei et al. (1995);
- Apart from preferential flow parallel to fault strike, there is no major fault acting as a significant conduit and no major regional deep flow influences;
- Recharge follows the same spatial trend with elevation as precipitation. The precipitation, evaporation and evapotranspiration mechanisms are not explicitly modeled but assumed to be integrated as “net recharge”. It is assumed that this approach will not unduly bias the model; and
- Water level data and creek flow data collected between late 2013 and early 2016 are representative of the pre-mining steady-state conditions and long-term trends.

3.4 Groundwater Model Setup

3.4.1 Model Domain

The model domain covers an area of approximately 28 x 12 km, with a total area of 390 km^2 (Figure 3-1). The domain is set to encompass the Blairmore, Gold, and Daisy Creek catchments, with the external boundaries considered to be sufficiently distant from the mining area to minimize influence of the boundary conditions on model predictions.

The upper surface of the model is defined based on DEM coverages from 1 m LIDAR contours and from the Shuttle Land Elevation Mission (SRTM) images. The base of the model is set at a fixed depth of 800 mbgs projected downward from the surface topography.



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RIVERSDALE RESOURCES

Grassy Groundwater Model

Model Domain

Job No: 1CM029.011
Source: GrassyFigures_FeFlow.pptx

Grassy Mountain Coal Project

Date:	Approved:	Figure:
July 2016	GF	3-1

3.4.2 Model Mesh

The finite element mesh is composed of 418,430 nodes. Spacing between nodes within the horizontal layers are refined, grading from 140 m at the edges of the model to about 30 m near the proposed open pit or surface water features (Figure 3-2). Vertical layers are set to a variable thickness, starting at about 40 m for the top layer and increasing gradually to about 140 m for the bottom layer, with a total of nine layers.

3.4.3 Model Properties

The complexity of the local-scale hydrogeology is simplified. The model assumes that overburden deposits play a minimal role on the overall groundwater system compared to fractured rock and are therefore not explicitly modeled. It also assumes that there is little large-scale variability in the bedrock, and that it may be effectively modeled as a single unit. The fractured bedrock is modeled as an equivalent porous media with the following properties:

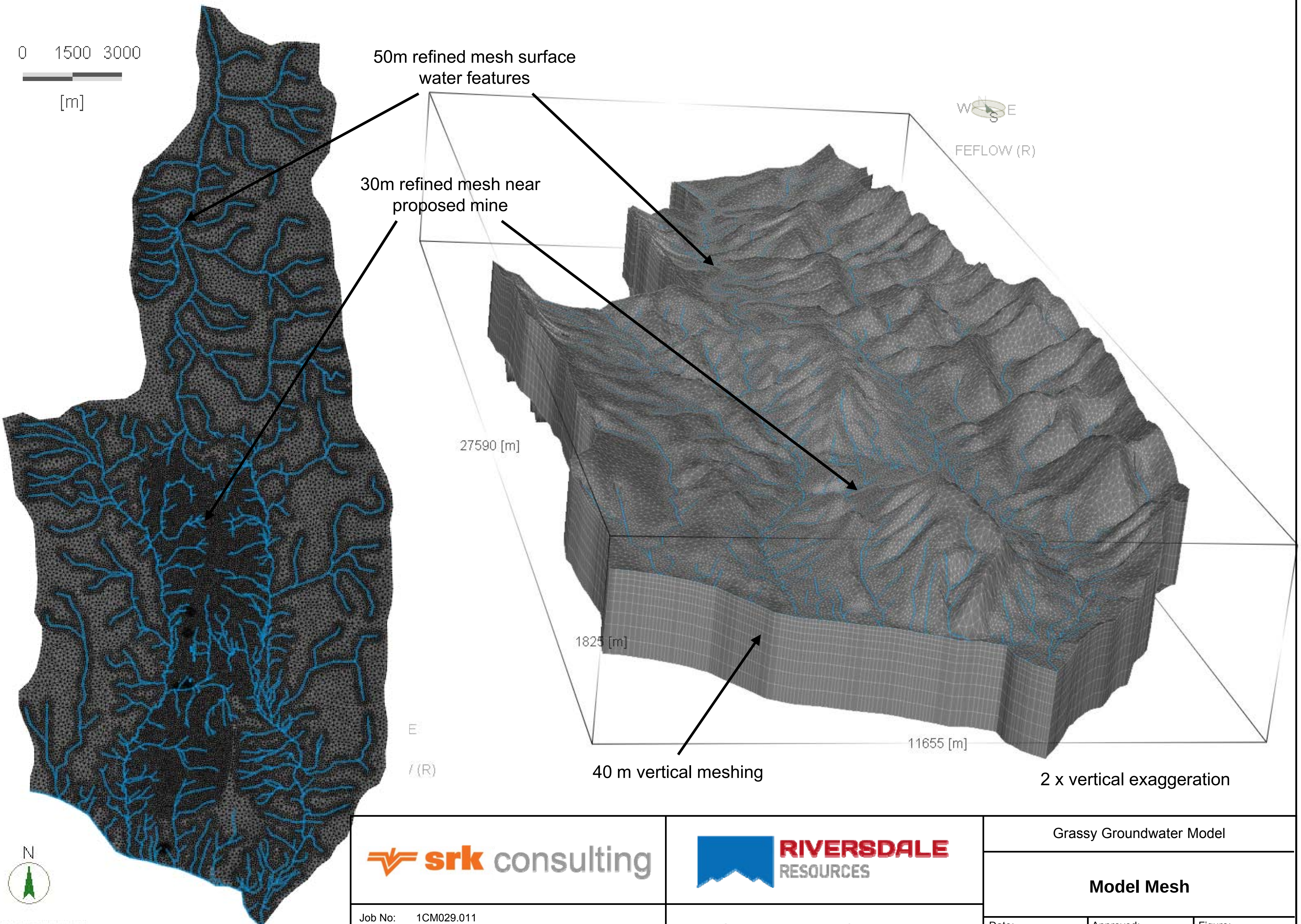
- Hydraulic conductivities (K) in bedrock, parallel to bedding, range between $6x10^{-10}$ to $1.7x10^{-7}$ m/s (Table 3-1). K values are constant within a given layer. As hydraulic testing generally targeted coal seams, the K of the host rock is not completely characterized;
- The K field is anisotropic with a conductivity tensor where K_1 and K_2 > K_3[4] (Figure 3-3). The highest conductivity is parallel to bedding in the north-south direction. The north-south thrust fault systems are modelled to impede flows in the east-west direction. The complexity of the bedding are reproduced based on geological maps, geological models, and the beds orientations at a regional scale;
- K decreases with depth due to increases in the lithostatic stress. Wei et al. (1995) developed a model based on 5,532 injection tests at dam sites in the Rocky Mountain Front Range. The decrease in K is defined as per Wei et al. model as a function of depth (z):

$$K(z) = K_0\left(1 - \frac{z}{58.0+1.02*z}\right)^3,$$

where K_0 is the K at the ground surface.

- Table 3-1 and Figure 3-3 present the site K data, together with the calibrated model K values. Note that values for the fractured bedrock incorporate the hydraulic barrier effects of the thrust faults in the K2 value, which otherwise would be similar to K1; and
- The values for specific storage, and specific yield were estimated from calibration of the model to transient conditions, and in consideration of typical values for the materials modelled. Dispersivity values were estimated from the published literature on fractured rock systems because there are no site-specific measurements. The specific storage (Ss) is assumed to range between 1.0×10^{-6} and 1.5×10^{-6}. The specific yield is assumed to range between 1.0×10^{-2} and 1.5×10^{-2} m^{-1}. The longitudinal and transverse dispersivities are assumed to be 60 m and 20 m respectively.

[4] K1 = hydraulic conductivity parallel to bedding and perpendicular to axis of syncline and anticline; K2 = hydraulic conductivity parallel to bedding and parallel to axis of syncline and anticline; K3 = hydraulic conductivity perpendicular to bedding.



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RIVERSDALE RESOURCES

Grassy Groundwater Model

Model Mesh

Job No: 1CM029.011
Source: 01b_PrMng_2018_Grassy_Mntn_FM-GwAge_Steady-State_Calibration_rev2_LNR.dac

Grassy Mountain Coal Project

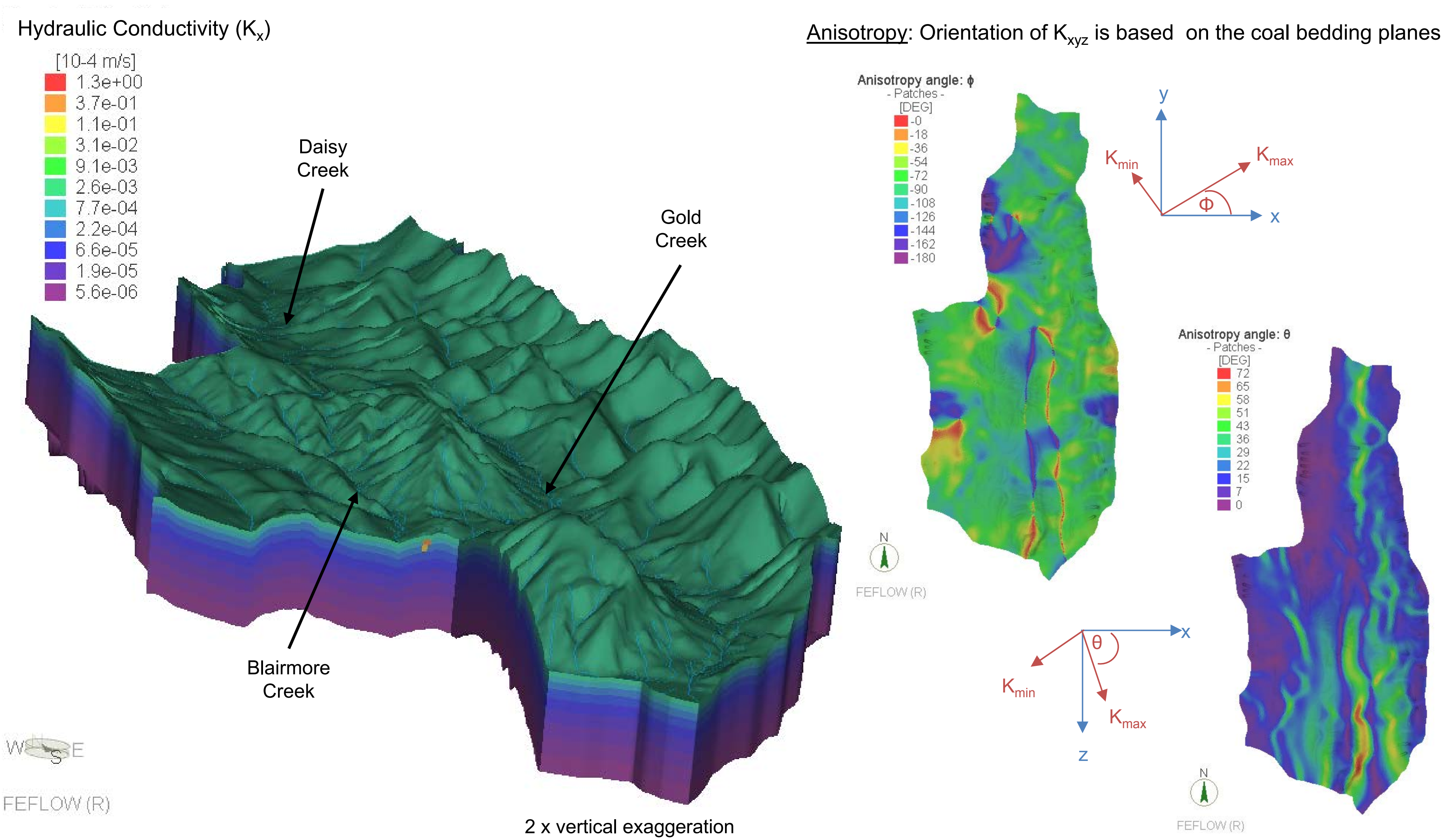
Date:	Approved:	Figure:
July 2016	GF	3-2

Table 3-1: Calibrated Hydraulic Conductivity Value by Model Layer

Model	Layer	Bedrock			Greenhill Mine			Greenhill Boisjoli Mine		
		K1	K2	K3	K1	K2	K3	K1	K2	K3
"Linear" Recharge	1	2.7E-07	8.4E-07	8.4E-09	-	-	-	-	-	-
	2	9.8E-08	3.1E-07	3.1E-09	1.9E-05	1.9E-05	1.9E-05	7.4E-05	7.4E-05	7.4E-05
	3	4.1E-08	1.3E-07	1.3E-09	7.8E-06	7.8E-06	7.8E-06	3.1E-05	3.1E-05	3.1E-05
	4	1.8E-08	5.6E-08	5.6E-10	3.4E-06	3.4E-06	3.4E-06	-	-	-
	5	8.4E-09	2.7E-08	2.7E-10	1.6E-06	1.6E-06	1.6E-06	-	-	-
	6	4.3E-09	1.4E-08	1.4E-10	8.2E-07	8.2E-07	8.2E-07	-	-	-
	7	2.4E-09	7.5E-09	7.5E-11	4.5E-07	4.5E-07	4.5E-07	-	-	-
	8	1.4E-09	4.5E-09	4.5E-11	2.7E-07	2.7E-07	2.7E-07	-	-	-
	9	8.9E-10	2.8E-09	2.8E-11	-	-	-	-	-	-
"Exponential" Recharge	1	1.7E-07	5.3E-07	5.3E-09	-	-	-	-	-	-
	2	6.1E-08	1.9E-07	1.9E-09	1.2E-05	1.2E-05	1.2E-05	4.6E-05	4.6E-05	4.6E-05
	3	2.6E-08	8.1E-08	8.1E-10	4.8E-06	4.8E-06	4.8E-06	1.9E-05	1.9E-05	1.9E-05
	4	1.1E-08	3.5E-08	3.5E-10	2.1E-06	2.1E-06	2.1E-06	-	-	-
	5	5.2E-09	1.7E-08	1.7E-10	1.0E-06	1.0E-06	1.0E-06	-	-	-
	6	2.7E-09	8.5E-09	8.5E-11	5.1E-07	5.1E-07	5.1E-07	-	-	-
	7	1.5E-09	4.7E-09	4.7E-11	2.8E-07	2.8E-07	2.8E-07	-	-	-
	8	8.8E-10	2.8E-09	2.8E-11	1.7E-07	1.7E-07	1.7E-07	-	-	-
	9	5.6E-10	1.8E-09	1.8E-11	-	-	-	-	-	-

Note: all values in m/s

- The Greenhill Mine was represented with K values from 60 to approximately 6000 times greater than the surrounding country rock, while the Greenhill Boisjoli Mine was modelled at about 240 to 24,000 times greater than the surrounding country rock. Specific yield was set at 0.1 and specific storage 1 x 10^{-5}.



Grassy Groundwater Model

Hydraulic Conductivity Distribution

Job No: 1CM029.011
Source: 01b_PrMng_2018_Grassy_Mntn_FM-GwAge_Steady-State_Calibration_rev2_LNR.dac

Grassy Mountain Coal Project

Date:	Approved:	Figure:
July 2016	GF	3-3

3.4.4 Boundary Conditions

Boundary conditions are described below and illustrated in Figure 3-4.

External Boundaries

- The western, eastern and northern model edges are assigned with a no-flow (or zero-flux) boundary condition, to correspond with interpreted flow divides;
- The top slice southern model edge is defined by a fixed head boundary condition along the Crowsnest River, with head values based on ground surface elevations; lower layers on the southern model edge are modelled as no-flow boundaries; and
- The base of the model is defined as a no-flow boundary, in view of the expected low permeability at this depth (800 m).

Internal Boundaries

Recharge

Recharge from precipitation and snowmelt is applied on the top slice and is assumed to follow a similar relationship to that observed between MAP and elevation. Recharge rates were calibrated to the base and alternative calibration models that matched the base flow estimates for Gold Creek, Blairmore Creek and Daisy Creek, for both steady-state and transient conditions.

The two recharge distributions, “Linear” and “Exponential”, corresponding to the base, and alternative calibration, models, are shown in Figure 3-5. The base case calibrated average recharge over the model domain is equivalent to 28% of MAP in both scenarios, and is generally consistent with observed base flow in Blairmore and Gold Creeks.

Rivers/Creeks

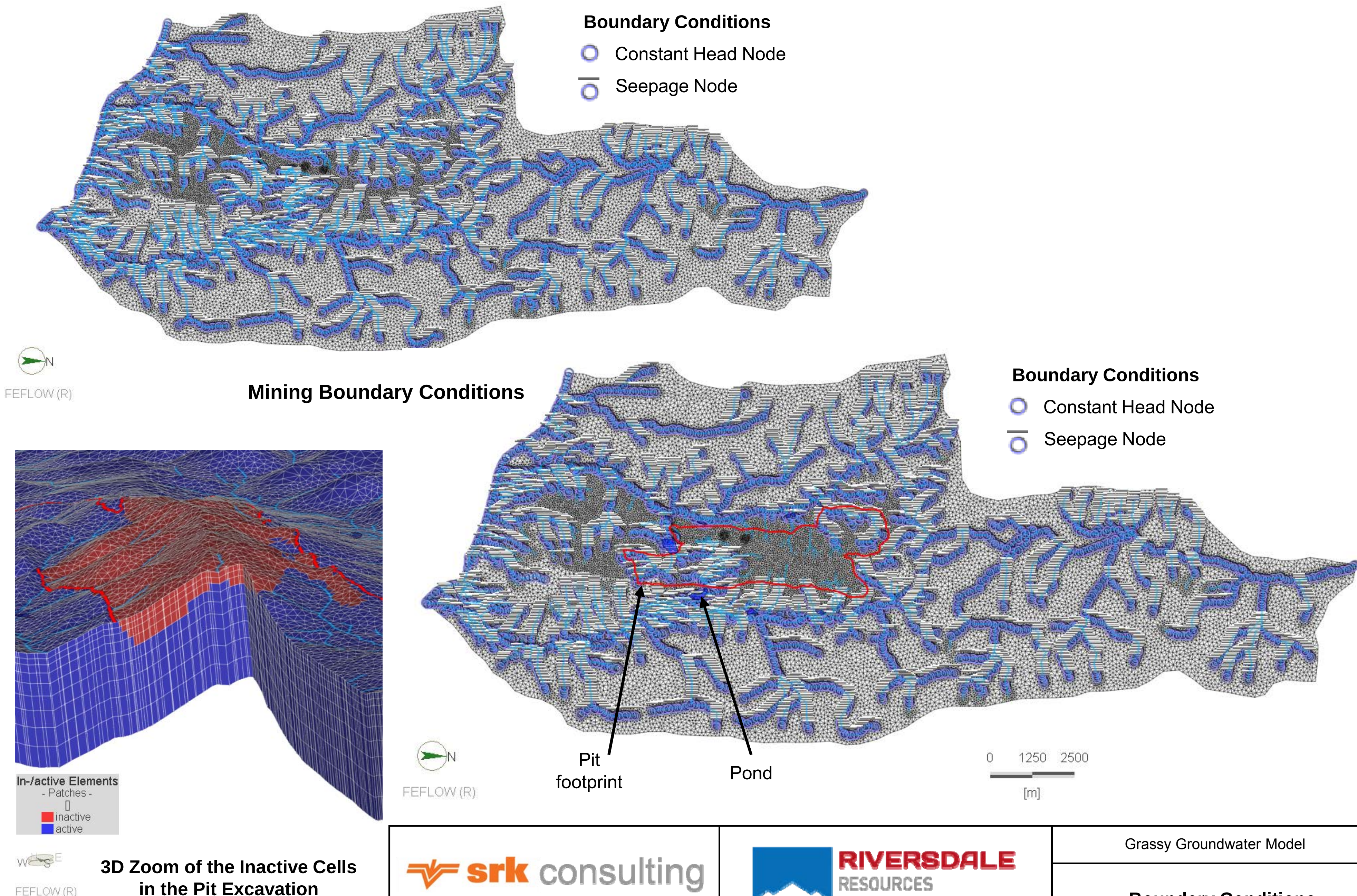
- The main watercourses (Blairmore Creek, Gold Creek, Daisy Creek, and Crowsnest River) are simulated as fixed head boundary conditions; seasonal fluctuations were not considered. Fixed head boundary conditions imply an unimpeded hydraulic connection exists between the rivers and the underlying groundwater system, freely allowing watercourses to function as sources and/or sinks to the groundwater flow system[5]; and
- The smaller creeks and headwaters are simulated using seepage boundary conditions[6]. The seepage boundary conditions allow for discharge to the creeks where the water table is above surface.

Springs/Old Underground Portals

- Discharges at the springs, observed near the proposed open pit and at the two historical underground portals, are simulated using seepage boundary conditions.

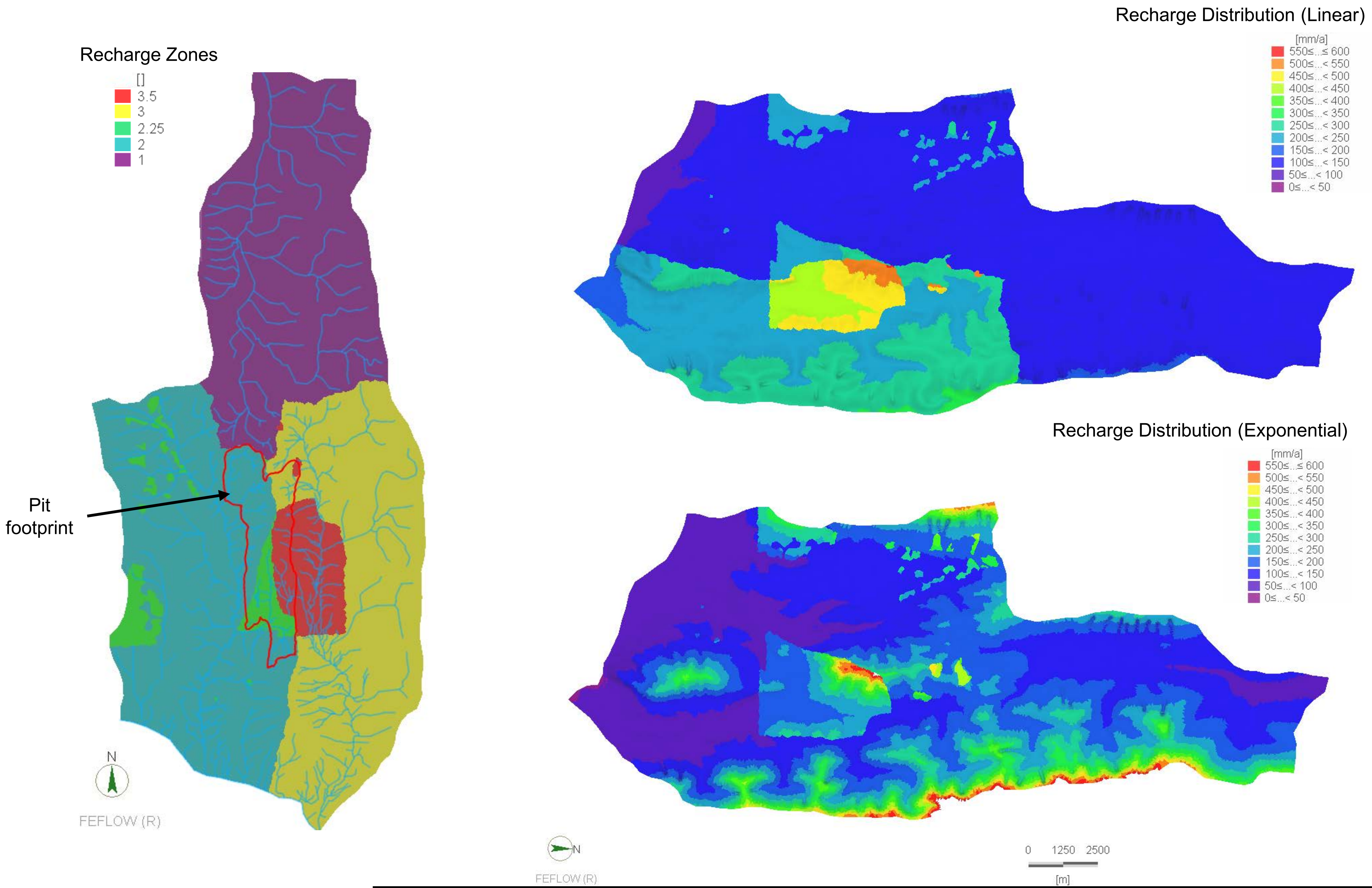
[5] This boundary type was selected in consideration of the dominantly rocky creek beds observed.
[6] A seepage condition is a condition that constrains a node to behave as a drain rather than a constant source of water, i.e. only allow for discharge of groundwater to the creek bed where the water table is above the level of the creek.

Pre-Mining Boundary Conditions



3D Zoom of the Inactive Cells in the Pit Excavation

srk consulting	RIVERSDALE RESOURCES	Grassy Groundwater Model
		Boundary Conditions
Job No: 1CM029.011 Source: 01b_PrMng_2018_Grassy_Mntn_FM-GwAge_Steady-State_Calibration_rev2_LNR.dac	Grassy Mountain Coal Project	Date: July 2016 — Approved: GF — Figure: **3-4**



srk consulting

RIVERSDALE RESOURCES

Grassy Groundwater Model

Groundwater Recharge Distributions

Job No: 1CM029.011
Source: 01b_PrMng_2018_Grassy_Mntn_FM-GwAge_Steady-State_Calibration_rev2_LNR.dac

Grassy Mountain Coal Project

Date:	Approved:	Figure:
July 2016	GF	3-5

3.5 Model Calibration

Model calibration involves varying the hydraulic parameters within a reasonable range defined by the conceptual model, in order to find the best match between simulated and observed data, and to identify areas where further information is needed. Frequently, the calibration process requires re-examination and changes to model structure (i.e., to the conceptual model). The calibration process undertaken on this model involved a two-step procedure:

1. Steady-State calibration to the pre-mining hydraulic head and base flow measurements collected between 2014 and 2016. Calibration was focused on:
   - Estimating of the K to recharge (K/R)[7] ratio based on the hydraulic head distribution;
   - Calibrating of recharge values by matching the measured base flow flux; and
   - Determining K with recharge constraint using the K/R ratio.

The steady-state calibration provided the initial hydraulic head distribution for subsequent transient models.

2. Transient calibration to seasonal hydraulic head and base flow fluctuations observed between 2014 and 2016. The transient calibration provides an estimate of the diffusivity (K/S) of the groundwater system, which can be used to constrain the absolute specific yield (S_y) and specific storage (S_s) based on the calibrated K value identified from the steady-state calibration.

This overall calibration approach provides an estimate of the regional K, storativity, and recharge values. However, although calibration is considered reasonable for larger-scale approximations, models may exhibit large uncertainties at the local scale due to localized heterogeneities not recognized or incorporated into the larger model.

3.5.1 Steady-State Calibration

Water levels used for calibration were based on mean annual water levels from data collected by Golder and MEMS between 2014 and 2016 from a total of 32 stations. Base flow calibration utilized measured and inferred data from 12 creek/ river stage stations, two mine portal stations, and four qualitative estimates from local springs. Base flow measurements and inferred values from the 12 river stage stations utilized mean annual results from the base flow separation analysis (SRK, 2016), which utilized the methodologies of Lyne and Hollick (1979) and Nathan and McMahon (1990). A complete list of the water level monitoring stations and calibration values are provided in Appendix B.

Updated base flow measurements from the Grassy Mountain watersheds indicates higher recharge within the Gold Creek watershed above station GC-01 (8.8 L/sec/km^2) to the Blairmore Creek watershed above station BL-02 (5.3 L/sec/km^2). These stations are considered to be most relevant as both lie near the bottom of the Project footprint. To replicate this base flow within the Grassy Mountain numerical groundwater model, a series of recharge vs. elevation and recharge distribution profiles were generated and compared based on the normalized root mean squared

[7] Note a range of calibrations may be obtained while maintaining a constant K/R ratio – e.g. high K, high R, med K, med R, etc.

error (NRMSE) in modelled base flows. Results suggested two possible conceptual models to explain the variable behaviour (Figure 3-6):

- "Linear" recharge model based on the trend identified in SRK (2015) with recharge increased by a factor of two Gold Creek catchment relative to Blairmore Creek and clear-cut areas increased by a factor of 2 relative to the catchment recharge values.
- Exponential recharge model, with recharge increased by a factor of two within clear cut areas. The function is as follows:

$$R = e^{0.0023E+1.02}$$

Where: R = mean annual recharge

E = elevation

The "Linear" model relied on varying the catchment-scale recharge via the construction of two discrete zones; whereas, the "Exponential" model increases the recharge at higher elevations, favouring increased recharge within the topographically higher Gold Creek catchment.

Initial calibration runs indicated a lower hydraulic head NRMSE within the "Exponential" model (5.2%) compared with the "Linear" model (11.2%).

Overall base flow predictions suggested an overestimation of base flows for the "Linear" model, of 14.2% and 1.4% within the Blairmore and Gold Creek catchments, respectively, while the "Exponential" model had a larger deviation of 28% and -31%, respectively.

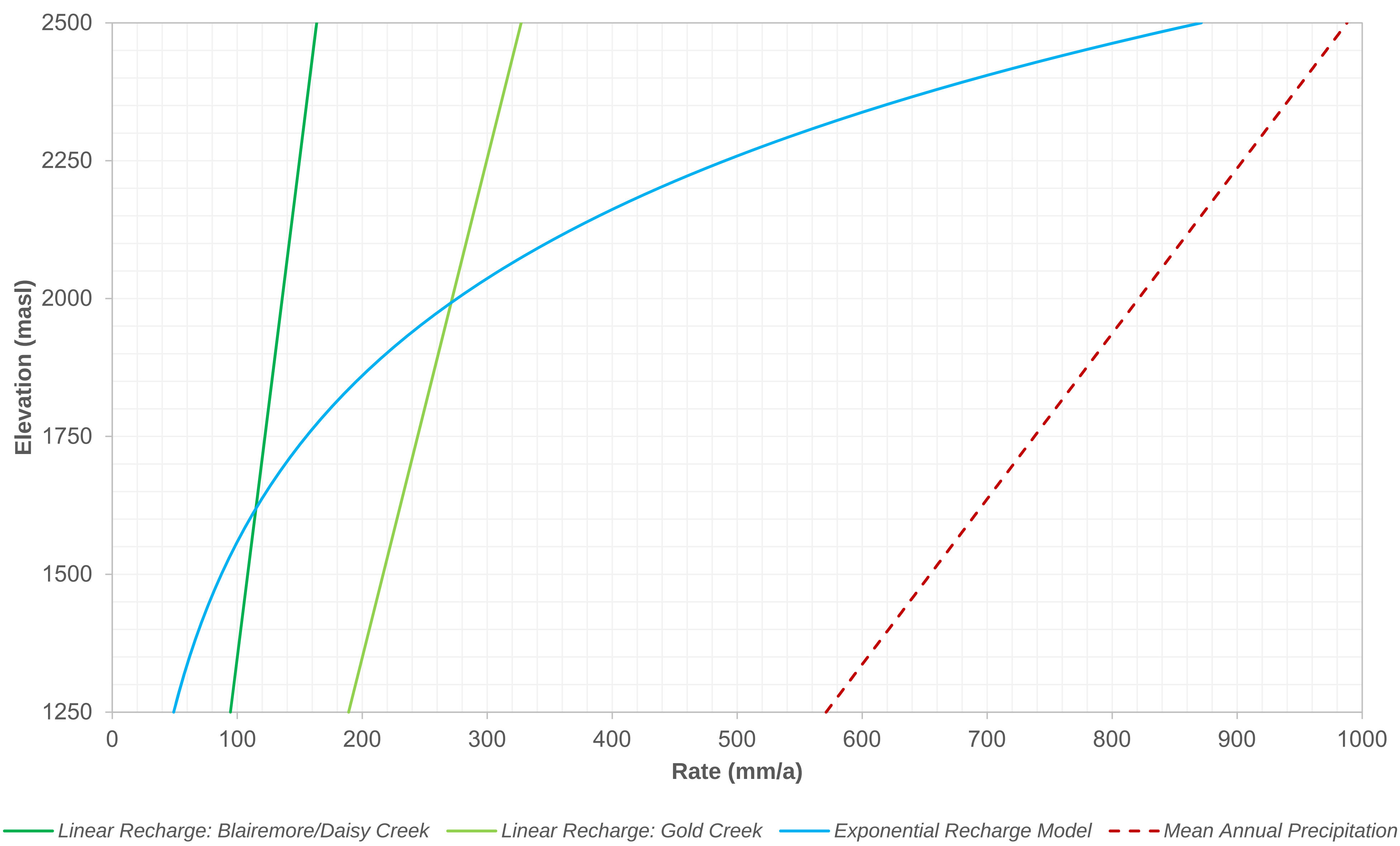
K was assumed to decrease with depth according to the model proposed by Wei et al. (1995), as prior modelling indicated an improved calibration when utilizing a decreasing K with depth compared to fixed values (SRK, 2015). However, K values were increased slightly from the prior model, with the K2 at surface increasing from 4.3×10^{-7} to 8.4×10^{-7} and 5.3×10^{-7} m/s in the "Linear" and "Exponential" recharge models, respectively. Ratios between the K_x, K_x, and K_z remained the same from prior modelling ($3K_x = K_y = 100K_z$).

In attempt to improve calibration, effects of anisotropy in the K tensor was undertaken through the comparison of two models:

- Constant anisotropy tensor equal to the mean regional trend ($\varphi = 90^o$, $\theta = 30^o$, and $\psi = 90^o$); and
- Locally varied anisotropy based on the regional sedimentary bedding orientation.

The latter model resulted in a reduction in the hydraulic heads NRMSE to 5.9% and 5.6%, for the "Linear" and "Exponential" models, respectively and 5.2% and 11.4% for the base flow NRMSE, respectively, resulting in an improved calibration when local anisotropy is included in the calibration.

Overall calibration for both models is considered reasonable, with combined steady-state NRMSE (equally weighted between hydraulic heads and base flows) of 5.5% and 8.5%, for the "Linear" and "Exponential" recharge models, respectively. Generally, a NRMSE threshold below 10% is considered reasonable (10%). The calibration plots are presented in Figure 3-7 through Figure 3-10.



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RIVERSDALE RESOURCES

Ground Water Model Update

Groundwater Recharge Models

Job No: 1CM029.011

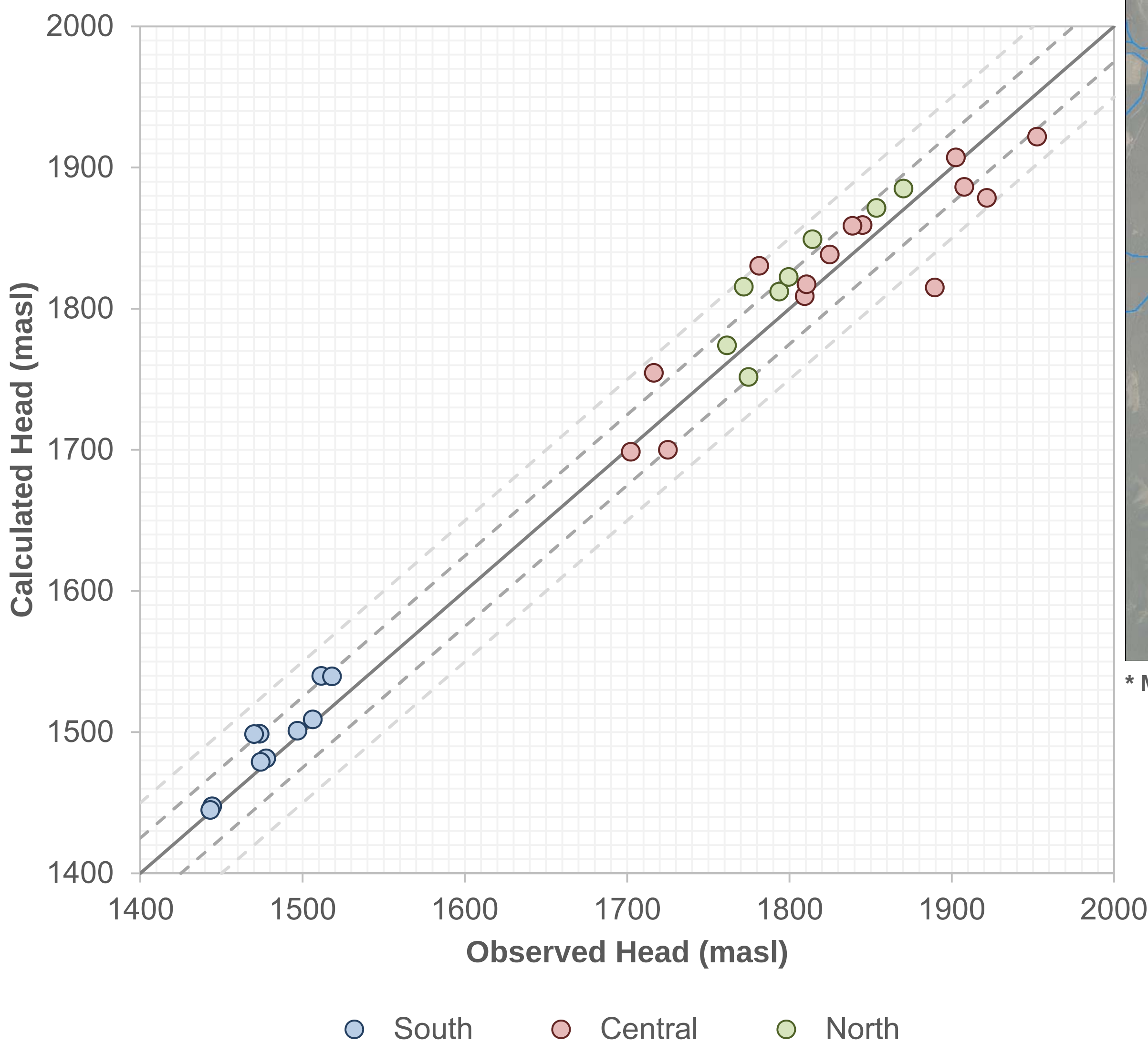
Filename: Groundwater_Calibration_Figures_1CM029.011_2016_Rev02_jm.pptx

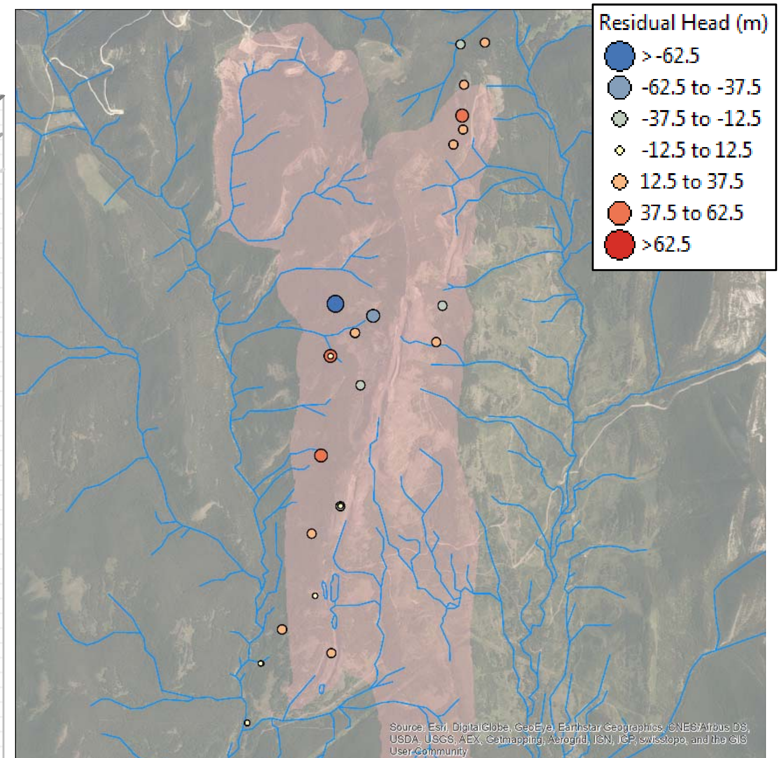
Grassy Mountain Coal Project

Date: July 2016

Approved: JM

Figure: 3-6



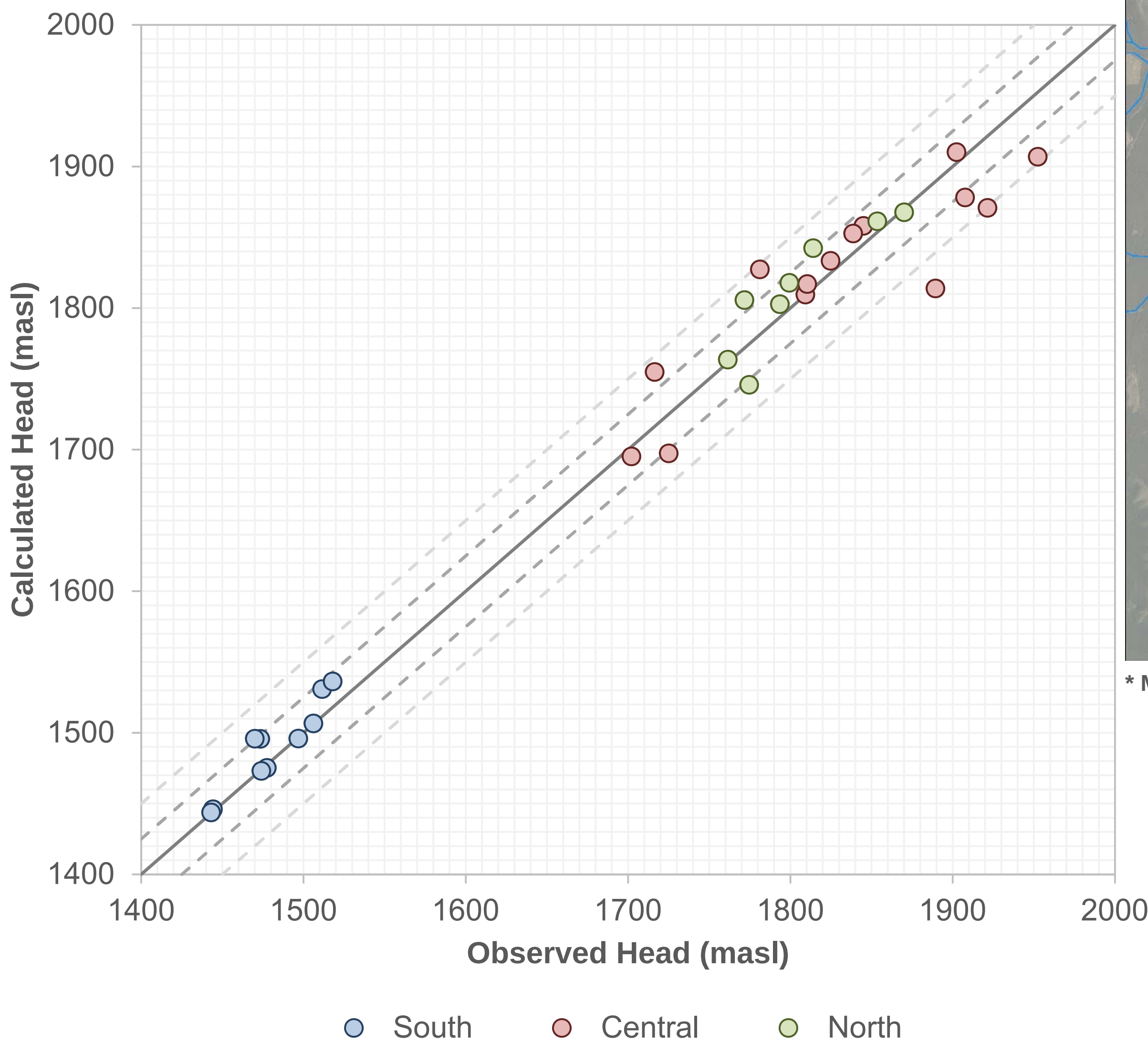


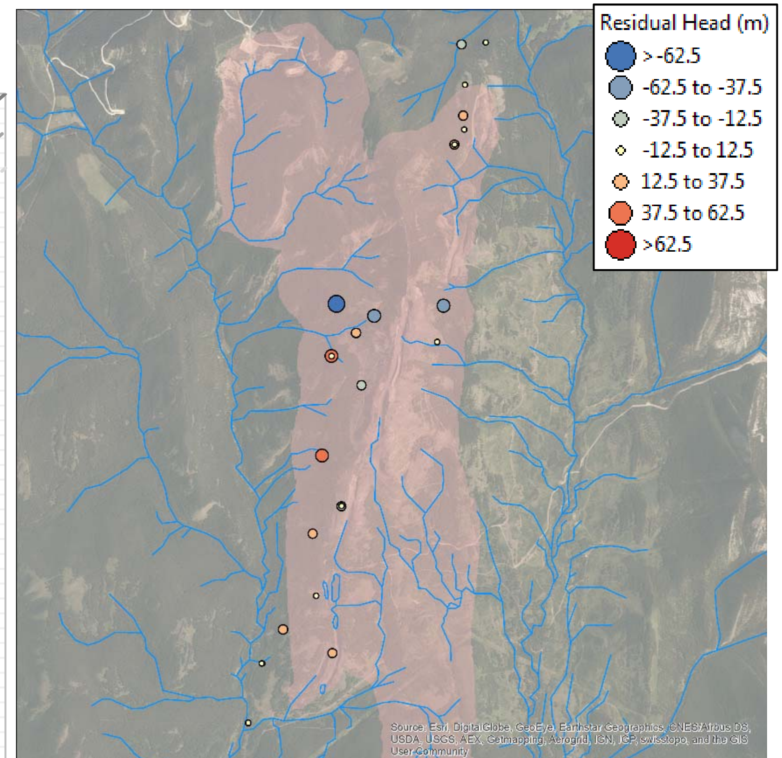
*** Mine footprint indicated by red shaded area**

Calibration Statistics

Mean Error = 6.9 m
Maximum Absolute Error = 74.3 m
Absolute Mean Error = 20.6 m
Root Mean Squared Error = 26.4 m
Norm. Root Mean Squared Error = 5.2%
Coeff. of Determ. (R^2) = 0.98

srk consulting	RIVERSDALE RESOURCES	Ground Water Model Update
		Steady-State Calibration: Hydraulic Heads ("Linear" Calibration)
Job No: 1CM029.011 Filename: Groundwater_Calibration_Figures_1CM029.011_2016_Rev02_jm.pptx	Grassy Mountain Coal Project	Date: July 2016 · Approved: JM · Figure: **3-7**



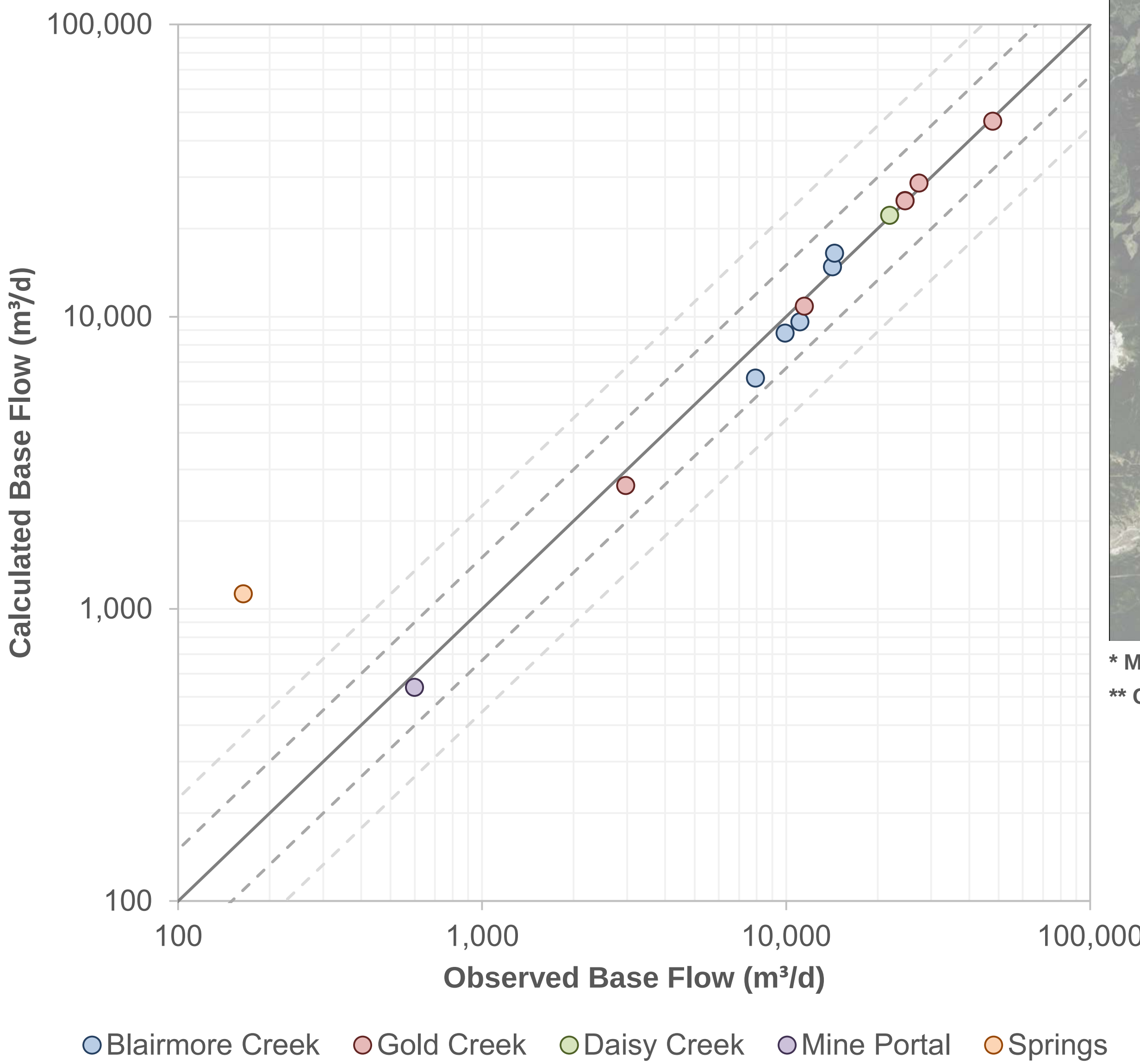


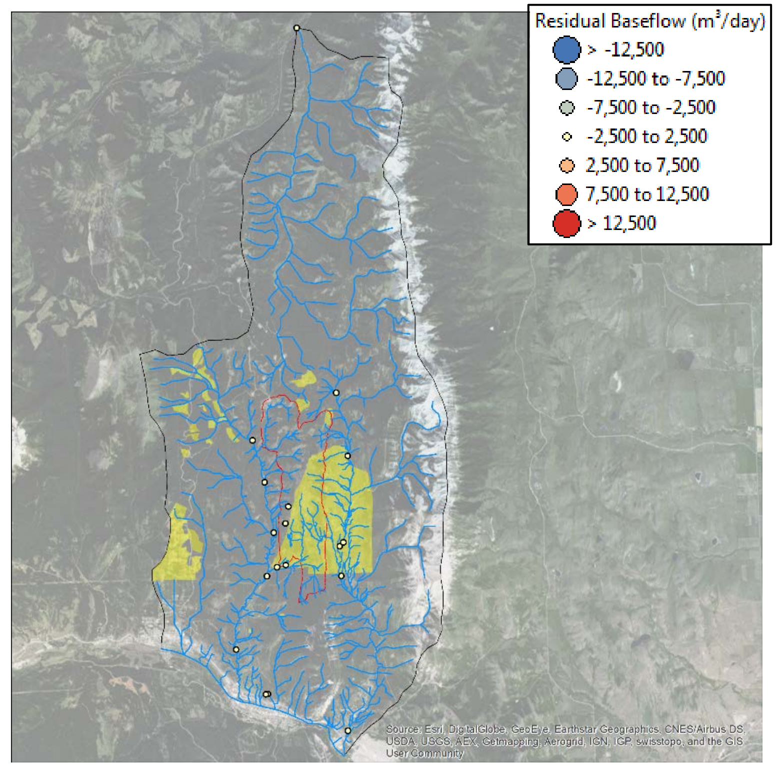
* Mine footprint indicated by red shaded area

Calibration Statistics

Mean Error = 1.8 m
Maximum Absolute Error = 75.4 m
Absolute Mean Error = 18.6 m
Root Mean Squared Error = 25.8 m
Norm. Root Mean Squared Error = 5.1%
Coeff. of Determ. (R^2) = 0.98

srk consulting	RIVERSDALE RESOURCES	Ground Water Model Update **Steady-State Calibration: Hydraulic Heads (“Exponential” Calibration)**
Job No: 1CM029.011 Filename: Groundwater_Calibration_Figures_1CM029.011_2016_Rev02_jm.pptx	Grassy Mountain Coal Project	Date: July 2016 / Approved: JM / Figure: **3-8**





* Mine footprint indicated by red polyline

** Clear-cut areas indicated by yellow shaded areas

Calibration Statistics

Mean Error = -58 m³/d

Maximum Absolute Error = 2,051 m³/d

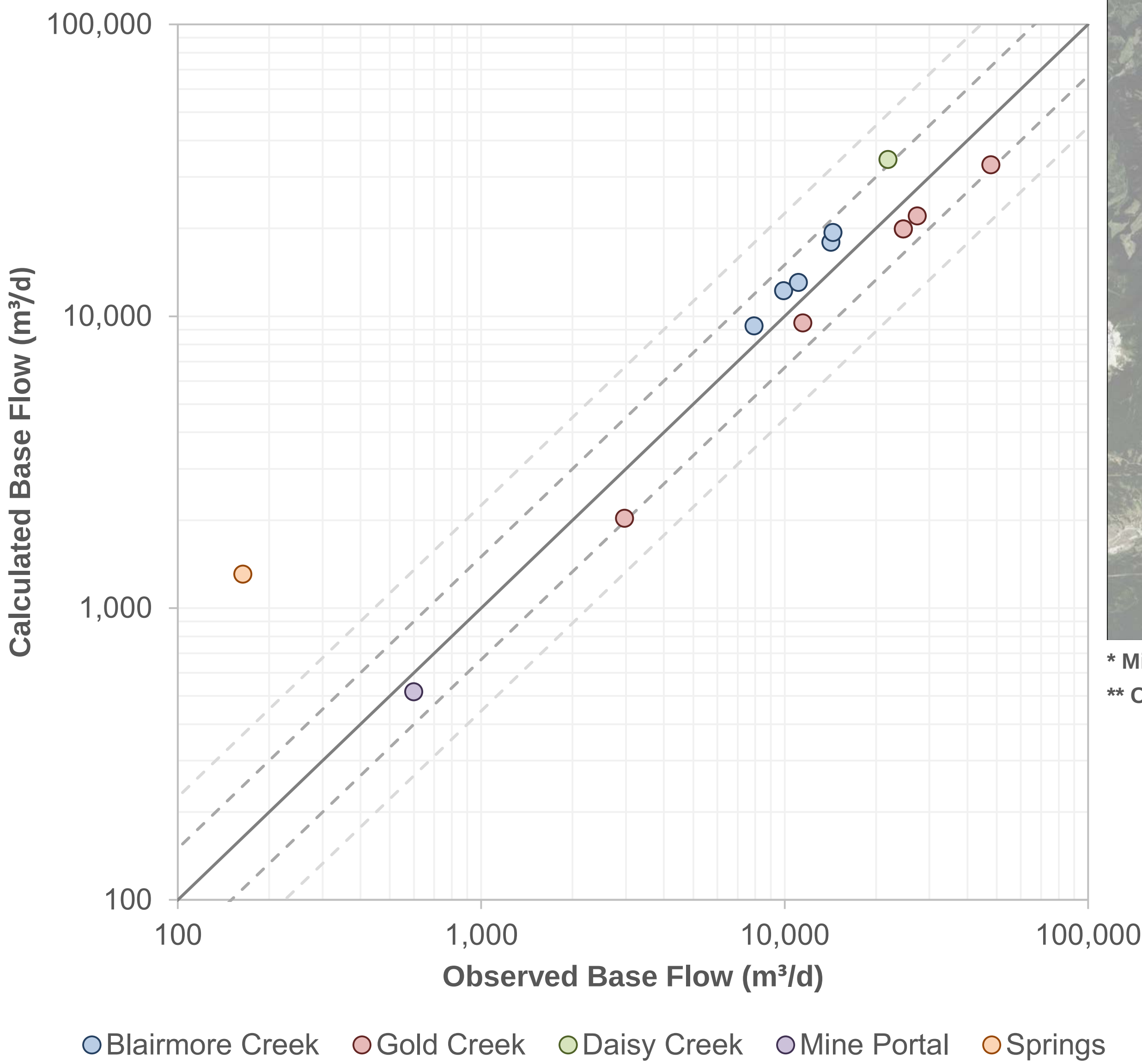
Absolute Mean Error = 656 m³/d

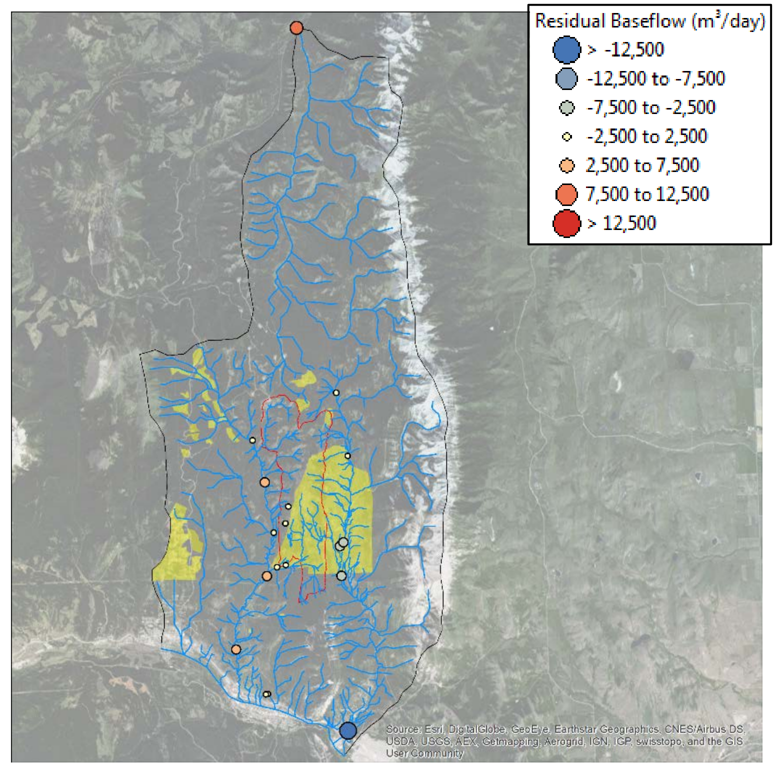
Root Mean Squared Error = 919 m³/d

Norm. Root Mean Squared Error = 1.9%

Coeff. of Determ. (R^2) = 0.99

srk consulting	RIVERSDALE RESOURCES	Ground Water Model Update **Steady-State Calibration: Base Flows (“Linear” Calibration)**
Job No: 1CM029.011 Filename: Groundwater_Calibration_Figures_1CM029.011_2016_Rev02_jm.pptx	Grassy Mountain Coal Project	Date: July 2016 / Approved: JM / Figure: 3-9





*** Mine footprint indicated by red polyline**

**** Clear-cut areas indicated by yellow shaded areas**

Calibration Statistics

Mean Error = -259 m³/d
Maximum Absolute Error = 14,839 m³/d
Absolute Mean Error = 3,183 m³/d
Root Mean Squared Error = 5,147 m³/d
Norm. Root Mean Squared Error = 10.8%
Coeff. of Determ. (R^2) = 0.83

srk consulting	RIVERSDALE RESOURCES	Ground Water Model Update
		Steady-State Calibration: Base Flows (“Exponential” Calibration)
Job No: 1CM029.011 Filename: Groundwater_Calibration_Figures_1CM029.011_2016_Rev02_jm.pptx	Grassy Mountain Coal Project	Date: July 2016 / Approved: JM / Figure: 3-10

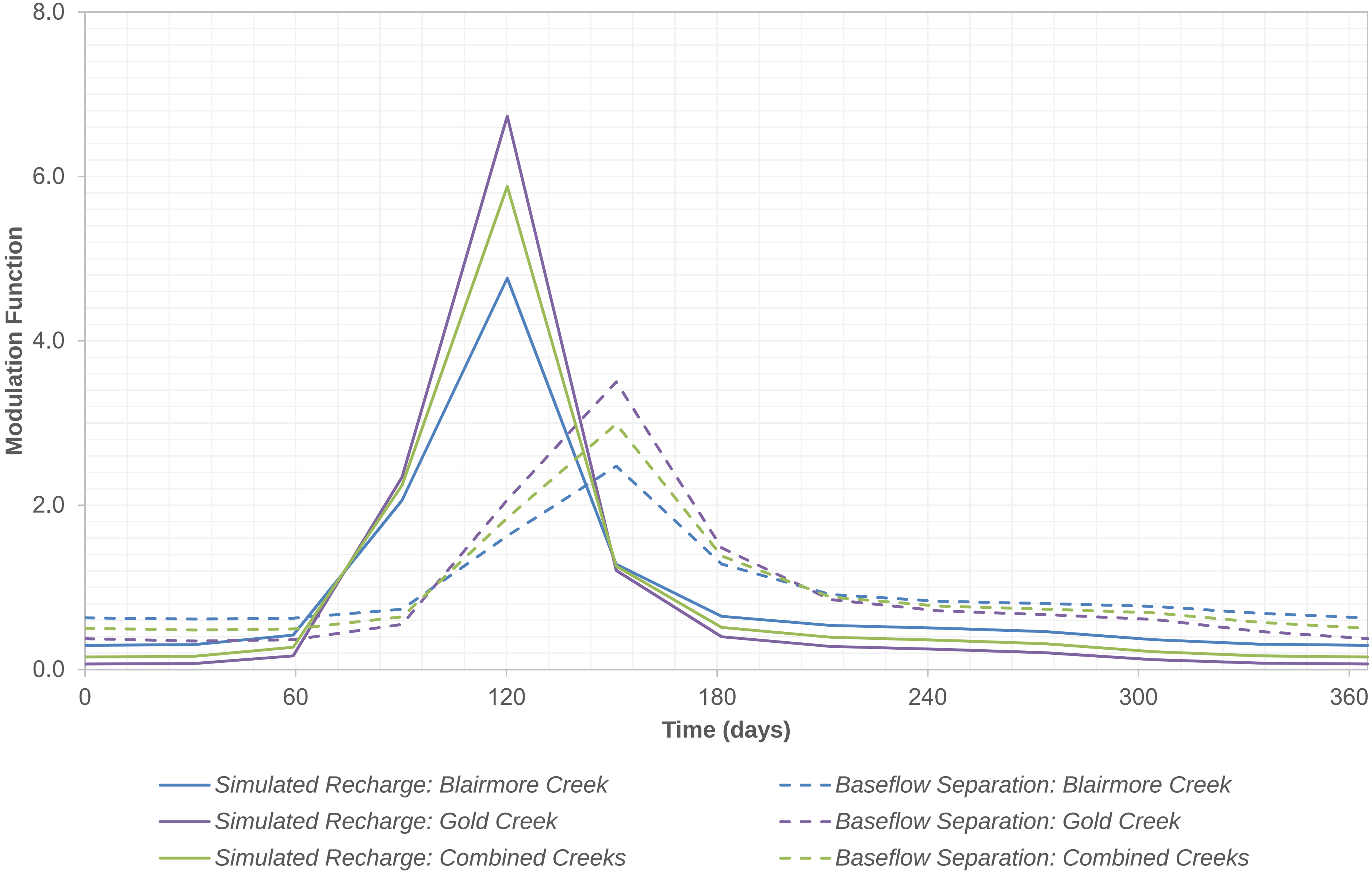
Large hydraulic head errors (30 to 87 m lower in modelled vs. observed values) in both models are found to occur in drill holes RGSC-0007 and RGSC-0008. However, measurement in both of these holes were collected from open holes during packer testing on a single occasion and are therefore uncertain due to localized disturbances to the hydraulic head regime during drilling. Additional large errors are observed in RGOH-129, RGSC-0006c and MW14-09-129, which had a modelled value substantially (44 to 79 m) higher than the observed values, and MW14-05-114, which had a value substantially (43 m) lower than the observed value. It is unclear at this time what may have caused these large errors, however groundwater levels in these locations may be indicative of localized compartmentalization or perched groundwater. These points remain incorporated in the calibration statistics; if removal of these is justified, the calibration statistics would improve significantly.

Calibration of base flows measurements show the largest errors at BL-04, near the top of the Blairmore catchment. Flow gauging data indicate highest unit base flows occur near the head of this catchment, and there may be greater uncertainty with respect to flows in the upper catchment. However, this station is located up-stream of mining infrastructure and considered to be less indicative of overall predictive model behaviour than stations near the proposed Grassy Mountain mine (i.e. BL-02, GC-01).

3.5.2 Transient Calibration

A transient groundwater calibration was conducted by matching recharge to seasonal water level and base flow fluctuations observed between 2014 and 2016. The calibration was conducted to estimate the specific yield (Sy) and storativity (Ss) based on the diffusivity (K/S) of the groundwater system. Simulations were conducted by keeping the K and yearly average recharge constant; while, varying the seasonal recharge, specific storage and specific yield to match the pre-mining (2014-2016) seasonal water level variability. Seasonal water level records were available from 14 of the 32 total water level stations. A complete list of the water level stations and annual water level fluctuations is provided in Appendix C.

Seasonal variability in recharge was simulated based on the base flow separation analysis by SRK (2016). The analysis utilized the methodology of Lyne and Hollick (1979) and Nathan and McMahon (1990) to estimate the base flow component of the Blairmore and Gold creeks independently from their total flow datasets. Results of the base flow separation analysis suggests increased base flow during the spring freshet, with a lower background throughout the remainder of the year (Figure 3-11).



** Modulation function defined as the average monthly unit recharge and Base Flow/average annual unit recharge and Base Flow*

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RIVERSDALE RESOURCES

Ground Water Model Update

Monthly Groundwater Recharge and Base Flow Modulation Function

Job No: 1CM029.011

Filename: Groundwater_Calibration_Figures_1CM029.011_2016_Rev02_jm.pptx

Grassy Mountain Coal Project

Date: July 2016

Approved: JM

Figure: **3-11**

Groundwater recharge was simulated from this profile by including a one month time lag (determined through the calibration process) from recharge to base flow, and applying a square factor to further increase recharge during the spring freshet, as follows:

$$R_{month} = \frac{BF_{month+1}^2}{\sum_{n=1}^{12} BF_n^2} * \%MAP$$

Where: R_{month} = monthly recharge

BF_{month} = monthly base flow

%MAP = amount of annual recharge as % of mean annual precipitation

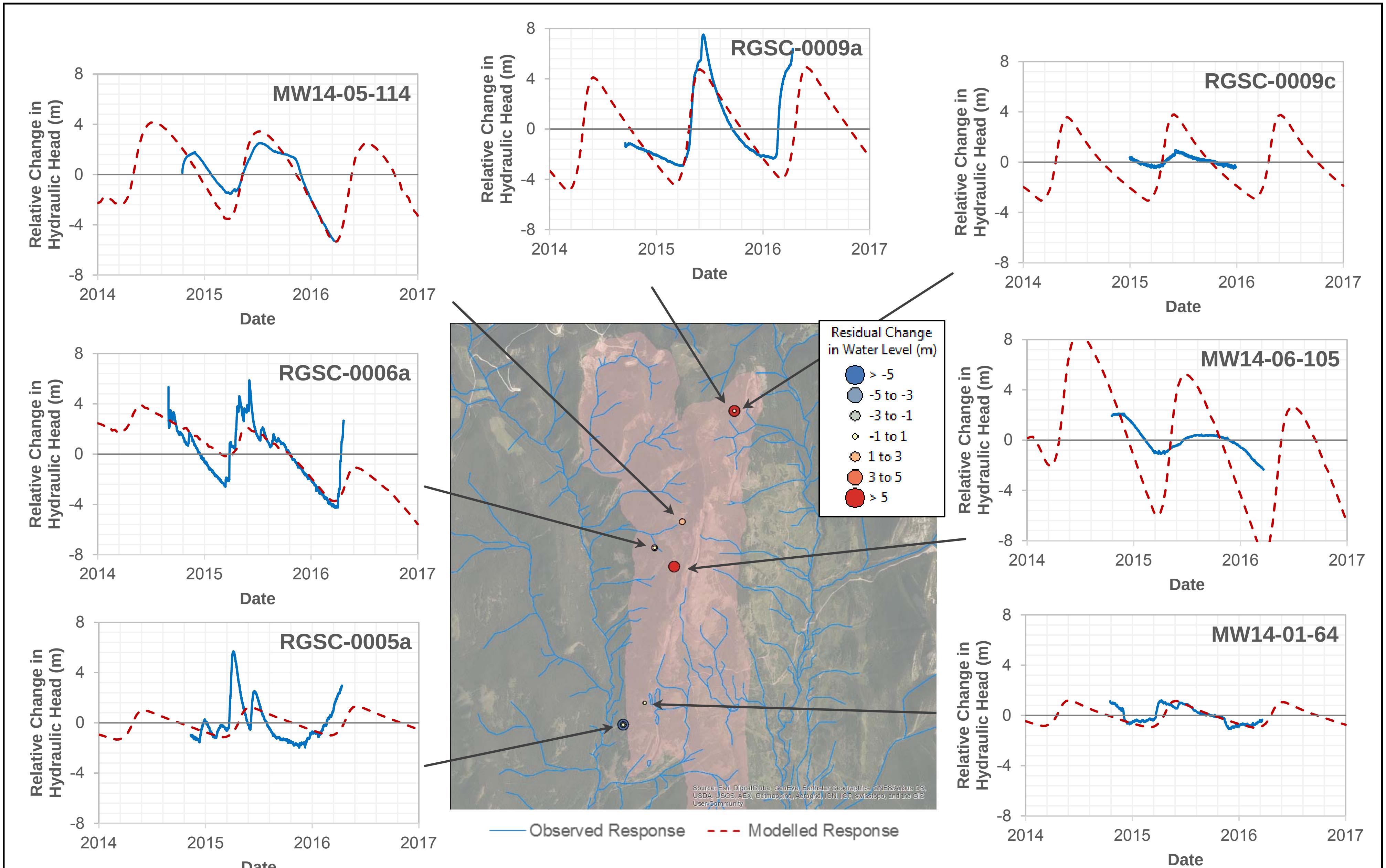
The “Linear” recharge model utilized independent monthly recharge profiles for each of Blairmore Creek and Gold Creek. The “Exponential” model used an average monthly recharge profile for the two catchments.

Examination of the water level variability in each of the 14 stations where levels were monitored indicates water level behaviour which does not fit the seasonal fluctuation profile at three wells: MW14-02-74, MW14-06-32, and MW14-06-105. The three wells can generally be split into two groups based on their behaviour:

- MW14-02-74: Measured pressures in MW14-02-74 are near atmospheric conditions (<1 m head) suggesting the piezometer string may be either empty or only have minor residual water not representative of in-situ conditions. Nearby piezometers to MW14-02-74 (south piezometer cluster) show seasonal groundwater fluctuations which are much larger (2 to 7 m) than the minor residual water that may be in MW14-02-74 (<1 m).
- MW14-06-32 and MW14-06-105: MW14-06-32 and MW14-06-105 represent a piezometers in close proximity to each other, located near the ridge of Grassy Mountain. Water level records from the two wells show greatly reduced variability compared to nearby wells (2 to 4 m vs. 7 to 10 m, respectively). In addition, numerical model estimates of seasonal variability in these piezometers greatly over-predict the degree of water level fluctuations (~20 m). This over-prediction may be caused by the elevated topographic setting of the piezometers (highest in the dataset) which is strongly affected by the unsaturated zone, or localized vertical and/or horizontal compartmentalization not captured within the model.

Single specific yield (S_y) and specific storage (S_s) values were used throughout each model for each transient calibration. Final calibration values suggest a calibrated S_y of 1.0 x 10^{-2} and 1.5 x 10^{-2} for the “Linear” and “Exponential” recharge models, respectively, and a S_s of 1.0 x 10^{-6} and 1.5 x 10^{-6} m^{-1}.

Overall calibration for both models is considered reasonable for a transient groundwater calibration, with numerical simulations demonstrating similar seasonal fluctuations to in-situ measurements (Figure 3-12 and Figure 3-13).



** Plots demonstrate the range good (RGC-006a) to poorly (MW14-06-105) matched in-situ seasonal trends.*

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Job No: 1CM029.011

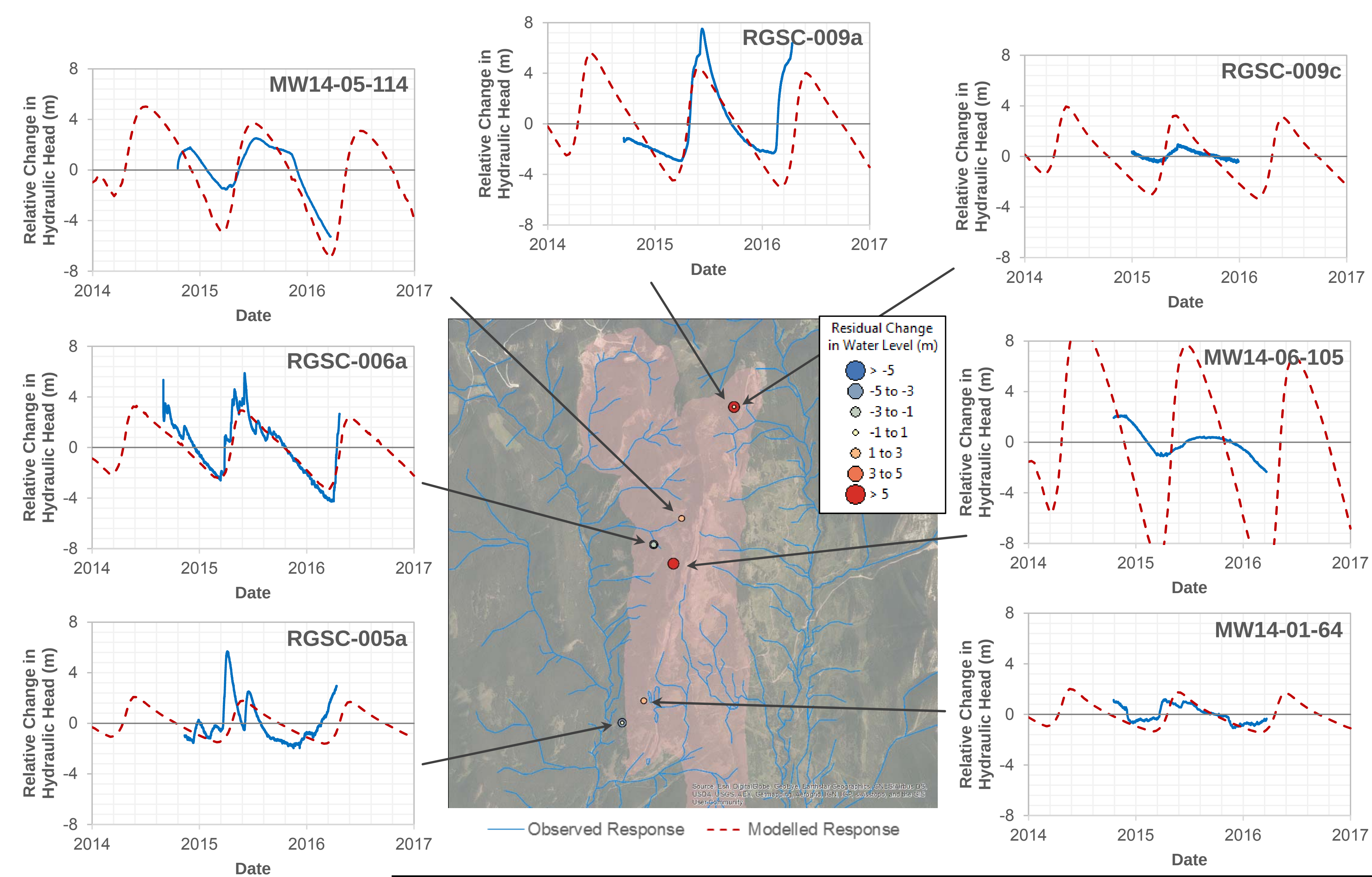
Filename: Groundwater_Calibration_Figures_1CM029.011_2016_Rev02_jm.pptx

Grassy Mountain Coal Project

Ground Water Model Update

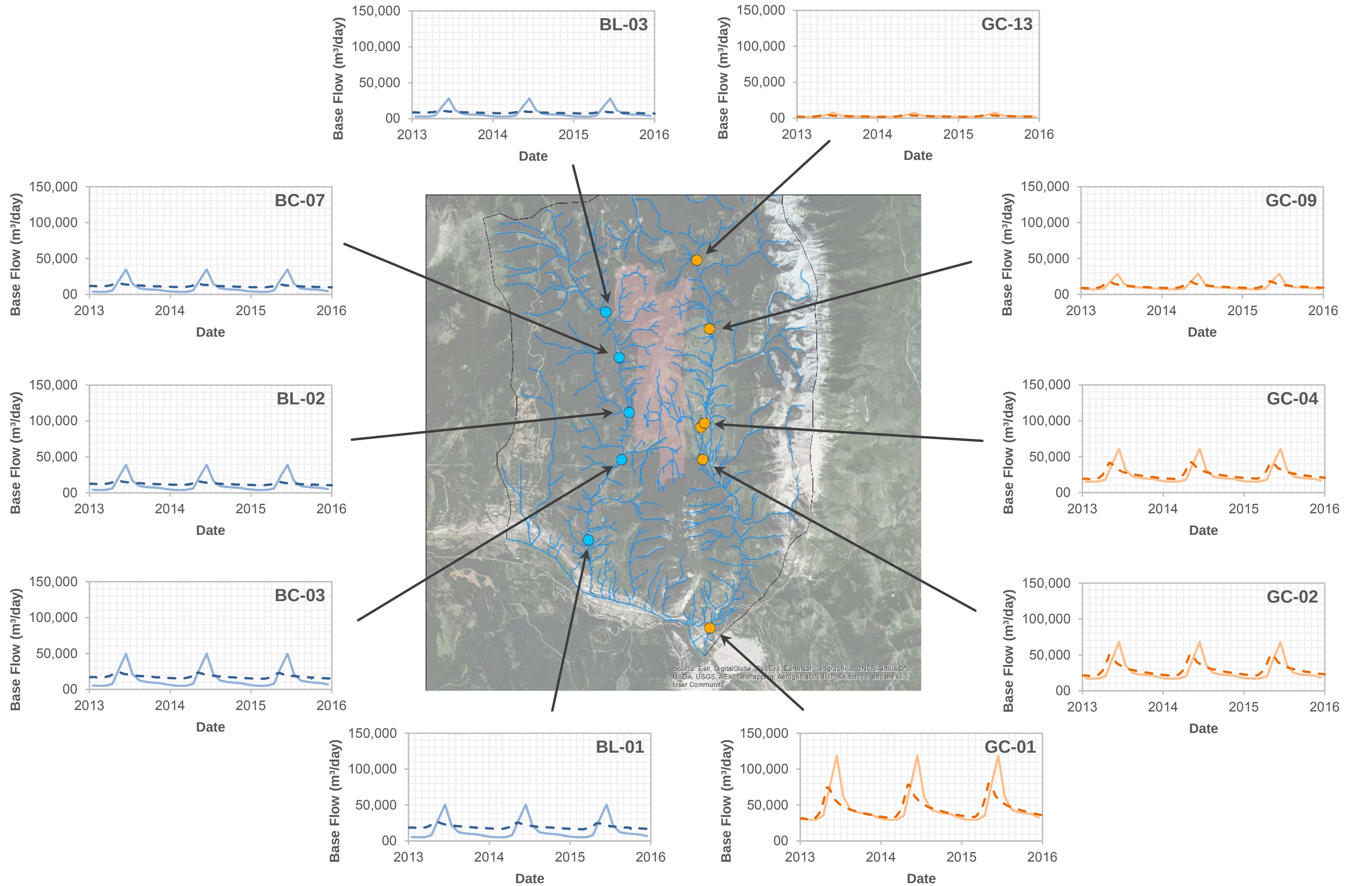
Transient Calibration: Monthly Hydraulic Heads (“Linear” Calibration)

Date:	Approved:	Figure:
July 2016	JM	3-12



** Plots demonstrate the range of good (RGC-006a) to poorly (MW14-06-105) matched in-situ seasonal trends.*

srk consulting	RIVERSDALE RESOURCES	Ground Water Model Update **Transient Calibration: Monthly Hydraulic Heads ("Exponential" Calibration)**
Job No: 1CM029.011 Filename: Groundwater_Calibration_Figures_1CM029.011_2016_Rev02_jm.pptx	Grassy Mountain Coal Project	Date: July 2016 · Approved: JM · Figure: **3-13**



- Oberserved Blairmore Creek Baseflow
- Calculated Blairmore Creek Baseflow
- Observed Gold Creek Baseflow
- Calculated Gold Creek Baseflow

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Ground Water Model Update

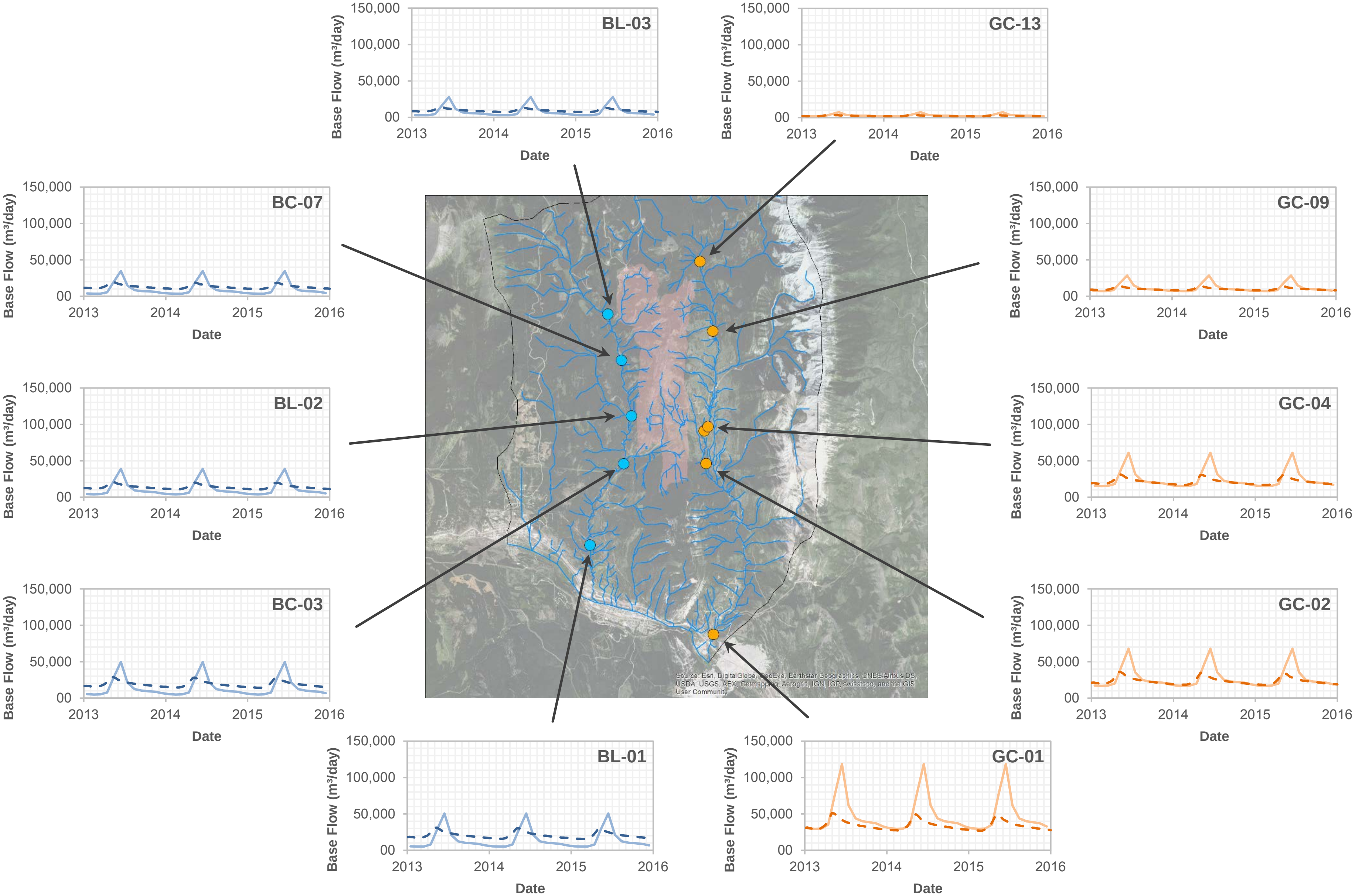
Transient Calibration: Monthly Base Flow Variability (“Linear” Calibration)

Job No: 1CM029.011

Filename: Groundwater_Calibration_Figures_1CM029.011_2016_Rev02_jm.pptx

Grassy Mountain Coal Project

Date:	Approved:	Figure:
July 2016	JM	3-14



Oberserved Blairmore Creek Baseflow
Calculated Blairmore Creek Baseflow
Observed Gold Creek Baseflow
Calculated Gold Creek Baseflow

srk consulting	RIVERSDALE RESOURCES	Ground Water Model Update
		Transient Calibration: Monthly Base Flow Variability (“Exponential” Calibration)
Job No: 1CM029.011 Filename: Groundwater_Calibration_Figures_1CM029.011_2016_Rev02_jm.pptx	Grassy Mountain Coal Project	Date: July 2016 | Approved: JM | Figure: 3-15

Some discrepancies between in-situ conditions and numerical simulations can be observed, with RGSC-009a showing a good match between model and simulation results; while, RGSC-009c, in the same borehole, shows an overall poor match. These discrepancies are the result of the regional nature of the numerical simulation which is unable to capture small-scale vertical and/or horizontal compartmentalization which result from complex localized sedimentary bedding.

A comparison of simulations with seasonal base flow behaviour is shown in Figure 3-14 and Figure 3-15. The overall match between in-situ conditions and numerical simulations is considered to be relatively good during low flow periods, while the model under-represents peak flow periods during spring freshet. However, uncertainty exists in the seasonal base flow behaviour as values were estimated analytically from the base flow separation analysis of Lyne and Hollick (1979) and Nathan and McMahon (1990). As a result, SRK focused the calibration to matching low flow periods and overall seasonal *in-situ* hydraulic head measurements.

3.6 Predictive Simulations

Groundwater flow simulation results were undertaken for both the “Linear” recharge and “Exponential” recharge calibrated models, using simulations for the following conditions:

- Steady-state and transient state baseline: 2014 to 2016 conditions, no active mining and no excavation;
- Steady-state Mining: One model per year of mining (between 2018 and 2040), the excavation and the surface water management system are implemented gradually for each year of mining as per the proposed mine plan progression;
- Steady-state EOM, 2041: The open pit is developed to full extent, the surface water management system is constructed and active, the two saturated rock fills[8] (saturated zone (SZ)1 and SZ2) located on the west side of Grassy Mountain are active, there are no saturated zones (SZ3) or pit lake on the east side; and
- Steady-state and transient state LTC, year 2046: The open pit, saturated rock fills, and pit lake are all at full extent; the surface water management system is decommissioned.

The steady-state conditions represent seasonally-averaged stable groundwater flow conditions for a given set of boundary conditions.

The transient conditions represent seasonal groundwater flow conditions. These models assume that the groundwater system is in equilibrium at time = 0 (i.e. initial condition assigned with predicted steady sate heads) and then run for three cycles of monthly variable recharge estimated by calibration (See Section 3.5.2).

The steady-state models applied to each year of the mining period were developed as a more numerically stable alternative to the transient model for the mining period. Comparison of the end-of-year head and base flow conditions indicated good correspondence, hence the annual

[8] Saturated backfill areas are planned for the Grassy Mountain Mine and will be managed as electrochemically-reducing zones and used for the removal of selenium and nitrate from mine contact water.

steady-state models were utilized for generating results as a result of the improved model stability. The recharge applied to the models, whether annual, or monthly, equates to about 28% of MAP. The pit is fully excavated (as per mine plan for the previous year) at the start of each respective simulation. The open pit is represented using seepage node boundary conditions[2]; the mesh elements that correspond to the volume of the pits are inactivated.

The ex-pit rock disposal areas are not explicitly modelled; they are accounted through variations of the recharge rates at the base of the rock disposal areas (i.e. original ground surface). The LTC scenario assumes that the recharge is not modified at the base of the ex-pit rock disposal areas relative to pre-mining conditions. The effects of a reduction and an augmentation of recharge over the rock disposals footprint are evaluated as part of the sensitivity analysis.

The pit lake and in-pit rock disposal areas are represented using fixed head nodes. The sedimentation ponds are assumed to be unlined and also represented using fixed head nodes. Pit lake stage elevations are assigned according to the proposed mine layout (Figure 2-16 and Figure 2-17), based on estimated filling rates[9] and the spill point[10] elevations.

Simulations also evaluated lifetime expectancy and exit probabilities[11], in order to evaluate unmitigated groundwater flow time from rock disposal areas and surface water management systems to Blairmore Creek, Gold Creek and their respective tributaries.

Long-term piezometric levels at the southern end of the backfilled pit will be close to the formal Boisjoli portal elevation, hence there may be potential for flow from the saturated fill zone SZ2 via the Boisjoli Greenhill underground mine, and from there via unmined rock to the Greenhill mine workings, located 90 m to the south below a tributary valley. Travel time for this flow path was evaluated using particle tracking. Table 3-2 summarizes how boundary conditions for each mine saturated zone and water management facility vary through the mine life and into closure.

---

9 Pit lake and saturated backfill filing rates were determined on the basis of a volume-elevation model and consideration of direct precipitation to the pit lake, runoff to the pit, water pumped back to the saturated zones and pit lake evaporation. This analysis was undertaken with a Goldsim model, and is documented in SRK (2016b). Volumes available for water storage in the saturation zones were provided by MEMs. For the pit lake, a storage curve (volume and surface area vs elevation) was developed using a Digital Elevation Model of the region and Global Mapper (2016). Cut and fill volumes were determined using Global Mapper for an area delineated around the pit lake perimeter at 1 m intervals from the lowest point of the DEM of 1570 masl to the elevation of interest plus a 2 m buffer (1752 masl). The time required to fill saturation zone and pit lake volumes was calculated based on their volumes and the inflow rate to each facility (calculated in the water balance model – SRK (2016b)).

10 As documented in SRK (2016b), maximum pit lake elevation will be maintained through passive discharge or other means.

11 *"FEFLOW provides the capabilities to calculate groundwater age, lifetime expectancy and exit probability, which provide the means to analyze flow dynamics, estimate risk vulnerability and evaluate outlet capture zones and the origin of water.*

Lifetime expectancy and exit probability are obtained by solving standard mass-transport equations. The simulation of lifetime expectancy and exit probability is based on the backward transport equation.

Lifetime expectancy is defined as the average time for groundwater still needed before exiting the domain via an outlet. It therefore corresponds to the expected travel time from the current location to an outflow boundary. Results for lifetime expectancy can be used for risk vulnerability assessments and the analysis of groundwater dynamics: Zones with longer lifetime expectancy indicate groundwater divides whereas areas close to outflow boundaries show shorter travel times.

The parameter exit probability can be used to calculate the probability of water exiting the model domain at specific locations. In contrast to age and lifetime expectancy simulations, boundary conditions for exit probability are not applied automatically. Instead, outflow locations for which the exit probability is to be calculated have to be selected manually. As the probability of exit is 100% at an outflow boundary, a probability BC with a value of 1 is typically assigned there. Assigning a probability boundary condition of 1 on a creek allows to delineate the capture zone of that creek and also to determine the origin of the water. Compared to standard particle tracking, exit probability can provide much more information on a capture zone: Heterogeneity effects are considered via dispersion and flow times are determined through temporal spreading of the probability plume." - Feflow 6.2 User Manual from DHI-WASY Software (page 13 and page 127)

Table 3-2: Summary of the Mine Boundary Conditions over Time

Year	Condition	Pit/Dump	SZ1*	SZ2*	SZ3*	PSSP	SWSP	RWP	SESP	WSP	ESP	NWSP	NESP
2018	*Baseline*	-	-	-	-	-	-	-	-	-	-	-	-
2019	*Mining*	*Year #1*	-	-	-	*Active*	*Active*	*Active*	*Active*	-	-	-	-
2020	*Mining*	*Year #2*	-	-	-	*Active*	*Active*	*Active*	*Active*	*Active*	-	-	-
2021	*Mining*	*Year #3*	-	-	-	*Active*	*Active*	*Active*	*Active*	*Active*	-	-	-
2022	*Mining*	*Year #4*	*1379*	-	-	*Active*	*Active*	*Active*	*Active*	*Active*	-	-	-
2023	*Mining*	*Year #5*	*1388*	-	-	*Active*	*Active*	*Active*	*Active*	*Active*	-	-	-
2024	*Mining*	*Year #6*	*1393*	-	-	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	-	-
2025	*Mining*	*Year #7*	*1399*	-	-	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	-
2026	*Mining*	*Year #8*	*1403*	-	-	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	-
2027	*Mining*	*Year #9*	*1408*	-	-	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	-
2028	*Mining*	*Year #10*	*1413*	-	-	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	-
2029	*Mining*	*Year #11*	*1419*	-	-	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	-
2030	*Mining*	*Year #12*	*1424*	-	-	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	-
2031	*Mining*	*Year #13*	*1429*	-	-	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*
2032	*Mining*	*Year #14*	*1436*	-	-	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*
2033	*Mining*	*Year #15*	*1443*	-	-	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*
2034	*Mining*	*Year #16*	*1450*	-	-	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*
2035	*Mining*	*Year #17*	*1458*	-	-	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*
2036	*Mining*	*Year #18*	*1465*	-	-	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*
2037	*Mining*	*Year #19*	*1465*	-	-	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*
2038	*Mining*	*Year #20*	*1465*	*1589*	-	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*
2039	*Mining*	*Year #21*	*1465*	*1621*	-	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*
2040	*Mining*	*Year #22*	*1465*	*1636*	-	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*
2041	*EOM*	*Year #23*	*1465*	*1636*	-	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*
2042	*Closure*	*Final pit shell and final in-pit and ex-pit rock disposal footprints*	*1465*	*1636*	-	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*
2043	*Closure*		*1465*	*1636*	*1640*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*
2044	*Closure*		*1465*	*1636*	*1671*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*
2045	*Closure*		*1465*	*1636*	*1685*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*	*Active*
2046	*LTC*		*1465*	*1636*	*1700*	*Closed*	*Closed*	*Closed*	*Closed*	*Closed*	*Closed*	*Closed*	*Closed*

Notes:

* Estimated water level (masl)

SZ, Saturated Zones

PSSP, Plant Site Sediment Pond (1460 masl)

SWSP, Southwest Surge Pond (1490 masl)

RWP, Raw Water Pond 1497 masl)

SESP, Southeast Surge Pond (1508 masl)

WSP, West Sediment Pond (1592 masl)

ESP, East Sediment Pond (1579 masl)

NWSP, Northwest Surge Pond (1602 masl)

NESP, Northeast Sediment Pond (1364 masl)

3.7 Model Results

3.7.1 Significance of Results

The British Columbia Groundwater Modeling Guidelines[12] (Wels et al., 2012) define three levels of modeling complexity, based on the potential impacts, modeling objectives, hydrogeological framework and data availability. The model developed to undertake this assessment may be classified as of moderate complexity, defined as follows:

"*These are conceptual or numerical models based on a reasonable, though limited, dataset and having limited calibration. These models may be used to determine the potential range of change or to "bracket" potential effects that may occur due to a given stress.*"

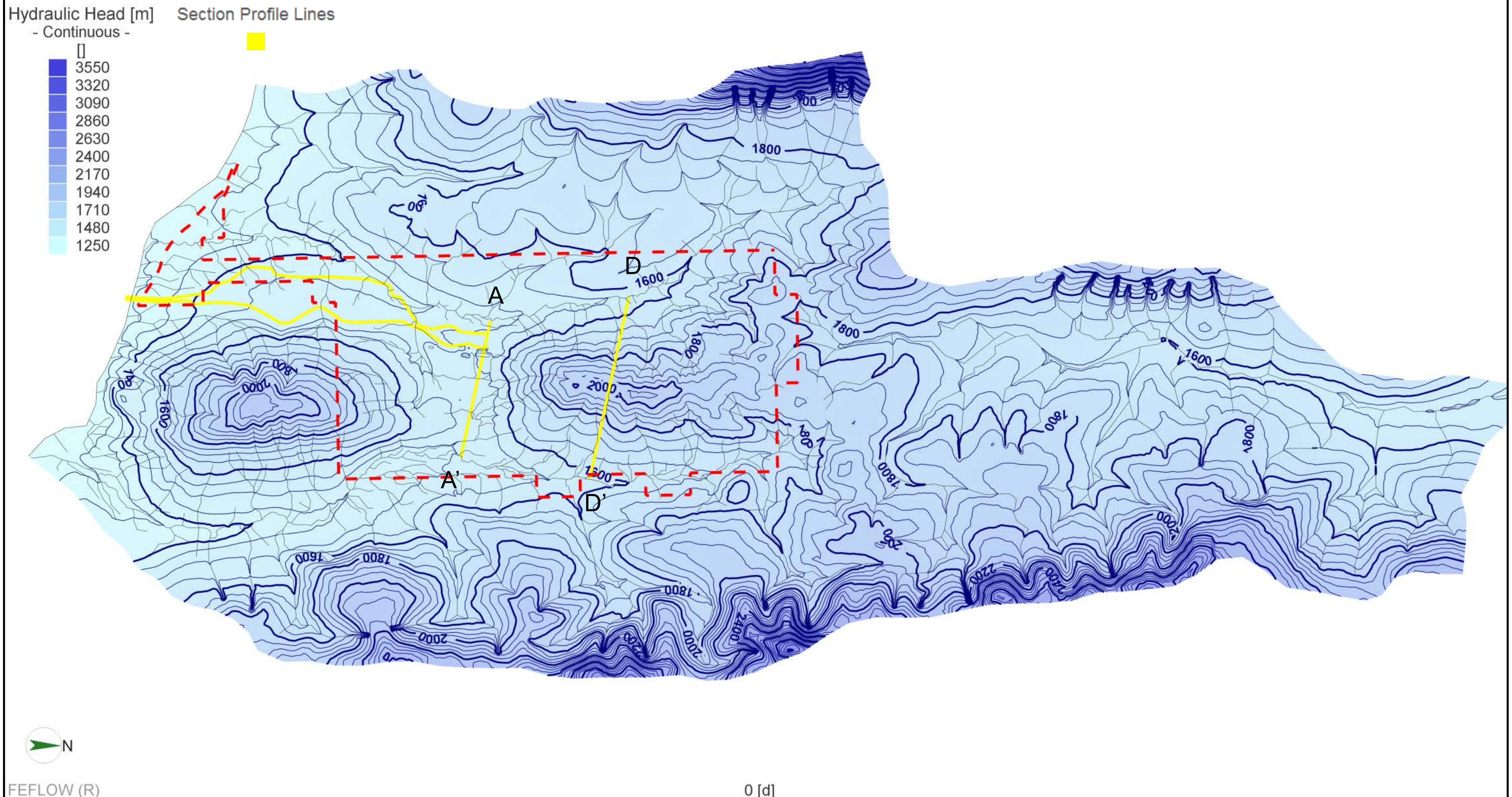
Hence, while specific results are calculated during the modelling process, there always remains a degree of uncertainty associated with these estimates. Quantification of the uncertainty may be a laborious and expensive process. SRK has attempted to quantify the uncertainty by providing a range of estimates; however, these ranges should not be viewed as definitive.

Model outputs are presented only for the "Linear" recharge calibrated model; however the results for the "Exponential" recharge model are discussed in the discussion on the potential range of uncertainty, Section 3.8.

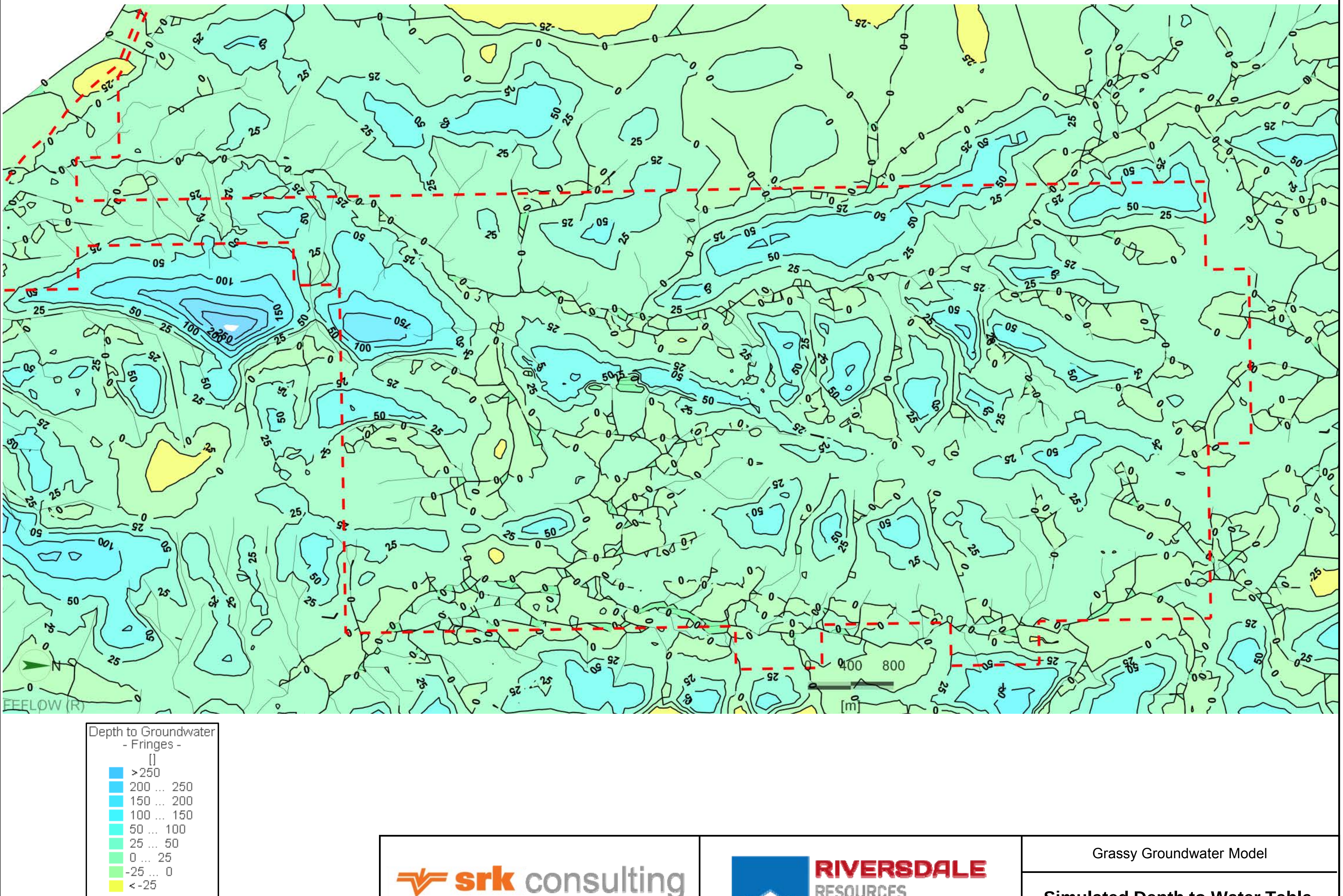
3.7.2 Baseline

The calculated baseline (average steady-state pre-mining) hydraulic head distribution and depth to water table distributions in plan and cross-section are presented in Figure 3-16 to Figure 3-19. The locations of cross sections A-A' and D-D' are shown in Figure 3-16. Monthly variation in base flow at key creek stations is shown in Figure 3-20. Monthly fluctuation in base flow tends to increase substantially in the downstream direction for Gold Creek, potentially a result of the presence of clear cut areas and higher elevation areas associated with Caudron Creek.

[12] The B.C. Modelling Guidelines were utilized as no similar guideline currently exists for Alberta and the B.C. jurisdiction includes hydrogeological environments similar to Albertan (i.e. eastern ranges of Rocky Mountains).



srk consulting	RIVERSDALE RESOURCES	Grassy Groundwater Model
		Simulated Water Table Elevation, Baseline
Job No: Source: GrassyFigures_FeFlow.pptx	Grassy Mountain Coal Project	Date: July 2016 / Approved: GF / Figure: **3-16**



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RIVERSDALE RESOURCES

Grassy Groundwater Model

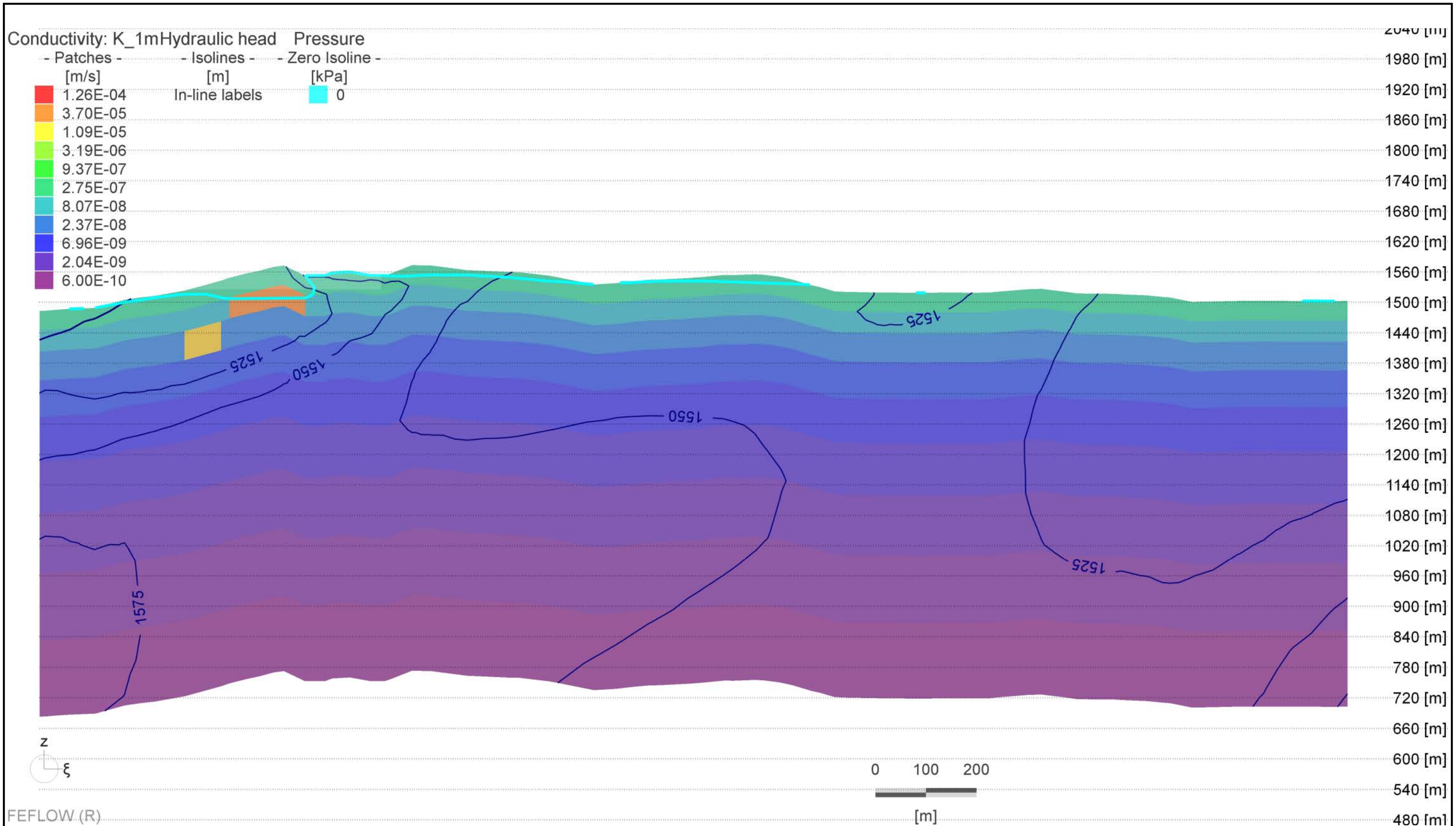
Simulated Depth to Water Table, Baseline

Job No: 1CM029.011

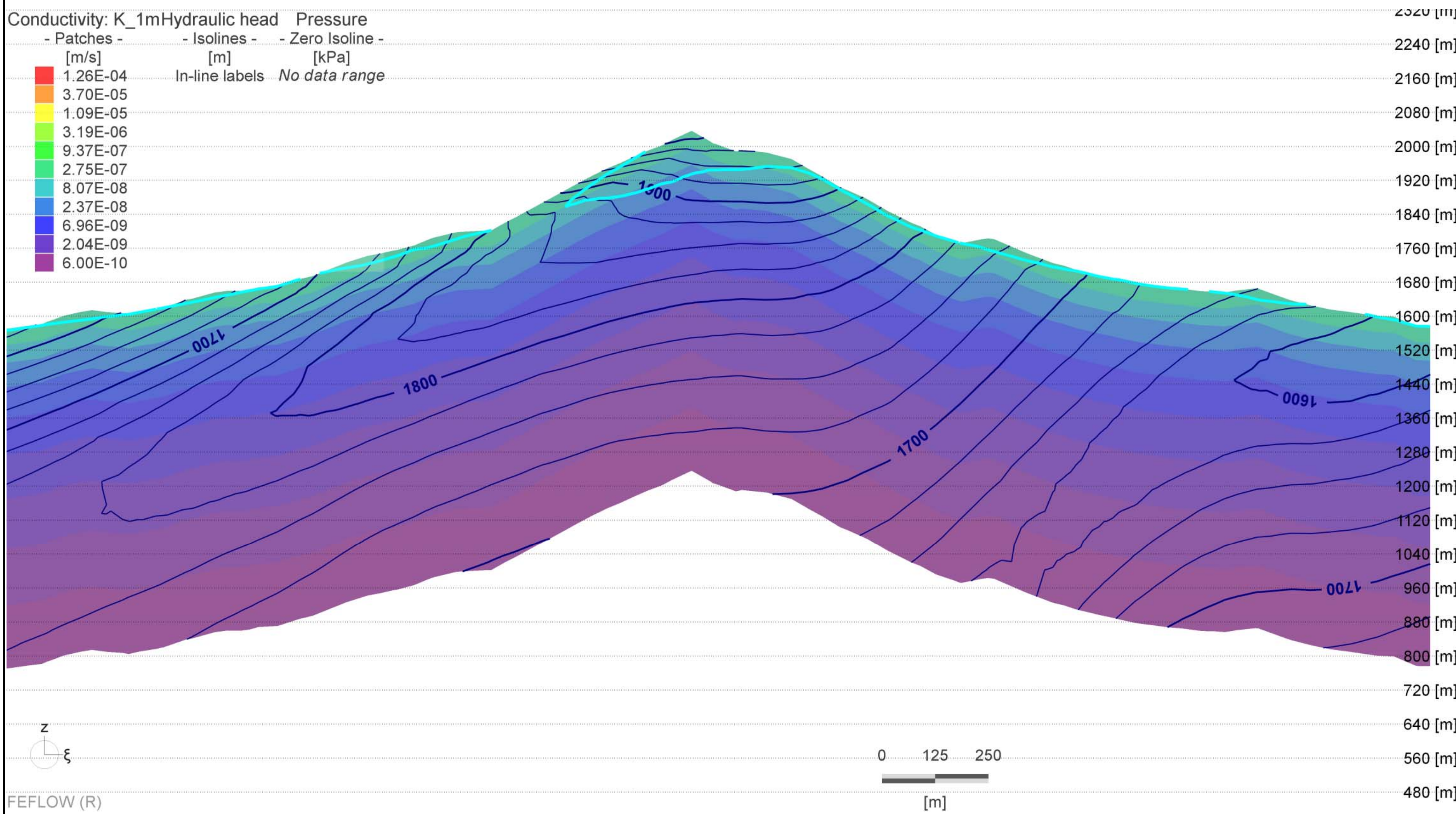
Source: GrassyFigures_FeFlow.pptx

Grassy Mountain Coal Project

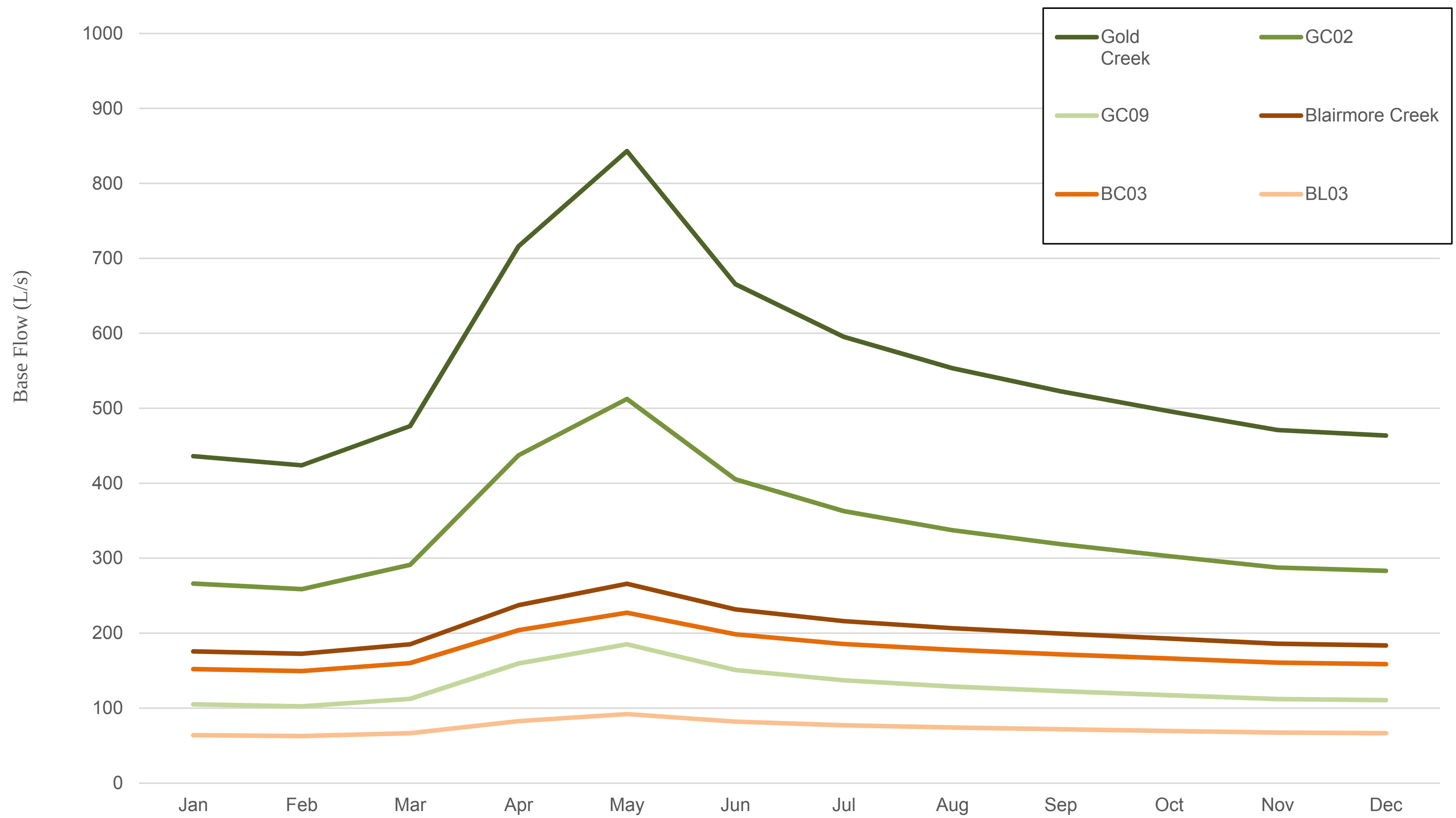
Date:	Approved:	Figure:
July 2016	GF	**3-17**



srk consulting	RIVERSDALE RESOURCES	Grassy Groundwater Model
		Piezometric Contours and K, Cross-Section A-A', Baseline
Job No: 1CM029.011 Source: GrassyFigures_FeFlow.pptx	Grassy Mountain Coal Project	Date: July 2016 · Approved: GF · Figure: **3-18**



srk consulting	RIVERSDALE RESOURCES	Grassy Groundwater Model
		Piezometric Contours and K, Cross-Section D-D', Baseline
Job No: 1CM029.011 Source: GrassyFigures_FeFlow.pptx	Grassy Mountain Coal Project	Date: July 2016 | Approved: GF | Figure: **3-19**



srk consulting	RIVERSDALE RESOURCES	Grassy Groundwater Model
		Monthly Variation in Simulated Base Flow
Job No: 1CM029.011 Source: GrassyFigures_FeFlow.pptx	Grassy Mountain Coal Project	Date: July 2016 / Approved: GF / Figure: **3-20**

3.7.3 Mining Period

Figure 3-21 shows the predicted average annual pit inflows and average annual creek base flows at station BC-03, a WBLM point on (Blairmore Creek) and GC-01 (Gold Creek) through the mine life and into closure for the “Linear” calibration model. Detailed steady-state model flow results through the mining period and into closure for are presented in Tables C-1 to C-3, Appendix C. Detailed steady-state model flow results through the mining period and into closure for the “Exponential” calibration model are presented in Tables C-4 to C-6, Appendix C.

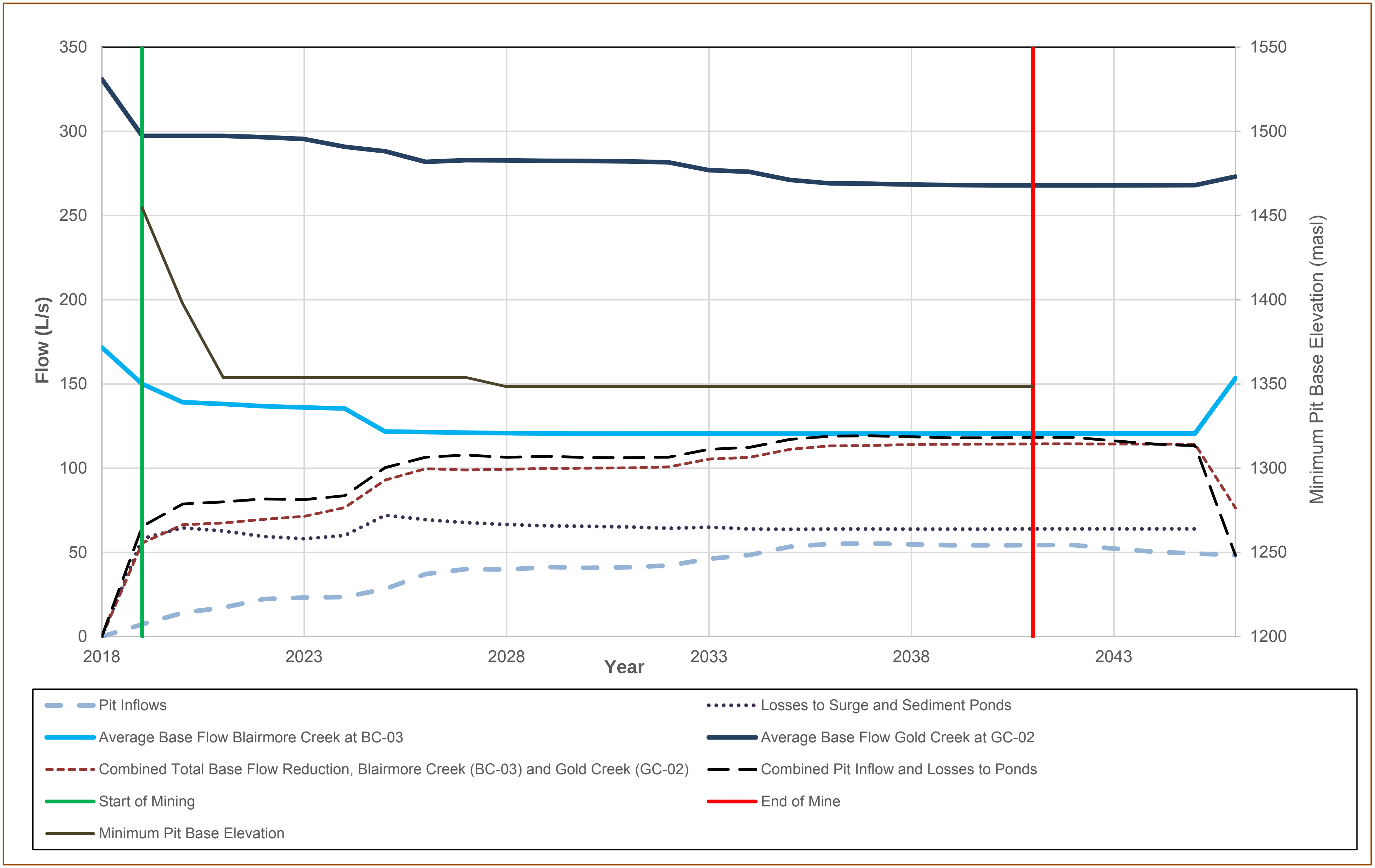
Mine pit inflows are predicted to rise gradually to a peak of about 55 L/s (4,781 m^3/d) in 2037. Inflows decrease from 2037 onward, as downward development from this point onward is in relatively low-permeability rock and as a result of depletion of storage in drained wall rock, the gradual flooding of the in-pit backfill and pit.

The surface water management system (drainage ditches, surge and sedimentation ponds) is predicted to capture a larger proportion of water than the pit, with a peak of 72 L/s in 2025. The water management system is dismantled in 2046, dramatically increasing the amount of groundwater reporting to Blairmore Creeks and to a lesser extent, Gold Creek.

Table 3-3 shows the calculated base flow for each station under the Baseline condition and the relative percent difference (RPD) at EOM.

Table 3-3: Predicted Changes to Base Flows of Blairmore, Gold and Daisy Creeks, Baseline to EOM

Watershed	Station	Average Annual Base Flow at Baseline (L/s)	Year of Peak Reduction	Best Estimate Relative % Difference at Peak Reduction
Blairmore Creek	BL-03	71	2046	-0.015%
	BC-07	102	2037	-23%
	BL-02	111	2037	-25%
	BC-03	172	2030	-30%
	BL-01	192	2030	-27%
	All	199	2030	-26%
Gold Creek	GC-13	31	2041	-10%
	GC-09	126	2041	-13%
	GC-04 (Caudron Creek)	288	2041	-10%
	GC-02	331	2041	-19%
	GC-01	540	2041	-12%
	All	543	2041	-12%
Daisy Creek	D1	257	2041	-0.036%



srk consulting

RIVERSDALE RESOURCES

Grassy Groundwater Model

Predicted Annual Pit Inflows and Creek Base Flow

Job No: 1CM029.011
Source: GrassyFigures_FeFlow.pptx

Grassy Mountain Coal Project

Date: July 2016 | Approved: GF | Figure: **3-21**

The modelling results indicate a 10% reduction in Gold Creek flows at GC-02 over the first year of operation, 2018 to 2019 and a more gradual reduction thereafter, with a maximum reduction of 63 L/s, or 19% of total base flow at EOM in 2041. Base flows increase following closure to a steady-state value that is 17.5% reduced relative to pre-mining conditions.

At Blairmore Creek at BC-03, a 12% reduction in base flow is predicted to occur over the first year of operation and a second reduction between 2024 and 2025, coinciding with a significant northward pushback of the southwest sector of the pit. Maximum base flow reduction is in 2037, with a reduction of 51 L/s, or 30% of total annual base flow.

Maximum combined base flow reduction at these two stations is 114 L/s (9,871 m^3/d), and this represents virtually all base flow reductions for these creeks. No base flow reduction is predicted for station BL-03, immediately upstream of the mine footprint on Blairmore Creek. A maximum reduction of 13% is predicted for GC-09, located immediately north of the mine footprint on Gold Creek.

Tributaries close to the mining operation will be affected a greater degree. Base flow in Daisy Creek is not predicted to be reduced to a significant extent. These predicted values represent best estimates, and incorporate a significant degree of uncertainty.

These base flow reductions result from the interception of groundwater in the pit and surface water management system and hence does not report to the creek as base flow. It is important to recognize that they do not take into account any mitigative measures that will be implemented by the surface water management system, hence are not “net” reductions.

3.7.4 End of Mine

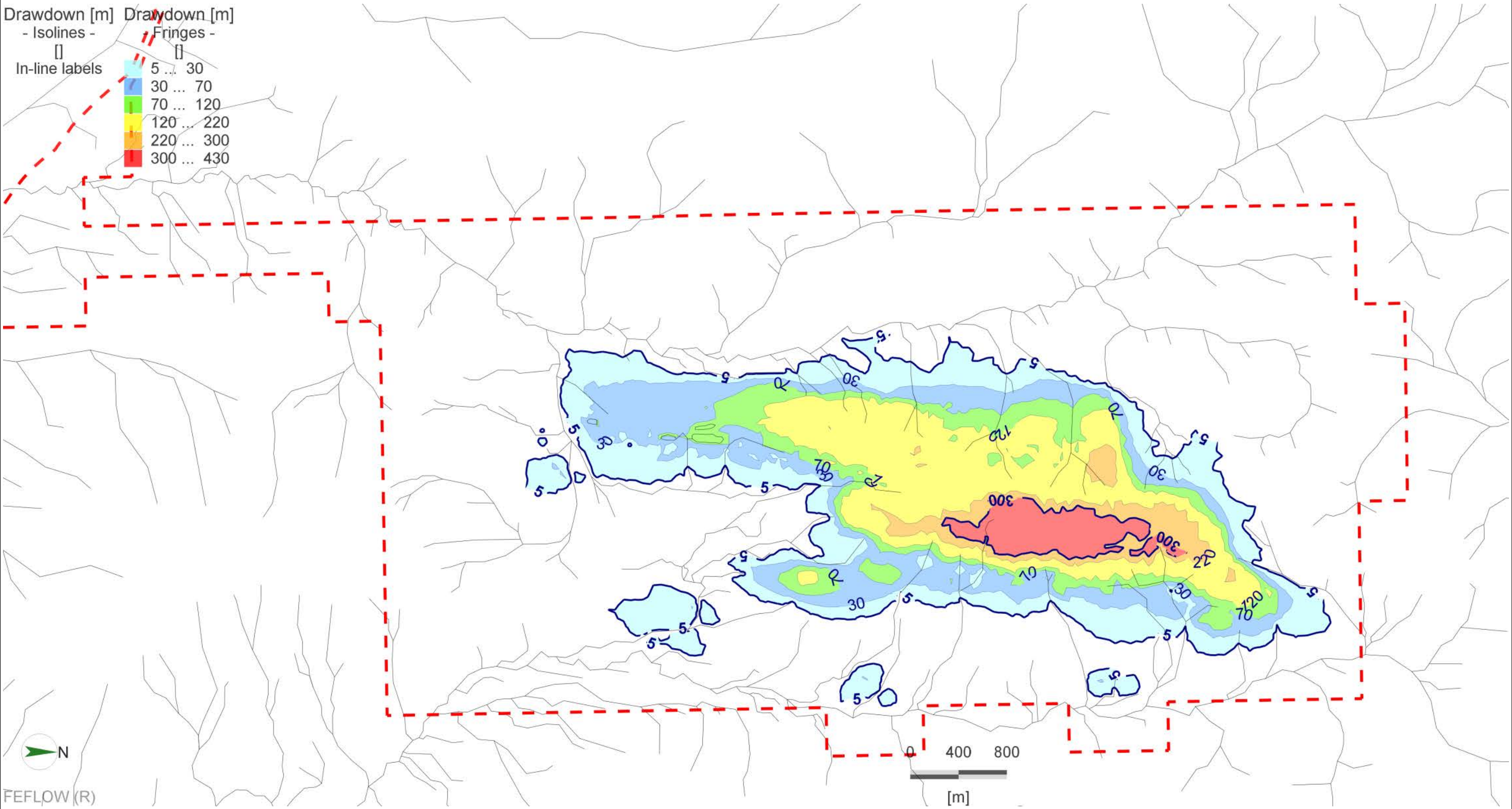
Predicted drawdown from the pit dewatering, based on the 5 m contour, extends close to Blairmore Creek and to the upper portion of Gold Creek catchment, as shown in

Figure 3-22. The drawdown cone, as defined by the 5 m drawdown contour[13], is approximately 10.0 km^2 in area, including 3.8 km^2 outside of the pit. Maximum in-pit drawdown is 430 m at the base of the pit at 1590 masl.

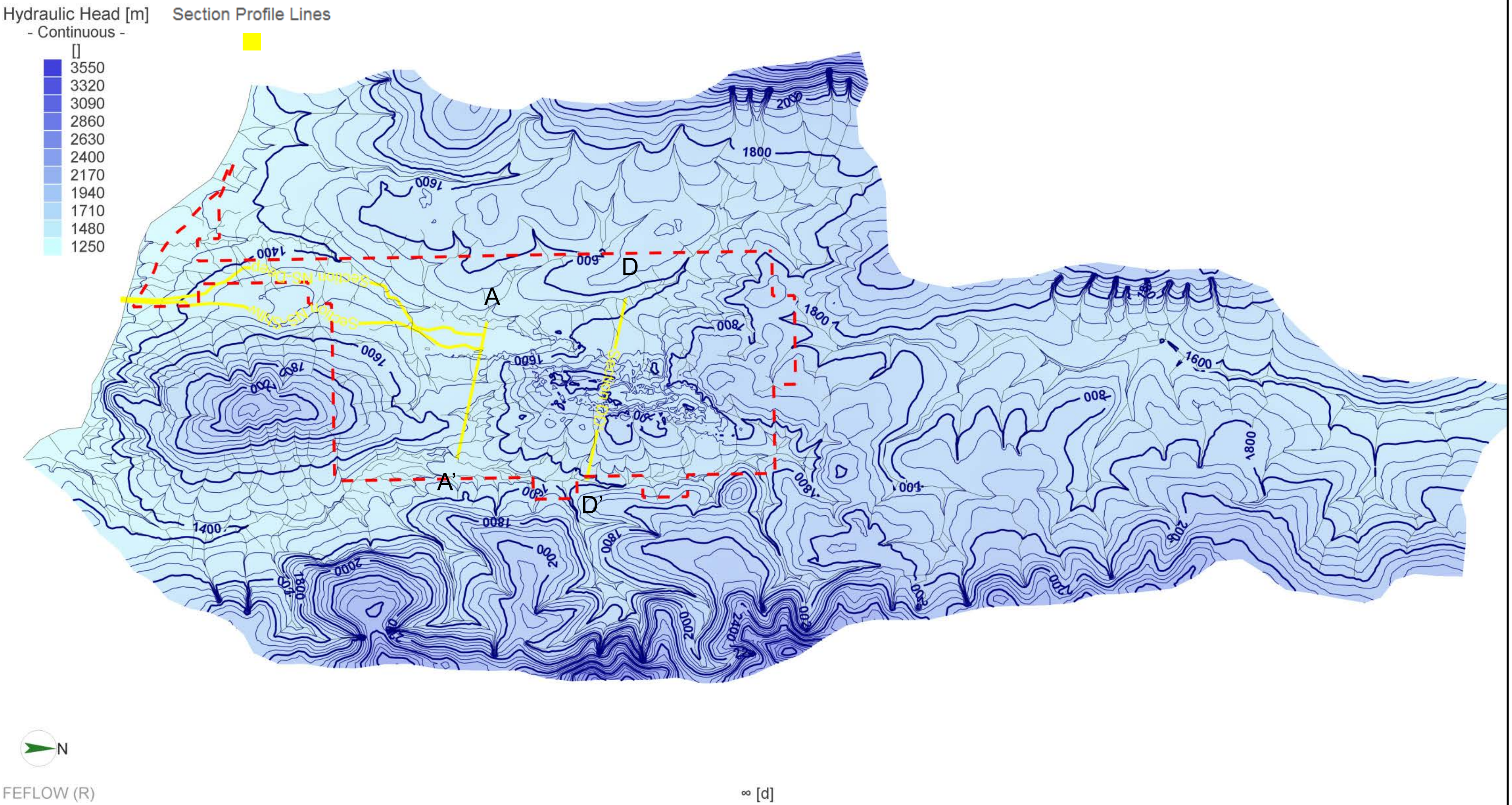
The extent of the mining-induced groundwater capture zone, or groundwater which will drain to the pit, including the pit areas, was predicted to be about 10.9 km^2 for EOM. The capture zone external to the pit was estimated at about 4.6 km^2.

The predicted water table surface at EOM is shown in Figure 3-23. Figure 3-24 shows predicted depth to water table for EOM. Figures C-1 and C-2, Appendix C show predicted piezometric contours for cross sections A-A’ and D-D’, respectively. Locations of these cross-sections are shown on Figure 3-16.

[13] Delineation of drawdown contours lesser than 5 m is rendered less accurate because of model error, hence there exists a greater degree of confidence with respect to the placement of the 5 m drawdown contour, than for the 1 m contour, for example.



srk consulting	RIVERSDALE RESOURCES	Grassy Groundwater Model **Predicted Drawdown, EOM**
Job No: 1CM029.011 Source: GrassyFigures_FeFlow.pptx	Grassy Mountain Coal Project	Date: July 2016 · Approved: GF · Figure: **3-22**



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RIVERSDALE RESOURCES

Grassy Groundwater Model

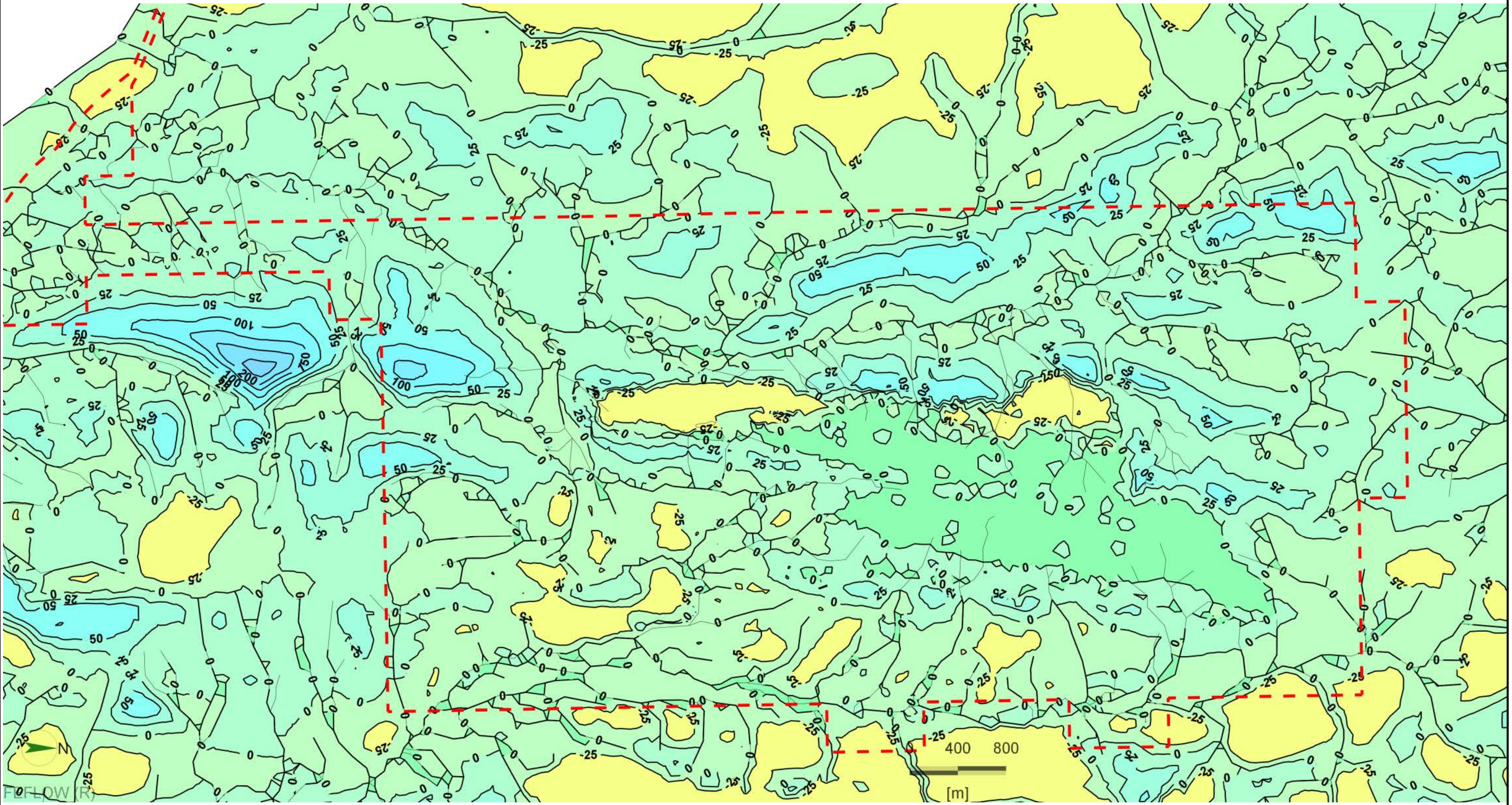
Simulated Water Table Elevation, EOM

Job No:

Source: GrassyFigures_FeFlow.pptx

Grassy Mountain Coal Project

Date:	Approved:	Figure:
July 2016	GF	3-23



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RIVERSDALE RESOURCES

Grassy Groundwater Model

Simulated Depth to Water Table, EOM

Job No: 1CM029.011
Source: GrassyFigures_FeFlow.pptx

Grassy Mountain Coal Project

Date: July 2016 | Approved: GF | Figure: **3-24**

The relative contributions of mining areas to creek base flow under the EOM condition have been estimated using exit probabilities, as defined in Section 3.6 and are presented in Table 3-4. Detailed results for the “Linear” model are presented in Tables C-8 and C-9, Appendix C. Detailed results for the “Exponential” model are presented in Tables C-12 and C-13, Appendix C.

Table 3-4: Calculated Mine Contributions to Creek Base Flows, EOM

Watershed	EOM Base flow (m^3/day)	Contribution to Base flow (%) from:			
		Back-Ground *Not affected*	Rock Disposal Areas	Pit Lake and Saturated Rock Fills	Sedimentation and Surge Ponds
Blairmore Creek (at BC-07)	78	98.8%	0.9%	0.1%	0.1%
Blairmore Creek (at BL-01)	141	99.0%	0.5%	0.3%	0.1%
Gold Creek (at GC-02)	268	99.8%	0.01%	0.00%	0.2%
Daisy Creek (at D1)	257	100.0%	0.00%	0.00%	0.00%

Notes:

Calculated contributions are expressed in percentages of the total calculated flow reporting to each station.
Where (-) is indicated, the corresponding source does not contribute to base flow.

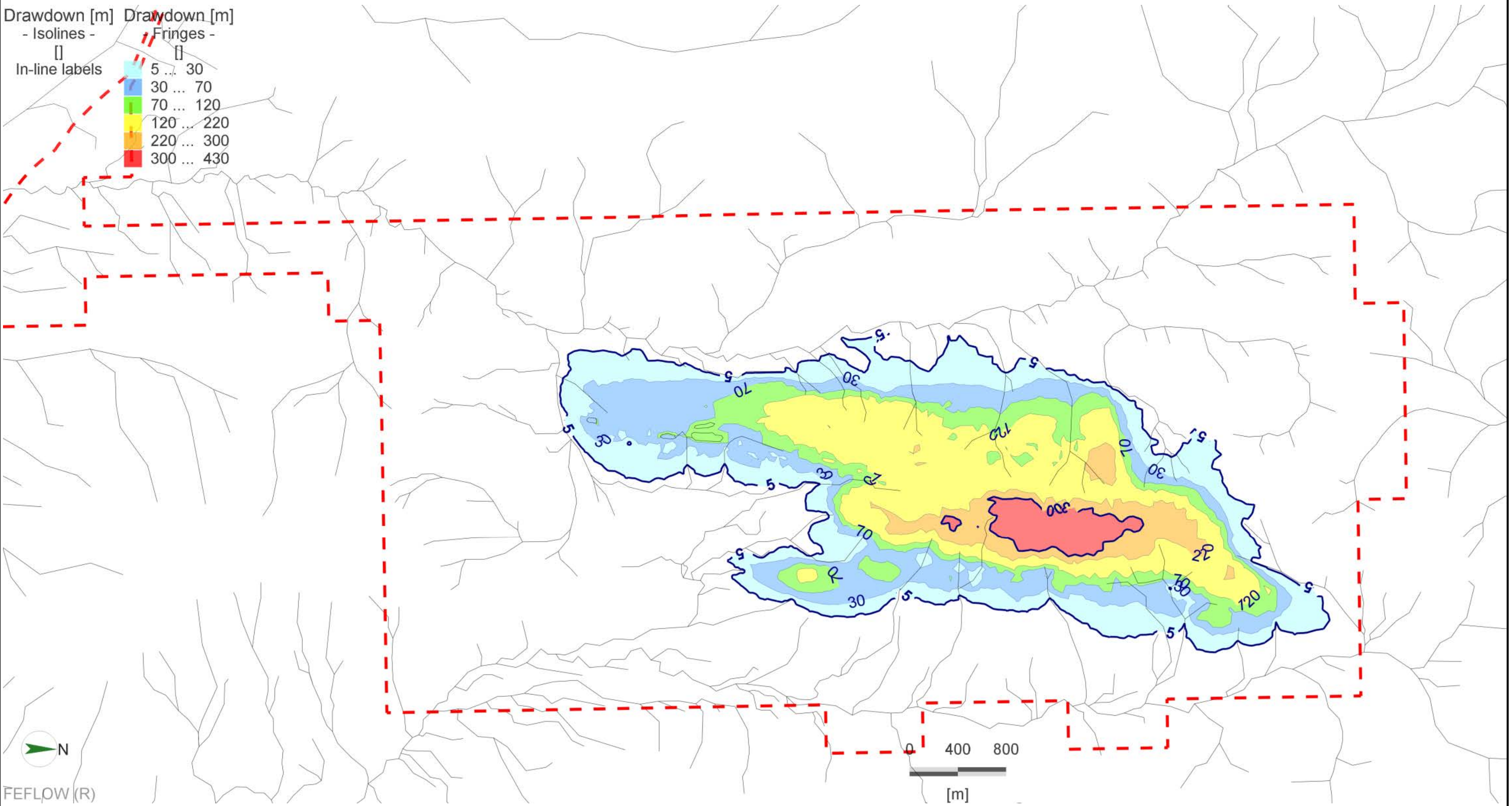
Combined with baseline groundwater quality and source terms, these results are used as inputs for the surface water balance analysis (SRK, 2016) to determine whether or not groundwater solute load could contribute significantly to effects on surface water quality.

The results indicate that Blairmore Creek will receive a higher proportion of mine contact water. The results indicate that of the total base flow at BC-07, in Blairmore Creek, approximately 1.2% will have originated from mine areas, dominantly from rock disposal areas at EOM, without mitigation. Approximately 1.0% of the base flow reporting to BC-01, near the confluence with the Crowsnest River will have originated from mine area.

Of the total base flow at GC-02, in Gold Creek, only 0.2% of the base flow will have originated from mine areas, and most of that from sediment and surge ponds. This represents the maximum percentage contribution for Gold Creek. At GC-01, near the confluence with the Crowsnest River, the percentage contribution is 0.1%.

3.7.5 Long-term Closure

The mining-induced drawdown for LTC is shown in Figure 3-25. Drawdown from the pit extends close to Blairmore Creek and to the upper portions of Gold Creek catchment, with only subtle changes from the EOM conditions. The drawdown cone is slightly reduced, relative to EOM, at approximately 9.4 km^2 in area, including about 3.1 km^2 outside of the pit. The extent of the mining-induced groundwater capture zone, or groundwater which will drain to the pit, including the pit areas, was predicted to be very similar to that at EOM, or about 10.9 km^2. The capture zone external to the pit was estimated at about 4.6 km^2.



Grassy Groundwater Model

Predicted Drawdown, LTC

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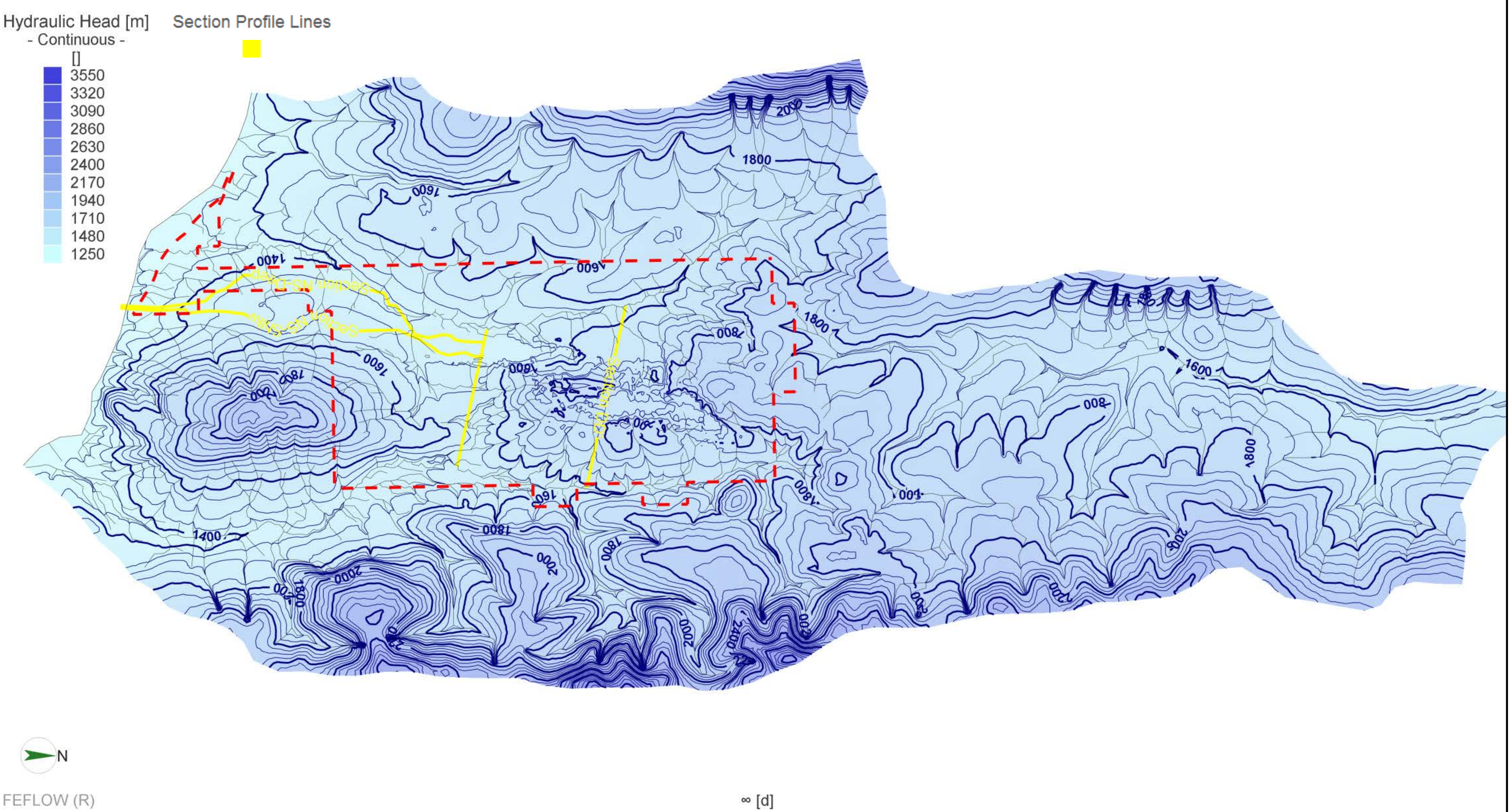
RIVERSDALE RESOURCES

Job No: 1CM029.011

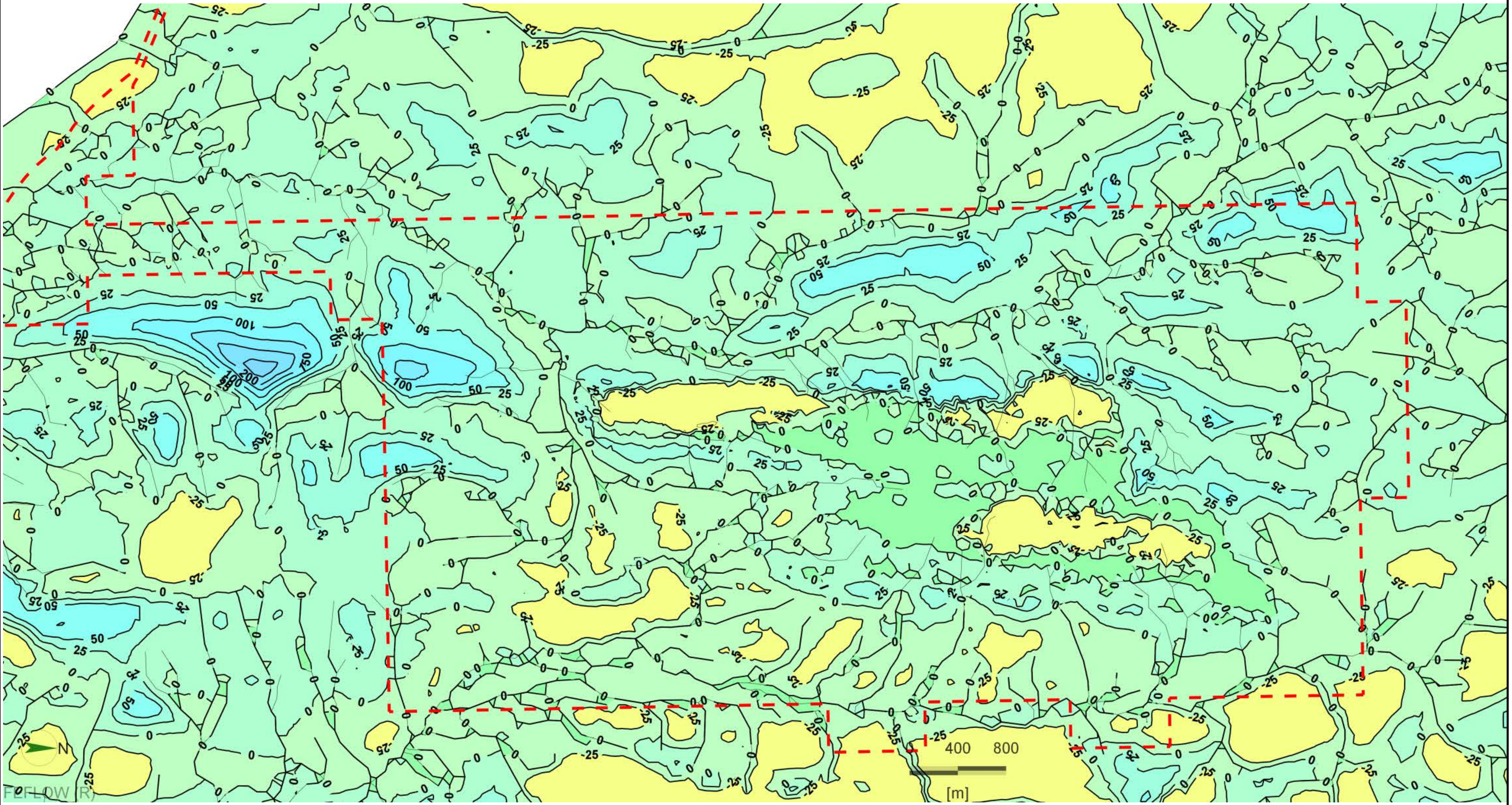
Source: GrassyFigures_FeFlow.pptx

Grassy Mountain Coal Project

Date:	Approved:	Figure:
July 2016	GF	3-25



srk consulting	RIVERSDALE RESOURCES	Grassy Groundwater Model
		Simulated Water Table Elevation, LTC
Job No: 1CM029.011 Source: GrassyFigures_FeFlow.pptx	Grassy Mountain Coal Project	Date: July 2016 / Approved: GF / Figure: **3-26**



Depth to Groundwater
- Fringes -
[]

- >250
- 200 ... 250
- 150 ... 200
- 100 ... 150
- 50 ... 100
- 25 ... 50
- 0 ... 25
- -25 ... 0
- <-25

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RIVERSDALE RESOURCES

Grassy Groundwater Model

Simulated Depth to Water Table, LTC

Job No: 1CM029.011
Source: GrassyFigures_FeFlow.pptx

Grassy Mountain Coal Project

Date:	Approved:	Figure:
July 2016	GF	**3-27**

The LTC average water table surface is shown in plan in Figure 3-26 and for cross-sections A-A' and D-D' in Figures C-3 and C-4, Appendix C, respectively. Of the total ex-pit waste rock area, about 3.6 km^2 lies external to the capture zone, and will drain towards Blairmore and Gold Creeks. Surface water capture ditches and sediment ponds will likely capture some of the shallower seepage which flows towards these creeks, however, other measures will be required if higher proportions of "contact" groundwater is to be captured.

The predicted long-term base flow reductions for LTC are summarized in Table 3-5.

Table 3-5: Predicted Changes to Base Flows of Blairmore, Gold and Daisy Creeks, Baseline to LTC

Watershed	Station	Base flow at Baseline (L/s)	Best Estimate Relative % Difference at LTC
Blairmore Creek	BL-03	71	-0.02%
	BC-07	102	-13%
	BL-02	111	-16%
	BC-03	172	-11%
	BC-01	192	-10%
	All	199	-9%
Gold Creek	GC-13	31	-10%
	GC-09	126	-11%
	GC-04 (Caudron Creek)	288	-9%
	GC-02	331	-18%
	GC-01	540	-6%
	All	543	-6%
Daisy Creek	D1	257	-0.03%

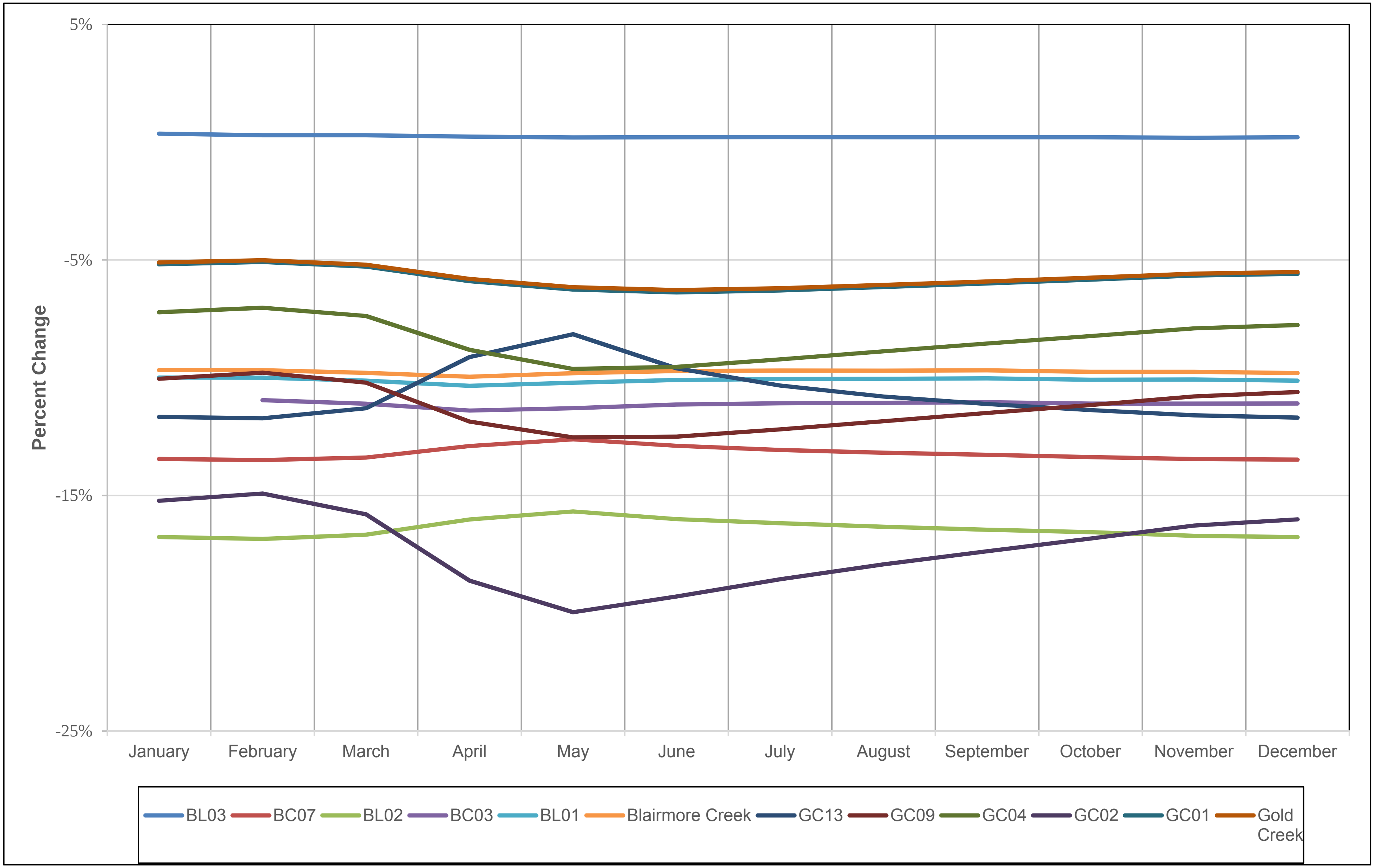
The predicted maximum base flow reduction in Blairmore Creek is 16% at station BL-02. The estimated reduction at the confluence with the Crowsnest River (BC-01) is 9%. The estimated maximum reduction in Gold Creek is 18% at station GC-02. The estimated reduction of Gold Creek base flow at the confluence with the Crowsnest River is 6%. It can be seen that base flows recover substantially once the surface water management system is dismantled; this system captures a higher proportion of flows reporting to Blairmore Creek than to Gold Creek.

A review of monthly base flow reductions was undertaken using the transient models. The results for the "Linear" calibration model are presented in Table 3-6. The results for the "Exponential" calibration model are presented in Table C-7, Appendix C.

Table 3-6: Monthly Base Flow Reduction, Baseline to LTC

Month	D1	BL03	BC07	BL02	BC03	BL01	Blairmore Creek	GC13	GC09	GC04	GC02	GC01	Gold Creek
	15	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	*27*
	Percent Change	**Percent Change**	**Percent Change**	**Percent Change**	**Percent Change**	**Percent Change**	**Percent Change**	**Percent Change**	**Percent Change**	**Percent Change**	**Percent Change**	**Percent Change**	**Percent Change**
January	0.14%	0.36%	-13.5%	-16.8%		-10.0%	-9.7%	-11.7%	-10.0%	-7.2%	-15.2%	-5.2%	-5.1%
February	0.14%	0.29%	-13.5%	-16.9%	-11.0%	-10.0%	-9.7%	-11.7%	-9.8%	-7.0%	-14.9%	-5.1%	-5.0%
March	0.14%	0.29%	-13.4%	-16.7%	-11.1%	-10.1%	-9.8%	-11.3%	-10.2%	-7.4%	-15.8%	-5.3%	-5.2%
April	0.12%	0.23%	-12.9%	-16.0%	-11.4%	-10.4%	-10.0%	-9.1%	-11.9%	-8.8%	-18.62	-5.9%	-5.8%
May	0.12%	0.20%	-12.6%	-15.7%	-11.3%	-10.2%	-9.8%	-8.2%	-12.5%	-9.6%	-20.0%	-6.3%	-6.2%
June	0.12%	0.21%	-12.8%	-16.0%	-11.1%	-10.1%	-9.7%	-9.6%	-12.5%	-9.5%	-19.3%	-6.4%	-6.3%
July	0.12%	0.21%	-13.1%	-16.2%	-11.1%	-10.1%	-9.7%	-10.3%	-12.2%	-9.2%	-18.6%	-6.3%	-6.2%
August	0.12%	0.21%	-13.2%	-16.3%	-11.1%	-10.1%	-9.7%	-10.8%	-11.9%	-8.9%	-17.9%	-6.2%	-6.1%
September	0.12%	0.21%	-13.3%	-16.5%	-11.0%	-10.0%	-9.7%	-11.1%	-11.5%	-8.6%	-17.4%	-6.0%	-5.9%
October	0.12%	0.21%	-13.4%	-16.6%	-11.1%	-10.1%	-9.8%	-11.4%	-11.2%	-8.2%	-16.8%	-5.8%	-5.8%
November	0.12%	0.18%	-13.5%	-16.7%	-11.1%	-10.1%	-9.8%	-11.6%	-10.8%	-7.9%	-16.3%	-5.7%	-5.6%
December	0.11%	0.21%	-13.5%	-16.8%	-11.1%	-10.1%	-9.8%	-11.7%	-10.6%	-7.8%	-16.0%	-5.6%	-5.5%

Average Transient Change	0.12%	0.23%	-13.2%	-16.4%	-11.1%	-10.1%	-9.8%	-10.7%	-11.3%	-8.4%	-17.2%	-5.8%	-5.7%
Steady State Change	-0.03%	-0.02%	-13.1%	-16.2%	-10.7%	-9.6%	-9.2%	-9.5%	-11.3%	-8.5%	-17.5%	-6.0%	-5.9%



srk consulting

RIVERSDALE RESOURCES

Grassy Groundwater Model

Monthly % Base Flow Reduction, Baseline to LTC

Job No: 1CM029.011
Source: GrassyFigures_FeFlow.pptx

Grassy Mountain Coal Project

Date: July 2016
Approved: GF
Figure: **3-28**

The data shows relatively consistent % base flow reductions by month for each station, with the exception of GC-02. As shown in Figure 3-28, base flows in GC-02 show a maximum % reduction in May, which is during the peak flow period and a minimum reduction in February, during a low flow period. Average transient change also appears to be similar to steady-state change. Hence it appears that use of steady-state simulation is a conservative means of estimating base flow reduction, even during low flow periods.

The corresponding “Exponential” calibration model predicted decreases in monthly base flow is shown in Figure C-5, Appendix C. This calibration shows similar values and trends to the “Linear” model, with a slightly more pronounced reduction during high flow periods.

The relative contributions of mining areas to creek base flow are presented in Table 3-7. Detailed results for the “Linear” model are presented in Tables C-10 and C-11, Appendix C. Detailed results for the “Exponential” model are presented in Tables C-14 and C-15, Appendix C. Combined with baseline groundwater quality and source terms, these results are used as inputs for the surface water balance analysis (SRK, 2016) to determine whether or not groundwater solute load could contribute significantly to effects on long-term surface water quality.

The results indicate that, of the total base flow at station BC-03, in Blairmore Creek, approximately 12.5% will have originated from mine areas, dominantly from waste rock storage areas. Approximately 11% of the base flow reporting to BC-01, near the confluence with the Crowsnest River, will have originated from mine area. The proportion of “contact” water reporting to the creeks increases substantially with the dismantling of the water management system.

Of the total base flow at station GC-02, in Gold Creek, only about 0.01% of the base flow will have originated from mine areas, whereas approximately1.5% of the base flow at station GC-01, near the confluence with the Crowsnest River, will be “contact” water.

Table 3-7: Calculated Mine Contributions to Creek Base Flows, LTC

Watershed	EOM Base flow (L/s)	% Contribution to Creek Base Flow			
		Back-Ground *Not affected*	Rock Disposal Areas	Pit Lake and Saturated Rock Fills	Sediment Pond
Blairmore Creek (at BC-03)	153	87.5%	12%	0.5%	N/A
Blairmore Creek (at BC-01)	173	89.4%	10%	0.4%	N/A
Gold Creek (at GC-02)	273	99.99%	0.01%	0.00%	N/A
Gold Creek (at GC-01)	508	98.5%	1.5%	0.00%	N/A
Daisy Creek (at D1)	257	100.0%	0.00%	0.00%	N/A

Notes:

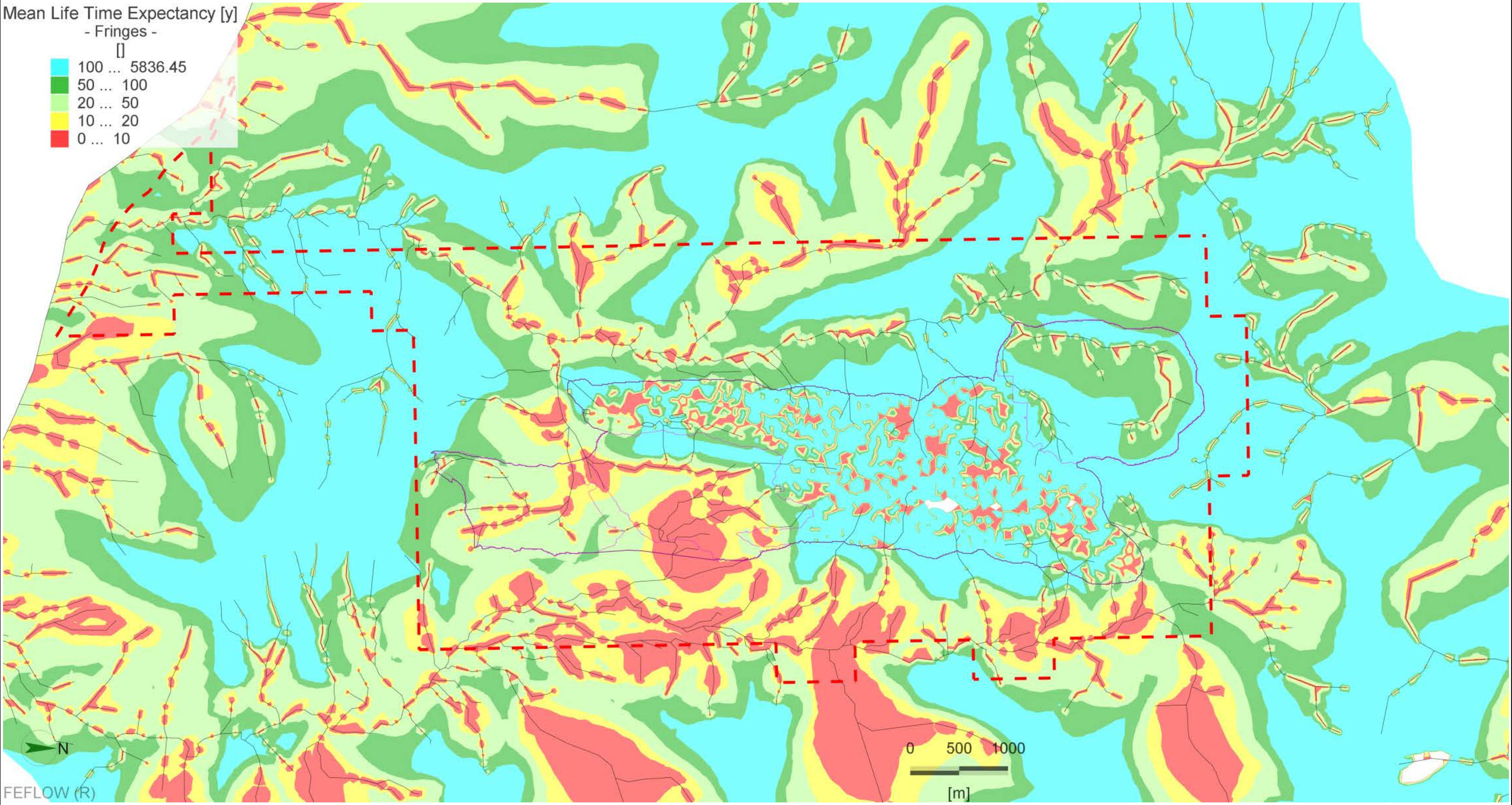
Calculated contributions are expressed in percentages of the total calculated flow reporting to each station.
Where (-) is indicated, the corresponding source does not contribute to base flow.

Numerical modelling suggests that any loading coming from the mine footprint will take some time to occur. As shown in Figure 3-29, it would, on average take less than 50 years to reach surface water receptors if rock dump seepage occurred within 100 m from a creek bed, and more than 50 years if loading occurred further away. With the presence of discrete fracture networks, mine-affected seepage could reach the creeks sooner, although in small quantities at first. The risk of significant loading via large-scale and deeper groundwater pathways is considered low compared to contributions from direct discharge from surface water management infrastructure, engineered drainage or discrete seeps.

Based on the location of proposed ex-pit waste rock disposal areas relative to Blairmore and Gold creeks and their tributaries, it appears that the great majority of solutes travelling from the base of the waste rock would not reach the tributaries or creeks for a minimum of 50 years, travelling via the MMF.

It should also be noted that only limited characterization of surficial unconsolidated deposits and the Blairmore Group rocks, which overly the MMF, has been undertaken to date. It may be that groundwater could reach the tributaries and creeks more rapidly via these shallower pathways.

The proposed mine plan puts the mine pit in contact with the northernmost extent of the underground Boisjoli Mine. Little is known about the interior of this mine. While there are no reports of backfilling of this mine, it is likely that caving of the workings potential reducing the overall hydraulic conductivity of the mine workings. The portal of this mine has collapsed, or has been buried by waste rock from previous surface mining. The location of the former portal corresponds to the position of Spring 1. Travel time simulations, with assumed K values for the Boisjoli mine workings up to four orders of magnitude higher than the surrounding country rock, found travel times less than one year through the mine and reporting to the tributary in front of the mine, with some travelling to the Grassy Mountain pit over a period of four years. Most of the flow reporting to the Greenhill mine flows to the portals quickly (less than one year), while a portion reports to the tributary north of the mine and between the Greenhill Boisjoli (North) and Greenhill (South) Mines. There is no indication of direct flow, via bedrock, from the North mine to the South mine.



srk consulting

RIVERSDALE RESOURCES

Grassy Groundwater Model

Groundwater Mean Life Expectancy (Years) LTC

Job No: 1CM029.011
Source: GrassyFigures_FeFlow.pptx

Grassy Mountain Coal Project

Date: July 2016 | Approved: GF | Figure: **3-29**

3.8 Model Sensitivity

3.8.1 Methodology

Multiple model runs were conducted to assess the sensitivity of the model predictions to changes of equal magnitude and direction for both K and recharge (R), K alone, R alone, K anisotropy and the explicit modeling of geological structures as important hydrogeological features. These parameters were varied without re-calibration of the model. The results of the sensitivity runs were analyzed by comparing:

- Baseline condition sensitivity models to the baseline condition base case (calibration) model.
- LTC sensitivity models to the LTC base case model.

The sensitivity of the following model outputs were evaluated through review of changes in:

- Hydraulic head calibration (%NRMSE) for baseline model as relative percent difference (RPD) between baseline and sensitivity models;
- RPD Base flows at stations BL03, BL07, BL02, BC-03, BL-01 and BC-01 (Blairmore Creek), D1 (Daisy Creek) and GC13, GC09, GC04, GC02, GC01 and confluence with the Crowsnest River (Gold Creek), Small Creeks (grouped), West Creek and CR-01 (Crowsnest River); and
- RPD average flow contributions to base flow from the ex-pit rock fill disposal area at stations BL03, BL07, BL02, BC-03, BL-01 and BC-01 (Blairmore Creek), D1 (Daisy Creek) and GC13, GC09, GC04, GC02, GC01 and confluence with the Crowsnest River (Gold Creek).

Sensitivity was tested in the following manner:

- 50% increases and 50% decreases of both K and R;
- 50% increases and 50% decreases of K alone;
- 50% increases and 50% decreases of R alone;
- Isotropic K within layers (i.e. $K_1 = K_2 = K_3$), K_1, K_2 horizontal, K_3 vertical, no progressive reduction of K with depth;
- $K_1 = K_3$, and progressive reduction of K with depth;
- $K_1 = K_2$, progressive reduction of K with depth and no effect from thrust faults;
- Influence of faults with lower K (i.e. K_1, K_2, K_3 all reduced by factor of 2.5); and
- Influence of faults with higher K (i.e. K_1, K_2, K_3 all increased by factor of 2.5).

The magnitude of change was selected within a range thought to be feasible in each case. Sensitivity runs were conducted for both the “Linear” and “Exponential” calibrated models.

The following qualitative sensitivity definitions were applied:

- High: more than 30% RPD;
- Medium: 15 to 30% RPD;
- Low: 5 to 15% RPD; and
- Null: less than 5% RPD.

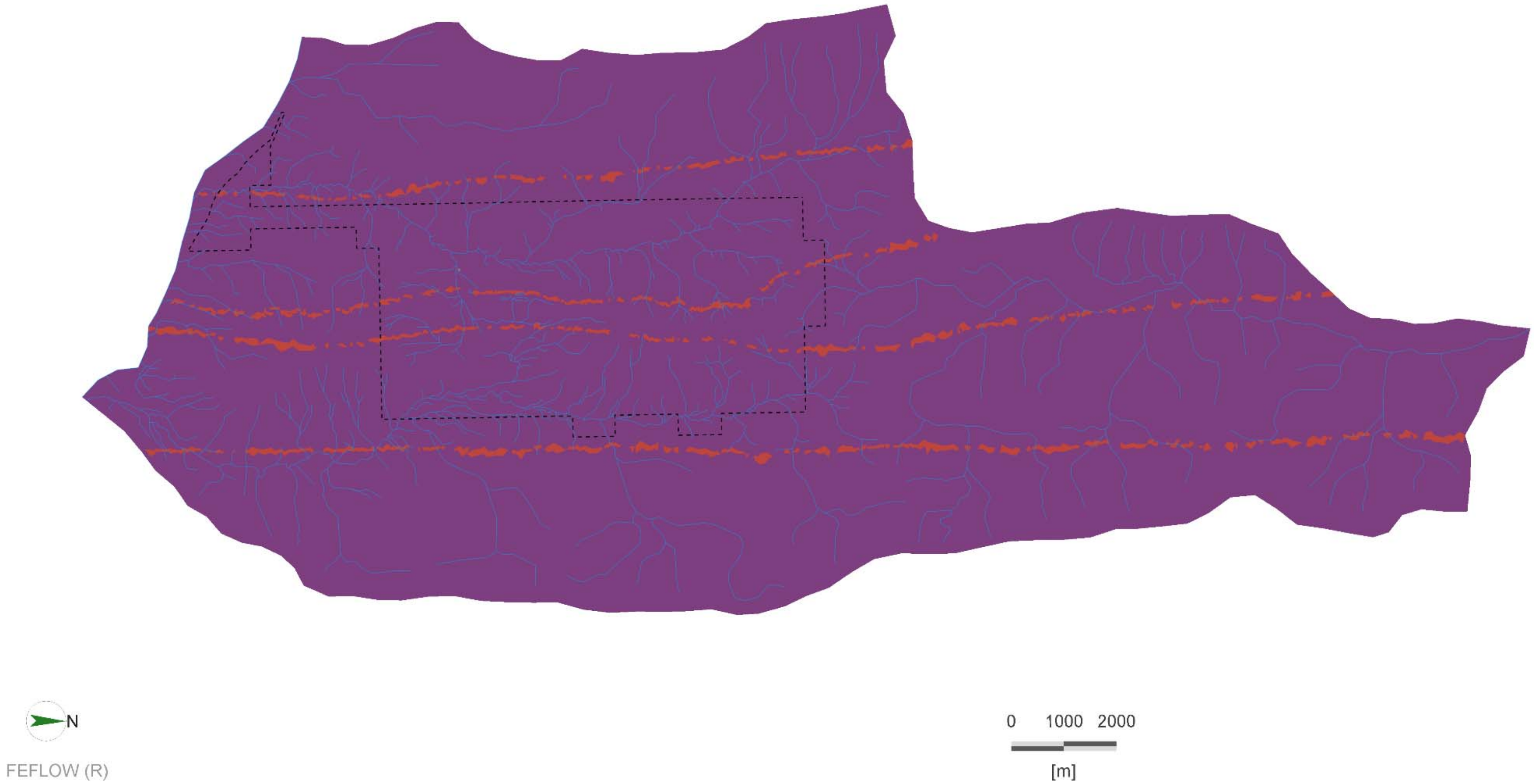
3.8.2 Results – "Linear" model

Table 3-8 and Table 3-9: show the sensitivities of the baseline and LTC predictions to changes in model parameters. Tables C-16 to C-21, Appendix C present the detailed results for the "Linear" model for baseline through LTC. Tables C-22 to C-27, Appendix C present the detailed results for the "Exponential" model for baseline through LTC.

Figure 3-30 shows the distribution of thrust faults used for the sensitivity analysis.

Table 3-8: Sensitivity of Baseline "Linear" Model

Parameter	Parameter variation	Effect on Hydraulic Head % NRMSE	Effect on Base Flow
K & R	Reduced by 50%	Null	High
	Increased by 50%	Null	High
K	Reduced by 50%	Null	Null
	Increased by 50%	Medium	Null
Recharge	Reduced by 50%	High	High
	Increased by 50%	Null	High
K anisotropy	Isotropic ($K_{xy} = K_z$, K_{xy} oriented horizontally)	Null	Null
	Isotropic within layers: K decreasing with depth. No influence from bedding and coal seam orientation	High	Null
	Anisotropic: primary K (K_x and K_y) parallel to bedding. No influence from thrust faults	Null	Null
Geological Structure	Low K Thrust faults (barrier to flow): 2.5 order of magnitude lower than background	Null	Null
	Low K Thrust faults (conduit to flow): 2.5 order of magnitude lower than background	Low	Null



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RIVERSDALE RESOURCES

Grassy Groundwater Model

Distribution of Thrust Faults for Sensitivity Models

Job No: 1CM029.011
Source: GrassyFigures_FeFlow.pptx

Grassy Mountain Coal Project

Date: July 2016

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Figure: **3-30**

The data indicate that the baseline model hydraulic head calibration is moderately sensitive to increases of "global" K and insensitive to decreases in K with little effect on base flows. Similarly, In terms of anisotropy, the use of isotropic conditions within layers that are oriented parallel to bedding has a strong effect on the hydraulic head calibration, but little effect on base flow values. This is indicative of the model constraints; recharge is directed directly to creek base flow.

Proportional increases or decreases on both K and recharge have little effect on the hydraulic head calibration, however strongly influence base flow values. Recharge is directly reflected in base flow values.

The incorporation of significant geological structures in the model, as shown in Figure 3-30, have only a limited effect on the model results.

Table 3-9: Sensitivity of LTC Condition Model, "Linear" Model

Parameter	Parameter Variation	Changes to Base Flow Predictions from Mining	Contributions to Base Flow from Rock Disposal Areas
K & R	Reduced by 50%	High	Null
	Increased by 50%	High	Null
K	Reduced by 50%	Null	Null
	Increased by 50%	Null	Null
Recharge	Reduced by 50%	High	Null
	Increased by 50%	High	Null
K anisotropy	Isotropic (K_{xy} = K_z, K_{xy} oriented horizontally)	Null	Low
	Anisotropic: K decreasing with depth. No influence from bedding and coal seam orientation	Null	Low
	Anisotropic: primary K (K_x and K_y) parallel to beddings. No influence from thrust faults	Null	Null
Geological Structure	Low K Thrust faults (barrier to flow): 2.5 order of magnitude lower than background	Null	Null
	Low K Thrust faults (conduit to flow): 2.5 order of magnitude lower than background	Null	Null
Recharge over the ex-pit rock disposal areas	Recharge increased by 50%	Null	Medium
	Recharge decreased by 50%	Null	Medium

As with the baseline model, the LTC model estimates of base flow are very sensitive to predictions of recharge. The contributions of mine contact water to base flow without mitigation are slightly sensitive to the degree of anisotropy present in the model and moderately sensitive to the percentage of recharge applied of the waste rock disposal areas.

Results of the sensitivity analyses are summarized in Table 3-10, according to sensitivity types as defined by Brown (1996).

Table 3-10: Sensitivity Types of the Grassy Groundwater Model

Change in Predictions Results		Change in Calibration: Insignificant	Change in Calibration: Significant
	Insignificant	**Type I** *Geological structures*	**Type II** *K anisotropy* *Hydraulic conductivity* *Recharge*
	Significant	**Type IV** *K & R together* *Recharge to waste rock disposal areas*	**Type III** *Recharge* *Hydraulic conductivity*

Note:

The influence of rock fill disposals to recharge is categorized as insignificant for the calibration, even though it cannot be compared to the current conditions model, to show that this parameter s only understood conceptually.

Sensitivity types are defined as:

- Type I: There are insignificant effects for both model calibration residuals and predictive model results (relative to modeling objectives). In other words, within a reasonable range of values the parameter is varied, but nothing significant happens as a result. This parameter type does not need further data collection or monitoring;
- Type II: There is a significant effect on model calibration, but an insignificant effect on predictive model results (relative to modeling objectives). The model calibration is affected (residuals increase for some part of the parameter range being tested) so the parameter has an effect on calibration goodness of fit. However, the results of the predictive model are still insensitive to this parameter;
- Type III: There are significant effects on both model calibration and model prediction results (relative to modeling objectives). The parameter has an effect on calibration goodness of fit and a corresponding effect on predictive model results; and
- Type IV: There is an insignificant effect on model calibration, but a significant effect on predictive model results (relative to modeling objectives). The model calibration is not affected and does not help constrain this parameter value, while the results of the predictive model are sensitive to this parameter.

Type I and II sensitivities are of little concern because the impact on predictions is insignificant. Type III sensitivity is of concern only for an uncalibrated model, or where a wide range of calibrations is possible, and a proper calibration of this parameter is the solution. The sensitivity is important but it is known and can be avoided by model calibration.

Type IV sensitivity is a cause for concern because non-uniqueness in a model input might allow a range of valid calibrations, but the choice of value significantly impacts model prediction. It is important to determine the actual value of this parameter and not rely on model calibration to estimate this parameter. It should be measured with good data (model field audit), and ideally the data should represent the same stresses as in the predictive model simulations.

The modelling of geological structures as both low K barriers to perpendicular flow or as conduits for flow parallel to the fault plane is the best example of a Type I variable. It has little impact on the model calibration, and, based on the sensitivity analyses undertaken, notably fault locations and orientations chosen, relatively little impact on the creek flow or proportions of mine contact water that could reach the creeks. However, it must be cautioned that structures oriented in such a manner as to connect mine facilities and creeks directly would result in significant movement of mine contact water to the creeks.

K anisotropy has an overall limited to strong effect on calibration, but a limited effect on model predictions in this case, hence is a Type II variable. However, this is dependent on the nature of the anisotropy. A certain orientation of bedding, for example, could lead to strong changes in model predictions. Hydraulic conductivity most closely fits a combined Type II/Type III variable. This is unusual, as in most hydrogeological environments, hydraulic conductivity is a Type III variable, affecting both calibration and model predictions strongly. However, this numerical model is highly constrained by a model of significant recharge in upland areas, with proportionally higher recharge at higher elevations, flowing to discharge point in valley bottom main stem creeks and their tributaries. Hence, while hydraulic conductivity strongly affects model calibration, it does not significantly affect base flow values. It does, however strongly affect travel time, and in this respect is also a Type III variable. If K is low enough, it would result in mounding of the water table, and reduce groundwater recharge, while increasing groundwater losses through evapotranspiration,

Recharge is also a combined Type II/ Type III variable in this model. It strongly affects calibration, and model predictions of base flow. However it does not affect the proportion of mine contact water in creek base flow since an increased amount of mine contact water flowing to creeks will be diluted by an equal proportion of non-contact water.

The sensitivity analysis showed that proportional changes of K and R together and recharge to rock disposal areas are categorized as Type IV parameters. While model calibration shows little sensitivity to these parameters, predictions undertaken with erroneous values are subject to significant error. Model calibration may be undertaken with a relatively broad range of K and R, but these changes are associated with significant effects to model predictions of base flow, if not necessarily predictions of proportions of mine contact water in base flow. As with changes in K, travel time estimates are strongly sensitive to proportional changes in K and R.

Recharge to waste rock disposal areas has little effect on model calibration, as these areas are limited with respect to the model domain. However, this variable has a strong effect on the proportion of mine contact water entering creek base flow, hence is a type IV variable.

The sensitivity of flow contributions from mine areas has also been evaluated for both “Linear” and “Exponential” models. The detailed results are presented in Tables C-22 to C31, Appendix C. As expected, the results are relatively insensitive to all parameters.

3.8.3 Results – “Exponential” Model

As expected, the hydraulic head %NRMSE shows the greatest sensitivity to changes in recharge, since the “Exponential” model provides for a more pronounced increase in recharge with elevation. However, this model predicts virtually the same base flows as the “linear” model with 50% increases and reductions in R and K.

The two models provide slightly differing (up to 10% RPD) results for predictions of proportions of contact water from saturated fill zones in creek base flow. However these volumes are a tiny fraction of the overall contact water volumes predicted to report to the creeks. Predictions of base flow originating from the waste rock storage areas correspond to within 8%.

3.8.4 Model Uncertainty

It is clear from the sensitivity analysis that the key model outputs base flow reporting to creeks is most sensitive to recharge. It is conceivable that recharge values, and hence, base flow could vary by as much as 50% higher or 33% lower than currently estimated values, hence base flow reductions due to mining could vary by a similar amount. However the percent reduction of base flow from pre-mining levels would not vary significantly. Similarly, there is uncertainty associated with the separation of the base flow component from the total flow hydrograph, notably during high flow periods.

It should be noted that there is a lesser amount of uncertainty associated with the determination base flow during low periods. These periods are critical for assessment of water quantity and quality and effects on the creeks. During low flow periods, virtually all flow in the creeks is base flow and is easily measured. Hence uncertainty with respect to long-term average low flow period base flows is associated with the period of record and base flow separation techniques.

There is a significant amount of uncertainty attributed to travel times for mine contact water to reach creeks via groundwater. In a fractured rock environment, isolated fracture pathways may be available for portions of mine contact water to reach the creeks relatively rapidly. However, this is likely to be a small proportion of the overall contact water flow. A groundwater monitoring program, including structural review, detailed creek low-flow water quantity and basic water quality surveys, geophysical surveys (e.g. EM induction or galvanic methods) and monitoring well installation and sampling should aid in the identification of such conduits and provide the basis for design of seepage capture systems, if required.

3.9 Limitations of the Groundwater Model

The model is constructed based on the available data and at the scale of the mine site it replicates reasonably well the site observations and the regional behavior of the groundwater system. Model results have highest confidence in the vicinity of the mine area, where there is relatively more data. There is only limited data available for unconsolidated sediments and the Blairmore Group rocks overlying the host Mist Mountain Group, and these units could affect the overall interaction between the mine and the creeks. Actual conditions may vary locally due to variations in K or other material properties where data is not available. Large-scale geological structures have been mapped but it is not possible to confirm, with the available data, where large-scale fractures and faults are connected and where they act as a conduit or as barrier to flows. These limitations should be considered when interpreting or using model results.

There also remains uncertainty with respect to the site-specific average annual base flows within Blairmore and Gold creeks, particularly those derived from the sub-catchments adjacent to the Project. Since the model is sensitive to the groundwater recharge/ values, this could have an important effect on the range of potential impacts. Site-specific low-flow measurement in the creeks, and in creek tributaries adjacent to the Project, is the best way to reduce uncertainty with respect to this parameter.

The sensitivity analysis showed also that the influence of rock fill disposal areas on recharge affect the groundwater discharge predictions. This is categorized as a Type IV parameter, which reflects the fact that although the model may be calibrated with a wide range of values for this parameter, there will be a corresponding wide range of estimates of mine contact water reporting to the creeks. Mechanisms within the rock disposals are uncertain at most mine sites because there is often not enough observational data to allow some sort of rock fill water balance to be developed. Some argue that compaction of the fine grained materials under rock fill areas decreases K further and more than offsets any increase in gradient caused by mounding in the rock disposals, resulting ultimately in a reduction of recharge, while others claim that recharge increases because of the storage capacity and resulting saturated conditions at the base of the rock disposals.

The numerical model has simplified the flow system by combining formations with potential varying hydraulic characteristics, by assuming hydraulic head values in large areas of the model, by applying uniform base flow values and relatively uniform recharge values etc.

4 Summary and Conclusions

A conceptual hydrogeological model of the proposed Grassy Mountain Coal Mine was developed largely on the basis of site geological, hydrological and hydrogeological investigation data. A numerical model was constructed based on the conceptual model and calibrated to pre-mining water levels, creek base flow estimated from site-specific and regional analysis and discharge measurements from local springs and old underground mine portals. A second numerical model was constructed and calibrated with an alternative groundwater recharge distribution. The two calibrated models, together with a sensitivity analysis of the effect changes of key input parameters have on the model outputs, provided the basis for assessing a range of probable responses of the hydrogeological system to mining.

The final calibrated models reproduced the regional hydrogeological system reasonably well, with a steady-state normalized root mean squared error (NRMSE) for calculated vs. observed hydraulic heads and base flows of 5.5 to 8.5%. NRMSE values less than 10% are commonly considered to be an acceptable level of model calibration.

A transient model was constructed and used to assess seasonal changes in hydraulic heads and base flows to creeks. While this model provided a reasonable match to seasonal hydraulic head and creek base flow values, it was found to be more efficient to utilize a series of annual steady-state models to simulate groundwater system behaviour through the operational period and closure.

The calibrated model were used to simulate the groundwater system at current conditions, at end-of-mine (EOM), and for long-term closure (LTC). The predictive simulations determined the following:

1. The extent of the mine drainage-induced drawdown cone, as defined by the 5 m drawdown contour, is 10 km^2 at end of mine (EOM), including 3.8 km^2 external to the pit and 9.4 km^2 at LTC, including 3.1 km^2 external to the pit. The drawdown cone extends beyond this area, but, considering model error, is considered to be less reliable.
2. The extent of the mining-induced groundwater capture zone, or groundwater which will drain to the pit, including the pit areas, was predicted to be about 10.9 km^2 for EOM and for LTC). The capture zone external to the pit was estimated at about 4.6 km^2.
3. The model indicates that, during the mine operation, the Project will cause a peak average annual reduction in base flow to Blairmore Creek and Gold Creek of 51 and 63 L/s, respectively, to occur in, or about, 2038. An estimated 54% of this reduction is predicted to be captured by the surge and sedimentation pond capture system, which will capture groundwater which would have flowed from creek tributaries to the main stems. A majority of this water captured is from the Blairmore Creek system. If this system is dismantled, as planned, in 2046, base flows will recover in Blairmore and Gold Creeks. Residual, long-term average annual base flow reductions in these creeks is predicted to be 18 L/s (11%) and 58 L/s (18%), respectively. Gold Creek is more strongly affected by the pit development. Peak base flow reductions are predicted on the southern edge of the mine development. No significant reduction of base flow is predicted for Daisy Creek, lying on the northern edge of

the Project area. Impacts to tributary creeks situated adjacent to the mining areas are likely to have larger percent base flow reductions than those listed above. Average annual base flow reductions for Blairmore Creek (BC-01) and Gold Creek (GC-01) at the confluence with the Crowsnest River are 9% and 6%, respectively.

These base flow reductions result from the interception of groundwater in the pit and surface water management system and hence does not report to the creek as base flow. They do not take into account any mitigative measures that will be implemented by the surface water management system, hence are not “net” reductions.

4. Predicted monthly % base flow reductions are generally similar to predicted average annual reductions except at GC-02 in Gold Creek, where the percent base flow reduction is predicted to be lower during low flow periods.

5. There remains uncertainty with respect to these base flow reductions, largely with respect to the range and long-term average base flow in Blairmore and Gold Creeks. This is due to a relatively short period of monitoring to date and also to uncertainties with respect to methods used to separate the base flow component from the total base flow component. Variations in the order of 33% lower and 50% higher are conceivable. However, there is a lesser amount of uncertainty associated with the determination base flow during low periods. These periods are critical for assessment of water quantity and quality and effects on the creeks. During low flow periods, virtually all flow in the creeks is base flow and is easily measured. Detailed monitoring of creek flow, especially during low flow periods should continue in order to provide more reliable estimates. Detailed flow measurement along the lengths of the creeks will also provide more detail with respect to key entry zones for base flow that can be used to aid in placement of groundwater monitoring wells.

6. It is estimated that during mine operations and closure that approximately 3.6 km^2 of a total in-pit and ex-pit waste rock footprint is external to the pit capture zone, and will drain towards (principally) Blairmore Creek and Gold Creek. Surface water capture ditches and sediment ponds will likely capture some of the shallower seepage which flows towards these creeks, but not all. A portion of the groundwater recharge which infiltrates the waste rock fill areas will flow below this system and discharge as base flow to the creeks if no capture systems are in place. An estimated annual average of 1.4 L/s (1.1% of average annual base flow) is predicted to flow toward Blairmore Creek above station BC-03 without mitigation at EOM and 19 L/s (12.5%) at LTC. At GC-02 on Gold Creek, an estimated annual average of 0.45 L/s (0.2% of average annual base flow) of mine-contact water is predicted to discharge as base flow in the absence of mitigation at EOM, whereas virtually no mine contact water is predicted to reach this station at LTC. Approximately 8 L/s (1.5% of average annual base flow) is predicted to reach GC-01 at LTC.

7. Mine-affected seepage originating from the waste rock disposal areas or in-pit saturated fill zones will take some time to reach Blairmore and Gold Creeks. Any seepage which occurs greater than 100 m from a tributary would require greater than 50 years, on average, to reach Blairmore and Gold Creeks. Although portions of the seepage may reach these creeks more rapidly via fracture networks, the risk of significant rapid loading via large scale and deeper groundwater pathways is considered low compared to contributions from direct surface runoff

discharge from surface water management infrastructure, engineered drainage or discrete seeps. However, some residual uncertainty exists with respect to the potential migration of mine-affected groundwater flow through unconsolidated deposits and the Blairmore Group rocks, overlying the host Mist Mountain Formation.

8. There remains some uncertainty with respect to the amount of groundwater recharge which will occur in waste rock storage areas. The amount of groundwater-affected seepage which reports to Blairmore Creek or Gold Creek is moderately sensitive to this value. Further evaluation of probable rock disposal area effects on recharge, both for operation rock disposal and rock disposal areas on closure (contoured and covered) will provide more confidence in estimates of contact water reaching the creeks.

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All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

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APPENDIX A
Creek Base Flow Data

CrowsNest@	0.003846	0.003558	0.003722	0.005628	0.021109	0.035807	0.015156	0.008718	0.007311	0.00684	0.006249	0.004758

Table D-1: Average Monthly Base Flow

Station	Total Area [km²]	Average Monthly Base Flow [m³/s]											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BL-02	24.23	0.0483	0.0446	0.0467	0.0706	0.2649	0.4493	0.1902	0.1094	0.0917	0.0858	0.0784	0.0597
BL-03	15.35	0.0345	0.0319	0.0334	0.0504	0.1892	0.3209	0.1358	0.0781	0.0655	0.0613	0.0560	0.0426
BC-01	49.80	0.0628	0.0581	0.0608	0.0919	0.3446	0.5846	0.2474	0.1423	0.1194	0.1117	0.1020	0.0777
BC-02	47.80	0.0630	0.0583	0.0610	0.0922	0.3458	0.5866	0.2483	0.1428	0.1198	0.1121	0.1024	0.0779
BC-03	40.53	0.0618	0.0572	0.0598	0.0905	0.3394	0.5758	0.2437	0.1402	0.1176	0.1100	0.1005	0.0765
BC-04	35.42	0.0592	0.0548	0.0573	0.0867	0.3250	0.5513	0.2334	0.1342	0.1126	0.1053	0.0962	0.0733
BC-05	32.65	0.0572	0.0529	0.0553	0.0837	0.3138	0.5323	0.2253	0.1296	0.1087	0.1017	0.0929	0.0707
BC-06	24.03	0.0480	0.0444	0.0464	0.0702	0.2634	0.4468	0.1891	0.1088	0.0912	0.0854	0.0780	0.0594
BC-07	20.57	0.0431	0.0399	0.0417	0.0631	0.2367	0.4015	0.1699	0.0978	0.0820	0.0767	0.0701	0.0533
BC-08	20.56	0.0431	0.0399	0.0417	0.0631	0.2366	0.4013	0.1699	0.0977	0.0819	0.0767	0.0700	0.0533
BC-09	20.39	0.0428	0.0396	0.0415	0.0627	0.2352	0.3989	0.1688	0.0971	0.0815	0.0762	0.0696	0.0530
BC-10	19.42	0.0413	0.0383	0.0400	0.0605	0.2269	0.3850	0.1629	0.0937	0.0786	0.0735	0.0672	0.0512
BC-11	18.85	0.0404	0.0374	0.0391	0.0592	0.2220	0.3766	0.1594	0.0917	0.0769	0.0719	0.0657	0.0500
BC-12	15.61	0.0349	0.0323	0.0338	0.0511	0.1917	0.3252	0.1377	0.0792	0.0664	0.0621	0.0568	0.0432
BC-13	15.30	0.0344	0.0318	0.0333	0.0503	0.1886	0.3200	0.1354	0.0779	0.0653	0.0611	0.0558	0.0425
BC-14	14.08	0.0321	0.0297	0.0311	0.0470	0.1763	0.2990	0.1266	0.0728	0.0611	0.0571	0.0522	0.0397
BCT02-01	4.96	0.0126	0.0117	0.0122	0.0185	0.0692	0.1175	0.0497	0.0286	0.0240	0.0224	0.0205	0.0156
BCT04-01	8.24	0.0202	0.0187	0.0195	0.0295	0.1108	0.1879	0.0795	0.0457	0.0384	0.0359	0.0328	0.0250
BCT05-01	0.81	0.0021	0.0020	0.0021	0.0031	0.0118	0.0200	0.0084	0.0049	0.0041	0.0038	0.0035	0.0027
BCT06-01	0.89	0.0024	0.0022	0.0023	0.0035	0.0130	0.0220	0.0093	0.0054	0.0045	0.0042	0.0038	0.0029
BCT07-01	3.23	0.0084	0.0078	0.0081	0.0123	0.0460	0.0780	0.0330	0.0190	0.0159	0.0149	0.0136	0.0104
BCT08-01	1.01	0.0027	0.0025	0.0026	0.0039	0.0147	0.0249	0.0105	0.0061	0.0051	0.0048	0.0043	0.0033
GC-01	63.09	0.3500	0.3408	0.3460	0.4069	0.9014	1.3709	0.7112	0.5056	0.4607	0.4456	0.4267	0.3791
GC-02	36.09	0.2002	0.1949	0.1979	0.2327	0.5156	0.7841	0.4068	0.2892	0.2635	0.2549	0.2441	0.2168
GC-03	32.93	0.1827	0.1779	0.1806	0.2124	0.4705	0.7156	0.3713	0.2639	0.2405	0.2326	0.2227	0.1979
GC-04	32.42	0.1798	0.1751	0.1778	0.2091	0.4632	0.7045	0.3655	0.2598	0.2367	0.2290	0.2193	0.1948
GC-05	30.84	0.1711	0.1666	0.1692	0.1989	0.4407	0.6702	0.3477	0.2472	0.2252	0.2179	0.2086	0.1853
GC-06	29.29	0.1625	0.1582	0.1606	0.1889	0.4185	0.6365	0.3302	0.2347	0.2139	0.2069	0.1981	0.1760
GC-07	17.32	0.0961	0.0936	0.0950	0.1117	0.2475	0.3764	0.1953	0.1388	0.1265	0.1224	0.1172	0.1041
GC-08	16.48	0.0914	0.0890	0.0904	0.1063	0.2354	0.3581	0.1858	0.1321	0.1203	0.1164	0.1115	0.0990
GC-09	15.12	0.0839	0.0817	0.0829	0.0975	0.2160	0.3286	0.1705	0.1212	0.1104	0.1068	0.1023	0.0909
GC-10	14.20	0.0788	0.0767	0.0779	0.0916	0.2029	0.3086	0.1601	0.1138	0.1037	0.1003	0.0961	0.0853
GC-11	13.69	0.0759	0.0739	0.0751	0.0883	0.1955	0.2974	0.1543	0.1097	0.0999	0.0967	0.0926	0.0822
GC-12	12.52	0.0694	0.0676	0.0687	0.0807	0.1789	0.2720	0.1411	0.1003	0.0914	0.0884	0.0847	0.0752
GC-13	3.92	0.0217	0.0211	0.0215	0.0253	0.0559	0.0851	0.0441	0.0314	0.0286	0.0277	0.0265	0.0235
GC-14	2.45	0.0136	0.0132	0.0134	0.0158	0.0350	0.0532	0.0276	0.0196	0.0179	0.0173	0.0166	0.0147
GCT06-01	2.79	0.0155	0.0151	0.0153	0.0180	0.0398	0.0606	0.0314	0.0223	0.0204	0.0197	0.0189	0.0167
GCT08-01	0.75	0.0041	0.0040	0.0041	0.0048	0.0107	0.0162	0.0084	0.0060	0.0055	0.0053	0.0051	0.0045
GCT09-01	0.75	0.0041	0.0040	0.0041	0.0048	0.0107	0.0162	0.0084	0.0060	0.0055	0.0053	0.0051	0.0045
GCT10-01	0.85	0.0047	0.0046	0.0047	0.0055	0.0121	0.0184	0.0096	0.0068	0.0062	0.0060	0.0057	0.0051
GCT011-01	1.10	0.0061	0.0059	0.0060	0.0071	0.0157	0.0238	0.0124	0.0088	0.0080	0.0077	0.0074	0.0066
GCT014-01	1.45	0.0081	0.0079	0.0080	0.0094	0.0208	0.0316	0.0164	0.0117	0.0106	0.0103	0.0098	0.0087

CrowsNest@	0.003846	0.003558	0.003722	0.005628	0.021109	0.035807	0.015156	0.008718	0.007311	0.00684	0.006249	0.004758

Table D-2: Average Monthly Unit Base Flow

Station	Total Area [km²]	Average Monthly Unit Base Flow [L/s]											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BL-02	24.23	2.0	1.8	1.9	2.9	10.9	18.5	7.8	4.5	3.8	3.5	3.2	2.5
BL-03	15.35	2.2	2.1	2.2	3.3	12.3	20.9	8.8	5.1	4.3	4.0	3.6	2.8
BC-01	49.80	1.3	1.2	1.2	1.8	6.9	11.7	5.0	2.9	2.4	2.2	2.0	1.6
BC-02	47.80	1.3	1.2	1.3	1.9	7.2	12.3	5.2	3.0	2.5	2.3	2.1	1.6
BC-03	40.53	1.5	1.4	1.5	2.2	8.4	14.2	6.0	3.5	2.9	2.7	2.5	1.9
BC-04	35.42	1.7	1.5	1.6	2.4	9.2	15.6	6.6	3.8	3.2	3.0	2.7	2.1
BC-05	32.65	1.8	1.6	1.7	2.6	9.6	16.3	6.9	4.0	3.3	3.1	2.8	2.2
BC-06	24.03	2.0	1.8	1.9	2.9	11.0	18.6	7.9	4.5	3.8	3.6	3.2	2.5
BC-07	20.57	2.1	1.9	2.0	3.1	11.5	19.5	8.3	4.8	4.0	3.7	3.4	2.6
BC-08	20.56	2.1	1.9	2.0	3.1	11.5	19.5	8.3	4.8	4.0	3.7	3.4	2.6
BC-09	20.39	2.1	1.9	2.0	3.1	11.5	19.6	8.3	4.8	4.0	3.7	3.4	2.6
BC-10	19.42	2.1	2.0	2.1	3.1	11.7	19.8	8.4	4.8	4.0	3.8	3.5	2.6
BC-11	18.85	2.1	2.0	2.1	3.1	11.8	20.0	8.5	4.9	4.1	3.8	3.5	2.7
BC-12	15.61	2.2	2.1	2.2	3.3	12.3	20.8	8.8	5.1	4.3	4.0	3.6	2.8
BC-13	15.30	2.2	2.1	2.2	3.3	12.3	20.9	8.9	5.1	4.3	4.0	3.7	2.8
BC-14	14.08	2.3	2.1	2.2	3.3	12.5	21.2	9.0	5.2	4.3	4.1	3.7	2.8
BCT02-01	4.96	2.5	2.4	2.5	3.7	14.0	23.7	10.0	5.8	4.8	4.5	4.1	3.1
BCT04-01	8.24	2.4	2.3	2.4	3.6	13.4	22.8	9.6	5.6	4.7	4.4	4.0	3.0
BCT05-01	0.81	2.7	2.5	2.6	3.9	14.6	24.8	10.5	6.0	5.1	4.7	4.3	3.3
BCT06-01	0.89	2.7	2.5	2.6	3.9	14.6	24.8	10.5	6.0	5.1	4.7	4.3	3.3
BCT07-01	3.23	2.6	2.4	2.5	3.8	14.2	24.1	10.2	5.9	4.9	4.6	4.2	3.2
BCT08-01	1.01	2.7	2.5	2.6	3.9	14.6	24.7	10.5	6.0	5.0	4.7	4.3	3.3
GC-01	63.09	5.5	5.4	5.5	6.4	14.3	21.7	11.3	8.0	7.3	7.1	6.8	6.0
GC-02	36.09	5.5	5.4	5.5	6.4	14.3	21.7	11.3	8.0	7.3	7.1	6.8	6.0
GC-03	32.93	5.5	5.4	5.5	6.4	14.3	21.7	11.3	8.0	7.3	7.1	6.8	6.0
GC-04	32.42	5.5	5.4	5.5	6.4	14.3	21.7	11.3	8.0	7.3	7.1	6.8	6.0
GC-05	30.84	5.5	5.4	5.5	6.4	14.3	21.7	11.3	8.0	7.3	7.1	6.8	6.0
GC-06	29.29	5.5	5.4	5.5	6.4	14.3	21.7	11.3	8.0	7.3	7.1	6.8	6.0
GC-07	17.32	5.5	5.4	5.5	6.4	14.3	21.7	11.3	8.0	7.3	7.1	6.8	6.0
GC-08	16.48	5.5	5.4	5.5	6.4	14.3	21.7	11.3	8.0	7.3	7.1	6.8	6.0
GC-09	15.12	5.5	5.4	5.5	6.4	14.3	21.7	11.3	8.0	7.3	7.1	6.8	6.0
GC-10	14.20	5.5	5.4	5.5	6.4	14.3	21.7	11.3	8.0	7.3	7.1	6.8	6.0
GC-11	13.69	5.5	5.4	5.5	6.4	14.3	21.7	11.3	8.0	7.3	7.1	6.8	6.0
GC-12	12.52	5.5	5.4	5.5	6.4	14.3	21.7	11.3	8.0	7.3	7.1	6.8	6.0
GC-13	3.92	5.5	5.4	5.5	6.4	14.3	21.7	11.3	8.0	7.3	7.1	6.8	6.0
GC-14	2.45	5.5	5.4	5.5	6.4	14.3	21.7	11.3	8.0	7.3	7.1	6.8	6.0
GCT06-01	2.79	5.5	5.4	5.5	6.4	14.3	21.7	11.3	8.0	7.3	7.1	6.8	6.0
GCT08-01	0.75	5.5	5.4	5.5	6.4	14.3	21.7	11.3	8.0	7.3	7.1	6.8	6.0
GCT09-01	0.75	5.5	5.4	5.5	6.4	14.3	21.7	11.3	8.0	7.3	7.1	6.8	6.0
GCT10-01	0.85	5.5	5.4	5.5	6.4	14.3	21.7	11.3	8.0	7.3	7.1	6.8	6.0
GCT011-01	1.10	5.5	5.4	5.5	6.4	14.3	21.7	11.3	8.0	7.3	7.1	6.8	6.0
GCT014-01	1.45	5.5	5.4	5.5	6.4	14.3	21.7	11.3	8.0	7.3	7.1	6.8	6.0

APPENDIX B
Groundwater Level Data

Table A-1: Continuous Groundwater Level Monitoring Stations

Monitoring Point	Instrument Type	Data Source	Easting	Northing	Surface elevation (masl)	Stickup (mag)	Dip	Az	Drillhole Depth (mbg)	Completion Depth (mbg)	Screened Interval (mbg)	Screen Length (m)	Sandpack Interval (mbg)	Sandpack Length (m)	Coal Seam	Instrument Depth (mbg)	Instrument Elevaiton (masl)
RGSC-0005a	VW29689	Golder	685118	5504574	1507.5	na	-70	100	na	58.3	na	na	na	na	Coal Seam 1 and Interburden	58.3	1449.2
RGSC-0005b	VW29684	Golder	685118	5504574	1507.5	na	-70	100	na	86.0	na	na	na	na	Coal Seam 1 and Interburden	86.0	1421.5
RGSC-0005c	VW29682	Golder	685118	5504574	1507.5	na	-70	100	na	120.0	na	na	na	na	Coal Seam 1 and Interburden	120.0	1387.5
RGSC-0006a	VW29688	Golder	685577	5507161	1826.0	na	-90	0	na	39.8	na	na	na	na	Coal Seam 1 and Interburden	39.8	1786.2
RGSC-0006b	VW29685	Golder	685577	5507161	1826.0	na	-90	0	na	77.5	na	na	na	na	Coal Seam 1 and Interburden	77.6	1748.4
RGSC-0006c	VW29681	Golder	685577	5507161	1826.0	na	-90	0	na	133.7	na	na	na	na	Coal Seam 1 and Interburden	133.7	1692.3
RGSC-0009a	VW29687	Golder	686742	5509160	1912.4	na	-70	20	na	60.4	na	na	na	na	Coal Seam 1 and Interburden	60.4	1852.0
RGSC-0009b	VW29686	Golder	686742	5509160	1912.4	na	-70	20	na	93.7	na	na	na	na	Coal Seam 1 and Interburden	93.7	1818.7
RGSC-0009c	VW29683	Golder	686742	5509160	1912.4	na	-70	20	na	135.4	na	na	na	na	Coal Seam 1 and Interburden	135.4	1777.0
MW14-01-64	Level logger	MEMS	685434	5504891	1542.4	0.94	-90	0	115.5	115.5	62.9 - 64.4	1.5	61.7 - 115.5	53.8	Coal Seam 2 (Middle)	63.7	1478.8
MW14-02-74	Level logger	MEMS	685588	5504347	1583.1	0.72	-90	0	99.4	99.9	72.3 - 73.8	1.5	71.1 - 99.9	28.8	Coal Seam 4 (Deep)	73.1	1510.1
MW14-05-114	Level logger	MEMS	685982	5507539	1925.1	0.92	-90	0	165.0	117.0	110.8 - 113.8	3.0	108.9 - 117.0	8.1	Coal Seam 2 (Middle)	112.3	1812.8
MW14-06-105	Level logger	MEMS	685864	5506885	1927.0	0.92	-90	0	153.0	117.0	110.8 - 113.8	3.0	108.9 - 117.0	8.1	Coal Seam 4 (Deep)	112.3	1814.7
MW14-06-32	Level logger	MEMS	685864	5506884	1928.4	0.96	-90	0	32.5	32.5	30.3 - 31.8	1.5	29.1 - 32.5	3.4	Coal Seam 1 (Shallow)	31.1	1897.4
RGOH3035 (Cougar Corner Test Well 1)	Level logger	MEMS															

Table A-2: Manual Groundwater Level Monitoring Data

Well ID	Data Source	Easting	Northing	Ground Elevation (masl)	Stickup (mag)	Dip	Az	Drillhole Depth (m)	Completion Depth (mbgs)	Screened Interval (mbgs)	Screen Length Length (m)	Coal Seam	Date	Water Level (mbgs)	Water Elevation (masl)	Comments
MW14-01-64	MEMS	685434	5504891	1542.4	0.94	-90	0	115.5	115.5	62.9 - 64.4	1.5	Coal Seam 2 (Middle)	2/2/2014	34.9	1507.5	
MW14-01-64	MEMS	685434	5504891	1542.4	0.94	-90	0	115.5	115.5	62.9 - 64.4	1.5	Coal Seam 2 (Middle)	10/16/2014	35.7	1506.7	
MW14-01-64	MEMS	685434	5504891	1542.4	0.94	-90	0	115.5	115.5	62.9 - 64.4	1.5	Coal Seam 2 (Middle)	4/17/2015	35.3	1507.1	
MW14-01-64	MEMS	685434	5504891	1542.4	0.94	-90	0	115.5	115.5	62.9 - 64.4	1.5	Coal Seam 2 (Middle)	3/21/2016	36.5	1505.9	
MW14-02-74	MEMS	685588	5504347	1583.1	0.72	-90	0	99.4	99.9	72.3 - 73.8	1.5	Coal Seam 4 (Deep)	2/3/2014	72.2	1510.9	
MW14-02-74	MEMS	685588	5504347	1583.1	0.72	-90	0	99.4	99.9	72.3 - 73.8	1.5	Coal Seam 4 (Deep)	10/16/2014	71.8	1511.3	
MW14-02-74	MEMS	685588	5504347	1583.1	0.72	-90	0	99.4	99.9	72.3 - 73.8	1.5	Coal Seam 4 (Deep)	4/17/2015	71.5	1511.6	
MW14-02-74	MEMS	685588	5504347	1583.1	0.72	-90	0	99.4	99.9	72.3 - 73.8	1.5	Coal Seam 4 (Deep)	3/21/2016	71.7	1511.4	
MW14-03-28	MEMS	685674	5505736	1752.4	0.96	-90	0	28.0	28.0	23.2 - 27.5	4.3	Coal Seam 1 (Shallow)	10/16/2014	No Value	No Value	Dry
MW14-03-28	MEMS	685674	5505736	1752.4	0.96	-90	0	28.0	28.0	23.2 - 27.5	4.3	Coal Seam 1 (Shallow)	4/17/2015	27.4	1725.0	
MW14-03-28	MEMS	685674	5505736	1752.4	0.96	-90	0	28.0	28.0	23.2 - 27.5	4.3	Coal Seam 1 (Shallow)	3/22/2016	No Value	No Value	Dry
MW14-03-90	MEMS	685674	5505739	1755.2	0.90	-90	0	138.3	103.8	88.7 - 90.2	1.5	Coal Seam 4 (Deep)	2/1/2014	53.2	1702.0	
MW14-03-90	MEMS	685674	5505739	1755.2	0.90	-90	0	138.3	103.8	88.7 - 90.2	1.5	Coal Seam 4 (Deep)	10/16/2014	52.9	1702.3	
MW14-03-90	MEMS	685674	5505739	1755.2	0.90	-90	0	138.3	103.8	88.7 - 90.2	1.5	Coal Seam 4 (Deep)	4/17/2015	52.8	1702.4	
MW14-03-90	MEMS	685674	5505739	1755.2	0.90	-90	0	138.3	103.8	88.7 - 90.2	1.5	Coal Seam 4 (Deep)	3/22/2016	53.7	1701.5	
MW14-04-11.5	MEMS	685809	5507377	1856.3	0.90	-90	0	12.0	12.0	9.0 - 11.5	2.5	Coal Seam 1 (Shallow)	10/15/2014	11.4	1844.9	
MW14-04-11.5	MEMS	685809	5507377	1856.3	0.90	-90	0	12.0	12.0	9.0 - 11.5	2.5	Coal Seam 1 (Shallow)	4/17/2015	11.4	1844.9	
MW14-04-11.5	MEMS	685809	5507377	1856.3	0.90	-90	0	12.0	12.0	9.0 - 11.5	2.5	Coal Seam 1 (Shallow)	3/24/2016	No Value	No Value	Damaged
MW14-04-93	MEMS	685809	5507380	1855.9	0.89	-90	0	116.0	93.0	90.0 - 93.0	3.0	Coal Seam 4 (Deep)	10/14/2014	17.2	1838.7	
MW14-04-93	MEMS	685809	5507380	1855.9	0.89	-90	0	116.0	93.0	90.0 - 93.0	3.0	Coal Seam 4 (Deep)	4/17/2015	17.3	1838.6	
MW14-04-93	MEMS	685809	5507380	1855.9	0.89	-90	0	116.0	93.0	90.0 - 93.0	3.0	Coal Seam 4 (Deep)	3/24/2016	No Value	No Value	Damaged
MW14-05-114	MEMS	685982	5507539	1925.1	0.92	-90	0	165.0	117.0	110.8 - 113.8	3.0	Coal Seam 2 (Middle)	10/14/2014	3.2	1921.9	
MW14-05-114	MEMS	685982	5507539	1925.1	0.92	-90	0	165.0	117.0	110.8 - 113.8	3.0	Coal Seam 2 (Middle)	4/17/2015	4.9	1920.2	
MW14-05-114	MEMS	685982	5507539	1925.1	0.92	-90	0	165.0	117.0	110.8 - 113.8	3.0	Coal Seam 2 (Middle)	3/24/2016	8.9	1916.2	
MW14-06-105	MEMS	685864	5506885	1927.0	0.92	-90	0	153.0	117.0	110.8 - 113.8	3.0	Coal Seam 4 (Deep)	10/14/2014	17.8	1909.2	
MW14-06-105	MEMS	685864	5506885	1927.0	0.92	-90	0	153.0	117.0	110.8 - 113.8	3.0	Coal Seam 4 (Deep)	4/17/2015	20.4	1906.6	
MW14-06-105	MEMS	685864	5506885	1927.0	0.92	-90	0	153.0	117.0	110.8 - 113.8	3.0	Coal Seam 4 (Deep)	3/23/2016	21.7	1905.3	
MW14-06-32	MEMS	685864	5506884	1928.4	0.96	-90	0	32.5	32.5	30.3 - 31.8	1.5	Coal Seam 1 (Shallow)	9/28/2014	25.1	1903.3	
MW14-06-32	MEMS	685864	5506884	1928.4	0.96	-90	0	32.5	32.5	30.3 - 31.8	1.5	Coal Seam 1 (Shallow)	4/17/2015	25.6	1902.8	
MW14-06-32	MEMS	685864	5506884	1928.4	0.96	-90	0	32.5	32.5	30.3 - 31.8	1.5	Coal Seam 1 (Shallow)	3/23/2016	26.8	1901.6	
MW14-07-48	MEMS	686580	5507292	1840.2	0.88	-90	0	66.5	49.5	46.6 - 48.1	1.5	Coal Seam 4 (Deep)	10/15/2014	16.7	1823.5	
MW14-07-48	MEMS	686580	5507292	1840.2	0.88	-90	0	66.5	49.5	46.6 - 48.1	1.5	Coal Seam 4 (Deep)	3/22/2016	14.4	1825.9	
MW14-08-79	MEMS	686844	5509725	1847.7	1.05	-90	0	145.0	82.0	76.9 - 79.9	3.0	Coal Seam 2 (Middle)	10/15/2014	50.4	1797.3	
MW14-08-79	MEMS	686844	5509725	1847.7	1.05	-90	0	145.0	82.0	76.9 - 79.9	3.0	Coal Seam 2 (Middle)	4/17/2015	58.0	1789.7	
MW14-09-129	MEMS	686827	5509435	1882.7	0.89	-90	0	146.0	146.0	127.4 - 129.0	1.6	Coal Seam 4 (Deep)	10/15/2014	111.0	1771.7	
MW14-09-129	MEMS	686827	5509435	1882.7	0.89	-90	0	146.0	146.0	127.4 - 129.0	1.6	Coal Seam 4 (Deep)	3/23/2016	No Value	No Value	Damaged
MW14-10-22	MEMS	686836	5509301	1926.0	0.98	-90	0	133.7	27.7	19.9 - 21.7	1.8	Coal Seam 1 (Shallow)	10/16/2014	No Value	No Value	Dry
MW14-10-22	MEMS	686836	5509301	1926.0	0.98	-90	0	133.7	27.7	19.9 - 21.7	1.8	Coal Seam 1 (Shallow)	4/17/2015	No Value	No Value	Dry
MW14-10-22	MEMS	686836	5509301	1926.0	0.98	-90	0	133.7	27.7	19.9 - 21.7	1.8	Coal Seam 1 (Shallow)	3/23/2016	No Value	No Value	Dry
MW15-11-18.5	MEMS	684919	5504250	1482.6	0.92	-90	0	18.6	18.6	15.5 - 18.5	3.0	Mudstone	4/17/2015	5.3	1477.3	
MW15-11-18.5	MEMS	684919	5504250	1482.6	0.92	-90	0	18.6	18.6	15.5 - 18.5	3.0	Mudstone	3/23/2016	5.0	1477.6	
MW15-11-9	MEMS	684917	5504249	1482.4	0.81	-90	0	9.2	9.2	6.2 - 9.2	3.0	Mudstone	4/17/2015	8.4	1474.0	
MW15-11-9	MEMS	684917	5504249	1482.4	0.81	-90	0	9.2	9.2	6.2 - 9.2	3.0	Mudstone	3/23/2016	8.3	1474.1	
MW15-12-14	MEMS	684791	5503688	1447.1	0.98	-90	0	13.7	13.7	9.9 -13.7	3.8	Mudstone	4/17/2015	3.0	1444.1	
MW15-12-14	MEMS	684791	5503688	1447.1	0.98	-90	0	13.7	13.7	9.9 -13.7	3.8	Mudstone	3/21/2016	2.7	1444.4	
MW15-12-7	MEMS	684791	5503690	1447.2	1.04	-90	0	6.8	6.8	3.8 - 6.8	3.0	Surficial deposits	4/17/2015	4.9	1442.3	
MW15-12-7	MEMS	684791	5503690	1447.2	1.04	-90	0	6.8	6.8	3.8 - 6.8	3.0	Surficial deposits	3/23/2016	3.5	1443.8	
RGOH-3012	Riversdale	685401	5505479	1600.0	na	-90	0	159.0	159.0	na	na	Coal Seams 1 & 2 & 4 and Interb	na	No Value	No Value	Artesian Flowing
RGOH-3029	Riversdale	687038	5510127	1761.4	na	-90	0	132.0	132.0	na	na	Coal Seams 1 & 2 & 4 and Interb	na	No Value	No Value	Artesian Flowing

Appendix F-6

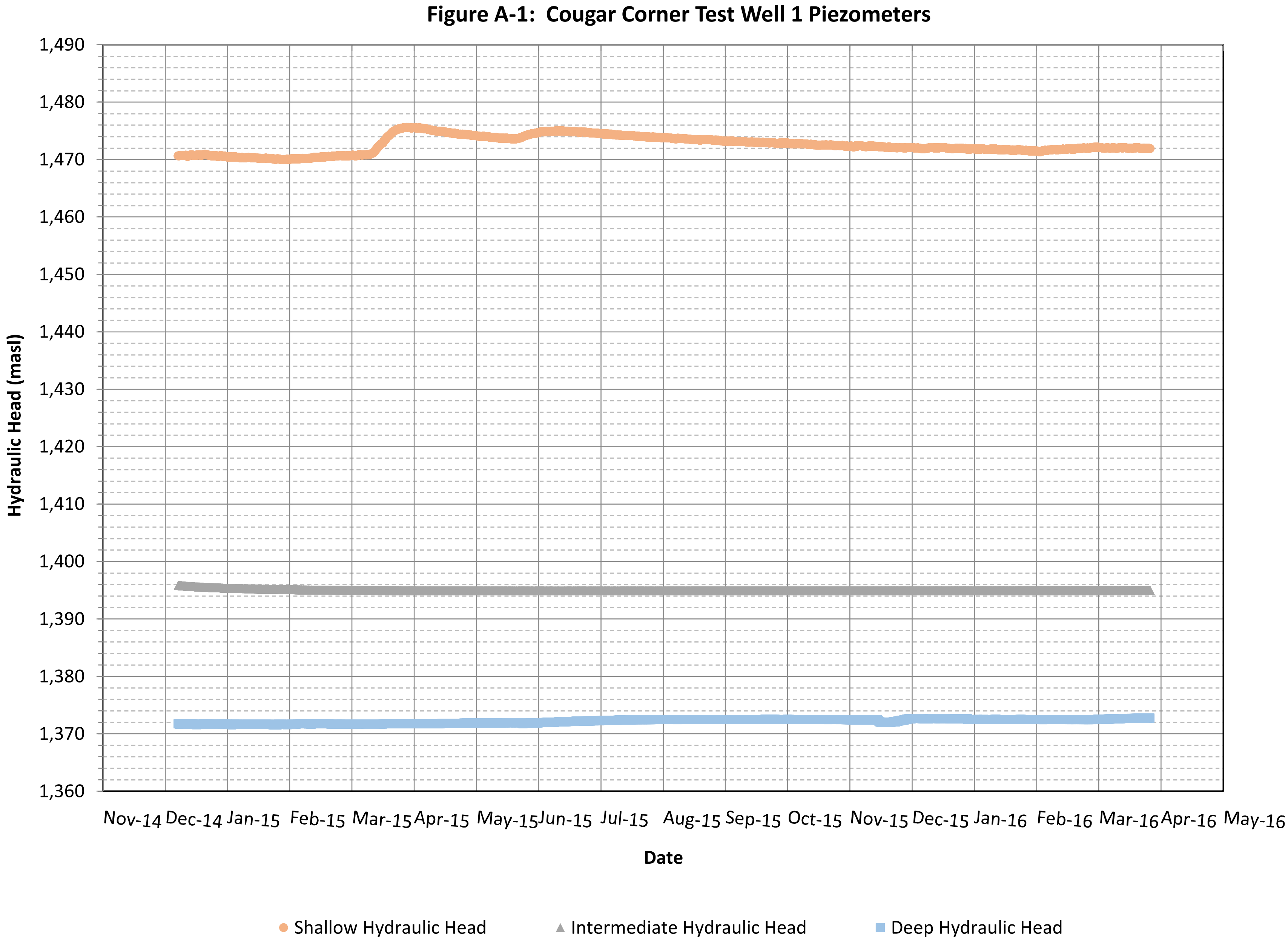


Figure A-1: Cougar Corner Test Well 1 Piezometers
Hydraulic Head (masl)
1,490
1,480
1,470
1,460
1,450
1,440
1,430
1,420
1,410
1,400
1,390
1,380
1,370
1,360
Nov-14
Dec-14
Jan-15
Feb-15
Mar-15
Apr-15
May-15
Jun-15
Jul-15
Aug-15
Sep-15
Oct-15
Nov-15
Dec-15
Jan-16
Feb-16
Mar-16
Apr-16
May-16
Date
Shallow Hydraulic Head
Intermediate Hydraulic Head
Deep Hydraulic Head

Appendix F-6

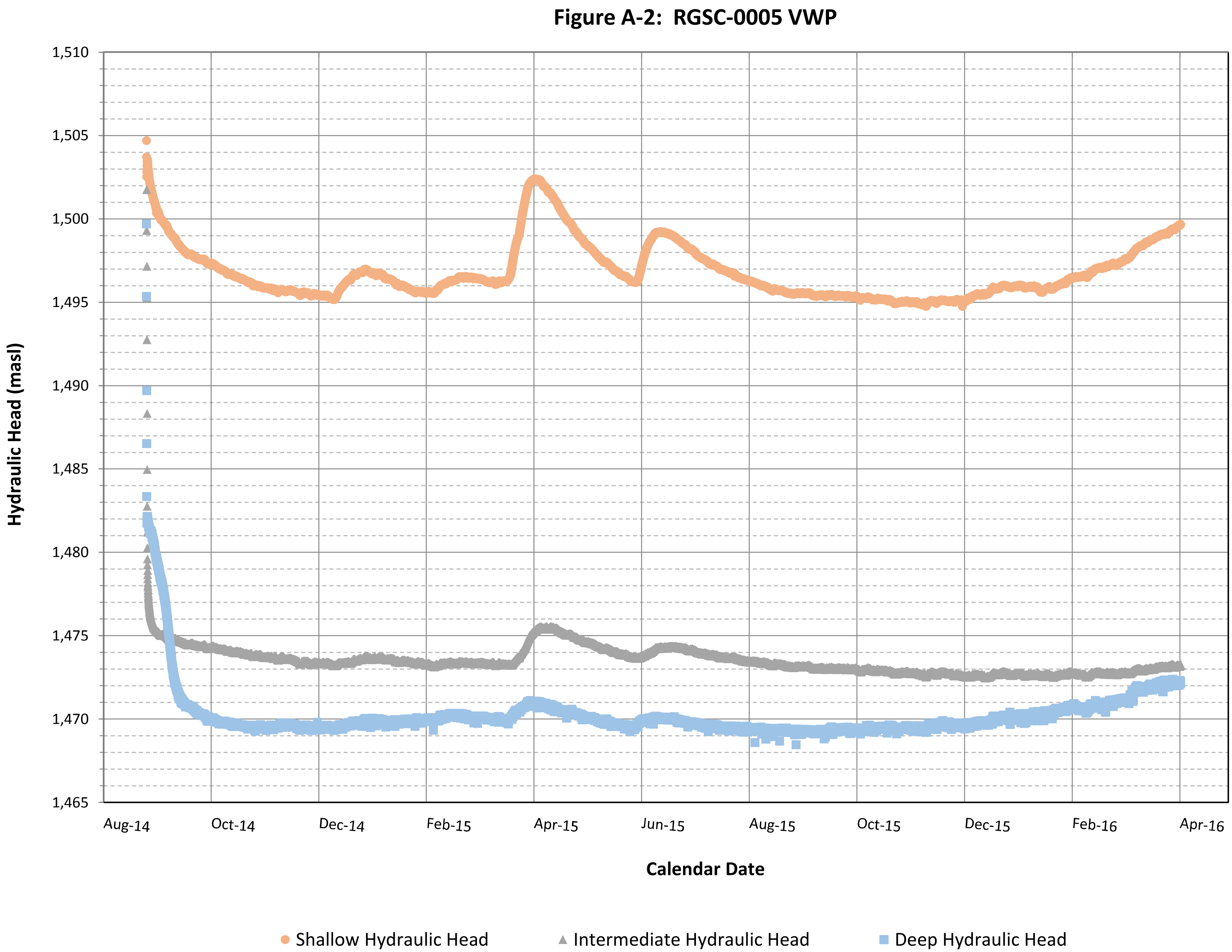
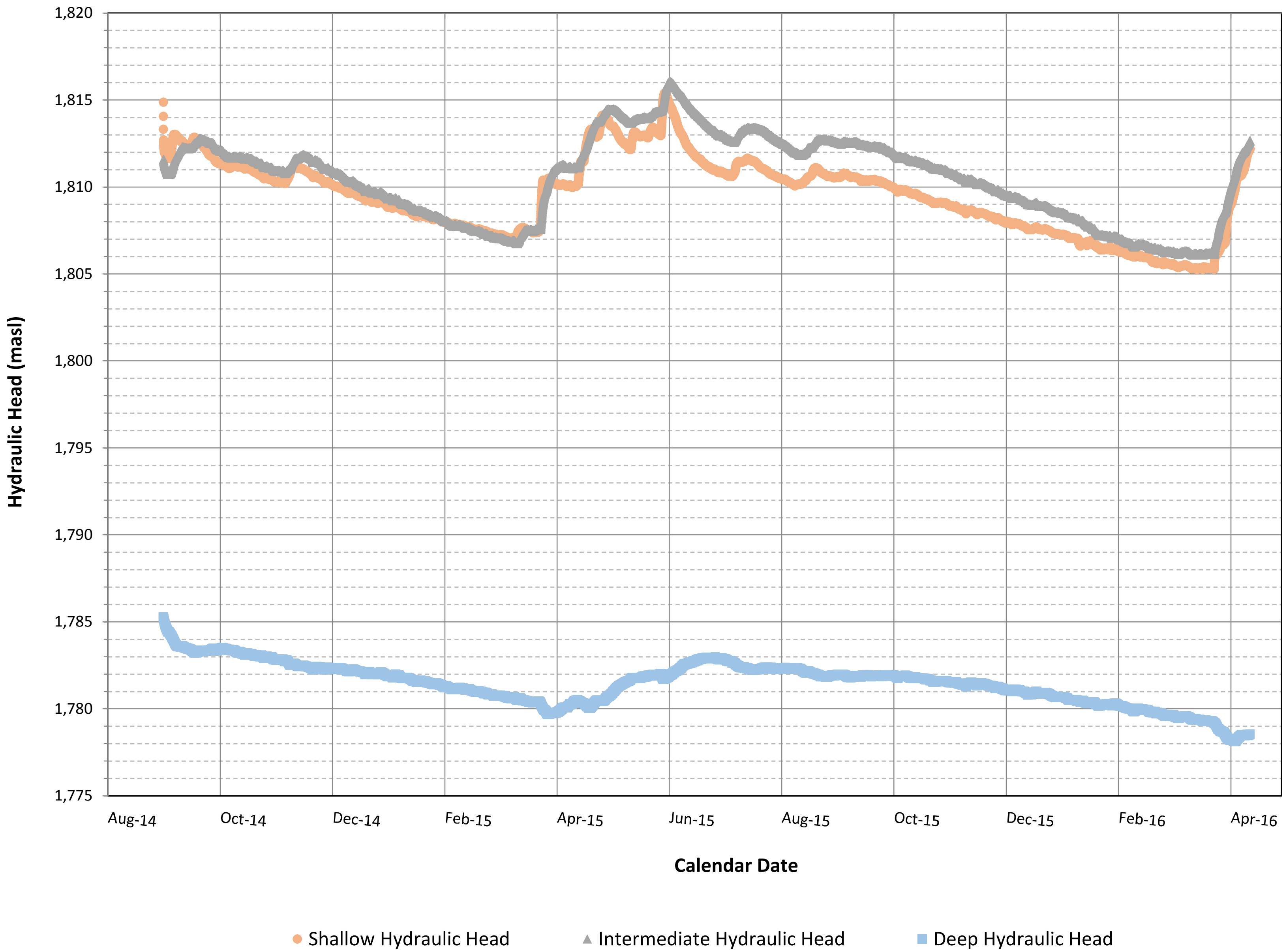


Figure A-2: RGSC-0005 VWP
1,510
1,505
1,500
1,495
1,490
1,485
1,480
1,475
1,470
1,465
Hydraulic Head (masl)
Aug-14
Oct-14
Dec-14
Feb-15
Apr-15
Jun-15
Aug-15
Oct-15
Dec-15
Feb-16
Apr-16
Calendar Date
Shallow Hydraulic Head
Intermediate Hydraulic Head
Deep Hydraulic Head

Appendix F-6

Figure A-3: RGSC-0006 VWP



Appendix F-6

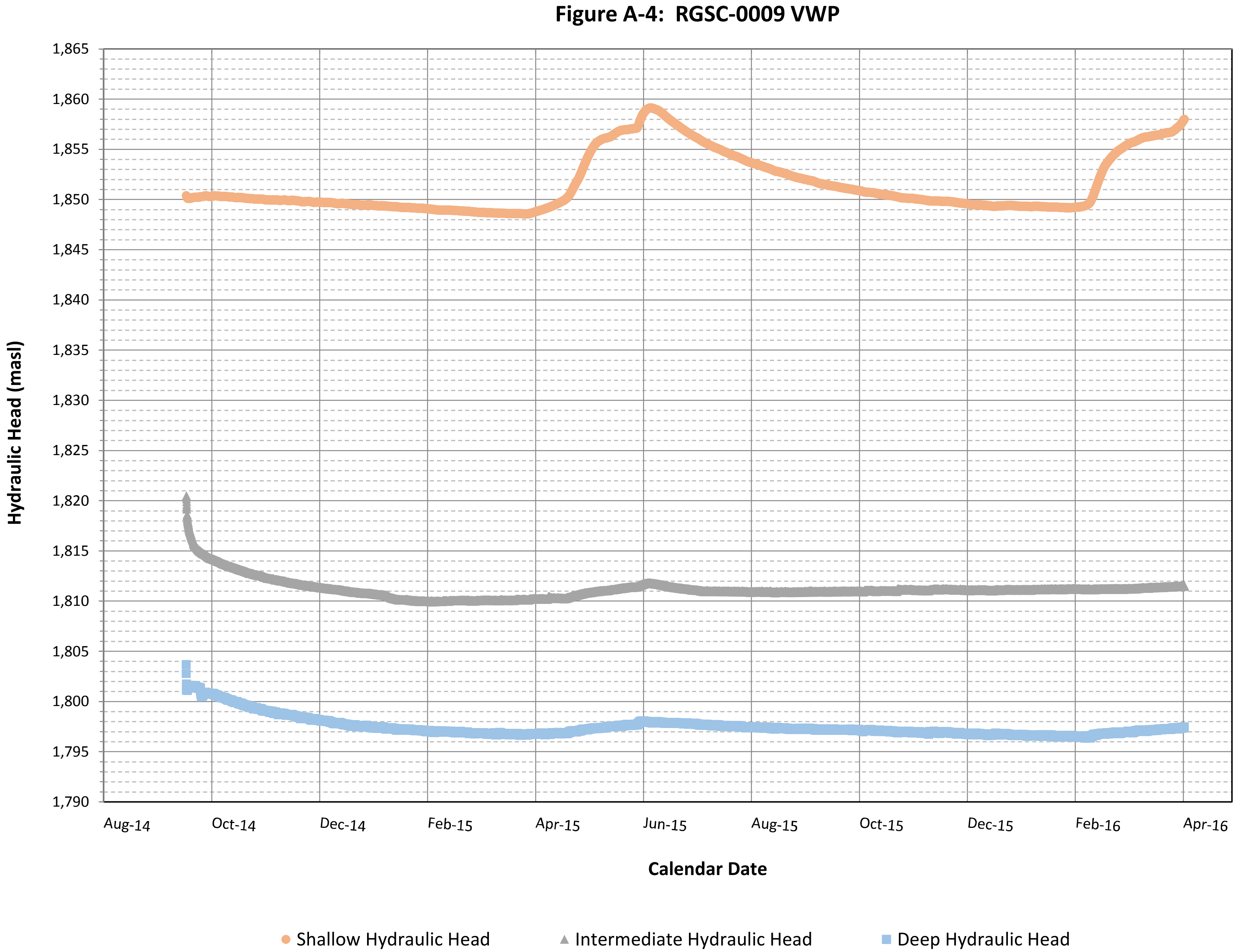


Figure A-4: RGSC-0009 VWP
1,865
1,860
1,855
1,850
1,845
1,840
1,835
1,830
1,825
1,820
1,815
1,810
1,805
1,800
1,795
1,790
Hydraulic Head (masl)
Aug-14
Oct-14
Dec-14
Feb-15
Apr-15
Jun-15
Aug-15
Oct-15
Dec-15
Feb-16
Apr-16
Calendar Date
Shallow Hydraulic Head
Intermediate Hydraulic Head
Deep Hydraulic Head

Appendix F-6

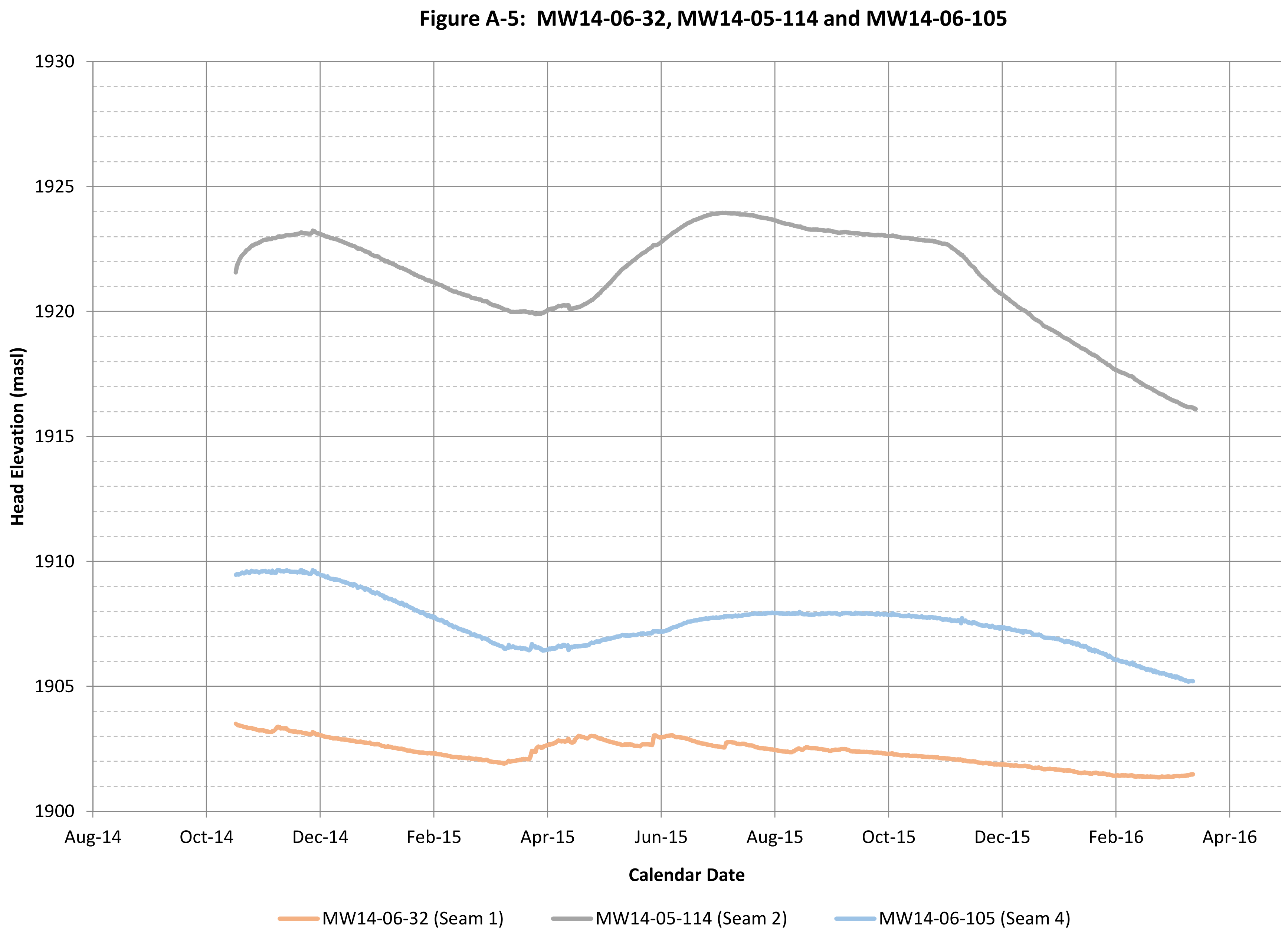
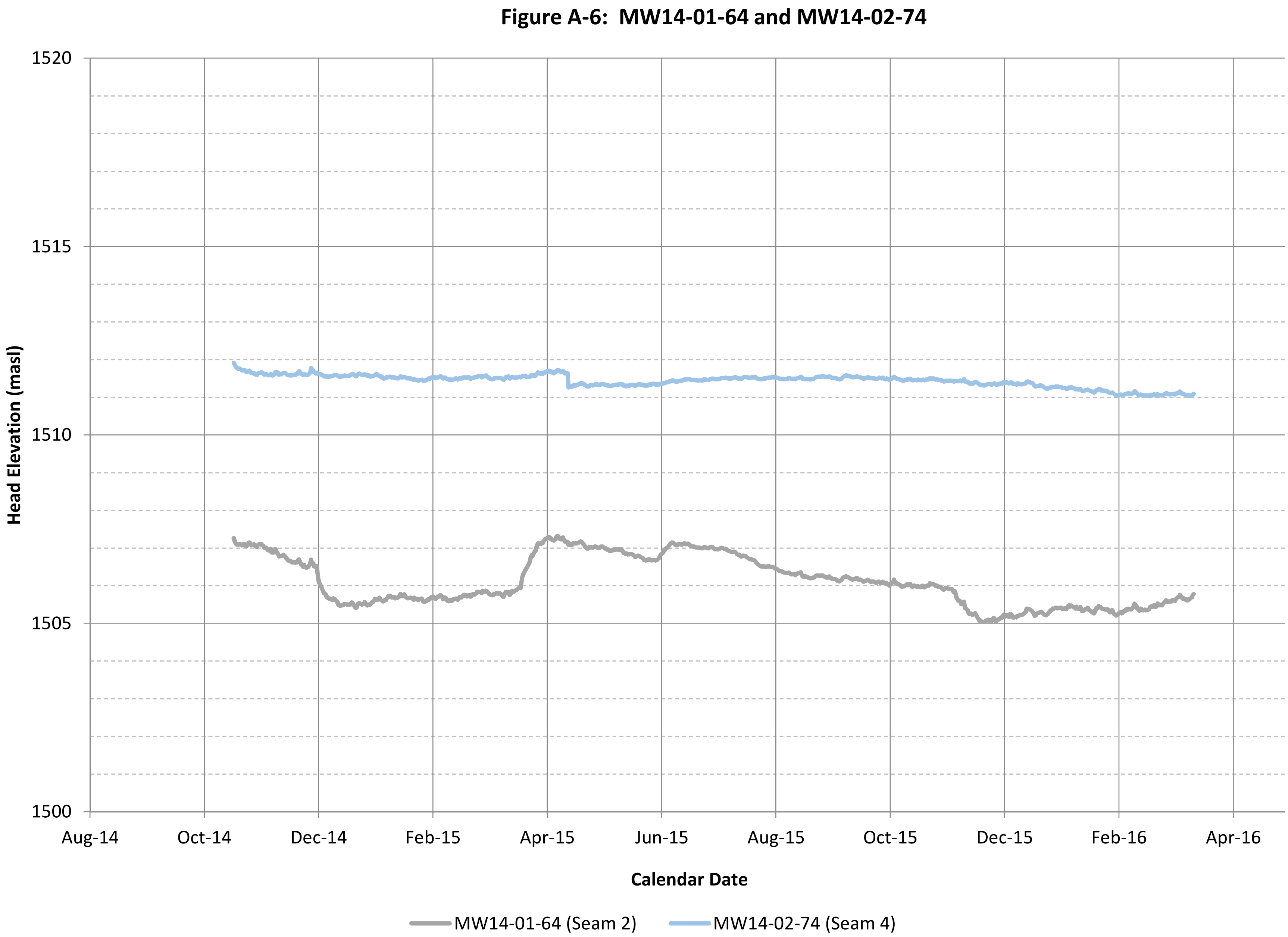


Figure A-5: MW14-06-32, MW14-05-114 and MW14-06-105
Head Elevation (masl)
1930
1925
1920
1915
1910
1905
1900
Aug-14
Oct-14
Dec-14
Feb-15
Apr-15
Jun-15
Aug-15
Oct-15
Dec-15
Feb-16
Apr-16
Calendar Date
MW14-06-32 (Seam 1)
MW14-05-114 (Seam 2)
MW14-06-105 (Seam 4)

Appendix F-6



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APPENDIX C
Groundwater Numerical Model Outputs

Table C-1: Flow Rate, Rivers and Creeks (m^3/d) : Steady State Models - Baseline to LTC - "Linear" Recharge

File name	year	Time (d)	*RIVER / CREEKS*															
			D1	**BL03**	**BC07**	**BL02**	**BC03**	**BL01**	**Blairmore Creek**	**GC13**	**GC09**	**GC04**	**GC02**	**GC01**	**Gold Creek**	**Small Creeks**	**West Creek**	**Crowsnest River**
01b_PrMng_2018_Grassy_Mntn_FM-GwAge_Steady-State_Calibration_rev2_LNR.dac	**2018**	∞	-22215	-6168	-8784	-9580	-14843	-16587	-17186	-2668	-10858	-24912	-28603	-46663	-46948	-4521	-4857	-764
12_Mng_2019_Grassy_Mmtn_FM_Steady_LNR.da	**2019**	∞	-22213	-6168	-8783	-9574	-12959	-14704	-15302	-2668	-10858	-24907	-25686	-46116	-44019	-4555	-4857	-764
13_Mng_2020_Grassy_Mmtn_FM_Steady_LNR.da	**2020**	∞	-22213	-6168	-7932	-8687	-12021	-13760	-14358	-2668	-10857	-24903	-25682	-43730	-44015	-4553	-4857	-764
14_Mng_2021_Grassy_Mmtn_FM_Steady_LNR.da	**2021**	∞	-22217	-6168	-7934	-8620	-11931	-13667	-14265	-2668	-10855	-24903	-25682	-43732	-44016	-4515	-4857	-764
15_Mng_2022_Grassy_Mmtn_FM_Steady_LNR.da	**2022**	∞	-22216	-6168	-8503	-8519	-11813	-13549	-14148	-2667	-10839	-24837	-25616	-43666	-43951	-4515	-4857	-764
16_Mng_2023_Grassy_Mmtn_FM_Steady_LNR.da	**2023**	∞	-22216	-6168	-7923	-8482	-11752	-13488	-14086	-2667	-10827	-24744	-25523	-43573	-43858	-4515	-4857	-764
17_Mng_2024_Grassy_Mmtn_FM_Steady_LNR.da	**2024**	∞	-22216	-6168	-7923	-8452	-11702	-13438	-14036	-2667	-10811	-24525	-25126	-43176	-43461	-4515	-4857	-764
18_Mng_2025_Grassy_Mmtn_FM_Steady_LNR.da	**2025**	∞	-22216	-6168	-6761	-7271	-10517	-12253	-12852	-2667	-10793	-24117	-24896	-42946	-43230	-4515	-4857	-764
19_Mng_2026_Grassy_Mmtn_FM_Steady_LNR.da	**2026**	∞	-22216	-6168	-6760	-7242	-10485	-12222	-12820	-2667	-10688	-23748	-24349	-42398	-42683	-4515	-4857	-764
20_Mng_2027_Grassy_Mmtn_FM_Steady_LNR.da	**2027**	∞	-22216	-6168	-6760	-7217	-10458	-12193	-12792	-2666	-10773	-23657	-24436	-42486	-42770	-4515	-4857	-764
21_Mng_2028_Grassy_Mmtn_FM_Steady_LNR.da	**2028**	∞	-22216	-6168	-6759	-7196	-10437	-12172	-12771	-2665	-10763	-23647	-24426	-42475	-42760	-4515	-4857	-764
22_Mng_2029_Grassy_Mmtn_FM_Steady_LNR.da	**2029**	∞	-22216	-6168	-6758	-7173	-10413	-12149	-12748	-2662	-10739	-23624	-24403	-42453	-42738	-4515	-4857	-764
23_Mng_2030_Grassy_Mmtn_FM_Steady_LNR.da	**2030**	∞	-22215	-6168	-6758	-7167	-10410	-12146	-12745	-2662	-10731	-23616	-24395	-42445	-42730	-4516	-4857	-764
24_Mng_2031_Grassy_Mmtn_FM_Steady_LNR.da	**2031**	∞	-22215	-6168	-6758	-7164	-10409	-12146	-12745	-2666	-10711	-23595	-24374	-42424	-42709	-4516	-4857	-764
25_Mng_2032_Grassy_Mmtn_FM_Steady_LNR.da	**2032**	∞	-22212	-6168	-6757	-7160	-10409	-12147	-12746	-2658	-10666	-23551	-24330	-42380	-42665	-4516	-4857	-764
26_Mng_2033_Grassy_Mmtn_FM_Steady_LNR.da	**2033**	∞	-22211	-6168	-6757	-7158	-10411	-12150	-12748	-2645	-10268	-23146	-23924	-41974	-42259	-4516	-4857	-764
27_Mng_2034_Grassy_Mmtn_FM_Steady_LNR.da	**2034**	∞	-22209	-6168	-6756	-7153	-10410	-12150	-12748	-2596	-10182	-23060	-23839	-41888	-42173	-4517	-4857	-764
28_Mng_2035_Grassy_Mmtn_FM_Steady_LNR.da	**2035**	∞	-22209	-6168	-6755	-7151	-10413	-12153	-12752	-2516	-9769	-22646	-23425	-41475	-41759	-4517	-4857	-764
29_Mng_2036_Grassy_Mmtn_FM_Steady_LNR.da	**2036**	∞	-22208	-6168	-6753	-7145	-10411	-12152	-12751	-2484	-9594	-22471	-23250	-41299	-41584	-4517	-4857	-764
30_Mng_2037_Grassy_Mmtn_FM_Steady_LNR.da	**2037**	∞	-22208	-6167	-6752	-7143	-10409	-12151	-12750	-2468	-9575	-22452	-23231	-41281	-41565	-4517	-4857	-764
31_Mng_2038_Grassy_Mmtn_FM_Steady_LNR.da	**2038**	∞	-22208	-6167	-6753	-7145	-10411	-12152	-12751	-2426	-9525	-22402	-23180	-41230	-41515	-4517	-4857	-764
32_Mng_2039_Grassy_Mmtn_FM_Steady_LNR.da	**2039**	∞	-22207	-6167	-6753	-7147	-10413	-12166	-12764	-2419	-9514	-22383	-23162	-41197	-41482	-4559	-4857	-764
33_Mng_2040_Grassy_Mmtn_FM_Steady_LNR.da	**2040**	∞	-22207	-6168	-6754	-7151	-10417	-12170	-12768	-2417	-9508	-22375	-23154	-41189	-41474	-4559	-4857	-764
34_Mng_2041_Grassy_Mmtn_FM_Steady_LNR.da	**2041**	∞	-22207	-6168	-6754	-7151	-10417	-12169	-12767	-2413	-9496	-22364	-23142	-41177	-41462	-4559	-4857	-764
35_Mng_2042_Grassy_Mmtn_FM_Steady_LNR.da	**2042**	∞	-22207	-6168	-6754	-7151	-10417	-12169	-12767	-2413	-9496	-22364	-23142	-41177	-41462	-4559	-4857	-764
36_Mng_2043_Grassy_Mmtn_FM_Steady_LNR.da	**2043**	∞	-22207	-6168	-6754	-7151	-10417	-12169	-12768	-2413	-9499	-22368	-23146	-41181	-41466	-4559	-4857	-764
37_Mng_2044_Grassy_Mmtn_FM_Steady_LNR.da	**2044**	∞	-22207	-6168	-6754	-7151	-10417	-12169	-12768	-2414	-9503	-22372	-23151	-41186	-41471	-4559	-4857	-764
38_Mng_2045_Grassy_Mmtn_FM_Steady_LNR.da	**2045**	∞	-22207	-6168	-6754	-7151	-10417	-12169	-12768	-2414	-9505	-22374	-23153	-41188	-41473	-4559	-4857	-764
72_[39]_LTC_2046_2056_Grassy_Mmtn_FM_Stea	**2046**	∞	-22207	-6167	-7634	-8029	-13250	-15003	-15600	-2414	-9632	-22790	-23596	-43883	-44192	-4558	-4857	-764
		Change in Baseflow	*-0.03%*	*-0.02%*	*-13.09%*	*-16.19%*	*-10.73%*	*-9.55%*	*-9.23%*	*-9.53%*	*-11.29%*	*-8.52%*	*-17.51%*	*-5.96%*	*-5.87%*	*0.83%*	*0.00%*	*0.03%*

Table C-2: Flow Rate, Rivers and Creeks (m^3/d) : Steady State Models - RPD, Baseline to LTC - "Linear" Recharge

year	Time (d)	*RIVER / CREEKS*															
		D1	BL03	BC07	BL02	BC03	BL01	Blairmore Creek	GC13	GC09	GC04	GC02	GC01	Gold Creek	Small Creeks	West Creek	Crowsnest River
2018	∞	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2019	∞	-0.01%	0.00%	0%	0%	-13%	-11%	-11%	0.0%	0.0%	0.0%	-10%	-1.2%	-6.2%	0.74%	0.00%	0.02%
2020	∞	-0.01%	0.00%	-10%	-9%	-19%	-17%	-16%	0.0%	0.0%	0.0%	-10%	-6.3%	-6.2%	0.70%	0.00%	0.02%
2021	∞	0.01%	0.00%	-10%	-10%	-20%	-18%	-17%	0.0%	0.0%	0.0%	-10%	-6.3%	-6.2%	-0.13%	0.00%	0.03%
2022	∞	0.01%	0.00%	-3%	-11%	-20%	-18%	-18%	0.0%	-0.2%	-0.3%	-10%	-6.4%	-6.4%	-0.13%	0.00%	0.03%
2023	∞	0.01%	0.00%	-10%	-11%	-21%	-19%	-18%	0.0%	-0.3%	-0.7%	-11%	-6.6%	-6.6%	-0.13%	0.00%	0.03%
2024	∞	0.01%	0.00%	-10%	-12%	-21%	-19%	-18%	0.0%	-0.4%	-1.6%	-12%	-7.5%	-7.4%	-0.12%	0.00%	0.03%
2025	∞	0.01%	0.00%	-23%	-24%	-29%	-26%	-25%	0.0%	-0.6%	-3.2%	-13%	-8.0%	-7.9%	-0.12%	0.00%	0.03%
2026	∞	0.01%	0.00%	-23%	-24%	-29%	-26%	-25%	0.0%	-1.6%	-4.7%	-15%	-9.1%	-9.1%	-0.12%	0.00%	0.03%
2027	∞	0.01%	0.00%	-23%	-25%	-30%	-26%	-26%	-0.1%	-0.8%	-5.0%	-15%	-9.0%	-8.9%	-0.13%	0.00%	0.03%
2028	∞	0.00%	0.00%	-23%	-25%	-30%	-27%	-26%	-0.1%	-0.9%	-5.1%	-15%	-9.0%	-8.9%	-0.13%	0.00%	0.03%
2029	∞	0.00%	0.00%	-23%	-25%	-30%	-27%	-26%	-0.2%	-1.1%	-5.2%	-15%	-9.0%	-9.0%	-0.13%	0.00%	0.03%
2030	∞	0.00%	0.00%	-23%	-25%	-30%	-27%	-26%	-0.2%	-1.2%	-5.2%	-15%	-9.0%	-9.0%	-0.12%	0.00%	0.03%
2031	∞	0.00%	0.00%	-23%	-25%	-30%	-27%	-26%	-0.1%	-1.4%	-5.3%	-15%	-9.1%	-9.0%	-0.12%	0.00%	0.03%
2032	∞	-0.01%	0.00%	-23%	-25%	-30%	-27%	-26%	-0.4%	-1.8%	-5.5%	-15%	-9.2%	-9.1%	-0.11%	0.00%	0.03%
2033	∞	-0.02%	0.00%	-23%	-25%	-30%	-27%	-26%	-0.9%	-5.4%	-7.1%	-16%	-10%	-10.0%	-0.11%	0.00%	0.03%
2034	∞	-0.03%	-0.01%	-23%	-25%	-30%	-27%	-26%	-2.7%	-6.2%	-7.4%	-17%	-10%	-10.2%	-0.10%	0.00%	0.03%
2035	∞	-0.03%	-0.01%	-23%	-25%	-30%	-27%	-26%	-5.7%	-10%	-9%	-18%	-11%	-11.1%	-0.09%	0.00%	0.03%
2036	∞	-0.03%	-0.01%	-23%	-25%	-30%	-27%	-26%	-6.9%	-12%	-10%	-19%	-11%	-11.4%	-0.08%	0.00%	0.03%
2037	∞	-0.03%	-0.01%	-23%	-25%	-30%	-27%	-26%	-7.5%	-12%	-10%	-19%	-12%	-11.5%	-0.08%	0.00%	0.03%
2038	∞	-0.03%	-0.01%	-23%	-25%	-30%	-27%	-26%	-9.1%	-12%	-10%	-19%	-12%	-11.6%	-0.08%	0.00%	0.03%
2039	∞	-0.03%	-0.01%	-23%	-25%	-30%	-27%	-26%	-9.3%	-12%	-10%	-19%	-12%	-11.6%	0.83%	0.00%	0.03%
2040	∞	-0.03%	-0.01%	-23%	-25%	-30%	-27%	-26%	-9.4%	-12%	-10%	-19%	-12%	-11.66%	0.83%	0.00%	0.03%
2041	∞	-0.04%	-0.01%	-23%	-25%	-30%	-27%	-26%	-9.6%	-13%	-10%	-19%	-12%	-11.68%	0.83%	0.00%	0.03%
2042	∞	-0.04%	-0.01%	-23%	-25%	-30%	-27%	-26%	-9.6%	-13%	-10%	-19%	-12%	-11.68%	0.83%	0.00%	0.03%
2043	∞	-0.04%	-0.01%	-23%	-25%	-30%	-27%	-26%	-9.5%	-13%	-10%	-19%	-12%	-11.68%	0.83%	0.00%	0.03%
2044	∞	-0.03%	-0.01%	-23%	-25%	-30%	-27%	-26%	-9.5%	-12%	-10%	-19%	-12%	-11.67%	0.83%	0.00%	0.03%
2045	∞	-0.03%	-0.01%	-23%	-25%	-30%	-27%	-26%	-9.5%	-12%	-10%	-19%	-12%	-11.66%	0.83%	0.00%	0.03%
2046	∞	-0.03%	-0.02%	-13%	-16%	-11%	-10%	-9%	-9.5%	-11%	-9%	-18%	-6%	-5.9%	0.83%	0.00%	0.03%

Table C-3: Flow Rate, Springs, Greenhill Portals, Saturated Zones and Ponds (m^3/d) : Steady State Baseline to LTC - "Linear" Recharge

File name	year	SPRINGS					GRNHLL PORTALS		PIT	SATURATED ZONES			PONDS (AND FLOW UPSTREAM OF PONDS)															
		Spring 1 (30 gpm)	**Spring 2 (?? gpm)**	**Spring 3 (1 gpm)**	**Spring 4 (1 gpm)**	**Spring 5 (~10 gpm)**	**Old Mine Portal 1**	**Old Mine Portal 2**	**Pit Wall**	**SZ1**	**SZ2**	**SZ3**	**PSSP**	***Blairmore Creek-To-PSSP***	**SWSP**	**RWP**	*Blairmore Creek-To-RWP*	**SESP**	*GC Creek-To-SESP*	**WSP**	*Blairmore Creek-To-WSP*	**ESP**	*GC Creek-To-ESP*	**NWSP**	*Blairmore Creek-To-NWSP*	**NESP**
01b_PrMng_2018_Grassy_Mntn_FM-GwAge_Steady-State_Calibration_rev2_LNR.dac	**2018**	-1033	#N/A	0	0	0	-494	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
12_Mng_2019_Grassy_Mmtn_FM_Steady_LNR.da	**2019**	-190	#N/A	0	0	0	-493	0	-632	na	na	na	-16	-302	10	-313	-1485	-543	-2382	na	na	na	na	na	na	na
13_Mng_2020_Grassy_Mmtn_FM_Steady_LNR.da	**2020**	0	#N/A	0	0	0	-491	0	-1223	na	na	na	-3	-185	27	-293	-1439	-543	-2298	7	-853	na	na	na	na	na
14_Mng_2021_Grassy_Mmtn_FM_Steady_LNR.da	**2021**	0	#N/A	0	0	0	-490	0	-1491	na	na	na	0	-151	35	-285	-1402	-543	-2250	7	-831	na	na	na	na	na
15_Mng_2022_Grassy_Mmtn_FM_Steady_LNR.da	**2022**	0	#N/A	0	0	0	-491	0	-1923	-60	na	na	0	-158	36	-285	-1389	-543	-2241	8	-566	na	na	na	na	na
16_Mng_2023_Grassy_Mmtn_FM_Steady_LNR.da	**2023**	0	#N/A	0	0	0	-490	0	-2004	-219	na	na	0	-153	39	-286	-1378	-543	-2236	8	-472	na	na	na	na	na
17_Mng_2024_Grassy_Mmtn_FM_Steady_LNR.da	**2024**	0	#N/A	0	0	0	-491	0	-2035	-469	na	na	0	-156	43	-287	-1369	-543	-2166	8	-446	-115	-162	na	na	na
18_Mng_2025_Grassy_Mmtn_FM_Steady_LNR.da	**2025**	0	#N/A	0	0	0	-491	0	-2444	-441	na	na	-1	-166	43	-287	-1365	-543	-2054	9	-422	-115	-162	14	-1176	na
19_Mng_2026_Grassy_Mmtn_FM_Steady_LNR.da	**2026**	0	#N/A	0	0	0	-491	0	-3211	-380	na	na	-1	-170	43	-287	-1363	-543	-1858	9	-392	-115	-163	14	-1172	na
20_Mng_2027_Grassy_Mmtn_FM_Steady_LNR.da	**2027**	0	#N/A	0	0	0	-490	0	-3468	-312	na	na	0	-159	44	-288	-1361	-542	-1808	11	-329	-115	-163	14	-1151	na
21_Mng_2028_Grassy_Mmtn_FM_Steady_LNR.da	**2028**	0	#N/A	0	0	0	-490	0	-3445	-320	na	na	0	-160	44	-288	-1360	-542	-1790	12	-276	-115	-163	14	-1129	na
22_Mng_2029_Grassy_Mmtn_FM_Steady_LNR.da	**2029**	0	#N/A	0	0	0	-490	0	-3569	-459	na	na	-1	-164	44	-288	-1360	-542	-1778	13	-231	-115	-163	14	-1109	na
23_Mng_2030_Grassy_Mmtn_FM_Steady_LNR.da	**2030**	0	#N/A	0	0	0	-491	0	-3526	-557	na	na	-2	-181	43	-288	-1361	-542	-1777	13	-201	-115	-163	14	-1102	na
24_Mng_2031_Grassy_Mmtn_FM_Steady_LNR.da	**2031**	0	#N/A	0	0	0	-491	0	-3559	-583	na	na	-3	-193	43	-288	-1361	-542	-1775	14	-165	-115	-163	14	-1089	na
25_Mng_2032_Grassy_Mmtn_FM_Steady_LNR.da	**2032**	0	#N/A	0	0	0	-491	0	-3649	-573	na	na	-5	-207	41	-291	-1362	-542	-1775	15	-126	-115	-163	14	-1043	na
26_Mng_2033_Grassy_Mmtn_FM_Steady_LNR.da	**2033**	0	#N/A	0	0	0	-492	0	-3994	-585	na	na	-6	-227	40	-291	-1363	-542	-1775	15	-86	-115	-163	14	-1002	-113
27_Mng_2034_Grassy_Mmtn_FM_Steady_LNR.da	**2034**	0	#N/A	0	0	0	-492	0	-4188	-567	na	na	-8	-247	39	-293	-1365	-542	-1775	16	-33	-115	-163	14	-940	-113
28_Mng_2035_Grassy_Mmtn_FM_Steady_LNR.da	**2035**	0	#N/A	0	0	0	-493	0	-4612	-573	na	na	-10	-270	38	-295	-1367	-542	-1774	17	-12	-115	-163	14	-913	-114
29_Mng_2036_Grassy_Mmtn_FM_Steady_LNR.da	**2036**	0	#N/A	0	0	0	-493	0	-4759	-573	na	na	-13	-293	35	-299	-1369	-542	-1774	19	0	-115	-163	14	-901	-123
30_Mng_2037_Grassy_Mmtn_FM_Steady_LNR.da	**2037**	0	#N/A	0	0	0	-493	0	-4781	-572	na	na	-13	-293	35	-299	-1369	-542	-1774	20	0	-115	-163	14	-899	-123
31_Mng_2038_Grassy_Mmtn_FM_Steady_LNR.da	**2038**	0	#N/A	0	0	0	-493	0	-4735	-584	-104	na	-13	-297	35	-297	-1369	-542	-1774	19	0	-115	-163	14	-900	-114
32_Mng_2039_Grassy_Mmtn_FM_Steady_LNR.da	**2039**	0	#N/A	0	0	0	-493	0	-4681	-584	-175	na	-13	-297	35	-298	-1368	-542	-1774	19	-1	-115	-163	14	-902	-113
33_Mng_2040_Grassy_Mmtn_FM_Steady_LNR.da	**2040**	0	#N/A	0	0	0	-493	0	-4683	-590	-174	na	-13	-329	35	-204	-1417	-542	-1775	18	-6	-115	-163	14	-906	-113
34_Mng_2041_Grassy_Mmtn_FM_Steady_LNR.da	**2041**	0	#N/A	0	0	0	-493	0	-4694	-584	-174	na	-13	-297	35	-298	-1368	-542	-1774	18	-6	-115	-163	14	-906	-113
35_Mng_2042_Grassy_Mmtn_FM_Steady_LNR.da	**2042**	0	#N/A	0	0	0	-493	0	-4694	-584	-174	na	-13	-297	35	-298	-1368	-542	-1774	18	-6	-115	-163	14	-906	-113
36_Mng_2043_Grassy_Mmtn_FM_Steady_LNR.da	**2043**	0	#N/A	0	0	0	-493	0	-4516	-584	-174	-179	-13	-297	35	-298	-1368	-542	-1774	18	-6	-115	-163	14	-906	-113
37_Mng_2044_Grassy_Mmtn_FM_Steady_LNR.da	**2044**	0	#N/A	0	0	0	-493	0	-4350	-585	-175	-340	-13	-297	35	-298	-1368	-542	-1774	18	-6	-115	-163	14	-906	-113
38_Mng_2045_Grassy_Mmtn_FM_Steady_LNR.da	**2045**	0	#N/A	0	0	0	-493	0	-4272	-585	-175	-415	-13	-297	35	-298	-1368	-542	-1774	18	-6	-115	-163	14	-906	-114
72_[39]_LTC_2046_2056_Grassy_Mmtn_FM_Steady_LNR.dac	**2046**	0	0	0	0	0	-493	0	-4172	-567	-176	-495	na	na	na	na	na	na	na	na	na	na	na	na	na	na

Table C-4: Flow Rate, Rivers and Creeks (m^3/d) : Steady State Models - Baseline to LTC - "Exponential" Recharge

File name	year	Time (d)	RIVER / CREEKS															
			D1	BL03	BC07	BL02	BC03	BL01	Blairmore Creek	GC13	GC09	GC04	GC02	GC01	Gold Creek	Small Creeks	West Creek	Crowsnest River
02b_PrMng_2018_Grassy_Mntn_FM_GwAge_Steady-State_Calibration_rev2_LNR.DAC	**2018**	∞	-34218	-9108	-12569	-13505	-18344	-19928	-20236	-2257	-9589	-20797	-22950	-33379	-33499	-3382	-4722	-762
40_Mng_2019_Grassy_Mmtn_FM_Steady_EXP.dac	**2019**	∞	-34118	-9047	-12468	-13390	-16814	-18400	-18706	-2233	-9516	-20630	-21076	-32767	-31545	-3353	-4709	-765
41_Mng_2020_Grassy_Mmtn_FM_Steady_EXP.dac	**2020**	∞	-34118	-9047	-11373	-12253	-15602	-17181	-17487	-2233	-9516	-20626	-21072	-31422	-31541	-3350	-4709	-764
42_Mng_2021_Grassy_Mmtn_FM_Steady_EXP.dac	**2021**	∞	-34118	-9047	-11377	-12175	-15489	-17066	-17372	-2234	-9515	-20623	-21069	-31418	-31538	-3347	-4709	-764
43_Mng_2022_Grassy_Mmtn_FM_Steady_EXP.dac	**2022**	∞	-34118	-9047	-12174	-12044	-15336	-16914	-17219	-2233	-9505	-20597	-21044	-31393	-31513	-3348	-4709	-764
44_Mng_2023_Grassy_Mmtn_FM_Steady_EXP.dac	**2023**	∞	-34118	-9047	-11378	-11987	-15250	-16827	-17132	-2233	-9494	-20535	-20981	-31330	-31450	-3347	-4709	-764
45_Mng_2024_Grassy_Mmtn_FM_Steady_EXP.dac	**2024**	∞	-34118	-9047	-11377	-11939	-15182	-16759	-17065	-2233	-9484	-20461	-20838	-31187	-31307	-3348	-4709	-764
46_Mng_2025_Grassy_Mmtn_FM_Steady_EXP.dac	**2025**	∞	-34118	-9047	-9762	-10302	-13543	-15121	-15427	-2233	-9472	-20224	-20671	-31020	-31140	-3348	-4709	-764
47_Mng_2026_Grassy_Mmtn_FM_Steady_EXP.dac	**2026**	∞	-34118	-9047	-9761	-10270	-13511	-15089	-15395	-2232	-9398	-19918	-20293	-30642	-30762	-3348	-4709	-764
48_Mng_2027_Grassy_Mmtn_FM_Steady_EXP.dac	**2027**	∞	-34118	-9047	-9760	-10237	-13477	-15055	-15361	-2231	-9459	-19910	-20357	-30706	-30825	-3348	-4709	-764
49_Mng_2028_Grassy_Mmtn_FM_Steady_EXP.dac	**2028**	∞	-34117	-9047	-9758	-10208	-13450	-15028	-15333	-2228	-9451	-19902	-20349	-30698	-30818	-3348	-4709	-764
50_Mng_2029_Grassy_Mmtn_FM_Steady_EXP.dac	**2029**	∞	-34117	-9047	-9757	-10176	-13421	-15000	-15305	-2226	-9438	-19890	-20337	-30686	-30805	-3348	-4709	-764
51_Mng_2030_Grassy_Mmtn_FM_Steady_EXP.dac	**2030**	∞	-34117	-9048	-9757	-10166	-13415	-14994	-15299	-2226	-9423	-19875	-20322	-30671	-30791	-3348	-4709	-764
52_Mng_2031_Grassy_Mmtn_FM_Steady_EXP.dac	**2031**	∞	-34115	-9047	-9756	-10160	-13414	-14993	-15299	-2228	-9411	-19863	-20309	-30658	-30778	-3349	-4709	-764
53_Mng_2032_Grassy_Mmtn_FM_Steady_EXP.dac	**2032**	∞	-34113	-9047	-9755	-10153	-13413	-14993	-15299	-2232	-9398	-19850	-20297	-30646	-30766	-3349	-4709	-764
54_Mng_2033_Grassy_Mmtn_FM_Steady_EXP.dac	**2033**	∞	-34111	-9047	-9754	-10149	-13414	-14996	-15302	-2222	-9165	-19610	-20057	-30406	-30526	-3350	-4709	-764
55_Mng_2034_Grassy_Mmtn_FM_Steady_EXP.dac	**2034**	∞	-34108	-9047	-9751	-10138	-13411	-14993	-15299	-2184	-9100	-19546	-19992	-30341	-30461	-3351	-4709	-764
56_Mng_2035_Grassy_Mmtn_FM_Steady_EXP.dac	**2035**	∞	-34107	-9047	-9747	-10131	-13411	-14995	-15301	-2127	-8830	-19275	-19722	-30071	-30190	-3351	-4709	-764
57_Mng_2036_Grassy_Mmtn_FM_Steady_EXP.dac	**2036**	∞	-34106	-9047	-9739	-10116	-13403	-14988	-15294	-2090	-8716	-19161	-19608	-29957	-30076	-3352	-4709	-765
58_Mng_2037_Grassy_Mmtn_FM_Steady_EXP.dac	**2037**	∞	-34105	-9047	-9737	-10112	-13400	-14985	-15291	-2064	-8686	-19131	-19577	-29926	-30046	-3352	-4709	-765
59_Mng_2038_Grassy_Mmtn_FM_Steady_EXP.dac	**2038**	∞	-34105	-9047	-9738	-10115	-13403	-14988	-15294	-2016	-8634	-19078	-19525	-29874	-29994	-3352	-4709	-765
60_Mng_2039_Grassy_Mmtn_FM_Steady_EXP.dac	**2039**	∞	-34105	-9047	-9740	-10122	-13410	-14995	-15301	-2002	-8613	-19056	-19502	-29852	-29971	-3352	-4709	-765
61_Mng_2040_Grassy_Mmtn_FM_Steady_EXP.dac	**2040**	∞	-34105	-9047	-9744	-10132	-13419	-15005	-15311	-1998	-8601	-19043	-19489	-29838	-29958	-3353	-4709	-765
62_Mng_2041_Grassy_Mmtn_FM_Steady_EXP.dac	**2041**	∞	-34105	-9047	-9744	-10132	-13419	-15004	-15310	-1993	-8585	-19026	-19472	-29822	-29941	-3352	-4709	-765
63_Mng_2042_Grassy_Mmtn_FM_Steady_EXP.dac	**2042**	∞	-34105	-9047	-9744	-10132	-13419	-15004	-15310	-1993	-8585	-19026	-19472	-29822	-29941	-3352	-4709	-765
64_Mng_2043_Grassy_Mmtn_FM_Steady_EXP.dac	**2043**	∞	-34105	-9047	-9744	-10132	-13419	-15004	-15310	-1993	-8589	-19032	-19478	-29827	-29947	-3352	-4709	-765
65_Mng_2044_Grassy_Mmtn_FM_Steady_EXP.dac	**2044**	∞	-34105	-9047	-9744	-10132	-13419	-15004	-15310	-1993	-8595	-19038	-19485	-29834	-29953	-3352	-4709	-765
66_Mng_2045_Grassy_Mmtn_FM_Steady_EXP.dac	**2045**	∞	-34105	-9047	-9744	-10132	-13419	-15004	-15310	-1993	-8598	-19041	-19488	-29837	-29957	-3352	-4709	-765
73_[67]_LTC_2046_2056_Grassy_Mmtn_FM_Steady_E	**2046**	∞	-34105	-9047	-10901	-11281	-16308	-17890	-18196	-1994	-8665	-19207	-19647	-31307	-31449	-3355	-4709	-765
Change in Baseflow			*-0.33%*	*-0.67%*	*-13.27%*	*-16.47%*	*-11.10%*	*-10.22%*	*-10.08%*	*-11.66%*	*-9.64%*	*-7.65%*	*-14.39%*	*-6.21%*	*-6.12%*	*-0.80%*	*-0.28%*	*0.29%*

Table C-5: Flow Rate, Rivers and Creeks (m^3/d) : Steady State Models - RPD, Baseline to LTC - "Exponential" Recharge

year	Time (d)	*RIVER / CREEKS*															
		D1	**BL03**	**BC07**	**BL02**	**BC03**	**BL01**	**Blairmore Creek**	**GC13**	**GC09**	**GC04**	**GC02**	**GC01**	**Gold Creek**	**Small Creeks**	**West Creek**	**Crowsnest River**
2018	∞	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2019	∞	-0.3%	-0.7%	-0.8%	-0.9%	-8.3%	-7.7%	-7.6%	-1.0%	-0.8%	-0.8%	-8.2%	-1.8%	-5.8%	-0.9%	-0.3%	0.3%
2020	∞	-0.3%	-0.7%	-9.5%	-9.3%	-14.9%	-13.8%	-13.6%	-1.0%	-0.8%	-0.8%	-8.2%	-5.9%	-5.8%	-0.9%	-0.3%	0.3%
2021	∞	-0.3%	-0.7%	-9.5%	-9.8%	-15.6%	-14.4%	-14.2%	-1.0%	-0.8%	-0.8%	-8.2%	-5.9%	-5.9%	-1.0%	-0.3%	0.3%
2022	∞	-0.3%	-0.7%	-3.1%	-10.8%	-16.4%	-15.1%	-14.9%	-1.1%	-0.9%	-1.0%	-8.3%	-6.0%	-5.9%	-1.0%	-0.3%	0.3%
2023	∞	-0.3%	-0.7%	-9.5%	-11.2%	-16.9%	-15.6%	-15.3%	-1.1%	-1.0%	-1.3%	-8.6%	-6.1%	-6.1%	-1.0%	-0.3%	0.3%
2024	∞	-0.3%	-0.7%	-9.5%	-11.6%	-17.2%	-15.9%	-15.7%	-1.1%	-1.1%	-1.6%	-9.2%	-6.6%	-6.5%	-1.0%	-0.3%	0.3%
2025	∞	-0.3%	-0.7%	-22.3%	-23.7%	-26.2%	-24.1%	-23.8%	-1.1%	-1.2%	-2.8%	-9.9%	-7.1%	-7.0%	-1.0%	-0.3%	0.3%
2026	∞	-0.3%	-0.7%	-22.3%	-24.0%	-26.3%	-24.3%	-23.9%	-1.1%	-2.0%	-4.2%	-11.6%	-8.2%	-8.2%	-1.0%	-0.3%	0.3%
2027	∞	-0.3%	-0.7%	-22.4%	-24.2%	-26.5%	-24.5%	-24.1%	-1.2%	-1.4%	-4.3%	-11.3%	-8.0%	-8.0%	-1.0%	-0.3%	0.3%
2028	∞	-0.3%	-0.7%	-22.4%	-24.4%	-26.7%	-24.6%	-24.2%	-1.3%	-1.4%	-4.3%	-11.3%	-8.0%	-8.0%	-1.0%	-0.3%	0.3%
2029	∞	-0.3%	-0.7%	-22.4%	-24.6%	-26.8%	-24.7%	-24.4%	-1.3%	-1.6%	-4.4%	-11.4%	-8.1%	-8.0%	-1.0%	-0.3%	0.3%
2030	∞	-0.3%	-0.7%	-22.4%	-24.7%	-26.9%	-24.8%	-24.4%	-1.4%	-1.7%	-4.4%	-11.5%	-8.1%	-8.1%	-1.0%	-0.3%	0.3%
2031	∞	-0.3%	-0.7%	-22.4%	-24.8%	-26.9%	-24.8%	-24.4%	-1.3%	-1.9%	-4.5%	-11.5%	-8.2%	-8.1%	-1.0%	-0.3%	0.3%
2032	∞	-0.3%	-0.7%	-22.4%	-24.8%	-26.9%	-24.8%	-24.4%	-1.1%	-2.0%	-4.6%	-11.6%	-8.2%	-8.2%	-1.0%	-0.3%	0.3%
2033	∞	-0.3%	-0.7%	-22.4%	-24.9%	-26.9%	-24.7%	-24.4%	-1.5%	-4.4%	-5.7%	-12.6%	-8.9%	-8.9%	-0.9%	-0.3%	0.3%
2034	∞	-0.3%	-0.7%	-22.4%	-24.9%	-26.9%	-24.8%	-24.4%	-3.2%	-5.1%	-6.0%	-12.9%	-9.1%	-9.1%	-0.9%	-0.3%	0.3%
2035	∞	-0.3%	-0.7%	-22.4%	-25.0%	-26.9%	-24.8%	-24.4%	-5.8%	-7.9%	-7.3%	-14.1%	-9.9%	-9.9%	-0.9%	-0.3%	0.3%
2036	∞	-0.3%	-0.7%	-22.5%	-25.1%	-26.9%	-24.8%	-24.4%	-7.4%	-9.1%	-7.9%	-14.6%	-10.3%	-10.2%	-0.9%	-0.3%	0.3%
2037	∞	-0.3%	-0.7%	-22.5%	-25.1%	-27.0%	-24.8%	-24.4%	-8.5%	-9.4%	-8.0%	-14.7%	-10.3%	-10.3%	-0.9%	-0.3%	0.3%
2038	∞	-0.3%	-0.7%	-22.5%	-25.1%	-26.9%	-24.8%	-24.4%	-10.7%	-10.0%	-8.3%	-14.9%	-10.5%	-10.5%	-0.9%	-0.3%	0.3%
2039	∞	-0.3%	-0.7%	-22.5%	-25.0%	-26.9%	-24.8%	-24.4%	-11.3%	-10.2%	-8.4%	-15.0%	-10.6%	-10.5%	-0.9%	-0.3%	0.3%
2040	∞	-0.3%	-0.7%	-22.5%	-25.0%	-26.8%	-24.7%	-24.3%	-11.4%	-10.3%	-8.4%	-15.1%	-10.6%	-10.6%	-0.9%	-0.3%	0.3%
2041	∞	-0.3%	-0.7%	-22.5%	-25.0%	-26.8%	-24.7%	-24.3%	-11.7%	-10.5%	-8.5%	-15.2%	-10.7%	-10.6%	-0.9%	-0.3%	0.3%
2042	∞	-0.3%	-0.7%	-22.5%	-25.0%	-26.8%	-24.7%	-24.3%	-11.7%	-10.5%	-8.5%	-15.2%	-10.7%	-10.6%	-0.9%	-0.3%	0.3%
2043	∞	-0.3%	-0.7%	-22.5%	-25.0%	-26.8%	-24.7%	-24.3%	-11.7%	-10.4%	-8.5%	-15.1%	-10.6%	-10.6%	-0.9%	-0.3%	0.3%
2044	∞	-0.3%	-0.7%	-22.5%	-25.0%	-26.8%	-24.7%	-24.3%	-11.7%	-10.4%	-8.5%	-15.1%	-10.6%	-10.6%	-0.9%	-0.3%	0.3%
2045	∞	-0.3%	-0.7%	-22.5%	-25.0%	-26.8%	-24.7%	-24.3%	-11.7%	-10.3%	-8.4%	-15.1%	-10.6%	-10.6%	-0.9%	-0.3%	0.3%
2046	∞	-0.3%	-0.7%	-13.3%	-16.5%	-11.1%	-10.2%	-10.1%	-11.7%	-9.6%	-7.6%	-14.4%	-6.2%	-6.1%	-0.8%	-0.3%	0.3%

Table C-6: Flow Rate, Springs, Greenhill Portals, Mine Pit, Saturated Zones and Ponds (m^3/d) : Steady State Models - Baseline to LTC - "Exponential" Recharge

File name	year	Time (d)	SPRINGS					GRNHLL PORTALS		PIT	SATURATED ZONES			PONDS (AND FLOW UPSTREAM OF PONDS)													
			Spring 1 (30 gpm)	**Spring 2 (?? gpm)**	**Spring 3 (1 gpm)**	**Spring 4 (1 gpm)**	**Spring 5 (~10 gpm)**	**Old Mine Portal 1**	**Old Mine Portal 2**	**Pit Wall**	**SZ1**	**SZ2**	**SZ3**	**PSSP**	***Blairmore Creek-To-PSSP***	**SWSP**	**RWP**	*Blairmore Creek-To-RWP*	**SESP**	*GC Creek-To-SESP*	**WSP**	*Blairmore Creek-To-WSP*	**ESP**	*GC Creek-To-ESP*	**NWSP**	*Blairmore Creek-To-NWSP*	**NESP**
02b_PrMng_2018_Grassy_Mntn_FM_GwAge_Steady-State_Calibration_rev2_LNR.DAC	**2018**	∞	-1379	#N/A	0	0	0	-598	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
40_Mng_2019_Grassy_Mmtn_FM_Steady_EXP.dac	**2019**	∞	-219	#N/A	0	0	0	-596	0	-678	na	na	na	7	-284	43	-349	-1377	-340	-1341	na	na	na	na	na	na	na
41_Mng_2020_Grassy_Mmtn_FM_Steady_EXP.dac	**2020**	∞	0	#N/A	0	0	0	-590	0	-1404	na	na	na	27	-89	65	-322	-1326	-340	-1290	36	-1122	na	na	na	na	na
42_Mng_2021_Grassy_Mmtn_FM_Steady_EXP.dac	**2021**	∞	0	#N/A	0	0	0	-587	0	-1736	na	na	na	32	-32	75	-308	-1273	-340	-1240	37	-1110	na	na	na	na	na
43_Mng_2022_Grassy_Mmtn_FM_Steady_EXP.dac	**2022**	∞	0	#N/A	0	0	0	-587	0	-2221	-85	na	na	32	-50	77	-307	-1260	-340	-1238	38	-784	na	na	na	na	na
44_Mng_2023_Grassy_Mmtn_FM_Steady_EXP.dac	**2023**	∞	0	#N/A	0	0	0	-587	0	-2254	-310	na	na	32	-35	81	-310	-1249	-340	-1237	38	-643	na	na	na	na	na
45_Mng_2024_Grassy_Mmtn_FM_Steady_EXP.dac	**2024**	∞	0	#N/A	0	0	0	-587	0	-2152	-622	na	na	32	-39	87	-310	-1238	-340	-1211	39	-600	-33	-60	na	na	na
46_Mng_2025_Grassy_Mmtn_FM_Steady_EXP.dac	**2025**	∞	0	#N/A	0	0	0	-588	0	-2449	-579	na	na	30	-54	88	-311	-1233	-340	-1175	40	-559	-33	-60	37	-1652	na
47_Mng_2026_Grassy_Mmtn_FM_Steady_EXP.dac	**2026**	∞	0	#N/A	0	0	0	-588	0	-3023	-508	na	na	30	-60	88	-311	-1231	-339	-1055	41	-516	-33	-61	37	-1647	na
48_Mng_2027_Grassy_Mmtn_FM_Steady_EXP.dac	**2027**	∞	0	#N/A	0	0	0	-588	0	-3318	-425	na	na	31	-52	89	-312	-1229	-339	-1019	44	-426	-33	-61	37	-1617	na
49_Mng_2028_Grassy_Mmtn_FM_Steady_EXP.dac	**2028**	∞	0	#N/A	0	0	0	-588	0	-3386	-420	na	na	30	-54	89	-312	-1227	-339	-1007	46	-352	-33	-61	37	-1570	na
50_Mng_2029_Grassy_Mmtn_FM_Steady_EXP.dac	**2029**	∞	0	#N/A	0	0	0	-588	0	-3443	-589	na	na	30	-63	88	-313	-1227	-339	-996	48	-282	-33	-61	37	-1550	na
51_Mng_2030_Grassy_Mmtn_FM_Steady_EXP.dac	**2030**	∞	0	#N/A	0	0	0	-589	0	-3437	-693	na	na	28	-95	87	-312	-1227	-339	-993	49	-236	-33	-61	37	-1557	na
52_Mng_2031_Grassy_Mmtn_FM_Steady_EXP.dac	**2031**	∞	0	#N/A	0	0	0	-590	0	-3469	-720	na	na	26	-114	86	-313	-1228	-339	-990	49	-185	-33	-61	37	-1517	na
53_Mng_2032_Grassy_Mmtn_FM_Steady_EXP.dac	**2032**	∞	0	#N/A	0	0	0	-591	0	-3550	-677	na	na	23	-130	84	-316	-1229	-339	-990	51	-132	-33	-61	37	-1469	na
54_Mng_2033_Grassy_Mmtn_FM_Steady_EXP.dac	**2033**	∞	0	#N/A	0	0	0	-592	0	-3838	-683	na	na	20	-170	82	-317	-1230	-339	-989	52	-77	-33	-61	37	-1405	-72
55_Mng_2034_Grassy_Mmtn_FM_Steady_EXP.dac	**2034**	∞	0	#N/A	0	0	0	-593	0	-4082	-641	na	na	17	-200	80	-320	-1232	-339	-989	57	-14	-33	-61	37	-1305	-72
56_Mng_2035_Grassy_Mmtn_FM_Steady_EXP.dac	**2035**	∞	0	#N/A	0	0	0	-594	0	-4359	-638	na	na	14	-238	78	-323	-1235	-339	-989	62	0	-33	-61	38	-1264	-72
57_Mng_2036_Grassy_Mmtn_FM_Steady_EXP.dac	**2036**	∞	0	#N/A	0	0	0	-596	0	-4460	-599	na	na	10	-270	74	-330	-1237	-339	-989	74	0	-33	-61	38	-1248	-69
58_Mng_2037_Grassy_Mmtn_FM_Steady_EXP.dac	**2037**	∞	0	#N/A	0	0	0	-596	0	-4491	-599	na	na	10	-270	74	-330	-1237	-339	-989	77	0	-33	-61	38	-1245	-68
59_Mng_2038_Grassy_Mmtn_FM_Steady_EXP.dac	**2038**	∞	0	#N/A	0	0	0	-596	0	-4408	-625	-145	na	10	-279	74	-328	-1237	-339	-989	75	0	-33	-61	38	-1246	-68
60_Mng_2039_Grassy_Mmtn_FM_Steady_EXP.dac	**2039**	∞	0	#N/A	0	0	0	-596	0	-4328	-626	-235	na	10	-279	74	-328	-1237	-339	-989	71	0	-33	-61	38	-1250	-68
61_Mng_2040_Grassy_Mmtn_FM_Steady_EXP.dac	**2040**	∞	0	#N/A	0	0	0	-596	0	-4345	-636	-222	na	10	-330	74	-180	-1312	-339	-989	66	0	-33	-61	38	-1255	-68
62_Mng_2041_Grassy_Mmtn_FM_Steady_EXP.dac	**2041**	∞	0	#N/A	0	0	0	-596	0	-4355	-627	-222	na	10	-279	74	-328	-1237	-339	-988	66	0	-33	-61	38	-1255	-67
63_Mng_2042_Grassy_Mmtn_FM_Steady_EXP.dac	**2042**	∞	0	#N/A	0	0	0	-596	0	-4355	-627	-222	na	10	-279	74	-328	-1237	-339	-988	66	0	-33	-61	38	-1255	-67
64_Mng_2043_Grassy_Mmtn_FM_Steady_EXP.dac	**2043**	∞	0	#N/A	0	0	0	-596	0	-4131	-627	-222	-216	10	-279	74	-328	-1237	-339	-989	66	0	-33	-61	38	-1255	-67
65_Mng_2044_Grassy_Mmtn_FM_Steady_EXP.dac	**2044**	∞	0	#N/A	0	0	0	-596	0	-3942	-627	-223	-397	10	-279	74	-328	-1237	-339	-989	66	0	-33	-61	38	-1255	-68
66_Mng_2045_Grassy_Mmtn_FM_Steady_EXP.dac	**2045**	∞	0	#N/A	0	0	0	-596	0	-3852	-627	-224	-482	10	-279	74	-328	-1237	-339	-989	66	0	-33	-61	38	-1255	-68
73_[67]_LTC_2046_2056_Grassy_Mmtn_FM_Steady_E	**2046**	∞	0	#N/A	0	0	0	-595	0	-3761	-606	-224	-561	na	na	na	na	na	na	na	na	na	na	na	na	na	na

Table C-7: Base Flow Reduction, Baseflow to LTC, Transient Model, "Exponential" Recharge

Time Step (d)	Total Time (d)	Adjusted Time (d)	Month	D1	BL03	BC07	BL02	BC03	BL01	Blairmore Creek	GC13	GC09	GC04	GC02	GC01	Gold Creek
				15	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	*27*
				RPD	RPD	RPD	RPD	RPD	RPD	RPD	RPD	RPD	RPD	RPD	RPD	RPD
0	0	746.00	January	-0.49%	-0.61%	-14.2%	-17.8%	-10.3%	-8.2%	-8.1%	-14.4%	-8.3%	-5.9%	-11.8%	-4.6%	-4.6%
31	31	775.50	February	-0.49%	-0.59%	-14.1%	-17.7%	-10.2%	-8.0%	-7.9%	-14.3%	-8.0%	-5.7%	-11.4%	-4.5%	-4.4%
28	59	805.00	March	-0.45%	-0.59%	-13.9%	-17.5%	-10.4%	-8.3%	-8.2%	-14.2%	-8.5%	-6.2%	-12.3%	-4.8%	-4.8%
31	90	835.50	April	-0.42%	-0.58%	-13.9%	-17.0%	-11.6%	-9.7%	-9.5%	-13.2%	-10.5%	-8.3%	-15.5%	-6.4%	-6.3%
30	120	866.00	May	-0.70%	-0.90%	-14.1%	-17.0%	-12.3%	-10.6%	-10.4%	-12.5%	-12.7%	-10.4%	-18.5%	-8.4%	-8.2%
31	151	896.50	June	-0.51%	-0.64%	-13.8%	-16.9%	-11.6%	-9.8%	-9.7%	-12.8%	-11.7%	-9.4%	-16.9%	-7.4%	-7.3%
30	181	927.00	July	-0.50%	-0.61%	-13.9%	-17.0%	-11.3%	-9.5%	-9.4%	-13.3%	-10.9%	-8.5%	-15.6%	-6.7%	-6.6%
31	212	958.00	August	-0.48%	-0.52%	-13.9%	-17.2%	-11.1%	-9.2%	-9.1%	-13.6%	-10.2%	-7.8%	-14.6%	-6.1%	-6.1%
31	243	988.50	September	-0.45%	-0.51%	-13.9%	-17.3%	-11.0%	-9.1%	-8.9%	-13.9%	-9.7%	-7.4%	-13.9%	-5.8%	-5.7%
30	273	1019.00	October	-0.46%	-0.55%	-14.0%	-17.4%	-10.8%	-8.9%	-8.8%	-14.1%	-9.3%	-6.9%	-13.2%	-5.5%	-5.4%
31	304	1049.50	November	-0.45%	-0.54%	-13.9%	-17.5%	-10.6%	-8.6%	-8.5%	-14.2%	-8.9%	-6.5%	-12.6%	-5.1%	-5.1%
30	334	1064.50	December	-0.46%	-0.57%	-13.9%	-17.4%	-10.4%	-8.5%	-8.36%	-14.19%	-8.72%	-6.39%	-12.27%	-5.03%	-5.00%

	D1	BL03	BC07	BL02	BC03	BL01	Blairmore Creek	GC13	GC09	GC04	GC02	GC01	Gold Creek
Average Transient Change	-0.49%	-0.60%	-14.0%	-17.3%	-11.0%	-9.0%	-8.9%	-13.7%	-9.8%	-7.5%	-14.0%	-5.9%	-5.8%
Steady State Change	-0.33%	-0.67%	-13.3%	-16.5%	-11.1%	-10.2%	-10.1%	-11.7%	-9.6%	-7.6%	-14.4%	-6.2%	-6.1%

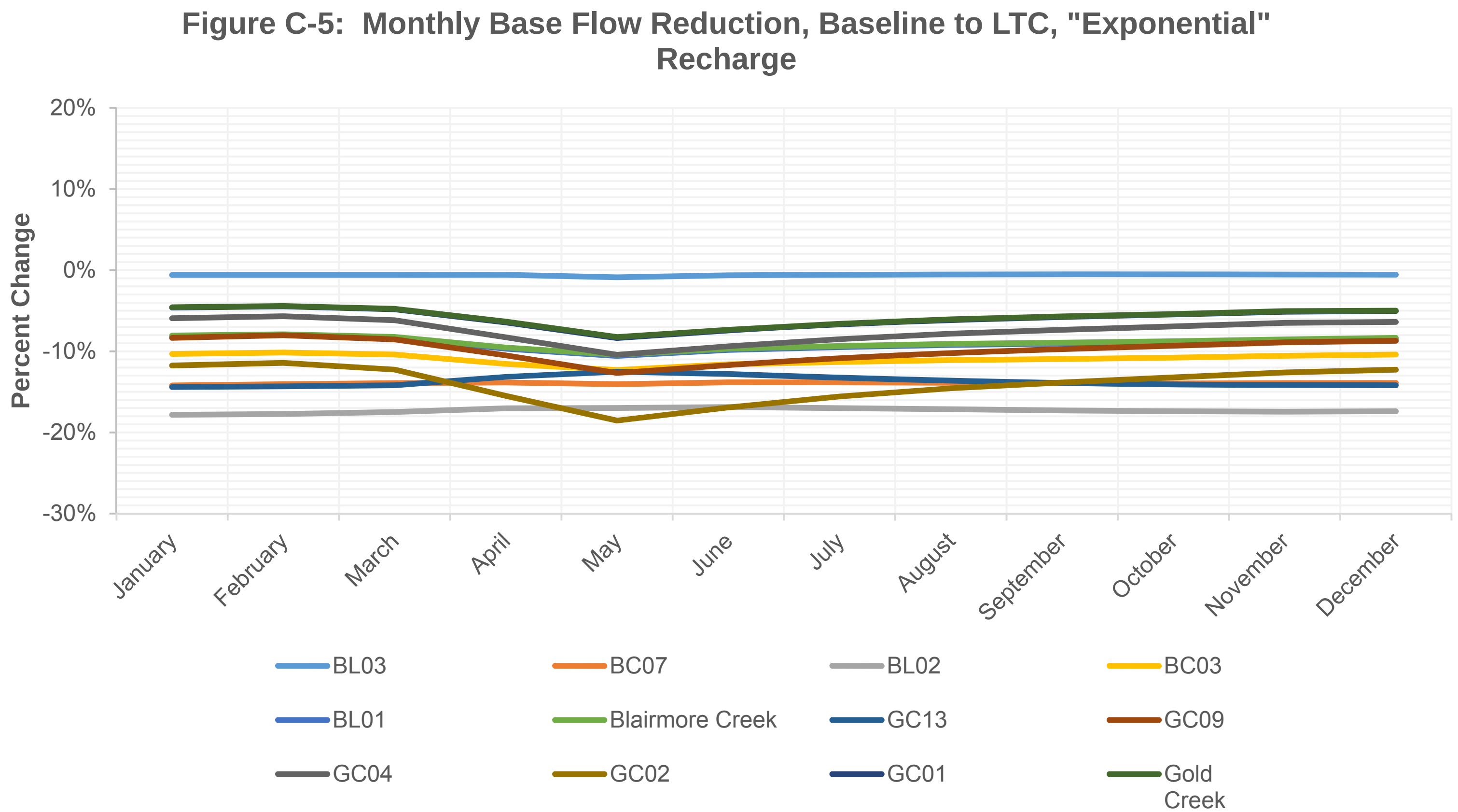
Figure C-5: Monthly Base Flow Reduction, Baseline to LTC, "Exponential" Recharge
Percent Change
20%
10%
0%
-10%
-20%
-30%
January
February
March
April
May
June
July
August
September
October
November
December
BL03
BC07
BL02
BC03
BL01
Blairmore Creek
GC13
GC09
GC04
GC02
GC01
Gold Creek

Table C-8: Flow contribution from sources (m3/d): Steady State Model - Linear Recharge - EOM

70-[34]_EOM_2041_Grassy_Mmtn_FM_Steady_LNR.dac

	Baseflow	Background	SZ1	SZ2	North Dump	South Dump	Central Dump	PSSP	RWP	SWSP	WSP	NWSP	SESP	ESP	NESP
BL03	*6167.500*	6143.082	0.000	0.000	24.417	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
BC07	*6753.810*	6672.388	0.000	9.586	63.499	0.000	0.000	0.000	0.000	0.000	6.622	1.715	0.000	0.000	0.000
BL02	*7150.660*	7058.249	7.889	11.081	64.274	0.000	0.001	0.000	0.000	0.000	7.434	1.732	0.000	0.000	0.000
BC03	*10416.500*	10300.149	28.150	11.281	64.911	0.035	0.006	2.698	0.002	0.000	7.525	1.744	0.000	0.000	0.000
BL01	*12168.900*	12052.509	28.155	11.282	64.916	0.054	0.006	2.708	0.002	0.000	7.525	1.744	0.000	0.000	0.000
Blairmore Creek (BC01)	*12767.441*	12651.050	28.155	11.282	64.916	0.054	0.006	2.708	0.002	0.000	7.525	1.744	0.000	0.000	0.000
D1	*22206.827*	22206.469	0.000	0.000	0.359	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GC13	*2413.250*	2413.250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GC09	*9495.860*	9482.635	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	13.225
GC04	*22363.600*	22345.326	0.000	0.000	0.000	0.004	0.179	0.000	0.000	0.000	0.000	0.000	0.104	4.683	13.303
GC02	*23142.400*	23103.511	0.002	0.000	0.000	1.899	0.248	0.000	0.009	0.000	0.000	0.000	18.743	4.684	13.303
GC01	*41177.499*	41138.357	0.002	0.000	0.000	2.142	0.249	0.000	0.010	0.000	0.000	0.000	18.751	4.684	13.303
Gold Creek	*41462.199*	41423.057	0.002	0.000	0.000	2.142	0.249	0.000	0.010	0.000	0.000	0.000	18.751	4.684	13.303

Total of backround + all sources must sum up to 100% of the total flow reported at the nodes respective to surface water stations
Flow rates will be converted to % for inut to water balance and load model and final reporting
Background (m3/d) = Predicted baseflow - Sum of all the sources

Table C-9: Flow contribution from sources (% of base flow): Steady State Model - Linear Recharge - EOM

	Background	SZ1	SZ2	North Dump	South Dump	Central Dump	PSSP	RWP	SWSP	WSP	NWSP	SESP	ESP	NESP
BL03	99.60%	0.00%	0.00%	0.40%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
BC07	98.79%	0.00%	0.14%	0.94%	0.00%	0.00%	0.00%	0.00%	0.00%	0.10%	0.03%	0.00%	0.00%	0.00%
BL02	98.71%	0.11%	0.15%	0.90%	0.00%	0.00%	0.00%	0.00%	0.00%	0.10%	0.02%	0.00%	0.00%	0.00%
BC03	98.88%	0.27%	0.11%	0.62%	0.00%	0.00%	0.03%	0.00%	0.00%	0.07%	0.02%	0.00%	0.00%	0.00%
BL01	99.04%	0.23%	0.09%	0.53%	0.00%	0.00%	0.02%	0.00%	0.00%	0.06%	0.01%	0.00%	0.00%	0.00%
Blairmore Creek (BC01)	99.09%	0.22%	0.09%	0.51%	0.00%	0.00%	0.02%	0.00%	0.00%	0.06%	0.01%	0.00%	0.00%	0.00%
D1	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC13	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC09	99.86%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.14%
GC04	99.92%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%	0.06%
GC02	99.83%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.08%	0.02%	0.06%
GC01	99.90%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.05%	0.01%	0.03%
Gold Creek	99.91%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.05%	0.01%	0.03%

Table C-10: Flow contribution from sources (m3/d): Steady State Model - "Linear" Recharge - LTC

72-[39]_LTC_2046_2056_Grassy_Mmtn_FM_Steady_LNR.dac

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	*6167.340*	6143.040	0.000	0.000	0.001	24.299	0.000	0.000
BC07	*7634.220*	6918.281	0.000	16.259	0.026	699.654	0.000	0.000
BL02	*8029.340*	7304.090	7.520	17.623	0.101	700.006	0.000	0.001
BC03	*13223.584*	11573.004	50.700	17.805	0.214	700.291	707.896	173.676
BL01	*14975.784*	13325.189	50.705	17.805	0.214	700.293	707.903	173.676
Blairmore Creek (BC01)	*15572.426*	13922.716	49.830	17.805	0.214	700.293	707.897	173.670
D1	*22207.127*	22206.769	0.000	0.000	0.000	0.359	0.000	0.000
GC13	*2413.740*	2413.720	0.000	0.000	0.020	0.000	0.000	0.000
GC09	*9632.130*	9631.989	0.000	0.000	0.140	0.000	0.000	0.000
GC04	*22789.700*	22788.803	0.000	0.000	0.705	0.000	0.010	0.182
GC02	*23595.600*	23592.254	0.003	0.000	0.713	0.000	2.268	0.361
GC01	*43883.199*	43211.297	0.033	0.001	0.882	0.000	49.244	621.742
Gold Creek	*44191.599*	43506.838	0.034	0.001	0.884	0.000	49.244	634.598

Total of backround + all sources must sum up to 100% of the total flow reported at the nodes respective to surface water stations
Flow rates will be converted to % for inut to water balance and load model and final reporting
Background (m3/d) = Predicted baseflow - Sum of all the sources

Table C-11: Flow contribution from sources (% of base flow): Steady State Model - "Linear" Recharge - LTC

	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	99.61%	0.00%	0.00%	0.00%	0.39%	0.00%	0.00%
BC07	90.62%	0.00%	0.21%	0.00%	9.16%	0.00%	0.00%
BL02	90.97%	0.09%	0.22%	0.00%	8.72%	0.00%	0.00%
BC03	87.52%	0.38%	0.13%	0.00%	5.30%	5.35%	1.31%
BL01	88.98%	0.34%	0.12%	0.00%	4.68%	4.73%	1.16%
Blairmore Creek (BC01)	89.41%	0.32%	0.11%	0.00%	4.50%	4.55%	1.12%
D1	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC13	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC09	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC04	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC02	99.99%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
GC01	98.47%	0.00%	0.00%	0.00%	0.00%	0.11%	1.42%
Gold Creek	98.45%	0.00%	0.00%	0.00%	0.00%	0.11%	1.44%

Table C-12: Flow contribution from sources (m3/d): Steady State Model - Exponential Recharge - LTC

71-[62]_EOM_2041_Grassy_Mmtn_FM_Steady_EXP.dac

	Baseflow	Background	SZ1	SZ2	North Dump	South Dump	Central Dump	PSSP	RWP	SWSP	WSP	NWSP	SESP	ESP	NESP
BL03	*9046.880*	9013.477	0.000	0.000	33.403	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BC07	*9744.210*	9625.899	0.000	17.560	94.250	0.000	0.000	0.000	0.000	0.000	5.825	0.676	0.000	0.000	0.000
BL02	*10132.000*	10000.313	8.557	20.330	95.555	0.000	0.000	0.000	0.000	0.000	6.554	0.691	0.000	0.000	0.000
BC03	*13419.067*	13259.254	33.065	20.791	96.754	0.098	0.006	1.746	0.004	0.000	6.650	0.700	0.000	0.000	0.000
BL01	*15004.267*	14844.281	33.099	20.808	96.802	0.157	0.006	1.757	0.004	0.000	6.652	0.700	0.000	0.000	0.000
Blairmore Creek (BC01)	*15310.094*	15150.106	33.099	20.808	96.802	0.158	0.006	1.757	0.004	0.000	6.652	0.700	0.000	0.000	0.000
D1	*34104.802*	34104.159	0.000	0.000	0.643	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GC13	*1992.760*	1992.760	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GC09	*8584.620*	8567.259	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	17.361
GC04	*19025.933*	18998.830	0.000	0.000	0.000	0.006	0.001	0.000	0.000	0.000	0.000	0.000	0.114	8.567	18.414
GC02	*19472.448*	19421.785	0.007	0.000	0.000	4.336	0.091	0.000	0.035	0.000	0.000	0.000	19.202	8.579	18.414
GC01	*29821.571*	29770.713	0.007	0.000	0.000	4.519	0.092	0.000	0.037	0.000	0.000	0.000	19.211	8.579	18.414
Gold Creek	*29941.171*	29890.313	0.007	0.000	0.000	4.519	0.092	0.000	0.037	0.000	0.000	0.000	19.211	8.579	18.414

Total of backround + all sources must sum up to 100% of the total flow reported at the nodes respective to surface water stations
Flow rates will be converted to % for inut to water balance and load model and final reporting
Background (m3/d) = Predicted baseflow - Sum of all the sources

Table C-13: Flow contribution from sources (% of base flow): Steady State Model - Exponential Recharge - LTC

	Background	SZ1	SZ2	North Dump	South Dump	Central Dump	PSSP	RWP	SWSP	WSP	NWSP	SESP	ESP	NESP
BL03	99.63%	0.00%	0.00%	0.37%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
BC07	98.79%	0.00%	0.18%	0.97%	0.00%	0.00%	0.00%	0.00%	0.00%	0.06%	0.01%	0.00%	0.00%	0.00%
BL02	98.70%	0.08%	0.20%	0.94%	0.00%	0.00%	0.00%	0.00%	0.00%	0.06%	0.01%	0.00%	0.00%	0.00%
BC03	98.81%	0.25%	0.15%	0.72%	0.00%	0.00%	0.01%	0.00%	0.00%	0.05%	0.01%	0.00%	0.00%	0.00%
BL01	98.93%	0.22%	0.14%	0.65%	0.00%	0.00%	0.01%	0.00%	0.00%	0.04%	0.00%	0.00%	0.00%	0.00%
Blairmore Creek (BC01)	98.96%	0.22%	0.14%	0.63%	0.00%	0.00%	0.01%	0.00%	0.00%	0.04%	0.00%	0.00%	0.00%	0.00%
D1	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC13	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC09	99.80%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.20%
GC04	99.86%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.05%	0.10%
GC02	99.74%	0.00%	0.00%	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.10%	0.04%	0.09%
GC01	99.83%	0.00%	0.00%	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.06%	0.03%	0.06%
Gold Creek	99.83%	0.00%	0.00%	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.06%	0.03%	0.06%

Table C-14: Flow contribution from sources (m3/d): Steady State Model - "Exponential" Recharge - LTC

73-[67]_LTC_2046_2056_Grassy_Mmtn_FM_Steady_EXP.dac

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	*9046.660*	9013.528	0.000	0.000	0.001	33.131	0.000	0.000
BC07	*10900.900*	9855.069	0.000	23.074	0.042	1022.715	0.000	0.000
BL02	*11280.700*	10224.251	7.559	25.339	0.201	1023.349	0.000	0.000
BC03	*16307.882*	14360.212	53.570	25.721	0.501	1023.905	690.696	153.275
BL01	*17890.282*	15942.522	53.597	25.736	0.511	1023.926	690.714	153.275
Blairmore Creek (BC01)	*18196.109*	16248.465	53.481	25.737	0.511	1023.926	690.714	153.275
D1	*34105.303*	34104.658	0.000	0.000	0.001	0.643	0.000	0.000
GC13	*1993.590*	1993.538	0.000	0.000	0.052	0.000	0.000	0.000
GC09	*8664.730*	8664.294	0.000	0.000	0.436	0.000	0.000	0.000
GC04	*19206.733*	19205.752	0.000	0.000	0.974	0.000	0.006	0.001
GC02	*19646.948*	19641.039	0.009	0.000	0.993	0.000	4.707	0.198
GC01	*31307.271*	30802.935	0.121	0.003	1.433	0.001	11.495	491.284
Gold Creek	*31448.971*	30931.993	0.122	0.003	1.440	0.001	11.495	503.918

Total of backround + all sources must sum up to 100% of the total flow reported at the nodes respective to surface water stations
Flow rates will be converted to % for inut to water balance and load model and final reporting
Background (m3/d) = Predicted baseflow - Sum of all the sources

Table C-15: Flow contribution from sources (% of base flow): Steady State Model - "Exponential" Recharge - LTC

	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	99.63%	0.00%	0.00%	0.00%	0.37%	0.00%	0.00%
BC07	90.41%	0.00%	0.21%	0.00%	9.38%	0.00%	0.00%
BL02	90.63%	0.07%	0.22%	0.00%	9.07%	0.00%	0.00%
BC03	88.06%	0.33%	0.16%	0.00%	6.28%	4.24%	0.94%
BL01	89.11%	0.30%	0.14%	0.00%	5.72%	3.86%	0.86%
Blairmore Creek (BC01)	89.30%	0.29%	0.14%	0.00%	5.63%	3.80%	0.84%
D1	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC13	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC09	99.99%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
GC04	99.99%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
GC02	99.97%	0.00%	0.00%	0.01%	0.00%	0.02%	0.00%
GC01	98.39%	0.00%	0.00%	0.00%	0.00%	0.04%	1.57%
Gold Creek	98.36%	0.00%	0.00%	0.00%	0.00%	0.04%	1.60%

Table C-16: Flow rate, Rivers and Creeks (m3/d) : Steady State Models - "Linear" Recharge - Sensitivities

File name	year	Time (d)	RIVER / CREEKS															
			D1	BL03	BC07	BL02	BC03	BL01	Blairmore Creek	GC13	GC09	GC04	GC02	GC01	Gold Creek	Small Creeks	West Creek	Crowsnest River
Sensitivity: K/R ratio increased by 50%																		
05_[01b]_PrMng_2018_Grassy_FM_Steady_Linear_SVY_KRx1.5.dac	***2018***	∞	-33322	-9252	-13176	-14371	-22264	-24881	-25779	-4002	-16286	-37368	-42905	-69994	-70421	-6782	-7286	-1146
76_[72]_LTC_2046_Grassy_FM_Steady_LNR_SVY_KRx1.5.dac	***2046***	∞	-33308	-9251	-11452	-12044	-19842	-22474	-23369	-3620	-14448	-34184	-35393	-65818	-66280	-6788	-7286	-1146
Sensitivity: K/R ratio reduced by 50%																		
06_[01b]_PrMng_2018_Grassy_FM_Steady_linear_SVY_KRx0.66.dac	***2018***	∞	-14810	-4112	-5856	-6387	-9895	-11058	-11457	-1779	-7238	-16608	-19069	-31109	-31298	-3014	-3238	-509
77_[72]_LTC_2046_Grassy_FM_Steady_LNR_SVY_KRx0.66.dac	***2046***	∞	-14803	-4112	-5090	-5353	-8819	-9988	-10386	-1609	-6421	-15193	-15730	-29252	-29458	-3017	-3238	-509
Sensitivity: Isotropic layer K distribution																		
07_[01b]_PrMng_2018_Grassy_FM_Steady_linear_SVY_Kiso.dac	***2018***	∞	-22240	-5874	-8245	-9149	-13703	-15780	-16411	-2627	-11217	-25627	-29143	-48721	-48985	-3797	-4663	-699
78_[72]_LTC_2046_Grassy_FM_Steady_LNR_SVY_Kiso.dac	***2046***	∞	-22236	-5874	-7372	-7781	-12275	-14351	-14978	-2430	-9852	-23148	-24094	-45537	-45824	-3799	-4664	-699
Sensitivity: No influence from bedding / K decrs. With depth																		
08_[01b]_PrMng_2018_Grassy_FM_Steady_linear_SVY_NoBedding.dac	***2018***	∞	-22719	-5970	-8429	-9117	-14101	-16168	-16867	-2686	-10386	-24999	-28738	-47948	-48240	-4145	-4505	-473
79_[72]_LTC_2046_Grassy_FM_Steady_LNR_SVY_noBedding.dac	***2046***	∞	-22705	-5970	-7519	-7901	-12682	-14747	-15442	-2440	-8861	-22193	-22968	-44107	-44414	-4145	-4505	-473
Sensitivity: Kx = Ky (no influence from thrust faults)																		
09_[01b]_PrMng_2018_Grassy_FM_Steady_linear_SVY_KxKySame.dac	***2018***	∞	-22215	-6168	-8784	-9580	-14843	-16587	-17186	-2668	-10858	-24912	-28603	-46663	-46948	-4521	-4857	-764
80_[72]_LTC_2046_Grassy_FM_Steady_LNR_SVY_KxKySame.dac	***2046***	∞	-22340	-6104	-7610	-7988	-13110	-15027	-15660	-2509	-9548	-22732	-23497	-44009	-44320	-4324	-4763	-598
Sensitivity: Faults with low K (Kxyz /2.5)																		
10_[01b]_PrMng_2018_Grassy_FM_Steady_linear_SVY_FltLow.dac	***2018***	∞	-22203	-6176	-8782	-9576	-14889	-16648	-17245	-2675	-10856	-24967	-28671	-46701	-46986	-4511	-4860	-773
81_[72]_LTC_2046_Grassy_FM_Steady_LNR_SVY_FltLow.dac	***2046***	∞	-22196	-6175	-7642	-8037	-13222	-14967	-15562	-2424	-9628	-22809	-23615	-43931	-44238	-4510	-4860	-773
Sensitivity: Faults with high K (Kxyz x2.5)																		
11_[01b]_PrMng_2018_Grassy_FM_Steady_linear_SVY_FltHigh.dac	***2018***	∞	-22230	-6153	-8771	-9566	-14732	-16484	-17087	-2661	-10856	-24900	-28574	-46598	-46881	-4541	-4852	-753
82_[72]_LTC_2046_Grassy_FM_Steady_LNR_SVY_FltHigh.dac	***2046***	∞	-22219	-6153	-7617	-8012	-13234	-14973	-15575	-2400	-9630	-22782	-23587	-43849	-44158	-4555	-4852	-753
Sensitivity: K increased by 50%																		
85_[01b]_PrMng_2018_Grassy_FM_Steady_linear_SVY_Kx1.5.dac	***2018***	∞	-22348	-6140	-8775	-9595	-14641	-16242	-16794	-2583	-10829	-24700	-28473	-46382	-46666	-4644	-4895	-938
89_[72]_LTC_2046_Grassy_FM_Steady_LNR_Kx1.5.dac	***2046***	∞	-22338	-6138	-7602	-8013	-13185	-14811	-15361	-2316	-9658	-22703	-23560	-43798	-44109	-4601	-4895	-938
Sensitivity: K reduced by 50%																		
86_results_Baseline_Grassy_linear_steady_SVY_Kx0.66.dac	***2018***	∞	-22288	-6179	-8767	-9520	-14906	-16837	-17465	-2725	-10843	-25031	-28717	-46899	-47190	-4440	-4799	-644
90_[72]_LTC_2046_Grassy_FM_Steady_LNR_Kx0.66.dac	***2046***	∞	-22300	-6178	-7663	-8041	-13239	-15166	-15794	-2478	-9590	-22800	-23570	-43923	-44234	-4441	-4799	-644
Sensitivity: R increased by 50%																		
87_results_Baseline_Grassy_linear_steady_SVY_Rx1.5.dac	***2018***	∞	-33527	-9272	-13115	-14179	-22381	-25457	-26432	-4118	-16222	-37660	-43199	-70608	-71054	-6561	-7138	-838
91_[72]_LTC_2046_Grassy_FM_Steady_LNR_Rx1.5.dac	***2046***	∞	-33449	-9267	-11495	-12062	-19859	-22749	-23690	-3717	-14385	-34199	-35355	-65884	-66352	-6662	-7199	-966
Sensitivity: R reduced by 50%																		
88_results_Baseline_Grassy_linear_steady_SVY_Rx0.66.dac	***2018***	∞	-14899	-4093	-5850	-6397	-9761	-10828	-11196	-1722	-7219	-16466	-18982	-30921	-31111	-3096	-3263	-625
92_[72]_LTC_2046_Grassy_FM_Steady_LNR_Rx0.66.dac	***2046***	∞	-14892	-4092	-5068	-5342	-8790	-9874	-10241	-1544	-6439	-15135	-15707	-29199	-29406	-3067	-3263	-625
Sensitivity: R Dump increased by 50%																		
01b_PrMng_2018_Grassy_Mntn_FM_GwAge_Steady_State_Calibration_rev2_LNR.dac	***2018***	∞	-22215	-6168	-8784	-9580	-14843	-16587	-17186	-2668	-10858	-24912	-28603	-46663	-46948	-4521	-4857	-764
83_[72]_LTC_2046_2056_Grassy_FM_Steady_LNR_SVY_Rdumpx1.5.dac	***2046***	∞	-22233	-6194	-8056	-8462	-14089	-15844	-16440	-2417	-9635	-22792	-23600	-44470	-44787	-4525	-4857	-764
Sensitivity: R Dump reduced by 50%																		
01b_PrMng_2018_Grassy_Mntn_FM_GwAge_Steady_State_Calibration_rev2_LNR.dac	***2018***	∞	-22215	-6168	-8784	-9580	-14843	-16587	-17186	-2668	-10858	-24912	-28603	-46663	-46948	-4521	-4857	-764
84_[72]_LTC_2046_Grassy_FM_Steady_LNR_SVY_Rdumpx0.66.dac	***2046***	∞	-22188	-6149	-7355	-7742	-12659	-14412	-15009	-2411	-9630	-22787	-23592	-43479	-43782	-4525	-4857	-764

Table C-17: Relative difference (%) : LTC/ Sensitivity Runs

File name	RIVER / CREEKS															
	D1	BL03	BC07	BL02	BC03	BL01	Blairmore Creek	GC13	GC09	GC04	GC02	GC01	Gold Creek	Small Creeks	West Creek	Crowsnest River
Base Case LTC Steady State	0%	0%	-13%	-16%	-11%	-10%	-9%	-10%	-11%	-9%	-18%	-6%	-6%	1%	0%	0%
Sensitivity: K/R ratio increased by 50%	0%	0%	-13%	-16%	-11%	-10%	-9%	-10%	-11%	-9%	-18%	-6%	-6%	0%	0%	0%
Sensitivity: K/R ratio reduced by 50%	0%	0%	-13%	-16%	-11%	-10%	-9%	-10%	-11%	-9%	-18%	-6%	-6%	0%	0%	0%
Sensitivity: Isotropic layer K distribution	0%	0%	-11%	-15%	-10%	-9%	-9%	-8%	-12%	-10%	-17%	-7%	-6%	0%	0%	0%
Sensitivity: No influence from bedding / K decrs. With depth	0%	0%	-11%	-13%	-10%	-9%	-8%	-9%	-15%	-11%	-20%	-8%	-8%	0%	0%	0%
Sensitivity: Kx = Ky (no influence from thrust faults)	1%	-1%	-13%	-17%	-12%	-9%	-9%	-6%	-12%	-9%	-18%	-6%	-6%	-4%	-2%	-22%
Sensitivity: Faults with low K (Kxyz /2.5)	0%	0%	-13%	-16%	-11%	-10%	-10%	-9%	-11%	-9%	-18%	-6%	-6%	0%	0%	0%
Sensitivity: Faults with high K (Kxyz x2.5)	0%	0%	-13%	-16%	-10%	-9%	-9%	-10%	-11%	-9%	-17%	-6%	-6%	0%	0%	0%
Sensitivity: K increased by 50%	0%	0%	-13%	-16%	-10%	-9%	-9%	-10%	-11%	-8%	-17%	-6%	-5%	-1%	0%	0%
Sensitivity: K reduced by 50%	0%	0%	-13%	-16%	-11%	-10%	-10%	-9%	-12%	-9%	-18%	-6%	-6%	0%	0%	0%
Sensitivity: R increased by 50%	0%	0%	-12%	-15%	-11%	-11%	-10%	-10%	-11%	-9%	-18%	-7%	-7%	2%	1%	15%
Sensitivity: R reduced by 50%	0%	0%	-13%	-16%	-10%	-9%	-9%	-10%	-11%	-8%	-17%	-6%	-5%	-1%	0%	0%
Sensitivity: R Dump increased by 50%	0%	0%	-8%	-12%	-5%	-4%	-4%	-9%	-11%	-9%	-17%	-5%	-5%	0%	0%	0%
Sensitivity: R Dump reduced by 50%	0%	0%	-16%	-19%	-15%	-13%	-13%	-10%	-11%	-9%	-18%	-7%	-7%	0%	0%	0%

Table C-18: Relative difference (%) : LTC/Baseline Sensitivity Runs

File name	RIVER / CREEKS															
	D1	BL03	BC07	BL02	BC03	BL01	Blairmore Creek	GC13	GC09	GC04	GC02	GC01	Gold Creek	Small Creeks	West Creek	Crowsnest River
Sensitivity: K/R ratio increased by 50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%	0%
Sensitivity: K/R ratio reduced by 50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%	0%
Sensitivity: Isotropic layer K distribution	0%	0%	2%	1%	0%	0%	0%	2%	-1%	-1%	0%	-1%	-1%	-1%	0%	0%
Sensitivity: No influence from bedding / K decrs. With depth	0%	0%	2%	3%	1%	1%	1%	0%	-3%	-3%	-3%	-2%	-2%	-1%	0%	0%
Sensitivity: Kx = Ky (no influence from thrust faults)	1%	-1%	0%	0%	-1%	0%	0%	4%	-1%	0%	0%	0%	0%	-5%	-2%	-22%
Sensitivity: Faults with low K (Kxyz /2.5)	0%	0%	0%	0%	0%	-1%	-1%	0%	0%	0%	0%	0%	0%	-1%	0%	0%
Sensitivity: Faults with high K (Kxyz x2.5)	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%	0%
Sensitivity: K increased by 50%	0%	0%	0%	0%	1%	1%	1%	-1%	0%	0%	0%	0%	0%	-2%	0%	0%
Sensitivity: K reduced by 50%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%	0%
Sensitivity: R increased by 50%	0%	0%	1%	1%	-1%	-1%	-1%	0%	0%	-1%	-1%	-1%	-1%	1%	1%	15%
Sensitivity: R reduced by 50%	0%	0%	0%	0%	1%	1%	1%	-1%	0%	0%	0%	0%	0%	-2%	0%	0%
Sensitivity: R Dump increased by 50%	0%	0%	5%	5%	6%	5%	5%	0%	0%	0%	0%	1%	1%	-1%	0%	0%
Sensitivity: R Dump reduced by 50%	0%	0%	-3%	-3%	-4%	-4%	-3%	0%	0%	0%	0%	-1%	-1%	-1%	0%	0%

Table C-19: Relative difference (%) : Baseline condition sensitivity models to the baseline condition base case model

File name	RIVER / CREEKS															
	D1	BL03	BC07	BL02	BC03	BL01	Blairmore Creek	GC13	GC09	GC04	GC02	GC01	Gold Creek	Small Creeks	West Creek	Crowsnest River
Sensitivity: K/R ratio increased by 50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Sensitivity: K/R ratio reduced by 50%	-33%	-33%	-33%	-33%	-33%	-33%	-33%	-33%	-33%	-33%	-33%	-33%	-33%	-33%	-33%	-33%
Sensitivity: Isotropic layer K distribution	0%	-5%	-6%	-5%	-8%	-5%	-5%	-2%	3%	3%	2%	4%	4%	-16%	-4%	-9%
Sensitivity: No influence from bedding / K decrs. With depth	2%	-3%	-4%	-5%	-5%	-3%	-2%	1%	-4%	0%	0%	3%	3%	-8%	-7%	-38%
Sensitivity: Kx = Ky (no influence from thrust faults)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sensitivity: Faults with low K (Kxyz /2.5)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
Sensitivity: Faults with high K (Kxyz x2.5)	0%	0%	0%	0%	-1%	-1%	-1%	0%	0%	0%	0%	0%	0%	0%	0%	-1%
Sensitivity: K increased by 50%	1%	0%	0%	0%	-1%	-2%	-2%	-3%	0%	-1%	0%	-1%	-1%	3%	1%	23%
Sensitivity: K reduced by 50%	0%	0%	0%	-1%	0%	2%	2%	2%	0%	0%	0%	1%	1%	-2%	-1%	-16%
Sensitivity: R increased by 50%	51%	50%	49%	48%	51%	53%	54%	54%	49%	51%	51%	51%	51%	45%	47%	10%
Sensitivity: R reduced by 50%	-33%	-34%	-33%	-33%	-34%	-35%	-35%	-35%	-34%	-34%	-34%	-34%	-34%	-32%	-33%	-18%
Sensitivity: R Dump increased by 50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sensitivity: R Dump reduced by 50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Table C-20: Relative difference (%) : Long-term closure sensitivity models to the long-term closure base case model

File name	RIVER / CREEKS															
	D1	BL03	BC07	BL02	BC03	BL01	Blairmore Creek	GC13	GC09	GC04	GC02	GC01	Gold Creek	Small Creeks	West Creek	Crowsnest River
Sensitivity: K/R ratio increased by 50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	49%	50%	50%
Sensitivity: K/R ratio reduced by 50%	-33%	-33%	-33%	-33%	-33%	-33%	-33%	-33%	-33%	-33%	-33%	-33%	-33%	-34%	-33%	-33%
Sensitivity: Isotropic layer K distribution	0%	-5%	-3%	-3%	-7%	-4%	-4%	1%	2%	2%	2%	4%	4%	-17%	-4%	-9%
Sensitivity: No influence from bedding / K decrs. With depth	2%	-3%	-2%	-2%	-4%	-2%	-1%	1%	-8%	-3%	-3%	1%	1%	-9%	-7%	-38%
Sensitivity: Kx = Ky (no influence from thrust faults)	1%	-1%	0%	-1%	-1%	0%	0%	4%	-1%	0%	0%	0%	0%	-5%	-2%	-22%
Sensitivity: Faults with low K (Kxyz /2.5)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%	1%
Sensitivity: Faults with high K (Kxyz x2.5)	0%	0%	0%	0%	0%	0%	0%	-1%	0%	0%	0%	0%	0%	0%	0%	-1%
Sensitivity: K increased by 50%	1%	0%	0%	0%	0%	-1%	-2%	-4%	0%	0%	0%	0%	0%	1%	1%	23%
Sensitivity: K reduced by 50%	0%	0%	0%	0%	0%	1%	1%	3%	0%	0%	0%	0%	0%	-3%	-1%	-16%
Sensitivity: R increased by 50%	51%	50%	51%	50%	50%	52%	52%	54%	49%	50%	50%	50%	50%	46%	48%	26%
Sensitivity: R reduced by 50%	-33%	-34%	-34%	-33%	-34%	-34%	-34%	-36%	-33%	-34%	-33%	-33%	-33%	-33%	-33%	-18%
Sensitivity: R Dump increased by 50%	0%	0%	6%	5%	6%	6%	5%	0%	0%	0%	0%	1%	1%	-1%	0%	0%
Sensitivity: R Dump reduced by 50%	0%	0%	-4%	-4%	-4%	-4%	-4%	0%	0%	0%	0%	-1%	-1%	-1%	0%	0%

Table C-21: Flow rate, Springs, Greenhill Mine Portals, Pit, Saturated Zones and Ponds (m3/d) : Steady State Models - "Linear" Recharge Sensitivities

File name	year	Time (d)	SPRINGS					GRNHLL PORTALS		PIT	SATURATED ZONES			PONDS (AND FLOW UPSTREAM OF PONDS)													
			Spring 1 (30 gpm)	Spring 2 (?? gpm)	Spring 3 (1 gpm)	Spring 4 (1 gpm)	Spring 5 (~10 gpm)	Old Mine Portal 1	Old Mine Portal 2	Pit Wall	SZ1	SZ2	SZ3	PSSP	Blairmore Creek-To-PSSP	SWSP	RWP	Blairmore Creek-To-RWP	SESP	GC Creek-To-SESP	WSP	Blairmore Creek-To-WSP	ESP	GC Creek-To-ESP	NWSP	Blairmore Creek-To-NWSP	NESP
Sensitivity: K/R ratio increased by 50%																											
05_[01b]_PrMng_2018_Grassy_FM_Steady_Linear_SVY_KRx1.5.dac	2018	∞	-1550	#N/A	0	0	0	-741	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
76_[72]_LTC_2046_Grassy_FM_Steady_LNR_SVY_KRx1.5.dac	2046	∞	0	#N/A	0	0	0	-739	0	-6284	-867	-263	-742	-34	-421	0	-422	-2116	-691	-2723	-15	-14	-52	-273	-28	-1347	-64
Sensitivity: K/R ratio reduced by 50%																											
06_[01b]_PrMng_2018_Grassy_FM_Steady_linear_SVY_KRx0.66.dac	2018	∞	-689	#N/A	0	0	0	-329	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
77_[72]_LTC_2046_Grassy_FM_Steady_LNR_SVY_KRx0.66.dac	2046	∞	0	#N/A	0	0	0	-329	0	-2793	-385	-117	-330	-15	-187	0	-188	-940	-307	-1210	-7	-6	-23	-122	-12	-599	-28
Sensitivity: Isotropic layer K distribution																											
07_[01b]_PrMng_2018_Grassy_FM_Steady_linear_SVY_Kiso.dac	2018	∞	-840	#N/A	0	0	0	-437	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
78_[72]_LTC_2046_Grassy_FM_Steady_LNR_SVY_Kiso.dac	2046	∞	0	#N/A	0	0	0	-437	0	-4027	-661	-229	-628	-15	-283	0	-240	-946	-304	-1582	-18	-12	-33	-201	-27	-835	-55
Sensitivity: No influence from bedding / K decrs. With depth																											
08_[01b]_PrMng_2018_Grassy_FM_Steady_linear_SVY_NoBedding.dac	2018	∞	-668	#N/A	-3	0	-13	-441	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
79_[72]_LTC_2046_Grassy_FM_Steady_LNR_SVY_noBedding.dac	2046	∞	0	#N/A	-1	0	0	-441	0	-4911	-484	-102	-429	-13	-219	-1	-154	-1284	-258	-1686	-25	-56	-31	-168	-22	-914	-36
Sensitivity: Kx = Ky (no influence from thrust faults)																											
09_[01b]_PrMng_2018_Grassy_FM_Steady_linear_SVY_KxKySame.dac	2018	∞	-1033	#N/A	0	0	0	-494	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
80_[72]_LTC_2046_Grassy_FM_Steady_LNR_SVY_KxKySame.dac	2046	∞	0	#N/A	0	0	0	-523	0	-4343	-495	-162	-464	-18	-265	-2	-214	-1394	-387	-1739	-19	-30	-33	-194	-22	-950	-35
Sensitivity: Faults with low K (Kxyz /2.5)																											
10_[01b]_PrMng_2018_Grassy_FM_Steady_linear_SVY_FltLow.dac	2018	∞	-968	#N/A	0	0	0	-494	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
81_[72]_LTC_2046_Grassy_FM_Steady_LNR_SVY_FltLow.dac	2046	∞	0	#N/A	0	0	0	-493	0	-4163	-573	-171	-494	-22	-273	0	-283	-1401	-461	-1824	-10	-9	-35	-182	-18	-898	-42
Sensitivity: Faults with high K (Kxyz x2.5)																											
11_[01b]_PrMng_2018_Grassy_FM_Steady_linear_SVY_FltHigh.dac	2018	∞	-1193	#N/A	0	0	0	-494	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
82_[72]_LTC_2046_Grassy_FM_Steady_LNR_SVY_FltHigh.dac	2046	∞	0	#N/A	0	0	0	-493	0	-4183	-590	-182	-496	-22	-297	0	-280	-1424	-460	-1803	-10	-9	-35	-182	-18	-895	-42
Sensitivity: K increased by 50%																											
85_[01b]_PrMng_2018_Grassy_FM_Steady_linear_SVY_Kx1.5.dac	2018	∞	-1341	#N/A	0	0	0	-624	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
89_[72]_LTC_2046_Grassy_FM_Steady_LNR_Kx1.5.dac	2046	∞	0	#N/A	0	0	0	-622	0	-4027	-655	-184	-527	-20	-273	0	-344	-1359	-515	-1855	-4	0	-37	-171	-19	-853	-45
Sensitivity: K reduced by 50%																											
86_results_Baseline_Grassy_linear_steady_SVY_Kx0.66.dac	2018	∞	-812	#N/A	-2	0	-1	-394	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
90_[72]_LTC_2046_Grassy_FM_Steady_LNR_Kx0.66.dac	2046	∞	0	#N/A	0	0	0	-393	0	-4316	-513	-165	-470	-22	-288	-2	-238	-1422	-423	-1779	-16	-23	-33	-189	-18	-935	-39
Sensitivity: R increased by 50%																											
87_results_Baseline_Grassy_linear_steady_SVY_Rx1.5.dac	2018	∞	-954	#N/A	-6	-8	-11	-475	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
91_[72]_LTC_2046_Grassy_FM_Steady_LNR_Rx1.5.dac	2046	∞	0	#N/A	0	0	0	-590	0	-6475	-769	-247	-706	-33	-432	-2	-356	-2133	-635	-2669	-24	-35	-50	-283	-27	-1402	-59
Sensitivity: R reduced by 50%																											
88_results_Baseline_Grassy_linear_steady_SVY_Rx0.66.dac	2018	∞	-894	#N/A	0	0	0	-416	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
92_[72]_LTC_2046_Grassy_FM_Steady_LNR_Rx0.66.dac	2046	∞	0	#N/A	0	0	0	-415	0	-2685	-436	-123	-351	-13	-182	0	-230	-906	na	na	na	na	na	na	na	na	na
Sensitivity: R Dump increased by 50%																											
01b_PrMng_2018_Grassy_Mntn_FM_GwAge_Steady_State_Calibration_rev2_LNR.dac	2018	∞	-1033	#N/A	0	0	0	-494	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
83_[72]_LTC_2046_2056_Grassy_FM_Steady_LNR_SVY_Rdumpx1.5.dac	2046	∞	0	#N/A	0	0	0	-493	0	-5584	-724	-241	-609	-23	-282	0	-294	-1822	-473	-2392	-11	-11	-35	-182	-20	-1283	-42
Sensitivity: R Dump reduced by 50%																											
01b_PrMng_2018_Grassy_Mntn_FM_GwAge_Steady_State_Calibration_rev2_LNR.dac	2018	∞	-1033	#N/A	0	0	0	-494	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
84_[72]_LTC_2046_Grassy_FM_Steady_LNR_SVY_Rdumpx0.66.dac	2046	∞	0	#N/A	0	0	0	-493	0	-3252	-474	-130	-417	-22	-280	0	-273	-1140	-453	-1423	-9	-7	-35	-182	-18	-644	-42

Table C-22: Flow rate, Rivers and Creeks (m3/d) : Steady State Models - "Exponential" Recharge - Sensitivities

File name	year	Time (d)	*RIVER / CREEKS*															
			D1	BL03	BC07	BL02	BC03	BL01	Blairmore Creek	GC13	GC09	GC04	GC02	GC01	Gold Creek	Small Creeks	West Creek	Crowsnest River
Sensitivity: K/R ratio increased by 50%																		
b05_[02b]_PrMng_2018_Grassy_FM_Steady-Exp_SVY_KRx1.5.dac	***2018***	∞	-51327	-13662	-18854	-20257	-27516	-29892	-30353	-3385	-14384	-31196	-34424	-50069	-50249	-5073	-7083	-1143
b76-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_KRx1.5.dac	***2046***	∞	-51158	-13569	-16352	-16922	-24409	-26774	-27232	-2990	-12996	-28810	-29469	-46981	-47193	-5089	-7063	-1144
Sensitivity: K/R ratio reduced by 50%																		
b06_[02b]_PrMng_2018_Grassy_FM_Steady-Exp_SVY_KRx0.66.dac	***2018***	∞	-22726	-5966	-8229	-8870	-12052	-13091	-13291	-1487	-6392	-13786	-15212	-22222	-22302	-2212	-3136	-519
b77-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_KRx0.66.dac	***2046***	∞	-22737	-6030	-7268	-7521	-10849	-11900	-12103	-1329	-5776	-12804	-13097	-20880	-20975	-2262	-3139	-509
Sensitivity: Isotropic layer K distribution																		
b07_[02b]_PrMng_2018_Grassy_FM_Steady-Exp_SVY_Kiso.dac	***2018***	∞	-34270	-8635	-11723	-12762	-16698	-18584	-18997	-2183	-10002	-21647	-23546	-35676	-35748	-2453	-4504	-617
b78-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_Kiso.dac	***2046***	∞	-34263	-8635	-10524	-10915	-15019	-16904	-17315	-2024	-8966	-19710	-20227	-33283	-33371	-2453	-4504	-617
Sensitivity: No influence from bedding / K decrs. With depth																		
b08_[02b]_PrMng_2018_Grassy_FM_Steady-Exp_SVY_noBedding.dac	***2018***	∞	-34782	-8761	-11876	-12618	-17091	-18921	-19336	-2353	-8890	-21088	-23333	-35212	-35279	-2874	-4409	-360
b79-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_noBedding.dac	***2046***	∞	-34768	-8760	-10704	-11085	-15459	-17289	-17702	-2133	-7666	-18818	-19196	-32016	-32095	-2874	-4408	-360
Sensitivity: Kx = Ky (no influence from thrust faults)																		
b09_[02b]_PrMng_2018_Grassy_FM_Steady-Exp_SVY_KxKySame.dac	***2018***	∞	-34204	-8962	-12290	-13191	-18050	-19735	-20094	-2357	-9499	-20899	-23012	-33819	-33908	-3155	-4666	-504
b80-[73]_LTC_2046_Grassy_FM_Steady_EXP_KxKySame.dac	***2046***	∞	-34198	-8960	-10869	-11231	-16168	-17850	-18206	-2153	-8535	-19191	-19569	-31528	-31636	-3151	-4666	-504
Sensitivity: Faults with low K (Kxyz /2.5)																		
b10_[02b]_PrMng_2018_Grassy_FM_Steady-Exp_SVY_FltLow.dac	***2018***	∞	-34095	-9058	-12471	-13400	-18322	-19891	-20196	-2229	-9505	-20625	-22787	-33163	-33282	-3340	-4712	-767
b81-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_FltLow.dac	***2046***	∞	-34106	-9046	-10901	-11281	-16273	-17849	-18154	-1994	-8664	-19206	-19646	-31321	-31462	-3393	-4708	-763
Sensitivity: Faults with high K (Kxyz x2.5)																		
b11_[02b]_PrMng_2018_Grassy_FM_Steady-Exp_SVY_FltHigh.dac	***2018***	∞	-34140	-9022	-12443	-13362	-17966	-19537	-19845	-2222	-9511	-20611	-22729	-33115	-33235	-3369	-4700	-754
b82-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY__FltHigh.dac	***2046***	∞	-34125	-9021	-10878	-11258	-16289	-17878	-18186	-1973	-8657	-19193	-19633	-31308	-31450	-3351	-4701	-755
Sensitivity: K increased by 50%																		
b85_[02b]_PrMng_2018_Grassy_FM_Steady-Exp_SVY_Kx1.5.dac	***2018***	∞	-34252	-8988	-12428	-13390	-17792	-19280	-19545	-2089	-9547	-20386	-22646	-32959	-33108	-3375	-4681	-1024
b89-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_Kx1.5.dac	***2046***	∞	-34225	-8987	-10883	-11282	-16184	-17669	-17933	-1838	-8768	-19134	-19644	-31398	-31559	-3373	-4681	-1025
Sensitivity: K reduced by 50%																		
b86_[02b]_PrMng_2018_Grassy_FM_Steady-Exp_SVY_Kx0.66.dac	***2018***	∞	-34204	-8990	-12363	-13270	-18322	-20005	-20353	-2314	-9523	-20784	-22908	-33538	-33638	-3271	-4692	-586
b90-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_Kx0.66.dac	***2046***	∞	-34171	-9071	-10955	-11319	-16381	-18059	-18410	-2093	-8572	-19210	-19599	-31350	-31470	-3291	-4685	-573
Sensitivity: R increased by 50%																		
b87_[02b]_PrMng_2018_Grassy_FM_Steady-Exp_SVY_Rx1.5.dac	***2018***	∞	-51459	-13605	-18768	-19979	-27590	-30078	-30604	-3478	-14246	-31327	-34518	-50313	-50463	-4936	-7028	-860
b91-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_Rx1.5.dac	***2046***	∞	-51256	-13607	-16432	-16978	-24572	-27089	-27614	-3140	-12857	-28814	-29399	-47025	-47205	-4936	-7028	-860
Sensitivity: R reduced by 50%																		
b88_[02b]_PrMng_2018_Grassy_FM_Steady-Exp_SVY_Rx0.66.dac	***2018***	∞	-22833	-5992	-8286	-8927	-11861	-12854	-13030	-1393	-6365	-13591	-15096	-21972	-22072	-2250	-3120	-683
b92-[73]_LTC_2046_Grassy_FM_Steady_EXP_Rx0.66.dac	***2046***	∞	-22817	-5991	-7255	-7521	-10789	-11779	-11955	-1225	-5845	-12756	-13096	-20932	-21039	-2249	-3120	-683
Sensitivity: R Dump increased by 50%																		
02b_PrMng_2018_Grassy_Mntn_FM_GwAge_Steady-State_Calibration_rev2_LNR	***2018***	∞	-34218	-9108	-12569	-13505	-18344	-19928	-20236	-2257	-9589	-20797	-22950	-33379	-33499	-3382	-4722	-762
b83-[73]_LTC_2046_Grassy_FM_Steady_EX_Rdumpx1.5.dac	***2046***	∞	-34149	-9081	-11491	-11885	-17256	-18838	-19143	-1999	-8670	-19211	-19653	-31642	-31792	-3391	-4708	-763
Sensitivity: R Dump reduced by 50%																		
02b_PrMng_2018_Grassy_Mntn_FM_GwAge_Steady-State_Calibration_rev2_LNR	***2018***	∞	-34218	-9108	-12569	-13505	-18344	-19928	-20236	-2257	-9589	-20797	-22950	-33379	-33499	-3382	-4722	-762
b84-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_Rdumpx0.66.dac	***2046***	∞	-34079	-9021	-10532	-10901	-15641	-17223	-17528	-1989	-8660	-19203	-19640	-31119	-31247	-3381	-4708	-763

Table C-23: Relative difference (%) : LTC/ Sensitivity Runs

File name	year	Time (d)	RIVER / CREEKS															
			D1	BL03	BC07	BL02	BC03	BL01	Blairmore Creek	GC13	GC09	GC04	GC02	GC01	Gold Creek	Small Creeks	West Creek	Crowsnest River
Base Case LTC Steady State	-	-	0%	-1%	-13%	-16%	-11%	-10%	-10%	-12%	-10%	-8%	-14%	-6%	-6%	-1%	0%	0%
Sensitivity: K/R ratio increased by 50%	-	-	0%	-1%	-13%	-16%	-11%	-10%	-10%	-12%	-10%	-8%	-14%	-6%	-6%	0%	0%	0%
Sensitivity: K/R ratio reduced by 50%	-	-	0%	1%	-12%	-15%	-10%	-9%	-9%	-11%	-10%	-7%	-14%	-6%	-6%	2%	0%	-2%
Sensitivity: Isotropic layer K distribution	-	-	0%	0%	-10%	-14%	-10%	-9%	-9%	-7%	-10%	-9%	-14%	-7%	-7%	0%	0%	0%
Sensitivity: No influence from bedding / K decrs. With depth	-	-	0%	0%	-10%	-12%	-10%	-9%	-8%	-9%	-14%	-11%	-18%	-9%	-9%	0%	0%	0%
Sensitivity: Kx = Ky (no influence from thrust faults)	-	-	0%	0%	-12%	-15%	-10%	-10%	-9%	-9%	-10%	-8%	-15%	-7%	-7%	0%	0%	0%
Sensitivity: Faults with low K (Kxyz /2.5)	-	-	0%	0%	-13%	-16%	-11%	-10%	-10%	-11%	-9%	-7%	-14%	-6%	-5%	2%	0%	-1%
Sensitivity: Faults with high K (Kxyz x2.5)	-	-	0%	0%	-13%	-16%	-9%	-8%	-8%	-11%	-9%	-7%	-14%	-5%	-5%	-1%	0%	0%
Sensitivity: K increased by 50%	-	-	0%	0%	-12%	-16%	-9%	-8%	-8%	-12%	-8%	-6%	-13%	-5%	-5%	0%	0%	0%
Sensitivity: K reduced by 50%	-	-	0%	1%	-11%	-15%	-11%	-10%	-10%	-10%	-10%	-8%	-14%	-7%	-6%	1%	0%	-2%
Sensitivity: R increased by 50%	-	-	0%	0%	-12%	-15%	-11%	-10%	-10%	-10%	-10%	-8%	-15%	-7%	-6%	0%	0%	0%
Sensitivity: R reduced by 50%	-	-	0%	0%	-12%	-16%	-9%	-8%	-8%	-12%	-8%	-6%	-13%	-5%	-5%	0%	0%	0%
Sensitivity: R Dump increased by 50%	-	-	0%	0%	-9%	-12%	-6%	-5%	-5%	-11%	-10%	-8%	-14%	-5%	-5%	0%	0%	0%
Sensitivity: R Dump reduced by 50%	-	-	0%	-1%	-16%	-19%	-15%	-14%	-13%	-12%	-10%	-8%	-14%	-7%	-7%	0%	0%	0%

Table C-24: Relative difference (%) : LTC/Baseline Sensitivity Runs

File name	year	Time (d)	RIVER / CREEKS															
			D1	BL03	BC07	BL02	BC03	BL01	Blairmore Creek	GC13	GC09	GC04	GC02	GC01	Gold Creek	Small Creeks	West Creek	Crowsnest River
Sensitivity: K/R ratio increased by 50%	-	-	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%
Sensitivity: K/R ratio reduced by 50%	-	-	0%	2%	2%	1%	1%	1%	1%	1%	0%	1%	0%	0%	0%	3%	0%	-2%
Sensitivity: Isotropic layer K distribution	-	-	0%	1%	3%	2%	1%	1%	1%	4%	-1%	-1%	0%	-1%	-1%	1%	0%	0%
Sensitivity: No influence from bedding / K decrs. With depth	-	-	0%	1%	3%	4%	2%	2%	2%	2%	-4%	-3%	-3%	-3%	-3%	1%	0%	0%
Sensitivity: Kx = Ky (no influence from thrust faults)	-	-	0%	1%	2%	2%	1%	1%	1%	3%	-1%	-1%	-1%	-1%	-1%	1%	0%	0%
Sensitivity: Faults with low K (Kxyz /2.5)	-	-	0%	1%	1%	1%	0%	0%	0%	1%	1%	1%	1%	1%	1%	2%	0%	-1%
Sensitivity: Faults with high K (Kxyz x2.5)	-	-	0%	1%	1%	1%	2%	2%	2%	0%	1%	1%	1%	1%	1%	0%	0%	0%
Sensitivity: K increased by 50%	-	-	0%	1%	1%	1%	2%	2%	2%	0%	1%	2%	1%	1%	1%	1%	0%	0%
Sensitivity: K reduced by 50%	-	-	0%	2%	2%	2%	1%	0%	1%	2%	0%	0%	0%	0%	0%	1%	0%	-2%
Sensitivity: R increased by 50%	-	-	0%	1%	1%	1%	0%	0%	0%	2%	0%	0%	0%	0%	0%	1%	0%	0%
Sensitivity: R reduced by 50%	-	-	0%	1%	1%	1%	2%	2%	2%	0%	1%	2%	1%	1%	1%	1%	0%	0%
Sensitivity: R Dump increased by 50%	-	-	0%	0%	5%	4%	5%	5%	5%	0%	0%	0%	0%	1%	1%	1%	0%	0%
Sensitivity: R Dump reduced by 50%	-	-	0%	0%	-3%	-3%	-4%	-3%	-3%	0%	0%	0%	0%	-1%	-1%	1%	0%	0%

Table C-25: Relative difference (%) : Baseline condition sensitivity models to the baseline condition base case model

File name	year	Time (d)	RIVER / CREEKS															
			D1	BL03	BC07	BL02	BC03	BL01	Blairmore Creek	GC13	GC09	GC04	GC02	GC01	Gold Creek	Small Creeks	West Creek	Crowsnest River
Sensitivity: K/R ratio increased by 50%	-	-	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Sensitivity: K/R ratio reduced by 50%	-	-	-34%	-34%	-35%	-34%	-34%	-34%	-34%	-34%	-33%	-34%	-34%	-33%	-33%	-35%	-34%	-32%
Sensitivity: Isotropic layer K distribution	-	-	0%	-5%	-7%	-6%	-9%	-7%	-6%	-3%	4%	4%	3%	7%	7%	-27%	-5%	-19%
Sensitivity: No influence from bedding / K decrs. With depth	-	-	2%	-4%	-6%	-7%	-7%	-5%	-4%	4%	-7%	1%	2%	5%	5%	-15%	-7%	-53%
Sensitivity: Kx = Ky (no influence from thrust faults)	-	-	0%	-2%	-2%	-2%	-2%	-1%	-1%	4%	-1%	0%	0%	1%	1%	-7%	-1%	-34%
Sensitivity: Faults with low K (Kxyz /2.5)	-	-	0%	-1%	-1%	-1%	0%	0%	0%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	0%	1%
Sensitivity: Faults with high K (Kxyz x2.5)	-	-	0%	-1%	-1%	-1%	-2%	-2%	-2%	-2%	-1%	-1%	-1%	-1%	-1%	0%	0%	-1%
Sensitivity: K increased by 50%	-	-	0%	-1%	-1%	-1%	-3%	-3%	-3%	-7%	0%	-2%	-1%	-1%	-1%	0%	-1%	34%
Sensitivity: K reduced by 50%	-	-	0%	-1%	-2%	-2%	0%	0%	1%	3%	-1%	0%	0%	0%	0%	-3%	-1%	-23%
Sensitivity: R increased by 50%	-	-	50%	49%	49%	48%	50%	51%	51%	54%	49%	51%	50%	51%	51%	46%	49%	13%
Sensitivity: R reduced by 50%	-	-	-33%	-34%	-34%	-34%	-35%	-35%	-36%	-38%	-34%	-35%	-34%	-34%	-34%	-33%	-34%	-10%
Sensitivity: R Dump increased by 50%	-	-	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sensitivity: R Dump reduced by 50%	-	-	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Table C-26: Relative difference (%) : Long-term closure sensitivity models to the long-term closure base case model

File name	year	Time (d)	RIVER / CREEKS															
			D1	BL03	BC07	BL02	BC03	BL01	Blairmore Creek	GC13	GC09	GC04	GC02	GC01	Gold Creek	Small Creeks	West Creek	Crowsnest River
Sensitivity: K/R ratio increased by 50%	-	-	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	52%	50%	50%
Sensitivity: K/R ratio reduced by 50%	-	-	-33%	-33%	-33%	-33%	-33%	-33%	-33%	-33%	-33%	-33%	-33%	-33%	-33%	-33%	-33%	-33%
Sensitivity: Isotropic layer K distribution	-	-	0%	-5%	-3%	-3%	-8%	-6%	-5%	2%	3%	3%	3%	6%	6%	-27%	-4%	-19%
Sensitivity: No influence from bedding / K decrs. With depth	-	-	2%	-3%	-2%	-2%	-5%	-3%	-3%	7%	-12%	-2%	-2%	2%	2%	-14%	-6%	-53%
Sensitivity: Kx = Ky (no influence from thrust faults)	-	-	0%	-1%	0%	0%	-1%	0%	0%	8%	-1%	0%	0%	1%	1%	-6%	-1%	-34%
Sensitivity: Faults with low K (Kxyz /2.5)	-	-	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%
Sensitivity: Faults with high K (Kxyz x2.5)	-	-	0%	0%	0%	0%	0%	0%	0%	-1%	0%	0%	0%	0%	0%	0%	0%	-1%
Sensitivity: K increased by 50%	-	-	0%	-1%	0%	0%	-1%	-1%	-1%	-8%	1%	0%	0%	0%	0%	1%	-1%	34%
Sensitivity: K reduced by 50%	-	-	0%	0%	0%	0%	0%	1%	1%	5%	-1%	0%	0%	0%	0%	-2%	0%	-25%
Sensitivity: R increased by 50%	-	-	50%	50%	51%	51%	51%	51%	52%	58%	48%	50%	50%	50%	50%	47%	49%	12%
Sensitivity: R reduced by 50%	-	-	-33%	-34%	-33%	-33%	-34%	-34%	-34%	-39%	-33%	-34%	-33%	-33%	-33%	-33%	-34%	-11%
Sensitivity: R Dump increased by 50%	-	-	0%	0%	5%	5%	6%	5%	5%	0%	0%	0%	0%	1%	1%	1%	0%	0%
Sensitivity: R Dump reduced by 50%	-	-	0%	0%	-3%	-3%	-4%	-4%	-4%	0%	0%	0%	0%	-1%	-1%	1%	0%	0%

Table C-27: Flow rate (m^3/d) : Steady State Models - Exponential recharge - Sensitivities

File name	year	Time (d)	SPRINGS					GRNHLL PORTALS		PIT	SATURATED ZONES			PONDS (AND FLOW UPSTREAM OF PONDS)													
			Spring 1 (30 gpm)	Spring 2 (?? gpm)	Spring 3 (1 gpm)	Spring 4 (1 gpm)	Spring 5 (~10 gpm)	Old Mine Portal 1	Old Mine Portal 2	Pit Wall	SZ1	SZ2	SZ3	PSSP	***Blairmore Creek-To-PSSP***	SWSP	RWP	*Blairmore Creek-To-RWP*	SESP	*GC Creek-To-SESP*	WSP	*Blairmore Creek-To-WSP*	ESP	*GC Creek-To-ESP*	NWSP	*Blairmore Creek-To-NWSP*	NESP
Sensitivity: K/R ratio increased by 50%																											
b05_[02b]_PrMng_2018_Grassy_FM_Steady-Exp_SVY_KRx1.5.dac	***2018***	∞	-2068	#N/A	0	0	0	-897	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
b76-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_KRx1.5.dac	***2046***	∞	0	0	0	0	0	-892	0	-5645	-909	-336	-841	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Sensitivity: K/R ratio reduced by 50%																											
b06_[02b]_PrMng_2018_Grassy_FM_Steady-Exp_SVY_KRx0.66.dac	***2018***	∞	-920	#N/A	0	0	0	-401	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
b77-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_KRx0.66.dac	***2046***	∞	0	0	0	0	0	-397	0	-2509	-404	-149	-374	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Sensitivity: Isotropic layer K distribution																											
b07_[02b]_PrMng_2018_Grassy_FM_Steady-Exp_SVY_Kiso.dac	***2018***	∞	-1104	#N/A	0	0	0	-587	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
b78-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_Kiso.dac	***2046***	∞	0	0	0	0	0	-587	0	-3430	-704	-271	-717	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Sensitivity: No influence from bedding / K decrs. With depth																											
b08_[02b]_PrMng_2018_Grassy_FM_Steady-Exp_SVY_noBedding.dac	***2018***	∞	-712	#N/A	0	0	-15	-563	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
b79-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_noBedding.dac	***2046***	∞	0	0	0	0	0	-563	0	-4509	-470	-118	-453	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Sensitivity: Kx = Ky (no influence from thrust faults)																											
b09_[02b]_PrMng_2018_Grassy_FM_Steady-Exp_SVY_KxKySame.dac	***2018***	∞	-1045	#N/A	0	0	0	-629	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
b80-[73]_LTC_2046_Grassy_FM_Steady_EXP_KxKySame.dac	***2046***	∞	0	0	0	0	0	-628	0	-3960	-502	-209	-520	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Sensitivity: Faults with low K (Kxyz /2.5)																											
b10_[02b]_PrMng_2018_Grassy_FM_Steady-Exp_SVY_FltLow.dac	***2018***	∞	-1287	#N/A	0	0	0	-598	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
b81-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_FltLow.dac	***2046***	∞	0	0	0	0	0	-595	0	-3764	-606	-224	-561	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Sensitivity: Faults with high K (Kxyz x2.5)																											
b11_[02b]_PrMng_2018_Grassy_FM_Steady-Exp_SVY_FltHigh.dac	***2018***	∞	-1667	#N/A	0	0	0	-596	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
b82-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY__FltHigh.dac	***2046***	∞	0	0	0	0	0	-594	0	-3751	-624	-234	-562	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Sensitivity: K increased by 50%																											
b85_[02b]_PrMng_2018_Grassy_FM_Steady-Exp_SVY_Kx1.5.dac	***2018***	∞	-1880	#N/A	0	0	0	-747	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
b89-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_Kx1.5.dac	***2046***	∞	0	0	0	0	0	-743	0	-3575	-697	-229	-600	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Sensitivity: K reduced by 50%																											
b86_[02b]_PrMng_2018_Grassy_FM_Steady-Exp_SVY_Kx0.66.dac	***2018***	∞	-1037	#N/A	0	0	0	-476	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
b90-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_Kx0.66.dac	***2046***	∞	0	0	0	0	0	-475	0	-3894	-532	-212	-530	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Sensitivity: R increased by 50%																											
b87_[02b]_PrMng_2018_Grassy_FM_Steady-Exp_SVY_Rx1.5.dac	***2018***	∞	-1588	#N/A	0	0	0	-714	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
b91-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_Rx1.5.dac	***2046***	∞	0	0	0	0	0	-713	0	-5842	-798	-318	-795	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Sensitivity: R reduced by 50%																											
b88_[02b]_PrMng_2018_Grassy_FM_Steady-Exp_SVY_Rx0.66.dac	***2018***	∞	-1253	#N/A	0	0	0	-498	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
b92-[73]_LTC_2046_Grassy_FM_Steady_EXP_Rx0.66.dac	***2046***	∞	0	0	0	0	0	-495	0	-2384	-465	-153	-400	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Sensitivity: R Dump increased by 50%																											
02b_PrMng_2018_Grassy_Mntn_FM_GwAge_Steady-State_Calibration_rev2_LN	***2018***	∞	-1379	#N/A	0	0	0	-598	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
b83-[73]_LTC_2046_Grassy_FM_Steady_EX_Rdumpx1.5.dac	***2046***	∞	0	0	0	0	0	-595	0	-5133	-750	-308	-692	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Sensitivity: R Dump reduced by 50%																											
02b_PrMng_2018_Grassy_Mntn_FM_GwAge_Steady-State_Calibration_rev2_LN	***2018***	∞	-1379	#N/A	0	0	0	-598	0	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
b84-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_Rdumpx0.66.dac	***2046***	∞	0	0	0	0	0	-595	0	-2851	-503	-164	-473	na	na	na	na	na	na	na	na	na	na	na	na	na	na

Table C-28: Flow contribution from sources (m3/d): Steady State Model - Linear Recharge - LTC - SENSITIVITIES TO KR RATIO

Sensitivity: K/R ratio increased by 50% *76-[72]_LTC_2046_Grassy_FM_Steady_LNR_SVY_KRx1.5.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	*9251.180*	9214.718	0.000	0.000	0.001	36.461	0.000	0.000
BC07	*11451.600*	10377.782	0.000	24.376	0.039	1049.403	0.000	0.000
BL02	*12044.200*	10956.422	11.280	26.416	0.150	1049.931	0.000	0.001
BC03	*19842.326*	17366.519	75.955	26.689	0.318	1050.358	1062.171	260.317
BL01	*22473.826*	19997.997	75.961	26.690	0.318	1050.361	1062.182	260.317
Blairmore Creek (BC01)	*23368.738*	20894.236	74.650	26.690	0.318	1050.361	1062.173	260.309
D1	*33307.741*	33307.203	0.000	0.000	0.000	0.538	0.000	0.000
GC13	*3620.380*	3620.350	0.000	0.000	0.029	0.000	0.000	0.000
GC09	*14448.100*	14447.890	0.000	0.000	0.210	0.000	0.000	0.000
GC04	*34183.900*	34182.569	0.000	0.000	1.043	0.000	0.015	0.273
GC02	*35392.700*	35387.699	0.004	0.000	1.055	0.000	3.399	0.542
GC01	*65817.648*	64809.569	0.049	0.001	1.305	0.000	73.863	932.860
Gold Creek	*66280.248*	65252.901	0.049	0.001	1.309	0.000	73.863	952.123

Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
99.61%	0.00%	0.00%	0.00%	0.39%	0.00%	0.00%
90.62%	0.00%	0.21%	0.00%	9.16%	0.00%	0.00%
90.97%	0.09%	0.22%	0.00%	8.72%	0.00%	0.00%
87.52%	0.38%	0.13%	0.00%	5.29%	5.35%	1.31%
88.98%	0.34%	0.12%	0.00%	4.67%	4.73%	1.16%
89.41%	0.32%	0.11%	0.00%	4.49%	4.55%	1.11%
100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
99.99%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
98.47%	0.00%	0.00%	0.00%	0.00%	0.11%	1.42%
98.45%	0.00%	0.00%	0.00%	0.00%	0.11%	1.44%

Sensitivity: K/R ratio decreased by 50% *77-[72]_LTC_2046_Grassy_FM_Steady_LNR_SVY_KRx0.66.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	*4111.640*	4095.434	0.000	0.000	0.000	16.205	0.000	0.000
BC07	*5089.580*	4612.328	0.000	10.833	0.017	466.401	0.000	0.000
BL02	*5352.980*	4869.523	5.013	11.740	0.067	466.636	0.000	0.000
BC03	*8818.796*	7718.436	33.759	11.862	0.141	466.825	472.076	115.696
BL01	*9988.356*	8887.986	33.762	11.862	0.141	466.827	472.081	115.696
Blairmore Creek (BC01)	*10386.117*	9286.337	33.180	11.862	0.141	466.827	472.077	115.693
D1	*14803.418*	14803.179	0.000	0.000	0.000	0.239	0.000	0.000
GC13	*1609.060*	1609.047	0.000	0.000	0.013	0.000	0.000	0.000
GC09	*6421.380*	6421.286	0.000	0.000	0.094	0.000	0.000	0.000
GC04	*15192.900*	15192.308	0.000	0.000	0.464	0.000	0.006	0.121
GC02	*15730.100*	15727.876	0.002	0.000	0.469	0.000	1.511	0.241
GC01	*29252.332*	28804.296	0.022	0.000	0.580	0.000	32.828	414.605
Gold Creek	*29457.932*	29001.333	0.022	0.000	0.582	0.000	32.828	423.166

Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
99.61%	0.00%	0.00%	0.00%	0.39%	0.00%	0.00%
90.62%	0.00%	0.21%	0.00%	9.16%	0.00%	0.00%
90.97%	0.09%	0.22%	0.00%	8.72%	0.00%	0.00%
87.52%	0.38%	0.13%	0.00%	5.29%	5.35%	1.31%
88.98%	0.34%	0.12%	0.00%	4.67%	4.73%	1.16%
89.41%	0.32%	0.11%	0.00%	4.49%	4.55%	1.11%
100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
99.99%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
98.47%	0.00%	0.00%	0.00%	0.00%	0.11%	1.42%
98.45%	0.00%	0.00%	0.00%	0.00%	0.11%	1.44%

Table C-29: Flow contribution from sources (m3/d): Steady State Model - Linear Recharge - LTC - SENSITIVITIES TO ANISOTROPY

Sensitivity: Isotropic layer K distribution *78-[72]_LTC_2046_Grassy_FM_Steady_LNR_SVY_Kiso.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	*5873.580*	5871.235	0.000	0.001	0.000	2.344	0.000	0.000
BC07	*7371.720*	6695.529	0.000	19.219	0.431	656.541	0.000	0.000
BL02	*7781.070*	7100.070	3.732	20.023	0.701	656.544	0.000	0.001
BC03	*12275.281*	10982.043	49.687	20.024	0.703	656.544	360.879	205.400
BL01	*14351.081*	13057.869	49.689	20.024	0.703	656.544	360.851	205.400
Blairmore Creek (BC01)	*14978.490*	13685.686	49.277	20.024	0.703	656.544	360.855	205.400
D1	*22235.872*	22235.824	0.000	0.000	0.000	0.048	0.000	0.000
GC13	*2429.580*	2429.577	0.000	0.000	0.003	0.000	0.000	0.000
GC09	*9852.300*	9851.966	0.000	0.000	0.334	0.001	0.000	0.000
GC04	*23147.500*	23146.120	0.000	0.000	1.121	0.001	0.001	0.258
GC02	*24093.900*	24091.902	0.000	0.000	1.122	0.001	0.529	0.346
GC01	*45536.500*	45007.747	0.001	0.000	1.122	0.001	29.535	498.094
Gold Creek	*45824.100*	45286.776	0.001	0.000	1.122	0.001	29.535	506.665

	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	99.96%	0.00%	0.00%	0.00%	0.04%	0.00%	0.00%
BC07	90.83%	0.00%	0.26%	0.01%	8.91%	0.00%	0.00%
BL02	91.25%	0.05%	0.26%	0.01%	8.44%	0.00%	0.00%
BC03	89.46%	0.40%	0.16%	0.01%	5.35%	2.94%	1.67%
BL01	90.99%	0.35%	0.14%	0.00%	4.57%	2.51%	1.43%
Blairmore Creek (BC01)	91.37%	0.33%	0.13%	0.00%	4.38%	2.41%	1.37%
D1	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC13	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC09	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC04	99.99%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC02	99.99%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC01	98.84%	0.00%	0.00%	0.00%	0.00%	0.06%	1.09%
Gold Creek	98.83%	0.00%	0.00%	0.00%	0.00%	0.06%	1.11%

Sensitivity: No influence from bedding / K decrs. With depth *79-[72]_LTC_2046_Grassy_FM_Steady_LNR_SVY_noBedding.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	*5969.530*	5967.301	0.000	0.000	0.000	2.229	0.000	0.000
BC07	*7518.660*	6861.286	0.000	8.838	0.002	648.534	0.000	0.000
BL02	*7900.710*	7240.494	2.000	9.543	0.005	648.658	0.000	0.009
BC03	*12682.200*	11323.511	36.140	9.546	0.007	648.663	507.934	156.398
BL01	*14746.900*	13387.968	36.142	9.547	0.007	648.663	508.173	156.399
Blairmore Creek (BC01)	*15441.900*	14083.710	35.450	9.547	0.007	648.664	508.129	156.393
D1	*22704.800*	22704.495	0.000	0.000	0.000	0.305	0.000	0.000
GC13	*2440.460*	2440.456	0.000	0.000	0.001	0.004	0.000	0.000
GC09	*8861.090*	8861.060	0.000	0.000	0.026	0.004	0.000	0.000
GC04	*22192.600*	22191.775	0.000	0.000	0.302	0.005	0.000	0.518
GC02	*22967.800*	22966.363	0.000	0.000	0.303	0.005	0.424	0.705
GC01	*44106.600*	43600.808	0.000	0.000	0.316	0.005	94.883	410.588
Gold Creek	*44413.600*	43902.857	0.000	0.000	0.316	0.005	94.883	415.539

	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	99.96%	0.00%	0.00%	0.00%	0.04%	0.00%	0.00%
BC07	91.26%	0.00%	0.12%	0.00%	8.63%	0.00%	0.00%
BL02	91.64%	0.03%	0.12%	0.00%	8.21%	0.00%	0.00%
BC03	89.29%	0.28%	0.08%	0.00%	5.11%	4.01%	1.23%
BL01	90.78%	0.25%	0.06%	0.00%	4.40%	3.45%	1.06%
Blairmore Creek (BC01)	91.20%	0.23%	0.06%	0.00%	4.20%	3.29%	1.01%
D1	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC13	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC09	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC04	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC02	99.99%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC01	98.85%	0.00%	0.00%	0.00%	0.00%	0.22%	0.93%
Gold Creek	98.85%	0.00%	0.00%	0.00%	0.00%	0.21%	0.94%

Sensitivity: Kx = Ky (no influence from thrust faults) *80-[72]_LTC_2046_Grassy_FM_Steady_LNR_SVY_KxKySame.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	*6103.730*	6088.287	0.000	0.000	0.000	15.443	0.000	0.000
BC07	*7609.730*	6889.152	0.000	14.122	0.004	706.453	0.000	0.000
BL02	*7987.570*	7261.970	4.197	14.756	0.017	706.629	0.000	0.001
BC03	*13109.745*	11562.603	39.592	14.809	0.034	706.712	619.074	166.921
BL01	*15026.545*	13479.374	39.593	14.809	0.034	706.712	619.102	166.921
Blairmore Creek (BC01)	*15659.745*	14113.297	38.881	14.809	0.034	706.713	619.095	166.916
D1	*22340.200*	22339.765	0.000	0.000	0.000	0.435	0.000	0.000
GC13	*2509.300*	2509.296	0.000	0.000	0.003	0.001	0.000	0.000
GC09	*9548.220*	9548.168	0.000	0.000	0.052	0.001	0.000	0.000
GC04	*22731.900*	22731.111	0.000	0.000	0.347	0.001	0.006	0.435
GC02	*23497.000*	23495.114	0.000	0.000	0.348	0.001	0.987	0.550
GC01	*44009.200*	43416.613	0.003	0.000	0.369	0.001	66.307	525.907
Gold Creek	*44320.100*	43718.994	0.003	0.000	0.370	0.001	66.307	534.425

	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	99.75%	0.00%	0.00%	0.00%	0.25%	0.00%	0.00%
BC07	90.53%	0.00%	0.19%	0.00%	9.28%	0.00%	0.00%
BL02	90.92%	0.05%	0.18%	0.00%	8.85%	0.00%	0.00%
BC03	88.20%	0.30%	0.11%	0.00%	5.39%	4.72%	1.27%
BL01	89.70%	0.26%	0.10%	0.00%	4.70%	4.12%	1.11%
Blairmore Creek (BC01)	90.12%	0.25%	0.09%	0.00%	4.51%	3.95%	1.07%
D1	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC13	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC09	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC04	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC02	99.99%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC01	98.65%	0.00%	0.00%	0.00%	0.00%	0.15%	1.19%
Gold Creek	98.64%	0.00%	0.00%	0.00%	0.00%	0.15%	1.21%

Table C-30: Flow contribution from sources (m3/d): Steady State Model - Linear Recharge - LTC - SENSITIVITIES TO FAULTS

Sensitivity: Faults with low K (Kxyz /2.5) *81-[72]_LTC_2046_Grassy_FM_Steady_LNR_SVY_FltLow.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	*6175.490*	6150.801	0.000	0.000	0.001	24.689	0.000	0.000
BC07	*7642.340*	6928.775	0.000	16.214	0.027	697.324	0.000	0.000
BL02	*8037.400*	7314.468	7.532	17.643	0.096	697.661	0.000	0.001
BC03	*13221.667*	11592.450	50.650	17.836	0.206	697.943	695.399	167.182
BL01	*14967.367*	13338.133	50.654	17.837	0.207	697.946	695.409	167.182
Blairmore Creek (BC01)	*15561.618*	13933.184	49.864	17.837	0.206	697.946	695.404	167.177
D1	*22196.327*	22195.969	0.000	0.000	0.000	0.358	0.000	0.000
GC13	*2423.520*	2423.508	0.000	0.000	0.012	0.000	0.000	0.000
GC09	*9627.510*	9627.359	0.000	0.000	0.150	0.000	0.000	0.000
GC04	*22808.800*	22807.898	0.000	0.000	0.710	0.000	0.010	0.182
GC02	*23614.800*	23611.436	0.003	0.000	0.719	0.000	2.278	0.364
GC01	*43930.993*	43253.079	0.030	0.001	0.886	0.000	50.705	626.291
Gold Creek	*44238.393*	43549.645	0.030	0.001	0.889	0.000	50.705	637.123

Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
99.60%	0.00%	0.00%	0.00%	0.40%	0.00%	0.00%
90.66%	0.00%	0.21%	0.00%	9.12%	0.00%	0.00%
91.01%	0.09%	0.22%	0.00%	8.68%	0.00%	0.00%
87.68%	0.38%	0.13%	0.00%	5.28%	5.26%	1.26%
89.11%	0.34%	0.12%	0.00%	4.66%	4.65%	1.12%
89.54%	0.32%	0.11%	0.00%	4.49%	4.47%	1.07%
100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
99.99%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
98.46%	0.00%	0.00%	0.00%	0.00%	0.12%	1.43%
98.44%	0.00%	0.00%	0.00%	0.00%	0.11%	1.44%

Sensitivity: Faults with high K (Kxyz x2.5) *82-[72]_LTC_2046_Grassy_FM_Steady_LNR_SVY_FltHigh.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	*6152.630*	6129.079	0.000	0.000	0.001	23.550	0.000	0.000
BC07	*7617.060*	6901.957	0.000	16.106	0.060	698.937	0.000	0.000
BL02	*8012.180*	7287.777	7.526	17.444	0.136	699.297	0.000	0.001
BC03	*13234.144*	11556.314	50.784	17.617	0.250	699.586	727.748	181.846
BL01	*14972.944*	13295.103	50.789	17.617	0.250	699.588	727.752	181.846
Blairmore Creek (BC01)	*15575.260*	13898.402	49.818	17.617	0.250	699.588	727.745	181.840
D1	*22218.528*	22218.147	0.000	0.000	0.000	0.381	0.000	0.000
GC13	*2399.540*	2399.511	0.000	0.000	0.029	0.000	0.000	0.000
GC09	*9630.100*	9629.957	0.000	0.000	0.143	0.000	0.000	0.000
GC04	*22781.600*	22780.718	0.000	0.000	0.690	0.000	0.009	0.182
GC02	*23586.700*	23583.400	0.003	0.000	0.698	0.000	2.241	0.358
GC01	*43849.439*	43183.437	0.037	0.001	0.869	0.000	47.332	617.763
Gold Creek	*44157.539*	43476.040	0.037	0.001	0.872	0.000	47.332	633.256

Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
99.62%	0.00%	0.00%	0.00%	0.38%	0.00%	0.00%
90.61%	0.00%	0.21%	0.00%	9.18%	0.00%	0.00%
90.96%	0.09%	0.22%	0.00%	8.73%	0.00%	0.00%
87.32%	0.38%	0.13%	0.00%	5.29%	5.50%	1.37%
88.79%	0.34%	0.12%	0.00%	4.67%	4.86%	1.21%
89.23%	0.32%	0.11%	0.00%	4.49%	4.67%	1.17%
100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
99.99%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
98.48%	0.00%	0.00%	0.00%	0.00%	0.11%	1.41%
98.46%	0.00%	0.00%	0.00%	0.00%	0.11%	1.43%

Table C-31: Flow contribution from sources (m3/d): Steady State Model - Linear Recharge - LTC - SENSITIVITIES TO K

Sensitivity: K increased by 50% *89-[72]_LTC_2046_Grassy_FM_Steady_LNR_Kx1.5.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	*6138.200*	6113.050	0.000	0.000	0.001	25.149	0.000	0.000
BC07	*7601.880*	6862.543	0.000	20.710	0.055	718.573	0.000	0.000
BL02	*8012.600*	7261.526	8.792	23.012	0.220	719.049	0.000	0.001
BC03	*13185.126*	11446.661	58.702	23.384	0.473	719.454	748.289	188.163
BL01	*14810.726*	13072.218	58.717	23.393	0.478	719.463	748.294	188.163
Blairmore Creek (BC01)	*15361.129*	13623.259	58.087	23.393	0.478	719.463	748.292	188.158
D1	*22338.141*	22338.070	0.000	0.000	0.000	0.071	0.000	0.000
GC13	*2315.510*	2315.474	0.000	0.000	0.036	0.000	0.000	0.000
GC09	*9658.420*	9658.114	0.000	0.000	0.305	0.000	0.000	0.000
GC04	*22702.761*	22701.686	0.000	0.000	0.941	0.000	0.008	0.126
GC02	*23560.261*	23555.637	0.006	0.000	0.957	0.000	3.313	0.347
GC01	*43797.759*	43064.767	0.074	0.002	1.283	0.000	29.928	701.703
Gold Creek	*44109.059*	43360.441	0.074	0.002	1.288	0.000	29.928	717.324

	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	99.59%	0.00%	0.00%	0.00%	0.41%	0.00%	0.00%
BC07	90.27%	0.00%	0.27%	0.00%	9.45%	0.00%	0.00%
BL02	90.63%	0.11%	0.29%	0.00%	8.97%	0.00%	0.00%
BC03	86.81%	0.45%	0.18%	0.00%	5.46%	5.68%	1.43%
BL01	88.26%	0.40%	0.16%	0.00%	4.86%	5.05%	1.27%
Blairmore Creek (BC01)	88.69%	0.38%	0.15%	0.00%	4.68%	4.87%	1.22%
D1	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC13	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC09	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC04	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC02	99.98%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
GC01	98.33%	0.00%	0.00%	0.00%	0.00%	0.07%	1.60%
Gold Creek	98.30%	0.00%	0.00%	0.00%	0.00%	0.07%	1.63%

Sensitivity: K reduced by 50% *90-[72]_LTC_2046_Grassy_FM_Steady_LNR_Kx0.66.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	*6177.720*	6153.953	0.000	0.000	0.000	23.766	0.000	0.000
BC07	*7663.040*	6945.809	0.000	14.453	0.013	702.764	0.000	0.000
BL02	*8041.320*	7317.252	5.597	15.424	0.041	703.003	0.000	0.001
BC03	*13239.132*	11653.246	45.440	15.534	0.090	703.193	654.315	167.313
BL01	*15166.032*	13580.134	45.442	15.534	0.090	703.194	654.325	167.313
Blairmore Creek (BC01)	*15793.632*	14208.450	44.737	15.535	0.090	703.194	654.318	167.308
D1	*22299.517*	22298.959	0.000	0.000	0.000	0.558	0.000	0.000
GC13	*2477.890*	2477.877	0.000	0.000	0.012	0.000	0.000	0.000
GC09	*9590.150*	9590.079	0.000	0.000	0.071	0.000	0.000	0.000
GC04	*22799.600*	22798.869	0.000	0.000	0.425	0.000	0.010	0.295
GC02	*23570.000*	23567.677	0.001	0.000	0.429	0.000	1.452	0.440
GC01	*43922.734*	43293.850	0.015	0.000	0.501	0.001	62.698	565.669
Gold Creek	*44234.434*	43595.145	0.015	0.000	0.503	0.001	62.698	576.073

	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	99.62%	0.00%	0.00%	0.00%	0.38%	0.00%	0.00%
BC07	90.64%	0.00%	0.19%	0.00%	9.17%	0.00%	0.00%
BL02	91.00%	0.07%	0.19%	0.00%	8.74%	0.00%	0.00%
BC03	88.02%	0.34%	0.12%	0.00%	5.31%	4.94%	1.26%
BL01	89.54%	0.30%	0.10%	0.00%	4.64%	4.31%	1.10%
Blairmore Creek (BC01)	89.96%	0.28%	0.10%	0.00%	4.45%	4.14%	1.06%
D1	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC13	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC09	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC04	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC02	99.99%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
GC01	98.57%	0.00%	0.00%	0.00%	0.00%	0.14%	1.29%
Gold Creek	98.55%	0.00%	0.00%	0.00%	0.00%	0.14%	1.30%

Table C-32: Flow contribution from sources (m3/d): Steady State Model - Linear Recharge - LTC - SENSITIVITIES TO R

Sensitivity: R reduced by 50% *91-[72]_LTC_2046_Grassy_FM_Steady_LNR_Rx1.5.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	9266.590	9230.940	0.000	0.000	0.000	35.649	0.000	0.000
BC07	11494.600	10418.753	0.000	21.680	0.020	1054.147	0.000	0.000
BL02	12062.000	10975.898	8.396	23.137	0.062	1054.505	0.000	0.002
BC03	19858.648	17479.819	68.159	23.302	0.135	1054.790	981.473	250.970
BL01	22749.048	20370.201	68.162	23.302	0.135	1054.791	981.488	250.970
Blairmore Creek (BC01)	23690.448	21312.675	67.104	23.303	0.135	1054.792	981.477	250.962
D1	33449.275	33448.438	0.000	0.000	0.000	0.836	0.000	0.000
GC13	3716.830	3716.811	0.000	0.000	0.018	0.001	0.000	0.000
GC09	14385.200	14385.093	0.000	0.000	0.106	0.001	0.000	0.000
GC04	34199.400	34198.303	0.000	0.000	0.638	0.001	0.016	0.442
GC02	35355.000	35351.517	0.002	0.000	0.643	0.001	2.177	0.661
GC01	65884.001	64940.676	0.023	0.000	0.752	0.001	94.046	848.503
Gold Creek	66351.601	65392.668	0.023	0.000	0.754	0.001	94.046	864.109

	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	99.62%	0.00%	0.00%	0.00%	0.38%	0.00%	0.00%
BC07	90.64%	0.00%	0.19%	0.00%	9.17%	0.00%	0.00%
BL02	91.00%	0.07%	0.19%	0.00%	8.74%	0.00%	0.00%
BC03	88.02%	0.34%	0.12%	0.00%	5.31%	4.94%	1.26%
BL01	89.54%	0.30%	0.10%	0.00%	4.64%	4.31%	1.10%
Blairmore Creek (BC01)	89.96%	0.28%	0.10%	0.00%	4.45%	4.14%	1.06%
D1	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC13	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC09	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC04	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC02	99.99%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
GC01	98.57%	0.00%	0.00%	0.00%	0.00%	0.14%	1.29%
Gold Creek	98.55%	0.00%	0.00%	0.00%	0.00%	0.14%	1.30%

Sensitivity: R Dump increased by 50% *92-[72]_LTC_2046_Grassy_FM_Steady_LNR_Rx0.66.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	4092.130	4075.363	0.000	0.000	0.001	16.766	0.000	0.000
BC07	5067.920	4575.029	0.000	13.807	0.036	479.048	0.000	0.000
BL02	5341.730	4841.014	5.861	15.341	0.146	479.366	0.000	0.001
BC03	8790.107	7631.130	39.136	15.590	0.315	479.636	498.859	125.442
BL01	9873.797	8714.791	39.146	15.595	0.319	479.642	498.863	125.442
Blairmore Creek (BC01)	10240.753	9082.172	38.726	15.595	0.319	479.642	498.861	125.438
D1	14892.094	14892.047	0.000	0.000	0.000	0.047	0.000	0.000
GC13	1543.670	1543.646	0.000	0.000	0.024	0.000	0.000	0.000
GC09	6438.950	6438.746	0.000	0.000	0.204	0.000	0.000	0.000
GC04	15135.174	15134.457	0.000	0.000	0.627	0.000	0.006	0.084
GC02	15706.874	15703.791	0.004	0.000	0.638	0.000	2.209	0.232
GC01	29198.506	28709.844	0.050	0.001	0.856	0.000	19.952	467.802
Gold Creek	29406.006	28906.927	0.050	0.001	0.859	0.000	19.952	478.216

	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	99.59%	0.00%	0.00%	0.00%	0.41%	0.00%	0.00%
BC07	90.27%	0.00%	0.27%	0.00%	9.45%	0.00%	0.00%
BL02	90.63%	0.11%	0.29%	0.00%	8.97%	0.00%	0.00%
BC03	86.81%	0.45%	0.18%	0.00%	5.46%	5.68%	1.43%
BL01	88.26%	0.40%	0.16%	0.00%	4.86%	5.05%	1.27%
Blairmore Creek (BC01)	88.69%	0.38%	0.15%	0.00%	4.68%	4.87%	1.22%
D1	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC13	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC09	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC04	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC02	99.98%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
GC01	98.33%	0.00%	0.00%	0.00%	0.00%	0.07%	1.60%
Gold Creek	98.30%	0.00%	0.00%	0.00%	0.00%	0.07%	1.63%

Sensitivity: R Dump increased by 50% *83-[72]_LTC_2046_2056_Grassy_FM_Steady_LNR_SVY_Rdumpx1.5.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	6193.870	6162.633	0.000	0.000	0.001	31.237	0.000	0.000
BC07	8056.210	7087.286	0.000	19.840	0.024	949.060	0.000	0.000
BL02	8461.820	7482.308	8.534	21.499	0.088	949.389	0.000	0.002
BC03	14089.282	11979.583	57.296	21.693	0.187	949.708	834.107	246.708
BL01	15843.682	13733.967	57.301	21.693	0.187	949.711	834.115	246.708
Blairmore Creek (BC01)	16440.424	14331.270	56.752	21.694	0.187	949.712	834.108	246.700
D1	22232.727	22231.835	0.000	0.000	0.000	0.892	0.000	0.000
GC13	2416.510	2416.490	0.000	0.000	0.020	0.000	0.000	0.000
GC09	9634.920	9634.791	0.000	0.000	0.129	0.000	0.000	0.000
GC04	22792.300	22791.317	0.000	0.000	0.739	0.000	0.012	0.232
GC02	23600.400	23596.609	0.003	0.000	0.747	0.000	2.595	0.446
GC01	44470.499	43582.304	0.027	0.000	0.903	0.000	70.005	817.258
Gold Creek	44786.699	43882.901	0.027	0.000	0.906	0.000	70.005	832.859

	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	99.50%	0.00%	0.00%	0.00%	0.50%	0.00%	0.00%
BC07	87.97%	0.00%	0.25%	0.00%	11.78%	0.00%	0.00%
BL02	88.42%	0.10%	0.25%	0.00%	11.22%	0.00%	0.00%
BC03	85.03%	0.41%	0.15%	0.00%	6.74%	5.92%	1.75%
BL01	86.68%	0.36%	0.14%	0.00%	5.99%	5.26%	1.56%
Blairmore Creek (BC01)	87.17%	0.35%	0.13%	0.00%	5.78%	5.07%	1.50%
D1	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC13	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC09	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC04	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC02	99.98%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
GC01	98.00%	0.00%	0.00%	0.00%	0.00%	0.16%	1.84%
Gold Creek	97.98%	0.00%	0.00%	0.00%	0.00%	0.16%	1.86%

Sensitivity: R Dump reduced by 50% *84-[72]_LTC_2046_Grassy_FM_Steady_LNR_SVY_Rdumpx0.66.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	6149.460	6130.295	0.000	0.000	0.001	19.164	0.000	0.000
BC07	7354.740	6801.638	0.000	14.448	0.029	538.625	0.000	0.000
BL02	7741.860	7179.945	7.041	15.829	0.116	538.929	0.000	0.001
BC03	12659.042	11305.073	46.985	16.032	0.250	539.169	623.875	127.658
BL01	14412.242	13058.259	46.989	16.033	0.250	539.171	623.882	127.658
Blairmore Creek (BC01)	15008.883	13655.732	46.167	16.033	0.250	539.171	623.876	127.654
D1	22188.327	22188.166	0.000	0.000	0.000	0.161	0.000	0.000
GC13	2411.480	2411.461	0.000	0.000	0.019	0.000	0.000	0.000
GC09	9630.030	9629.861	0.000	0.000	0.169	0.000	0.000	0.000
GC04	22787.400	22786.598	0.000	0.000	0.638	0.000	0.008	0.156
GC02	23591.800	23588.800	0.003	0.000	0.646	0.000	2.038	0.312
GC01	43478.899	42952.010	0.043	0.001	0.830	0.000	35.118	490.897
Gold Creek	43781.899	43244.594	0.043	0.001	0.833	0.000	35.118	501.309

	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	99.69%	0.00%	0.00%	0.00%	0.31%	0.00%	0.00%
BC07	92.48%	0.00%	0.20%	0.00%	7.32%	0.00%	0.00%
BL02	92.74%	0.09%	0.20%	0.00%	6.96%	0.00%	0.00%
BC03	89.30%	0.37%	0.13%	0.00%	4.26%	4.93%	1.01%
BL01	90.61%	0.33%	0.11%	0.00%	3.74%	4.33%	0.89%
Blairmore Creek (BC01)	90.98%	0.31%	0.11%	0.00%	3.59%	4.16%	0.85%
D1	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC13	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC09	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC04	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC02	99.99%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
GC01	98.79%	0.00%	0.00%	0.00%	0.00%	0.08%	1.13%
Gold Creek	98.77%	0.00%	0.00%	0.00%	0.00%	0.08%	1.15%

Table C-33: Flow contribution from sources (m3/d): Steady State Model - Exponential Recharge - LTC - SENSITIVITIES TO KR RATIO

Sensitivity: K/R ratio increased by 50% *b76-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_KRx1.5.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	*13568.500*	13518.779	0.000	0.000	0.001	49.719	0.000	0.000
BC07	*16352.200*	14786.658	0.000	34.612	0.063	1530.866	0.000	0.000
BL02	*16921.600*	15340.136	11.338	38.013	0.300	1531.812	0.000	0.001
BC03	*24409.403*	21530.667	79.519	38.587	0.748	1532.642	999.565	227.675
BL01	*26774.103*	23895.235	79.560	38.610	0.763	1532.673	999.587	227.675
Blairmore Creek (BC01)	*27231.692*	24352.998	79.387	38.610	0.763	1532.673	999.587	227.674
D1	*51158.452*	51157.483	0.000	0.000	0.001	0.968	0.000	0.000
GC13	*2990.330*	2990.252	0.000	0.000	0.077	0.000	0.000	0.000
GC09	*12996.200*	12995.549	0.000	0.000	0.651	0.000	0.000	0.000
GC04	*28809.548*	28808.084	0.000	0.000	1.453	0.000	0.008	0.002
GC02	*29469.121*	29460.574	0.014	0.000	1.483	0.000	6.757	0.293
GC01	*46980.913*	46228.194	0.174	0.004	2.144	0.001	16.584	733.813
Gold Creek	*47193.413*	46421.812	0.174	0.004	2.154	0.001	16.584	752.684

	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	99.63%	0.00%	0.00%	0.00%	0.37%	0.00%	0.00%
BC07	90.43%	0.00%	0.21%	0.00%	9.36%	0.00%	0.00%
BL02	90.65%	0.07%	0.22%	0.00%	9.05%	0.00%	0.00%
BC03	88.21%	0.33%	0.16%	0.00%	6.28%	4.09%	0.93%
BL01	89.25%	0.30%	0.14%	0.00%	5.72%	3.73%	0.85%
Blairmore Creek (BC01)	89.43%	0.29%	0.14%	0.00%	5.63%	3.67%	0.84%
D1	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC13	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC09	99.99%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
GC04	99.99%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
GC02	99.97%	0.00%	0.00%	0.01%	0.00%	0.02%	0.00%
GC01	98.40%	0.00%	0.00%	0.00%	0.00%	0.04%	1.56%
Gold Creek	98.37%	0.00%	0.00%	0.00%	0.00%	0.04%	1.59%

Sensitivity: K/R ratio decreased by 50% *b77-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_KRx0.66.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	*6030.450*	6008.351	0.000	0.000	0.001	22.098	0.000	0.000
BC07	*7267.630*	6571.834	0.000	15.383	0.028	680.385	0.000	0.000
BL02	*7520.720*	6817.847	5.039	16.895	0.133	680.805	0.000	0.000
BC03	*10848.579*	9569.140	35.343	17.150	0.332	681.174	444.251	101.189
BL01	*11899.579*	10620.081	35.361	17.160	0.339	681.188	444.261	101.189
Blairmore Creek (BC01)	*12102.997*	10823.576	35.284	17.160	0.339	681.188	444.261	101.188
D1	*22737.101*	22736.670	0.000	0.000	0.001	0.430	0.000	0.000
GC13	*1329.030*	1328.995	0.000	0.000	0.034	0.000	0.000	0.000
GC09	*5776.080*	5775.791	0.000	0.000	0.289	0.000	0.000	0.000
GC04	*12804.221*	12803.571	0.000	0.000	0.646	0.000	0.004	0.001
GC02	*13097.398*	13093.599	0.006	0.000	0.659	0.000	3.003	0.130
GC01	*20880.428*	20545.885	0.078	0.002	0.953	0.000	7.371	326.139
Gold Creek	*20974.828*	20631.893	0.078	0.002	0.957	0.000	7.371	334.526

	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	99.63%	0.00%	0.00%	0.00%	0.37%	0.00%	0.00%
BC07	90.43%	0.00%	0.21%	0.00%	9.36%	0.00%	0.00%
BL02	90.65%	0.07%	0.22%	0.00%	9.05%	0.00%	0.00%
BC03	88.21%	0.33%	0.16%	0.00%	6.28%	4.10%	0.93%
BL01	89.25%	0.30%	0.14%	0.00%	5.72%	3.73%	0.85%
Blairmore Creek (BC01)	89.43%	0.29%	0.14%	0.00%	5.63%	3.67%	0.84%
D1	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC13	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC09	99.99%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
GC04	99.99%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
GC02	99.97%	0.00%	0.00%	0.01%	0.00%	0.02%	0.00%
GC01	98.40%	0.00%	0.00%	0.00%	0.00%	0.04%	1.56%
Gold Creek	98.37%	0.00%	0.00%	0.00%	0.00%	0.04%	1.59%

Table C-34: Flow contribution from sources (m3/d): Steady State Model - Exponential Recharge - LTC - SENSITIVITIES TO ANISOTROPY

Sensitivity: Isotropic layer K distribution *b78-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_Kiso.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	*8634.810*	8630.118	0.000	0.001	0.000	4.691	0.000	0.000
BC07	*10524.300*	9564.915	0.000	22.668	0.643	936.074	0.000	0.000
BL02	*10915.409*	9949.254	5.226	23.647	1.202	936.080	0.000	0.000
BC03	*15018.626*	13610.333	60.009	23.650	1.207	936.080	252.190	135.157
BL01	*16903.726*	15495.427	60.015	23.650	1.207	936.080	252.190	135.157
Blairmore Creek (BC01)	*17315.228*	15907.100	59.846	23.650	1.207	936.080	252.190	135.156
D1	*34262.648*	34262.583	0.000	0.000	0.000	0.064	0.000	0.000
GC13	*2024.200*	2024.194	0.000	0.000	0.005	0.000	0.000	0.000
GC09	*8965.840*	8964.897	0.000	0.000	0.941	0.002	0.000	0.000
GC04	*19709.529*	19706.774	0.000	0.000	2.751	0.002	0.000	0.001
GC02	*20227.229*	20223.580	0.000	0.000	2.756	0.002	0.716	0.175
GC01	*33282.910*	32911.665	0.002	0.000	2.758	0.002	0.854	367.629
Gold Creek	*33370.710*	32993.693	0.002	0.000	2.758	0.002	0.854	373.401

	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	99.95%	0.00%	0.00%	0.00%	0.05%	0.00%	0.00%
BC07	90.88%	0.00%	0.22%	0.01%	8.89%	0.00%	0.00%
BL02	91.15%	0.05%	0.22%	0.01%	8.58%	0.00%	0.00%
BC03	90.62%	0.40%	0.16%	0.01%	6.23%	1.68%	0.90%
BL01	91.67%	0.36%	0.14%	0.01%	5.54%	1.49%	0.80%
Blairmore Creek (BC01)	91.87%	0.35%	0.14%	0.01%	5.41%	1.46%	0.78%
D1	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC13	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC09	99.99%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
GC04	99.99%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
GC02	99.98%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
GC01	98.88%	0.00%	0.00%	0.01%	0.00%	0.00%	1.10%
Gold Creek	98.87%	0.00%	0.00%	0.01%	0.00%	0.00%	1.12%

Sensitivity: No influence from bedding / K decrs. With depth *b79-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_noBedding.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	*8759.610*	8755.808	0.000	0.000	0.000	3.802	0.000	0.000
BC07	*10704.300*	9779.210	0.000	13.981	0.003	911.106	0.000	0.000
BL02	*11085.148*	10155.420	2.835	15.569	0.009	911.312	0.000	0.004
BC03	*15459.169*	14052.368	42.977	15.577	0.014	911.324	330.898	106.010
BL01	*17289.069*	15881.677	43.023	15.578	0.015	911.328	331.411	106.036
Blairmore Creek (BC01)	*17702.230*	16295.303	42.588	15.578	0.015	911.328	331.389	106.028
D1	*34768.400*	34767.928	0.000	0.000	0.000	0.472	0.000	0.000
GC13	*2133.460*	2133.445	0.000	0.000	0.001	0.014	0.000	0.000
GC09	*7665.960*	7665.860	0.000	0.000	0.083	0.017	0.000	0.000
GC04	*18818.300*	18817.497	0.000	0.000	0.690	0.018	0.000	0.095
GC02	*19195.700*	19192.115	0.000	0.000	0.695	0.018	1.853	1.019
GC01	*32016.100*	31741.153	0.000	0.000	0.729	0.018	32.768	241.433
Gold Creek	*32095.200*	31817.911	0.000	0.000	0.729	0.018	32.769	243.773

	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	99.96%	0.00%	0.00%	0.00%	0.04%	0.00%	0.00%
BC07	91.36%	0.00%	0.13%	0.00%	8.51%	0.00%	0.00%
BL02	91.61%	0.03%	0.14%	0.00%	8.22%	0.00%	0.00%
BC03	90.90%	0.28%	0.10%	0.00%	5.90%	2.14%	0.69%
BL01	91.86%	0.25%	0.09%	0.00%	5.27%	1.92%	0.61%
Blairmore Creek (BC01)	92.05%	0.24%	0.09%	0.00%	5.15%	1.87%	0.60%
D1	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC13	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC09	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC04	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC02	99.98%	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%
GC01	99.14%	0.00%	0.00%	0.00%	0.00%	0.10%	0.75%
Gold Creek	99.14%	0.00%	0.00%	0.00%	0.00%	0.10%	0.76%

Sensitivity: Kx = Ky (no influence from thrust faults) *b80-[73]_LTC_2046_Grassy_FM_Steady_EXP_KxKySame.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	*8960.020*	8936.478	0.000	0.000	0.000	23.541	0.000	0.000
BC07	*10869.200*	9816.337	0.000	17.623	0.011	1035.228	0.000	0.000
BL02	*11230.700*	10171.574	4.709	18.806	0.066	1035.545	0.000	0.000
BC03	*16167.712*	14387.131	37.700	18.907	0.145	1035.725	554.510	133.594
BL01	*17849.512*	16068.901	37.705	18.908	0.146	1035.727	554.533	133.594
Blairmore Creek (BC01)	*18206.064*	16426.048	37.120	18.908	0.146	1035.727	554.526	133.590
D1	*34198.163*	34197.399	0.000	0.000	0.000	0.763	0.000	0.000
GC13	*2153.260*	2153.254	0.000	0.000	0.006	0.001	0.000	0.000
GC09	*8535.070*	8534.934	0.000	0.000	0.135	0.001	0.000	0.000
GC04	*19191.000*	19190.340	0.000	0.000	0.583	0.001	0.003	0.072
GC02	*19569.000*	19565.761	0.001	0.000	0.591	0.001	2.449	0.198
GC01	*31528.081*	31117.612	0.014	0.000	0.726	0.001	19.642	390.085
Gold Creek	*31635.781*	31217.540	0.014	0.000	0.728	0.001	19.642	397.856

	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	99.74%	0.00%	0.00%	0.00%	0.26%	0.00%	0.00%
BC07	90.31%	0.00%	0.16%	0.00%	9.52%	0.00%	0.00%
BL02	90.57%	0.04%	0.17%	0.00%	9.22%	0.00%	0.00%
BC03	88.99%	0.23%	0.12%	0.00%	6.41%	3.43%	0.83%
BL01	90.02%	0.21%	0.11%	0.00%	5.80%	3.11%	0.75%
Blairmore Creek (BC01)	90.22%	0.20%	0.10%	0.00%	5.69%	3.05%	0.73%
D1	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC13	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC09	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC04	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC02	99.98%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
GC01	98.70%	0.00%	0.00%	0.00%	0.00%	0.06%	1.24%
Gold Creek	98.68%	0.00%	0.00%	0.00%	0.00%	0.06%	1.26%

Table C-35: Flow contribution from sources (m3/d): Steady State Model - Exponential Recharge - LTC - SENSITIVITIES TO FAULTS

Sensitivity: Faults with low K (Kxyz /2.5) *b81-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_FltLow.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	*9045.680*	9012.532	0.000	0.000	0.001	33.146	0.000	0.000	99.63%	0.00%	0.00%	0.00%	0.37%	0.00%	0.00%
BC07	*10901.400*	9857.705	0.000	23.075	0.042	1020.577	0.000	0.000	90.43%	0.00%	0.21%	0.00%	9.36%	0.00%	0.00%
BL02	*11281.100*	10226.791	7.558	25.342	0.200	1021.208	0.000	0.000	90.65%	0.07%	0.22%	0.00%	9.05%	0.00%	0.00%
BC03	*16272.969*	14353.811	53.014	25.725	0.499	1021.761	666.376	151.783	88.21%	0.33%	0.16%	0.00%	6.28%	4.09%	0.93%
BL01	*17849.369*	15930.123	53.041	25.740	0.509	1021.782	666.392	151.783	89.25%	0.30%	0.14%	0.00%	5.72%	3.73%	0.85%
Blairmore Creek (BC01)	*18154.495*	16235.365	52.925	25.740	0.509	1021.782	666.392	151.783	89.43%	0.29%	0.14%	0.00%	5.63%	3.67%	0.84%
D1	*34105.701*	34105.055	0.000	0.000	0.001	0.645	0.000	0.000	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC13	*1993.550*	1993.498	0.000	0.000	0.052	0.000	0.000	0.000	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC09	*8664.130*	8663.696	0.000	0.000	0.434	0.000	0.000	0.000	99.99%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
GC04	*19206.332*	19205.356	0.000	0.000	0.969	0.000	0.006	0.001	99.99%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
GC02	*19646.047*	19640.349	0.009	0.000	0.989	0.000	4.505	0.195	99.97%	0.00%	0.00%	0.01%	0.00%	0.02%	0.00%
GC01	*31320.642*	30818.828	0.116	0.003	1.429	0.001	11.056	489.209	98.40%	0.00%	0.00%	0.00%	0.00%	0.04%	1.56%
Gold Creek	*31462.242*	30947.841	0.116	0.003	1.436	0.001	11.056	501.789	98.37%	0.00%	0.00%	0.00%	0.00%	0.04%	1.59%

Sensitivity: Faults with high K (Kxyz x2.5) *b82-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY__FltHigh.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	*9020.520*	8987.934	0.000	0.000	0.001	32.585	0.000	0.000	99.64%	0.00%	0.00%	0.00%	0.36%	0.00%	0.00%
BC07	*10878.100*	9826.875	0.000	22.851	0.107	1028.267	0.000	0.000	90.34%	0.00%	0.21%	0.00%	9.45%	0.00%	0.00%
BL02	*11257.800*	10196.022	7.505	25.092	0.271	1028.910	0.000	0.000	90.57%	0.07%	0.22%	0.00%	9.14%	0.00%	0.00%
BC03	*16289.393*	14325.116	53.440	25.455	0.591	1029.476	693.259	162.056	87.94%	0.33%	0.16%	0.00%	6.32%	4.26%	0.99%
BL01	*17877.993*	15913.638	53.466	25.469	0.599	1029.496	693.269	162.056	89.01%	0.30%	0.14%	0.00%	5.76%	3.88%	0.91%
Blairmore Creek (BC01)	*18185.706*	16221.477	53.340	25.469	0.599	1029.496	693.269	162.055	89.20%	0.29%	0.14%	0.00%	5.66%	3.81%	0.89%
D1	*34125.075*	34124.399	0.000	0.000	0.001	0.675	0.000	0.000	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC13	*1972.830*	1972.774	0.000	0.000	0.056	0.000	0.000	0.000	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC09	*8657.430*	8656.996	0.000	0.000	0.434	0.000	0.000	0.000	99.99%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
GC04	*19193.000*	19192.034	0.000	0.000	0.959	0.000	0.005	0.001	99.99%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC02	*19632.717*	19627.066	0.010	0.000	0.978	0.000	4.471	0.192	99.97%	0.00%	0.00%	0.00%	0.00%	0.02%	0.00%
GC01	*31307.876*	30810.797	0.118	0.003	1.422	0.001	10.752	484.784	98.41%	0.00%	0.00%	0.00%	0.00%	0.03%	1.55%
Gold Creek	*31450.276*	30937.986	0.118	0.003	1.432	0.001	10.752	499.984	98.37%	0.00%	0.00%	0.00%	0.00%	0.03%	1.59%

Table C-36: Flow contribution from sources (m3/d): Steady State Model - Exponential Recharge - LTC - SENSITIVITIES TO K

Sensitivity: K increased by 50% *b89-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_Kx1.5.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	*8987.050*	8951.924	0.000	0.000	0.002	35.124	0.000	0.000
BC07	*10882.600*	9810.102	0.000	32.339	0.094	1040.065	0.000	0.000
BL02	*11282.088*	10195.919	8.251	36.620	0.381	1040.917	0.000	0.000
BC03	*16183.882*	14239.380	66.238	37.423	0.951	1041.653	636.519	161.718
BL01	*17668.729*	15723.866	66.419	37.498	0.997	1041.706	636.525	161.718
Blairmore Creek (BC01)	*17932.954*	15988.158	66.349	37.499	0.998	1041.707	636.525	161.717
D1	*34225.039*	34224.909	0.000	0.000	0.001	0.130	0.000	0.000
GC13	*1837.980*	1837.898	0.000	0.000	0.082	0.000	0.000	0.000
GC09	*8768.060*	8767.115	0.000	0.000	0.945	0.000	0.000	0.000
GC04	*19133.510*	19131.850	0.000	0.000	1.653	0.000	0.006	0.001
GC02	*19644.055*	19636.401	0.018	0.001	1.689	0.000	5.706	0.242
GC01	*31398.021*	30812.463	0.207	0.006	2.418	0.001	14.947	567.979
Gold Creek	*31559.121*	30962.568	0.208	0.006	2.431	0.001	14.947	578.960

Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
99.61%	0.00%	0.00%	0.00%	0.39%	0.00%	0.00%
90.14%	0.00%	0.30%	0.00%	9.56%	0.00%	0.00%
90.37%	0.07%	0.32%	0.00%	9.23%	0.00%	0.00%
87.98%	0.41%	0.23%	0.01%	6.44%	3.93%	1.00%
88.99%	0.38%	0.21%	0.01%	5.90%	3.60%	0.92%
89.16%	0.37%	0.21%	0.01%	5.81%	3.55%	0.90%
100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
99.99%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
99.99%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
99.96%	0.00%	0.00%	0.01%	0.00%	0.03%	0.00%
98.14%	0.00%	0.00%	0.01%	0.00%	0.05%	1.81%
98.11%	0.00%	0.00%	0.01%	0.00%	0.05%	1.83%

Sensitivity: K reduced by 50% *b90-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_Kx0.66.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	*9071.420*	9038.065	0.000	0.000	0.000	33.354	0.000	0.000
BC07	*10954.500*	9899.992	0.000	17.729	0.021	1036.757	0.000	0.000
BL02	*11318.500*	10255.632	6.419	19.205	0.099	1037.145	0.000	0.000
BC03	*16381.455*	14528.200	45.031	19.407	0.240	1037.520	612.884	138.174
BL01	*18059.055*	16205.776	45.037	19.408	0.241	1037.525	612.895	138.174
Blairmore Creek (BC01)	*18409.605*	16556.965	44.408	19.408	0.241	1037.525	612.888	138.171
D1	*34170.915*	34169.950	0.000	0.000	0.000	0.965	0.000	0.000
GC13	*2093.340*	2093.314	0.000	0.000	0.026	0.000	0.000	0.000
GC09	*8571.600*	8571.414	0.000	0.000	0.185	0.001	0.000	0.000
GC04	*19209.592*	19208.896	0.000	0.000	0.638	0.001	0.005	0.052
GC02	*19599.111*	19595.010	0.005	0.000	0.649	0.001	3.233	0.214
GC01	*31349.846*	30908.477	0.062	0.001	0.898	0.001	16.660	423.747
Gold Creek	*31469.946*	31018.160	0.062	0.001	0.902	0.001	16.660	434.160

Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
99.63%	0.00%	0.00%	0.00%	0.37%	0.00%	0.00%
90.37%	0.00%	0.16%	0.00%	9.46%	0.00%	0.00%
90.61%	0.06%	0.17%	0.00%	9.16%	0.00%	0.00%
88.69%	0.27%	0.12%	0.00%	6.33%	3.74%	0.84%
89.74%	0.25%	0.11%	0.00%	5.75%	3.39%	0.77%
89.94%	0.24%	0.11%	0.00%	5.64%	3.33%	0.75%
100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
99.98%	0.00%	0.00%	0.00%	0.00%	0.02%	0.00%
98.59%	0.00%	0.00%	0.00%	0.00%	0.05%	1.35%
98.56%	0.00%	0.00%	0.00%	0.00%	0.05%	1.38%

Table C-37: Flow contribution from sources (m3/d): Steady State Model - Exponential Recharge - LTC - SENSITIVITIES TO R

Sensitivity: R reduced by 50% *b91-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_Rx1.5.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	*13607.100*	13557.068	0.000	0.000	0.001	50.031	0.000	0.000
BC07	*16431.700*	14849.938	0.000	26.594	0.032	1555.136	0.000	0.000
BL02	*16977.700*	15383.398	9.628	28.807	0.148	1555.718	0.000	0.001
BC03	*24572.132*	21792.249	67.546	29.110	0.360	1556.280	919.326	207.261
BL01	*27088.532*	24308.614	67.555	29.112	0.361	1556.288	919.342	207.261
Blairmore Creek (BC01)	*27614.358*	24835.398	66.611	29.112	0.361	1556.288	919.332	207.256
D1	*51256.373*	51254.926	0.000	0.000	0.000	1.447	0.000	0.000
GC13	*3140.010*	3139.970	0.000	0.000	0.039	0.001	0.000	0.000
GC09	*12857.400*	12857.122	0.000	0.000	0.277	0.001	0.000	0.000
GC04	*28814.438*	28813.395	0.000	0.000	0.956	0.001	0.008	0.078
GC02	*29398.567*	29392.416	0.007	0.000	0.973	0.001	4.849	0.321
GC01	*47024.670*	46362.616	0.093	0.002	1.347	0.001	24.990	635.620
Gold Creek	*47204.970*	46527.291	0.093	0.002	1.352	0.001	24.990	651.239

	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	99.63%	0.00%	0.00%	0.00%	0.37%	0.00%	0.00%
BC07	90.37%	0.00%	0.16%	0.00%	9.46%	0.00%	0.00%
BL02	90.61%	0.06%	0.17%	0.00%	9.16%	0.00%	0.00%
BC03	88.69%	0.27%	0.12%	0.00%	6.33%	3.74%	0.84%
BL01	89.74%	0.25%	0.11%	0.00%	5.75%	3.39%	0.77%
Blairmore Creek (BC01)	89.94%	0.24%	0.11%	0.00%	5.64%	3.33%	0.75%
D1	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC13	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC09	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC04	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC02	99.98%	0.00%	0.00%	0.00%	0.00%	0.02%	0.00%
GC01	98.59%	0.00%	0.00%	0.00%	0.00%	0.05%	1.35%
Gold Creek	98.56%	0.00%	0.00%	0.00%	0.00%	0.05%	1.38%

Sensitivity: R Dump increased by 50% *b92-[73]_LTC_2046_Grassy_FM_Steady_EXP_Rx0.66.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	*5991.370*	5967.953	0.000	0.000	0.001	23.416	0.000	0.000
BC07	*7255.080*	6540.081	0.000	21.560	0.063	693.376	0.000	0.000
BL02	*7521.405*	6797.293	5.501	24.413	0.254	693.944	0.000	0.000
BC03	*10789.255*	9492.919	44.160	24.949	0.634	694.435	424.346	107.812
BL01	*11779.186*	10482.609	44.281	24.999	0.665	694.471	424.350	107.812
Blairmore Creek (BC01)	*11955.336*	10658.805	44.234	25.000	0.665	694.471	424.350	107.811
D1	*22816.726*	22816.639	0.000	0.000	0.001	0.086	0.000	0.000
GC13	*1225.320*	1225.265	0.000	0.000	0.055	0.000	0.000	0.000
GC09	*5845.370*	5844.740	0.000	0.000	0.630	0.000	0.000	0.000
GC04	*12755.673*	12754.566	0.000	0.000	1.102	0.000	0.004	0.001
GC02	*13096.037*	13090.933	0.012	0.000	1.126	0.000	3.804	0.161
GC01	*20932.047*	20541.674	0.139	0.004	1.612	0.000	9.965	378.653
Gold Creek	*21039.347*	20641.645	0.139	0.004	1.621	0.000	9.965	385.973

	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	99.61%	0.00%	0.00%	0.00%	0.39%	0.00%	0.00%
BC07	90.14%	0.00%	0.30%	0.00%	9.56%	0.00%	0.00%
BL02	90.37%	0.07%	0.32%	0.00%	9.23%	0.00%	0.00%
BC03	87.98%	0.41%	0.23%	0.01%	6.44%	3.93%	1.00%
BL01	88.99%	0.38%	0.21%	0.01%	5.90%	3.60%	0.92%
Blairmore Creek (BC01)	89.16%	0.37%	0.21%	0.01%	5.81%	3.55%	0.90%
D1	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC13	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC09	99.99%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
GC04	99.99%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
GC02	99.96%	0.00%	0.00%	0.01%	0.00%	0.03%	0.00%
GC01	98.14%	0.00%	0.00%	0.01%	0.00%	0.05%	1.81%
Gold Creek	98.11%	0.00%	0.00%	0.01%	0.00%	0.05%	1.83%

Sensitivity: R Dump increased by 50% *b83-[73]_LTC_2046_Grassy_FM_Steady_EX_Rdumpx1.5.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	*9080.710*	9036.736	0.000	0.000	0.001	43.973	0.000	0.000
BC07	*11491.000*	10070.011	0.000	26.055	0.038	1394.895	0.000	0.000
BL02	*11885.000*	10452.029	8.725	28.505	0.174	1395.568	0.000	0.001
BC03	*17256.452*	14783.864	59.895	28.882	0.420	1396.215	781.986	205.190
BL01	*18838.352*	16365.669	59.924	28.895	0.430	1396.241	782.002	205.190
Blairmore Creek (BC01)	*19143.378*	16670.820	59.799	28.896	0.430	1396.241	782.002	205.190
D1	*34149.001*	34147.551	0.000	0.000	0.001	1.449	0.000	0.000
GC13	*1999.080*	1999.034	0.000	0.000	0.046	0.000	0.000	0.000
GC09	*8669.800*	8669.429	0.000	0.000	0.371	0.000	0.000	0.000
GC04	*19211.231*	19210.226	0.000	0.000	0.968	0.000	0.006	0.031
GC02	*19653.449*	19647.401	0.008	0.000	0.987	0.000	4.787	0.265
GC01	*31642.446*	31005.789	0.097	0.002	1.394	0.001	15.857	619.307
Gold Creek	*31792.346*	31140.071	0.097	0.002	1.400	0.001	15.857	634.919

	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	99.52%	0.00%	0.00%	0.00%	0.48%	0.00%	0.00%
BC07	87.63%	0.00%	0.23%	0.00%	12.14%	0.00%	0.00%
BL02	87.94%	0.07%	0.24%	0.00%	11.74%	0.00%	0.00%
BC03	85.67%	0.35%	0.17%	0.00%	8.09%	4.53%	1.19%
BL01	86.87%	0.32%	0.15%	0.00%	7.41%	4.15%	1.09%
Blairmore Creek (BC01)	87.08%	0.31%	0.15%	0.00%	7.29%	4.08%	1.07%
D1	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC13	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC09	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC04	99.99%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
GC02	99.97%	0.00%	0.00%	0.01%	0.00%	0.02%	0.00%
GC01	97.99%	0.00%	0.00%	0.00%	0.00%	0.05%	1.96%
Gold Creek	97.95%	0.00%	0.00%	0.00%	0.00%	0.05%	2.00%

Sensitivity: R Dump reduced by 50% *b84-[73]_LTC_2046_Grassy_FM_Steady_EXP_SVY_Rdumpx0.66.dac*

	Baseflow	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	*9021.310*	8994.170	0.000	0.000	0.001	27.139	0.000	0.000
BC07	*10531.700*	9717.095	0.000	22.665	0.047	791.892	0.000	0.000
BL02	*10901.300*	10076.668	6.702	25.273	0.231	792.425	0.000	0.000
BC03	*15641.458*	14082.746	49.582	25.731	0.594	792.885	579.811	110.109
BL01	*17222.758*	15663.963	49.607	25.750	0.603	792.901	579.825	110.109
Blairmore Creek (BC01)	*17527.784*	15969.098	49.497	25.750	0.603	792.902	579.825	110.109
D1	*34079.001*	34078.689	0.000	0.000	0.001	0.312	0.000	0.000
GC13	*1989.260*	1989.208	0.000	0.000	0.051	0.000	0.000	0.000
GC09	*8659.510*	8659.039	0.000	0.000	0.471	0.000	0.000	0.000
GC04	*19202.532*	19201.563	0.000	0.000	0.963	0.000	0.005	0.001
GC02	*19640.446*	19635.001	0.011	0.000	0.985	0.000	4.285	0.164
GC01	*31119.039*	30715.066	0.137	0.004	1.475	0.001	10.916	391.440
Gold Creek	*31246.939*	30835.650	0.137	0.004	1.484	0.001	10.916	398.746

	Background	SZ1	SZ2	SZ3	North Dump	South Dump	Central Dump
BL03	99.70%	0.00%	0.00%	0.00%	0.30%	0.00%	0.00%
BC07	92.27%	0.00%	0.22%	0.00%	7.52%	0.00%	0.00%
BL02	92.44%	0.06%	0.23%	0.00%	7.27%	0.00%	0.00%
BC03	90.03%	0.32%	0.16%	0.00%	5.07%	3.71%	0.70%
BL01	90.95%	0.29%	0.15%	0.00%	4.60%	3.37%	0.64%
Blairmore Creek (BC01)	91.11%	0.28%	0.15%	0.00%	4.52%	3.31%	0.63%
D1	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC13	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GC09	99.99%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
GC04	99.99%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
GC02	99.97%	0.00%	0.00%	0.01%	0.00%	0.02%	0.00%
GC01	98.70%	0.00%	0.00%	0.00%	0.00%	0.04%	1.26%
Gold Creek	98.68%	0.00%	0.00%	0.00%	0.00%	0.03%	1.28%

APPENDIX D: FIELD PROCEDURE

FIELD PROCEDURES

The following provides a description of the monitoring well drilling, installation and development, groundwater monitoring and sampling and slug testing.

1.0 MONITORING WELL DRILLING, INSTALLATION AND DEVELOPMENT

1.1 General

1. All dimensions, depths, purge volumes are to be recorded and dated.
2. All wells should typically be constructed using 51 mm (2 inch) ID PVC pipe.
3. Screen should typically be 10-slot openings.
4. If a sand pack is required, it should be made using 10-20 sand or equivalent.
5. Silt socks may be placed over the screen when installing in very fine grained materials.
6. All wells are to have steel surface protector sealed into place. Protector is to have a lockable lid with padlock.
7. Development is to be by bailer, air lift, pump and/or Waterra until water is acceptably free of sediment.
8. Slug test is to be done with bailer or solid slug.
9. All wells are to have elevation of top of casing established to a common datum.
10. Name and depth of well are to be written on the well cap inside the surface protector.

1.2 Monitoring Well Drilling and Installation

Monitoring wells are drilled using solid stem or hollow stem auger, mud or air rotary rig or, in certain cases, a sonic rig. The diameter of the hole varies depending on the drilling methods, but is typically about 6 to 7 inches in diameter, allowing for the completion of a well.

During drilling, cuttings are collected and logged to provide a geological description of the units encountered. Information recorded includes depth, primary and secondary texture, percentage of coarse fragment, colour, moisture, consistency or strength. Based on the lithological log, an interval to be screened is selected for completion of a monitoring well.

Monitoring wells are completed typically using 51 mm (2 inch) schedule 40 solid PVC pipes for the well casing and 51 mm (2 inch) schedule 40 machine slotted 0.0010 PVC pipe for the well screen. For wells installed to depths greater than 40 m schedule 80 PVC casing and screen should be used. Well casing and screens can be threaded together to the desire length, and the bottom of the well is sealed using a bottom cap. The filter pack either consists of the natural formation (for lose medium- to coarse-grained sands) or is artificially made (for well packed sand or fine-grained material) using 10-20 Colorado Silica Sand. The filter pack is brought to a minimum of 0.3 m to 0.5 m above the top of the screen. The well is then sealed using about 0.5 m of bentonite pellets, then bentonite chips to surface. For wells exceeding a total depth of 30 m, cement or high solids bentonite grout may be used to complete the seal. The well casing is cut approximately 1 m above ground surface and protected using a lockable casing protector. All well completion details are recorded with the lithological log.

1.3 Well Development

Well development is conducted following well installation and consists in purging 20 liters per metre of standing water or until the well is dry, whichever comes first. At the end of the purging, water should flow clean. If this not the case, additional purging should be considered.

Purging can be conducted using dedicated weighted bailer, waterra, air lift with a compressor or a submersible pump (*e.g.* Grundfos, or whale pump) as appropriate. Purging details including date, volume and method employed should be recorded.

2.0 GROUNDWATER MONITORING AND SAMPLING

2.1 General

1. Appropriate bottles, preservatives, *etc*. from the laboratory are to be ordered allowing for duplicates, as required, and possible breakage.
2. Current depth to water in the well is to be measured. The presence and thickness of any free phase product should also be measured.
3. Well to provide the duplicate sample is selected.
4. Monitoring well is to be purged of three well volumes or until dry. Purge water is to be collected for disposal, as appropriate. Amount purged is to be measured and recorded.
5. Field parameters of EC, temperature and pH are to be measured and recorded. Compare to previous measurements and determine if there is need for further purging.
6. Labelled sample containers are to be filled using dedicated sampling equipment, filtered and preservative added as appropriate.
7. Duplicate samples are to be collected.
8. Any field equipment; *i.e.*, water level tape, field chemistry probe, *etc*. is to be rinsed and, as appropriate, decontaminated before moving to the next well.
9. Samples are to be packed in cooler with ice; keep them from freezing and shipped or delivered to the receiving laboratory.

2.2 Water Levels Monitoring

Water levels are typically measured using a Solinst water level tape. If product is anticipated or suspected to be present, an interface probe is used instead. The proper probe or water level tape is selected prior to heading in the field, after reviewing historical data.

In the field, water levels are typically measured in metres below the top of casing. The measuring tape or probe is rinsed (or decontaminated) as appropriate between wells. Depth to water as well as the date, time and weather conditions are recorded on the field sheet.

2.3 Groundwater Sampling

Groundwater sampling is conducted after monitoring water levels so the amount of water to be purged can be calculated. Typically, monitoring wells are purged 6 liters per meter of standing water (water column) or until the well is dry. Purged water is collected for later disposal as required. Volume purged, method used (*e.g.* bailer, waterra, *etc.*), date and time are recorded on the monitoring sheet. Water level is then allowed to recover prior to sampling the well. If the well is slow to respond this could take several days; however, sampling should be conducted with 24 hours of purging wherever possible.

Sampling is conducted using appropriate bottles (or containers) and preservative as supplied by the laboratory. All bottles and container are labelled prior to sampling (including well ID, sampling date and time, and parameters to be analysed). Field parameters including electrical conductivity (EC), pH and temperature are measured and recorded on the field sheet. Values should be compared to prior sampling events to determine if further purging is required. Laboratory bottles are filled using dedicated sampling equipment, filtering and adding preservative as required. Duplicate samples are collected at selected wells concurrent with the non-duplicate for that well for each individual bottle to be sent to the laboratory. This means for instance: the trace elements sample for regular analysis for that well is collected simultaneously with the duplicate sample. Field equipment (including the chemistry probe) are rinsed or decontaminated as appropriate between each wells. Purged water is disposed of as appropriate.

Groundwater samples are packed in coolers with ice, but keeping them from freezing and shipped or delivered to the receiving laboratory. The chain of custody (CoC) is filled in the field and provided to the laboratory with the samples.

Upon returning from the field, notification is provided to the data manager to enter data collected in the field into the database ESDat. The data manager ensures the laboratory results are returned with a reasonable turnaround time and review the quality of the data (including a review of the duplicate data) following MEMS QA/QC procedures. Anomalous data are flag for review to take appropriate actions, as needed.

3.0 HYDRAULIC CONDUCTIVITY TESTING

3.1 General

1. Well construction and available historical data are to be reviewed to select the appropriate testing method. Order the proper equipment (*e.g.* pressure transducer with appropriate reading range, solid slug, bailer, pneumatic tester).
2. Current depth to water in the well is to be measured. Confirm pre-test water level has stabilized.
3. Pressure transducer (level logger or level troll) is to be programmed selecting an appropriate reading interval.
4. Pressure transducer is to be installed in the monitoring well (at the proper depth selected) and left in for 5 to 10 min for the pressure to equilibrate and for the pressure transducer to record the pre-test water level.
5. Hydraulic test is to be conducted by removing a slug of water (typically 1L liter using a bailer), adding a solid slug or using the pneumatic tester. The test is to be repeated as needed to conduct an additional test, which may be accomplished by removing the solid slug, if applicable.
6. Water level is to be measured at the beginning of the test and during the recovery to assess when the test is completed (*i.e.* when water level has recovered 67% or more).
7. Once the test is complete, the pressure transducer is to be retrieved from the well and the data downloaded.
8. Back at the office, the hydraulic conductivity test is to be solved using AQTESOLV.

3.2 Field Testing

Hydraulic conductivity testing is conducted at monitoring wells, as required, after the well has been properly developed and the water level has stabilized. In some instances, a preliminary test may be conducted during well development to obtain preliminary results as an order of magnitude.

Appropriate methods to conduct slug tests include bailing a known volume of water (typically 1 liter using a dedicated bailer for the well), inserting a solid slug of known volume or using a pneumatic tester (for high hydraulic conductivity typically higher than 1×10^{-5} m/s). Water levels are recorded during the test using pressure transducers (level logger or level troll), but manual readings are also collected as a back-up and to monitor the percentage of recovery. A test is considered complete if water level has recovered at least 67% to the pre-test water level. Slug test data are downloaded in the field and checked to confirm whether the test is satisfactory or whether re-testing is required.

Slug test conducted in low conductivity (less than 1 x 10^{-7} m/s) material may take several days to be completed. For such units, a barometric logger is used in addition to the pressure transducer to record the atmospheric pressure in order to compensate the pressure readings collected by the pressure transducer.

3.3 Data interpretation

Data collected in the field is analysed in the office using AQTESOLV. Data from the pressure transducers are compensated for barometric pressure effect, as required. The data are then analysed using the appropriate solving method including, but not limited to, Bouwer-Rice, Hvorslev, KGS and Butler-Zhan.