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2.6 Surface Water Information

This section has been developed in accordance with:

- Section 38-14.1-14(1)(n)(o)(p), North Dakota Century Code (NDCC);
- Section 38-14.1-27(b), NDCC;
- Section 69-05.2-08-02, North Dakota Administrative Code (NDAC);
- Section 69-05.2-08-04(1)(2), NDAC;
- Section 69-05.2-08-07, NDAC;
- Section 69-05.2-09-12(1)(2), NDAC; and
- Section 69-05.2-16-05, NDAC.

South Heart Coal, LLC (SHC) intends to develop the South Heart Lignite Mine located in Stark County, North Dakota. The Surface Water Study Area (Primary Study Area) shown in Figure 2.6-1 includes the area within the Permit Boundary and adjacent areas. The Extended Surface Water Study Area (Secondary Study Area) includes the Heart River watershed upstream of the town of South Heart, the South Branch Heart River, the Norwegian Creek watershed, and contributing subwatersheds. Figure 2.6-1 also shows the downstream watershed below the town of South Heart to the Patterson Dam just west of the town of Dickinson, North Dakota.

This section presents a description of the existing hydrological and current surface water conditions in the study areas. The rivers, streams and channels of the Heart River and South Branch Heart River within the Primary Study Area were characterized through hydrometric (gaging) stations and water quality sampling and analyses. Selected existing reservoirs and stock ponds within and adjacent to the Primary Study Area were also characterized for water quality and quantity. Selection criteria for stock pond characterization were developed with the intent to incorporate a representative sampling of the various watersheds within the Primary Study Area. All identified stock ponds were cataloged as a part of the Surface Water Structure Survey. Stock tanks and ponds fed by wells were not characterized.

Also, included in this section is a discussion of surface water Probable Hydrological Consequences resulting from proposed mining operations. A monitoring plan for future activities is provided.

2.6.1 Site Geomorphology

2.6.1.1 Watershed Description

The Primary Study Area is characterized by gentle topography with variable relief ranging from 100 to 200 feet (ft) within drainage sub-basins. The drainage density is relatively low (about three miles per square mile) with vegetated watercourses and sheet flow providing for most surface water conveyance. Few alluvial watercourses,(comprising mainly the Heart River, South Branch Heart River, and a few channels of the larger sub-basins) were identified. Major drainages within the Primary Study Area include:

- A portion of the Heart River;
- The South Branch Heart River – an intermittent tributary flowing northeast through the Primary Study Area into the Heart River;
- An ephemeral tributary (West Tributary) which flows from west to east through the Primary Study Area into the South Branch Heart River;
- An ephemeral tributary (South Tributary) which flows from south to north into the South Branch Heart River; and
- Additional minor ephemeral drainages to the Heart River and South Branch Heart River.

The Secondary Study Area includes a portion of the Heart River watershed and the South Branch Heart River watershed. The Secondary Study Area lies in the Missouri Slope Upland physiographic region, which is characterized by rolling hills with shale and sandstone bedrock (Missouri River Basin Commission 1978, Biek and Murphy 1997). The 1:250,000-scale digital elevation model (DEM) for the watershed indicates that there is a total elevation change of 607 ft from the headwater regions of the Heart River to Patterson Lake, and an overall gradient of 0.43 percent (USGS 2006). The maximum elevation, 3,002 ft above mean sea level (amsl), is located in the headwaters of Bull Creek. The minimum elevation, 2,395 ft amsl, is located near Patterson Lake.

The Heart River begins in the prairie of Billings County, North Dakota in the Little Missouri National Grassland near the South Unit of Theodore Roosevelt National Park. It generally flows eastward, approximately 180 miles, through Stark County near the towns of Belfield and South Heart toward Patterson Lake. Approximately 15 miles downstream of the Primary Study Area, the Heart River is impounded by the Patterson Lake Dam, impounding Patterson Lake. The Heart River flows through Patterson Lake and downstream past Dickinson. It is joined by the Green River at Gladstone, and turns east-southeastward into Grant County, passing through Lake Tschida, which is formed by the Heart Butte Dam. Below this dam, the river turns northeastward into Morton County where it joins the Missouri River at Mandan, North Dakota.

The South Branch Heart River is a major tributary to the Heart River, originating in the southeast corner of Billings County. From the headwaters, it flows northeast through Stark County to its confluence with the Heart River near the town of South Heart immediately adjacent to the Primary Study Area.

Norwegian Creek is a smaller tributary of the Heart River; its confluence with the Heart River is located just upstream of the Primary Study Area (EPA 2002). The primary land use within this watershed is dry land agricultural. Erosion within the watershed is at times severe as a result of extensive cultivated and grazed agricultural lands (Wax 2006).

The occurrence of alluvial channels appears to be related mainly to the size of the watershed and channel gradient. Existing alluvial channels are typically characterized by a primary channel in a confined valley with terraces. The primary channel has near-vertical side slopes with widths varying from approximately 3 ft to 20 ft. The alluvial channels have beds and banks composed of silty-clay material. Most of the watercourses are dry in the summer. Some of the alluvial channels, such as the Heart River, are wet in the summer and convey small amounts of discharge.

2.6.1.2 Channel Characterization

Golder Associates Inc. (Golder) conducted a geomorphic survey of the Primary Study Area in May 2007. Geomorphic features surveyed within the South Branch Heart River drainage system include 8 alluvial sites, 14 vegetated sites, and 2 erosional sites (mapped as SA, SV, and SE in Figure 2.6-2, respectively). Two alluvial channels and 11 vegetated watercourses were surveyed within the Heart River drainage system.

Field data collected at each alluvial site includes the following:

- Description of bed, bank and floodplain sediment material of alluvial channels;
- Presence and width of active floodplain;
- Cross section survey of up to three transects at each site, depending on the uniformity of the geomorphic characteristics along the reach, to identify bankfull, terrace and floodplain levels with respect to the channel bottom;
- Water level in the channel at the time of the survey;
- Cross section survey of each vegetated site to identify the base width;
- Profile survey to determine the channel local gradient and bank slope;
- Type of vegetation across floodplains of alluvial channels and in vegetated channels; and
- Photographs to document the conditions at the time of the survey.

A summary of the channel characteristics, including cross-sections, was provided in the report "*Alluvial Valley Floor Study, South Heart Project, Stark County, North Dakota, Revision 4*" to assist the Public Service Commission (PSC) with evaluating the presence of Alluvial Valley Floors in and adjacent to the SHLM. The report is discussed in more detail in Section 2.8. The geomorphic field data collected at the alluvial sites were used in combination with information obtained from topographic maps to develop geomorphic relationships between channel type and slope, drainage area, and maximum overland flow path length. The relationships between the drainage area and channel are presented in Figure 2.6-3 and the relationship between overland flow path length and ground slope is presented in Figure 2.6-4. Table 2.6-1 provides geomorphic characteristics (field-based and map-derived) of the alluvial sites surveyed.

Overland flow path lengths and local slopes were obtained from topographic maps for 30 sites in the Primary Study Area. Two slopes were measured: 1) a local slope at the downstream end of the flow path length (terminal slope), and 2) an average slope of the flow path length (average slope). Maximum overland flow path lengths within the Primary Study Area ranged from 150 ft for a 0.25 slope to 1,500 ft for a slope of 0.02.

2.6.1.3 Potential Erosion Features Survey

Significant agricultural activity in the Primary Study Area was identified; therefore, erosion sites tend to be roads, road crossings and corrals. Three typical erosion sites in the Primary Study Area were inspected in May 2007. Two of these sites are labeled SE1 and SE3 in Figure 2.6-2. A brief description of the observations at each site is provided below.

South Heart Erosion Site SE1

Erosion site SE1 within the Primary Study Area consists of a road that crosses an alluvial tributary to the South Branch Heart River, as shown in Figure 2.6-2. The roadway crest elevation is at the height of the upper terrace, traversing the entire width of the active floodplain. Two large culverts (C27A: 27 inches and C27B: 30 inches) convey water flows under the roadway, one at the main channel and one at a side channel that appears to be active only in large flow events. During high flow events, flow that would normally spread out onto the floodplain is obstructed by the roadway and conveyed through the two culverts. The concentrated, high velocity flow through the culverts has created scour holes downstream of the roadway. Accelerated bank erosion at this site may result in higher sediment concentrations locally.

South Heart Erosion SE3

Erosion site SE3 consists of a tractor crossing location on the Heart River about 300 ft downstream of SA9, as shown in Figure 2.6-2. The wheel ruts run perpendicular to the bank and are causing considerable headward erosion in this direction.

2.6.2 Structures and Ponds

Golder identified existing man-made water structures and documented their locations using hand-held GPS units during the development of the Surface Water Baseline Study. The structure survey within the Primary Study Area was completed on May 20 and 21, 2007. Thirty-six culverts, one bridge, and twenty earthen dams were identified by the survey. The ponds created behind earthen dams are classified as livestock (stock) ponds. The survey was limited to those stock ponds that have been constructed within drainageways. Seven additional ponds (excavated and without earthern dams) were identified in the fall of 2006, prior to the structure survey.

Table 2.6-2 provides culvert diameters and Table 2.6-3 provides the length and structure type for each bridge and dam. Table 2.6-4 lists all identified ponds and provides basic descriptions of each including location, use, estimated volume, and probpable impacts from mining.includes the excavated stock ponds identified during the initial site investigations in the fall of 2006. Figure 2.6-5 shows the locations of structures identified during both surveys.

One bridge structure was identified within the Primary Study Area. Bridge B-23 is located in Section 23 near the west section line, and spans the South Branch Heart River. The bridge is a concrete structure, that is 85-ft long and 12-ft high. It has a road way width of 35-ft, and two intermediate supports.

Land Use Considerations for Stock Ponds

Land use issues related to stock ponds are included in Land Use Section 2.7-1 of the permit application. Westech completed a wildlife field baseline study in the spring of 2007. The baseline study identified the presence of ducks nesting around the stock ponds as well as other water-related birds (e.g., red-winged blackbird, yellow-headed blackbird, and killdeer). Most of the duck nests found were located in vegetated drainage bottoms upstream and downstream from the stock ponds. Other wildlife that seem to benefit from the stock ponds include frogs, garter snakes, turtles, raccoons, and white-tailed deer. Therefore, the ponds are considered to be small but important wildlife features.

Most of the existing stock ponds are located along smaller drainages where riparian grasses and shrubs grow upstream and downstream.

2.6.3 Surface Water Quantity

Characterization and quantification of stream flows and water volumes consisted of historic data review and surface baseline field measurements. Streams in and near the Primary Study Area are generally ephemeral or intermittent except for the perennial Heart River near the town of South Heart. As described in Section 2.6.1, the Primary Study Area includes intermittent and ephemeral channels and vegetated drainages.

For evaluation of surface water, these drainages were divided in eight individual catchment areas within the Primary Study Area. The drainage areas of these catchments range from 261 square miles (mi^2) for the Heart River downstream of the Primary Study Area to 1.5 mi^2 for the upstream end of the West Tributary (Figure 2.6-6A). The water gaging stations for the current baseline study and watersheds for each catchment within the Primary Study Area are shown on Figure 2.6-6B, in accordance with Public Service Commission (PSC) regulation 69-05.2-08-07(1). Table 2.6-5 summarizes the drainage area for each catchment.

Historic data augmented by additional field measurements support the characterization and quantification of stream flows and water volumes within the Primary Study Area. Long-term (greater than 30 years) historic water quantity data is available for the Heart River at the U. S. Geological Survey (USGS) gaging station 06343000 in the Heart River near the town of South Heart (USGS 2007) downstream of the Primary Study Area – which includes drainage SHHR-01 and SHHR-02. Short-term (less than 5 years) historic water quantity data is available for the South Branch Heart River (USGS gaging station 06342900) and Norwegian Creek (USGS gaging station 06342850). Although the gaging station at North Creek (USGS gaging station 06342970) is outside of the Secondary Study Area, flow from this stream contributes to the flow at the gage on the Heart River and was therefore evaluated (USGS 2007). Table 2.6-6 provides a summary of information for the four gages evaluated

2.6.3.1 Historic Water Quantity Data

The USGS gaging station 06343000 was used for historic flow reference related to the Primary Study Area. The USGS gaging stations 06342900, 06342850, and 06342970 are located upstream of USGS Station 06343000.

Stream flow represents the final output of water in the hydrologic cycle as it moves in the watershed. It is the most visible component of the hydrologic cycle and a key component of many ecological systems within a watershed. Stream flow is influenced primarily by climatic factors, but it is also influenced by land use and ground water.

Heart River stream flow generally takes several forms, including baseflow, high-sustained flows, and high pulse flows. Each of these flow levels serves various functions within the watershed. These flow levels provide for a variety of beneficial uses for both aquatic life and the human population within the watershed.

Surface water flows in the lower watershed on the agricultural lands is driven by snowmelt and precipitation events. Flow records indicate low discharges, generally baseflow, through the winter months with an increase during March and April, resulting from snowmelt. Large flows during summer and fall are attributed to precipitation events.

According to Armstrong (1984), the baseflow of the Heart River is generally less than 1 cubic foot per second (cfs). The baseflow source is ground water seepage from sandstone or lignite beds or underflow from stream sediments. Table 2.6-7 provides the average monthly baseflow as determined by the modeling program PART (Rutledge 1998) which was used to process baseflow measured at the USGS gage on the Heart River (06343000). The program is based on stream flow partitioning using daily stream flow measurements and designates days when baseflow is equal to stream flow based on antecedent stream flow (contrasted to antecedent precipitation with some other methods) and linear interpolation for days when surface runoff occurs. The results, shown Table 2.6-7, indicate that the months of March and April contribute significantly to the total annual baseflow. Over the full year, calculated baseflow is 4.3 cfs. However, considering that baseflow for half the year is less than 0.02 cfs, an annual value of 4.3 cfs is not representative. Excluding the months of March and April when stream flow is dominated by snowmelt, calculated baseflow is 1.1 cfs, which is consistent with the maximum value reported by Armstrong (1984).

Table 2.6-8 provides the average monthly stream flow for the Heart River, South Branch Heart River, Norwegian Creek, and North Creek. The total flow within the South Branch Heart River, Norwegian Creek, and North Creek is significantly less than the flow in the Heart River as presented in Table 2.6-8. For instance, only 0.5 percent of the measured flows in the Heart River returned no flow while 50 percent of the measured flows for the South Branch Heart River returned no flow, 82 percent for Norwegian Creek returned no flow, and 51 percent for North Creek returned no flow. In these smaller streams, flow appears to be entirely dominated by snowmelt and precipitation events. This indicates insignificant or zero baseflow to the South Branch Heart River, Norwegian Creek, and North Creek; therefore, a detailed baseflow analysis was not completed.

Monthly Average Flows

Several methods can be used to evaluate stream flows. Annual averages (or means) are commonly used to evaluate inter-year trends. A total monthly or yearly flow volume plot can be useful in determining if there has been a change in stream flow levels over the long term.

Monthly averages (or means) may be used to evaluate inter-year flow trends on a monthly basis as well as intra-year flow trends. Monthly averages aid in visualizing the relative contribution of monthly flows to total annual flows as well as monthly flows interrelationships. In addition, monthly averages can indicate how monthly values vary with annual increases or decreases in precipitation and snow pack. Mean monthly flows for the Heart River near South Heart at USGS Gage 06343000 are shown in Table 2.6-8.

Time-Series Hydrographs

A hydrograph presents stream flow in a basic form – stream flow (or stage) versus time. A hydrograph can provide very detailed information when completed on a daily or hourly time step. Actual hydrographs, as opposed to aggregates, are used to describe the elements or phases of the hydrologic cycle and provide the best insights into specific hydrologic responses. Unfortunately, because of the complexity of hydrograph response, it may be difficult to automate or numerically analyze individual hydrographs. Therefore, analysis is often best completed through observation. A mean daily flow hydrograph of the Heart River stream flows is presented in Figure 2.6-7.

Exceedance Probability Analysis

Exceedance probability plots were developed from the USGS gage near South Heart to define the likelihood of flow values throughout the year. The exceedance probability charts were developed from historic data and represent the probability of the stream flow exceeding the given flow value at that time of the year. The historic record is approximately 40 years long and represents a maximum probability of 1/40 or 2.5 percent. Statistically, a reasonable degree of confidence can be extended to show the 10 percent and 90 percent exceedance values. Figure 2.6-7 presents the 10 percent, 50 percent and 90 percent daily flow exceedance curves at the USGS stream gages near the town of South Heart. The upper and lower lines (90 percent exceedance and 10 percent exceedance) define the 80 percent confidence envelope, which is historically 80 percent of the observed flows between these two lines.

2.6.3.2 Surface Water Gaging Stations

Flumes and well-type gaging stations were installed between November 2006 and November 2007 to measure stage height along primary and secondary drainages and selected other minor channels within the Primary Study Area. Surface water flows were calculated from stage height to characterize seasonal variations. Stage height was measured at theSurface water flows for the Primary Study Area were measured to identify seasonal variations for the Heart River and intermittent and ephemeral tributaries within the Primary Study Area. Surface water flow was measured at 8 flume- or well-type gaging stations installed and located during the current baseline study within these catchments on or near the Primary Study Area. The gaging stations are shown in Figure 2.6-6B and summarized as follows:

- Heart River
  - SHHR-01 - located upstream of the proposed SHLM
  - SHHR-02 - located downstream of the proposed SHLM and downstream of the confluence of the South Branch Heart River with the Heart River
- South Branch Heart River
  - SHSB-03 - located upstream of the proposed SHLM
  - SHSB-03A – located upstream of the proposed SHLM, downstream of SHSB-03
  - SHSB-01 - located downstream of the proposed SHLM
- South Tributary
  - SHUN-03 - located on upstream of the proposed SHLM
  - SHUN-04 - located immediately upstream of its confluence with the South Branch Heart River
- West Tributary
  - SHUN-02 - located approximately mid way along the channel of the West Tributary
  - SHUN-01 - located near the mouth of the West Tributary, upstream of its confluence with the South Branch Heart River, and downstream of SHUN-02

- Three stations located upstream from proposed mining activities include:
  - SHHR-01 located on the Heart River;
  - SHSB-03 located on the South Branch Heart River; and
  - SHUN-03 located on the South Tributary.
- Three stations located downstream from proposed mining activities include:

- SHHR-02 located downstream on the Heart River;
- SHSB-01 located downstream on the South Branch Heart River; and
- SHUN-04 located on the South Tributary just upstream of its confluence with the South Branch Heart River.

- Two stations located on the West Tributary include:
  - SHUN-02 located approximately mid way within the West Tributary; and
  - SHUN-01 located near the mouth of the West Tributary.

The station locations were selected based on criteria listed in Table 2.6-9. Flumes were sized based on USGS stream flow hydrographs and pro-rated to the watershed area reporting to pre-selected gaging locations. The primary purpose of the flumes is to accurately measure low flow conditions. Well-type stations were installed along the Heart River where channel and flow conditions made flume installation impractical. Table 2.6-10 provides a summary of information for each gaging station installed for the current baseline study. The information includes the station ID, watershed area in square miles and flume size and type.

The primary measuring devices (flumes) were sized based on USGS stream flow histograms and pro-rated to the watershed area reporting to pre-selected gaging locations. The primary purpose of the gaging stations is to accurately measure low flow conditions. High flow is being recorded for reference only and is based on cross sections surveyed on natural terrain.

Stage height at each station was recorded using pressure transducers and data loggers recording at 5-minute intervals between November 2006 and December 2009. For most gaging stations, the transducers were either removed from the streams or affected by ice from approximately late October or early November through mid-March, resulting in data gaps during the winter months. SHSB-01 was equipped with a heating unit that inhibits freezing, allowing monitoring throughout the winter.

Continuous data collection is achieved through In-Situ Level Troll 500 (Troll 500), a self-contained, automated, high-capacity, programmable datalogger. The instruments contain a long-lasting battery pack, pressure transducer, temperature probe, and data storage. The instruments are vented to the atmosphere to measure gauge pressure and avoid recording flow depth variations resulting from fluctuations in atmospheric pressure.

The pressure transducers were installed vertically in the flume stilling wells and were anchored with U-bolts. A plastic coated metal conduit protects the vented cable from the transducer to the weather sealed box which is mounted above the ground at the end of the flume wing walls. The vented cable terminates with a small desiccant cap in the weather sealed box.

All Troll 500s were programmed to record water level in ft, temperature in degree Celsius (°C), and gauge pressure in pounds per square inch (psi) at 5 minute intervals. The loggers were set to overwrite the oldest data when the memory is full. The dataloggers have a storage capacity of 90 days at the programmed five-minute recording interval; therefore, given that data download has been scheduled on a monthly basis, data overwrite did not and will not occur. The media was set to fresh water with a specific gravity of 0.999. The Troll 500 used Firmware version 2.02. The water level reading was calibrated to zero by filling the stilling wells with distilled water.

Flumes were established and data recording began in November or December of 2006, depending on the station. Daily average flows were calculated from the measured stage heights using the rating curves specific to each flume or developed from channel profiles for well-type gaging stations (Table 2.6-5). Stage data from the transducers were processed as follows:

- If the temperature recorded by the transducer was above freezing, daily average flow was calculated from the stage heights.
- If recorded temperatures were below freezing (0° Celsius), streams were assumed to either not be flowing, or any flow that was measured was assumed to be influenced by ice. If more than 6 hours with 50 percent or more of the 5-minute data points indicated temperature recordings at or below freezing, that day was designated as “ice-influenced”. Ice-influenced days were given the designation “ICE”, and no daily average flow was calculated for these days.
- If the number of ice-influenced points fell below this threshold, all stage heights recorded when the temperature recording was above freezing were used to calculate a daily average flow.
- In the event that stage exceeded flume height, daily average flows were calculated using maximum flume height, and then flagged with “FE”.

- In the event that the calculated average daily flow fell below the minimum measureable flume flow, the daily average flow was set to 0 cubic feet per second (cfs).

Daily average flows at each of the gaging stations are pPresented in Appendix 2.6-1 as hydrographs and tables. Surface water flows along each monitored drainage are discussed below., are the flow hydrographs for all eight stations (in cfs). The flow data collected were converted to flow (cfs) by an empirical relationship with the height of the flume at that station developed from data provided by the flume manufacturer, or profile of the channel for well-type gaging stations. For reporting and processing purposed, flow calculation data were selected (filtered) by the following criteria:

- Recorded temperature below 0°C = invalid data (frozen flume stilling well).
- Recorded as negative head = 0 (no flow). Negative values resulted and were recorded because by design, the flume stilling well bottom is located below the invert of the flume.
- Recorded head greater than flume height full flume capacity, as reported by manufacturer, FreeFlow Inc. (Gretna, Nebraska; www.freeflowinc.com/capacity.htm). This approach was taken because the primary purpose of stream gaging is to accurately record low flow; therefore, the maximum measuring capacity of the flumes is less than peak storm event flows.

Flow was calculated from head in the H flumes using unique equations fitted for each flume size (1.0, 1.5, and 2.0 ft). The equations were derived from curve fitting to measured flow data provided by FreeFlow Inc. The different curve fit equations and applicable flow depths are presented in Table 2.6-11.

All valid data points, as determined by the filters developed for calculating flow from head, are shown on the hydrographs for the stations (Appendix 2.6-1). Appendix 2.6-1 data illustrate the seasonal variation for the surface water quantity for the Primary Study Area.

Heart River

Heart River flows were monitoring by two gaging stations, SHHR-01 and SHHR-02. Stage heights were converted to flows using a rating curve developed from measured stream cross sections and manual stream discharge measurements. Rating curves were difficult to develop due to changing hydraulic conditions with different stage heights and challenges in manually measuring a range of flows to develop a more accurate rating curve. High flows tend to occur quickly and with high intensity making manual flow measurements difficult and dangerous to obtain. The rating curves, therefore, represent an estimate of flow and not an exact value.

Between November 2006 and December 2009, estimated flow at SHHR-01 ranged from 0 to 6 ~~cubic feet per second (~~cfs~~)~~, with an average daily flow of 1 cfs. Downstream of SHHR-01, estimated flow at SHHR-02 ranged from 0 to 14 cfs, with an average daily flow of 1 cfs. Flow overtopped the stream banks for both SHHR-01 and SHHR-02 between March 16 and 23, 2009 and April 12 and 16, 2009 due to an ice dam that formed downstream of the gages and backed up flow. Rating curves relating the stage measurements to discharge for these gages no longer apply when streamflow exceeds the stream banks, therefore calculated flows for these dates are deemed invalid and were not included in the calculations of maximum and mean average daily streamflows.

South Branch Heart River

South Branch Heart River flows were monitored at three gaging stations, namely SHSB-03, SHSB-03A, and SHSB-01. Flow at SHSB-03 may not be representative of actual flow in the South Branch Heart River because it was located near a beaver pond which likely created backwater conditions. Flow measurements at SHSB-03 were discontinued in November 2007. A new station, SHSB-03A, was established approximately 1.8 miles downstream from SHSB-03 and began measuring flows in March 2008.

Minimum daily average flows along the South Branch Heart were 0 cfs at all locations while maximum daily average flows ranged from 6 cfs at SHSB-03A to 11 cfs at SHSB-01. Mean daily average flows ranged from 0.2 (SHSB-03A) to 0.9 cfs (SHSB-03A). Flows measured at SHSB-03, as discussed above, were likely erroneous due to backwater from a beaver pond and were not consider in assessing variations in spatial and temporal trends in flow. No distinct seasonal variation was observed in gages SHSB-03A and SHSB-01, other than slightly higher flow in the spring of 2009 at SHSB-01. Flow was typically close to zero at SHSB-03A and SHSB-01, with distinct peaks in response to precipitation events from approximately May through November. Flow was generally not measured in the winter months due to the removal of transducers (SHSB-03A), or equipment issues (SHSB-01). Limited data was collected during the winter of 2007 at SHSB-01, during which time flows were at or near 0 cfs.

South Tributary

South Tributary flows were monitored at SHUN-03 and SHUN-04. Minimum flow at both gages was 0 cfs, maximum average daily flow was 1.5 cfs (SHUN-03) and 5.4 cfs (SHUN-04), indicating an increase in flow downstream. Both locations along the South Tributary had flows typically close to 0 cfs, and responded quickly to precipitation events throughout the spring and summer months. Flow was generally not measured in the winter months because transducers were removed to avoid freezing; however, some flow measurements were collected in January and February of 2007 at SHUN-03, indicating relatively lower flow (0 to 0.2 cfs) in the winter months.

West Tributary

West Tributary flows were monitored at SHUN-02 and SHUN-01. The West Tributary at the gaged locations rarely had any flow, with a minimum average daily flow of 0 cfs at both stations, and a maximum average daily flow of 1.3 cfs at both stations. Mean average daily flow was 0.01 cfs (SHUN-01) and 0.05 cfs (SHUN-02), indicating a slight decrease in flow downstream between these two gages. The infrequent flow events generally occurred in spring and fall.

~~Only two hydrographs were developed for stations SHHR-01 and SHSB-03 because no valid hourly average flow were selected before March as determined by the filters. Limited data is reported for three gaging stations (SHUN-01, SHUN-02, and SHUN-04) because the transducers provided unreliable data when damaged by freezing conditions. As a result, only data subsequent to the repair in late April are reported. Data from two nearby USGS gaging stations were acquired from the USGS North Dakota Water Science Center in an attempt to supplement the collected data. However, USGS also flags the data where ice was in the flumes as invalid and this "non-data" period spanned nearly all data points from November through March, overlapping nearly 100 percent with the "non-data" period collected for these stations.~~

~~When inspecting these hydrographs, one should note the different scale used on the y-axis between the stations. While the high flow recorded for SHHR-01 (which did not place a ceiling on the value for calculated flow) is over 200 cfs, the peaks for SHUN-01 and SHUN-02 are many orders of magnitude lower at 0.0008 and 0.003 cfs, respectively. This is consistent with Golder's site observations, where no surface water flow was observed in the channel at either SHUN-01 and SHUN-02.~~

2.6.3.3 Surface Water Rights

Surface water rights were assessed through site inspection and an irrigation water rights search in Stark County's database. Figure 2.6-8 depicts the location of the water rights identified and Table 2.6-112 provides the data shown in the figure.

The site inspection and interviews with current land operators confirmed that surface irrigation for agricultural production is not currently practiced within the Primary Study Area or adjacent parcels because of limited water supply and poor water quality (Land Use Section 2.7.1). These observations are supported by the records of the North Dakota State Water Commission (NDSWC), which administers water use permits in the state. The NDSWC records reveal no existing Conditional or Perfected water permits for the irrigation of cropland within the Primary Study Area.

Table 2.6-112 also includes water right owner, watershed, and yearly use information for each water right identified. The principal uses of water in and surrounding the Primary Study Area are livestock, domestic and municipal supply. Most of the water used is from ground water sources. Surface water, where available, is typically used for livestock watering.

2.6.4 Surface Water Quality

The quality of water in surface water bodies in and near the Primary Study Area was characterized using the historic record and a field sampling program at water quality stations established for the current baseline study.

North Dakota categorizes surface waters into surface water quality classes according to the beneficial use of the waterbody. Examples of beneficial uses for a waterbody are fishing, swimming, and drinking. State of North Dakota water quality standards are established in Century Code Chapter 33-16-02.1 and are administered by the North Dakota Department of Health (NDDH).

The Heart River between Belfield and South Heart is classified by the NDDH as a Class 1A stream. The South Branch Heart River is classified by the NDDH as a Class 3 stream. The NDDH definition of Class 1A and Class 3 streams is presented below (NDDH 2001).

Class 1A - The quality of the waters in this class shall be suitable for the propagation and/or protection of resident fish species and other aquatic biota and for swimming, boating, and other water recreation. The quality of the waters shall be for irrigation, stock watering, and wildlife without injurious effects. After treatment consisting of coagulation, settling, filtration, and chlorination, or equivalent treatment processes, the water quality shall meet the bacteriological, physical, and chemical requirements of the department for municipal or domestic use. Treatment for municipal use may also require softening to meet the requirements of the department.

Class 3 - The quality of the waters in this class shall be suitable for agricultural and industrial uses such as stock watering, irrigation, washing, and cooling. These streams have low average flows and, generally, prolonged periods of no flow. They are of limited seasonal value for immersion recreation, fish life, and aquatic biota. The quality of these waters must be maintained to protect recreation, fish, and aquatic biota.

2.6.4.1 Historic Water Quality Data

Twenty documents relating to water quality in the vicinity of the Primary Study Area were reviewed. The following water quality databases were also reviewed:

- North Dakota Department of Health;
- North Dakota State Water Commission;
- U.S. Geological Survey (USGS); and
- U.S. Environmental Protection Agency (EPA).

Of these, a portion contained water quality data for waters in and near the Primary Study Area. Table 2.6-12~~3~~ provides a summary of historic water quality data including; source titles, dates, primary agencies and the type of water quality information contained in each report.

The majority of the existing or historical surface water quality data available for this Secondary Study Area has been collected by the USGS at four surface water gaging stations near the Study Area. Data at these stations were collected during the period from 1979 to 1996. The specific site location of the data collected by the USGS includes:

Station Description	Station ID	Latitude	Longitude
South Branch Heart River below Bull Creek	6342890	46°49’05”	103°04’47” NAD27
South Branch Heart River near South Heart	6342900	46°50’24”	103°01’12” NAD27

Heart River at South Heart	6342920	46°52'09"	102°59'42" NAD27
Norwegian Creek near Belfield	6342850	46°51'12"	103°08'51" NAD27

Typical sampling parameters collected by USGS at multiple flows included suspended sediment, bed sediment particle size, temperature, pH, specific conductance, dissolved oxygen, total phosphorous, and total nitrogen. Two of the USGS stream gaging stations (06342850 and 06342900) included bacteria, metals, and radioactivity data. Data for these four sites are summarized in Appendix 2.6-2 (USGS 1997).

In 2002, the EPA also collected limited sediment and total phosphorous at five sites located on the Heart River and the South Branch Heart River in or near the Primary Study Area. This data is presented in Appendix 2.6-3.

2.6.4.2 Established Water Quality Impairments

The federal Clean Water Act requires states to assess water quality in their water bodies and periodically prepare lists (called a "303d list") of water bodies which are non-supporting of their assigned beneficial uses. The NDDH established a 303(d) list in 1998, reviewing the existing water quality data available for areas within and surrounding the Primary Study Area including the Heart River, South Branch Heart River, Norwegian Creek, and Patterson Lake. As a result of this existing data review, the NDDH determined that the South Branch Heart River and the Heart River from Belfield to Patterson Lake contained water quality impairments (NDDH 1998). Parameters of concern for the Heart River system, in general, included nutrients, sediment, habitat alterations, flow alterations, organic enrichment, and low dissolved oxygen (DO) (EPA 2002). Specific information developed for Patterson Lake identifies nutrient and sediment as the main impairments for the Upper Heart River Basin. This includes the South Branch Heart River and Heart River between Belfield and South Heart, both of which are included within three miles of the surface water resource Primary Study Area.

The NDDH identified the Heart River from Belfield to Patterson Lake, a 30.37 mile long segment, located within the Primary Study Area, as an impaired river system (EPA 2002). This stretch is designated as impaired on the 1998 North Dakota 303(d) list of impaired water bodies for not meeting the designated aquatic life (partially supporting) and recreational (partially supporting) uses because of nutrients, sediment, habitat, organic enrichment, and bacteria. Although the listed cause of impairment is unknown along this stretch of the Heart River (EPA 2002), nonpoint source (NPS) pollution (e.g., siltation/sedimentation and stream habitat loss or degradation) was reported as the primary cause of aquatic life use impairment along rivers and streams (NDDH 2006).

According to the 1998 303(d) list, the South Branch Heart River is also impaired as a result of sediment and habitat loss or degradation and is only partially supporting aquatic life. This impaired segment is 12.75 miles in length from its headwaters to the confluence with the Heart River near the town of South Heart. The listed cause of impairment is sediment/siltation (EPA 2002).

Inclusion on a state's 303(d) list requires the setting of a Total Maximum Daily Load (TMDL) for listed pollutants in that water_body. A TMDL is the identification of the maximum amount of a pollutant that can exist in a water_body, while still allowing it to support its assigned beneficial uses. Effectively, a TMDL is a water quality management plan. The TMDLs generally consist of:

- A technical study identifying the pollutants causing the water quality problem and the sources of these pollutants;
- Public involvement in key decision steps of the process;
- Waste loads (point source) or load allocations (non-point source) for pollutant sources which distribute allowable levels of pollutant discharges among contributing sources;
- A margin of safety to ensure water quality standards will be met under the worst conditions likely to be experienced;
- Population growth factor to ensure the allocations will continue to be adequate for more than the immediate time period;
- A consideration of seasonal variation of flows and contaminant concentrations (water quality standards must be met during all seasons of the year);
- An implementation strategy to prevent, reduce or clean up excess pollution;
- A follow-up monitoring plan to demonstrate success of pollution controls contained in the implementation plan or the need for additional action;
- An administrative record;

- Reasonable assurances for the success of the implementation plan; and
- An estimate of when the waterbody will meet standards.

As part of the 303(d) impairment analysis for the Heart River, a USGS station was monitored in the Heart River near South Heart (USGS Station #06343000). Review of the data from this station indicated that the Heart River is phosphorus limited, with a total nitrogen to total phosphorus (TP) ratio of 9.1 (EPA 2002). The South Branch Heart River and Ash Creek had the highest nutrient yields.

The sediment load for the Heart River from Belfield downstream to Patterson Lake and the South Branch Heart River downstream to its confluence with the Heart River was also reviewed during the TMDL water quality analysis. The South Branch Heart River was found to have the highest sediment yield. Loadings were found to be highest in early spring when run off of winter stored nutrients from livestock, wind, and soils move into the rivers with the melting snow and spring rains (Wax 2006).

2.6.4.3 Study Area Surface Water Quality

Surface water quality samples were collected from streams, ponds, and reservoirs shown on Figure 2.6-9. The criteria for the selection of water quality sampling sites are provided in Table 2.6-13. Samples were collected to assess seasonal variation in water quality according to the schedule presented in Table 2.6-14. Although most locations were visited during each designated sampling event, samples were not always collected due to frozen water or insufficient flow. Samples were analyzed for the parameters required by 69-05.2-08-07(3)(b) and 69-5.2-08-04(2) as well as additional parameters.

~~Monthly water quality sampling events for the current baseline study were completed at 21 monitoring stations on the Heart River, South Branch Heart River, the west and south unnamed tributaries to the South Branch Heart River, and stock ponds and reservoirs. The locations of these 21 sites are shown on Figure 2.6-9 and include the flow gaging locations discussed previously in Section 2.6.3.2. Samples were analyzed for the parameters required by 69-05.2-08-07(3)(b) and 69-5.2-08-04(2). These required parameters are presented in Table 2.6-14. The criteria for site selection of water quality sampling stations are provided in Table 2.6-15.~~

Grab water samples were collected by qualified personnel near each hydrometric station where a representative, well-mixed sample could be obtained. All sampling equipment was single-use or decontaminated with Alconox® or other suitable laboratory-grade detergents and rinsed with deionized water prior to reuse.

Samples were collected in laboratory-provided sample bottles with appropriate preservatives. Field parameters were measured at the time of sample collection. Handling, labeling, storing and shipping of samples were in accordance with approved standard sampling protocols.

Immediately after collection, samples were stored in a cooler and kept at approximately 4° C, but not allowed to freeze. The samples were shipped daily to the analytical laboratory via overnight shipping. In order to assure quality delivery, strict chain-of-custody procedures were followed to maintain the integrity of the samples. The chain-of-custody was recorded on approved forms. Quality assurance (QA) and quality control (QC) samples consisted of one blind duplicate sample and one equipment sample collected for every 20 samples and submitted to the analytical laboratory along with the "real" surface water samples. The QA/QC samples were analyzed for the same parameters as the "real" surface water samples.

Samples were analyzed by an approved, qualified analytical laboratory for the testing suites provided in PSC Regulation 69-05.2-08-07 and othersshown in Table 2.6-14. The analytical laboratory was instructed to use standard methods consistent with PSC and NDDH guidelines and regulations for analysis of waters and to follow standard QA/QC procedures. All water quality sampling and analyses were conducted according to the most recent edition of Standard Methods for the Examination of Water and Wastewater or those in 40 CFR Parts 136 and 434, as required by PSC Regulation 69-05.2-08-04.

A summary of water quality results required by 69-05.2-08-07 (3)b are presented in Table 2.6-15. Water quality results for all parameters are presented in Appendix 2.6-4. Surface water quality is discussed below by water body.

Heart River

The Heart River was sampled at two locations: 1) SHHR-01; and 2) SHHR-02. From September 2006 until the end of 2009, 36 samples were collected at the two locations. The sites were visited an additional four times but samples were not collected because the river was frozen or there was insufficient flow.

Waters from the upstream (SHHR-01) and the downstream (SHHR-02) sampling locations are chemically similar. Total dissolved solids (TDS) and laboratory specific conductance (SC) range from 528 to 6,290 milligrams per liter (mg/L) and 707 to 2,416 micromhos per centimeter (µmhos/cm), respectively. The average TDS and SC concentrations at sampling locations along the Heart River are higher than the sampling locations on the other streams across the site. Values in laboratory pH range from 6.7 to 9.6, averaging 8.8. Total suspended solids (TSS) concentrations range from 7 to 10,600 mg/L, with the majority of concentrations below 100 mg/L. Peaks in TSS occur only at the downstream location (SHHR-02), predominantly following notable precipitation events or runoff. Precipitation is typically higher in late fall (October to November) and spring (May) resulting in periods of higher flow and higher concentrations of TSS. Along the Heart River, higher TSS concentrations occur at the downstream sampling location (SHHR-02) than at the upstream sampling location (SHHR-01). The relatively higher TSS at SHHR-02 is likely attributed to its location downstream of the confluence with the South Branch Heart River, which had similar TSS concentrations during the same time periods. At SHHR-02, peaks in total metals concentrations appear to correspond with periods of high TSS because high concentrations of suspended particles provide attachment sites for metals.

South Branch Heart River

The South Branch Heart River was sampled at two locations: 1) SHSB-01 and 2) SHSB-03. From September 2006 until the end of 2009, 31 samples were collected at these two locations. An additional 9 visits were made with the intent to sample; however, samples could not be collected due to inadequate flow.

TDS and laboratory SC range from 267 to 3,820 mg/L and 298 to 1,870 μmhos/cm, respectively, with values typically higher at the upstream location (SHSB-03). TSS concentrations range from 4 to 4,560 mg/L, with the majority of concentrations below 100 mg/L. The peaks in TSS are similar to those measured at location SHHR-02 on the Heart River, occurring mainly following notable precipitation events in the fall and spring. Most of these peaks are more prominent at the downstream (SHSB-01) location. Values in laboratory pH range from 6.5 to 9.6, averaging 7.8. Waters from the upstream (SHSB-03) and the downstream (SHSB-01) sampling locations are chemically similar. The analytical results do not indicate any other distinct temporal or spatial trends.

South Tributary

There are two sampling sites located along the South Tributary, SHUN-03 and SHUN-04. From September 2006 until the end of 2009, 25 samples were collected at the two locations. The sites were visited an additional 15 times but a sample was not collected because the stream was frozen or there was insufficient flow.

TDS and laboratory SC range from 223 to 5,540 mg/L, and 223 to 778 μmhos/cm, respectively, with values typically higher downstream at SHUN-04. A TDS concentration of 58,200 mg/L was reported by the laboratory for the May 2009 sample at SHUN-03, but the value has been considered erroneous through data validation. TSS concentrations range from 1 to 2,200 mg/L, and increase following notable precipitation events in the fall and spring. Values in laboratory pH range from 6.4 to 9.2, averaging 7.6. Waters from the upstream (SHUN-03) and the downstream (SHUN-04) sampling locations are chemically similar in terms of major ion and metals concentrations.

West Tributary

There are two sampling sites located along the West Tributary, SHUN-01 and SHUN-02. From September 2006 until the end of 2009, the two locations were each visited 20 times; however, insufficient flow precluded the collection of any water quality samples.

Reservoirs and Ponds

In total, from September 2006 until the end of 2009, 67 reservoir samples were collected from the 13 locations. Each site was visited 11 to 15 times, but a sample was not always collected due to frozen or dry conditions. TDS and laboratory SC range from 78 to 8,960 mg/L and 105 to 8,810 μmhos/cm, respectively. TSS concentrations range from 78 to 8,960 mg/L, with the majority of concentrations below 250 mg/L. Values in laboratory pH range from 5.9 to 10, averaging 8.3.

~~The average, maximum, and minimum values at the 21 sample locations for water quality parameters, required by 69-05.2-08-07 (3)b, are presented in Table 2.6-16. All parameters are reported in mg/l except for pH (which is in pH units). Values for pH were determined in the field, while the remaining parameters were determined in the laboratory. Where the result for any given parameter at a sampling date was reported as below the reporting limit of the test, site averages were calculated using the reporting limit for that sampling date. For the parameters reported here, this only occurred for Total Suspended Solids (TSS). All of the water quality laboratory results for Total Dissolved~~

Solids (TDS), TSS, pH, and total iron, and for other parameter not required by the regulations (69-05.2-08-07 (3)b) for the current baseline period are presented in Appendix 2.6-4.

Surface water chemistry for parameters required by the regulations, including TDS, TSS, total iron, and pH, was examined to determine if there were temporal or seasonal trends in water chemistry at each sampling location and to determine if there were spatial (e.g., upgradient versus downgradient locations) trends in water chemistry. Observations are provided below.

- The TDS fluctuates over time at each sampling location, but does not appear to follow any particular temporal or seasonal trend based on available data. Spatially, TDS is generally lower (< 1,000 mg/L) along the west and south tributaries (with the exception of SHRES-23 and SHRES-23A), and generally higher (2000-5000 mg/L) along the Heart River and its contributing seeps and reservoirs on the northern portion of the site.

- Values for surface water pH are relatively uniform and constant (approximately pH= 8) across all sampled reaches, with the exception of elevated pH values (pH in the 9-10 range) near the upper portion of the West Tributary (i.e., SHRES-16C and SHRES-16D).

- The TSS and total iron follow similar trends. For example, when TSS values are elevated, total iron values are as well. This relationship is expected because if TSS values are elevated, the suspended particles likely contain iron based on the geology and mineralogy of the area (Section 2.3). However, the occurrences of elevated TSS and iron do not appear to follow a temporal trend based on available data. Spatially, a trend of elevated iron and TSS appears to originate from the South Tributary in the southern portion of the site (i.e. SHUN-03 and SHUN-04), which then propagates downgradient. However, other isolated areas of elevated TSS and iron are also observed (e.g. SHRES-16B).

Periodically, some of the sampling sites were dry or completely frozen, thus water quality samples could not be collected. The number of samples collected at each site is indicated in Table 2.6-16.

2.6.5 Surface Water Probable Hydrologic Consequences (PHCs)

A probable hydrologic consequences (PHC) assessment is one component of the planning process that is employed to minimize disturbance to the hydrologic balance in the Permit Area and prevent material damage outside the Permit Area. The PHC assessment identifies potential impacts so that measures can be planned to mitigate those impacts. The PHC determination provides a projection of residual impacts after implementation of preventive and mitigative measures.

The surface water PHC assessment identifies the expected impact that the proposed mining and reclamation operation will have on:

- Flooding or stream flow alteration;
- Sediment yield from the disturbed area;
- Acidity, TSS and TDS, and other important surface water-quality parameters;
- Recharge capacity; and
- Developed water resources such as stock ponds.

The types of impacts that may result from mining are identified in the initial iterations of the PHC process. These anticipated impacts are the focus of the preventive and mitigative measures developed in the plans for operations and reclamation to minimize disturbance to the hydrologic balance in the Permit Area and to prevent material damage to the hydrologic balance outside the Permit Area.

Baseline information describes site-specific conditions prior to mining and is the foundation on which PHC is developed. The Primary Study Area is dissected by the South Branch Heart River and its two unnamed tributaries, the West Tributary and the South Tributary. The Heart River lies to the north of the Primary Study Area.

Eight monitoring stations were established for baseline characterization of stream flow and water quality as shown in Figure 2.6-6B.

2.6.5.1 Effects of Mining and Reclamation Operations on Flooding and Stream Flow Alteration and Sediment Yields

Three sedimentation ponds have been designed in the operational water management plan to mitigate potential water quality impacts and to prevent the additional contributions of sediment to stream flow. These sediment control structures are designed with sufficient capacity to contain flows from the 10-year, 24-hour storm and to contain the sediment yield from at least three years of maximum disturbance. The operational plan is to pump down the pond within a two-week period following storm events to provide sufficient containment capacity for a 10-year, 24-hour event that may occur in the future. It is anticipated that the water pumped from the ponds will either be used for dust suppression and other mine water needs or it will be discharged to the South Branch Heart River when water quality is suitable for discharge.

This plan for mine water management during active mining will reduce storm water-related flows and sediment yields from the areas disturbed by mining from the disturbed and undisturbed areas draining to these structures. Flows greater than the 10-year, 24-hour storm will discharge through the pond spillway and into the natural drainage. This section of the PHC includes an assessment of the potential alteration in stream flows resulting from the containment of storm runoff in these sediment control structures and in the mine pit.

Estimates of changes in stream flows were developed for baseline and operational mining conditions. These estimates were developed using SEDCAD4 for the drainage areas that are directly affected by mining and at control points corresponding to the baseline stream flow and water quality monitoring stations established at three key locations within the Primary Study Area on the West Tributary of the South Branch near Mouth (SHUN-01) on the south tributary just upstream of its confluence with the South Branch Heart River, (SHUN-04), and downstream of the Primary Study Area on the South Branch Heart River at Mouth (SHSB-01). The SEDCAD software, developed by Civil Software and accepted by the Office of Surface Mining and most state coal regulatory agencies, includes storm water runoff modeling based on the synthetic unit hydrograph and runoff curve number (CN) approach developed by the Soil Conservation Service (SCS).

The runoff CN technique is used to estimate the runoff from rainfall for a given amount of precipitation. The CNs have been estimated empirically for a wide combination of hydrologic soil groups and land use and treatment classes. The CN method is based on observable physical properties (soil and cover) of the runoff subareas. The soils are classified into one of four hydrologic soil groups (HSG) on the basis of infiltration rates. The cover factor in the estimation of a CN takes into account the land use, vegetation type, surface treatment, among other watershed characteristics. The CN is determined by the combination of the component soil types and cover from tables that have been published by the SCS (now the Natural Resources Conservation Service (NRCS)) and the Office of Surface Mining (OSM).

In applying the method to complex watersheds, the drainage basins above a particular prediction point or control point are subdivided into subwatershed areas based on the stream channel network. Designated subwatersheds must drain to a particular channel reach or structure. The CN for each combination of soil type and land use and the relative area within each combination of soil type and land use is used to estimate a weighted average or composite CN for each subwatershed. The Muskingum method is used to route the estimated runoff from the subwatersheds through the channel network.

The modeling, which was performed for this assessment, utilized soils information delineated within the Primary Study Area with soils information for surrounding counties to develop CNs representative of pre-mining, operational and reclaimed conditions. Pre-mining vegetation in the area was assumed to be crop land. The assumptions used for CNs are summarized in Table 2.6-16~~7~~.

Table 2.6-17~~8~~ provides a comparison of surface water flows and runoff volumes for two storm frequencies for baseline and mine operational conditions. The two storms were the 2-year, 24-hour storm of 1.9 inches (a representative annual storm) and the 10-year, 24-hour storm of 3.1 inches. The three mining conditions were pre-mining, worst case operational conditions, and reclamation. The operational mining conditions assume that all flows from disturbed areas and from undisturbed areas that cannot be diverted around active mine disturbance up to a 10-year, 24-hour event are contained by the sedimentation ponds and the mine pit. The volume and peak flow from precipitation up to a 10-year, 24-hour event from drainage areas intercepted by mining would not contribute to the flow in the South Branch Heart River. The relative effect of the estimated flow reductions during mine operations on the flows in the South Branch Heart River are indicated on Table 2.6-17~~8~~.

During final reclamation, the sedimentation ponds and the feeder collection ditches are removed in accordance with bond release requirements. As noted on Table 2.6-16~~7~~, the expectation is that final reclamation would yield good pasture and cropland conditions, which generates lower CNs than the existing fair condition. Consequently, slightly lower flows than pre-mining baseline conditions are anticipated following reclamation as indicated in Table 2.6-18~~9~~. Both the peak flow and runoff volume for the 10-year, 24-hour precipitation event are reduced following reclamation in comparison with the pre-mine baseline conditions. The estimated changes in flows in the South Branch Heart River are miniscule relative to the magnitude of the flows in the river.

Although the disturbance of the land surface by mining and reclamation activities can significantly increase erosion and sediment yields, the potential for increased sediment loads to streams within the Permit Boundary is mitigated by the planned surface water controls, diversions, sediment control berms, and sediment control structures. Furthermore, erosion, by wind or by water, is minimized to the extent possible by reclaiming areas soon after mining and revegetating slopes that will remain undisturbed for several years or more such as on cut and fill slopes along haul roads and on topsoil and overburden stockpiles.

The water management plan includes designs for sediment control structures to contain and treat sediment-laden runoff from the affected areas. The sedimentation ponds have been designed so that the runoff occurring as a result of a 10-year, 24-hour precipitation event will be contained within the structures. The sedimentation ponds have additional capacity to store at least 3-years of sediment yield from the maximum disturbance condition within the area draining to the pond.

The channel of the South Branch Heart River within the Primary Study Area is incised and unstable with bank sloughing and channel widening. The channel will not be affected by mining activities except at the discharge point for the sedimentation pond. The rate of channel erosion will not increase as a result of planned mining activities.

The planned reclamation approaches include re-contouring to simulate natural topography, construction of geomorphic channels that are sustainable in the long-term and revegetation. The important elements of the pre-mining fluvial system will be re-established to approximate pre-mining conditions. In a geomorphic approach, stream channels are allowed to mature by gradual degradation and aggradation, with erosion rates comparable to the natural environment. For a geomorphic channel, “completion of the channel construction” occurs when the channel and its flood plain have adapted to flow conditions and the flood plains are vegetated. In the Western US, it is believed that a 10-year transition period is needed to reach “maturity” and demonstrate reclamation success. During this transition period when the flood plains are not yet fully vegetated and the channels are adapting to the flow regime, some channel or floodplain erosion may occur. Best Management Practices (BMPs) will be applied to prevent and mitigate erosion and sediment contributions from the additional contribution of sediment from the Permit Area. The BMPs include grass filters, straw wattles, and berms to contain runoff from the disturbed area until reclamation standards are attained.

In summary, peak flows, runoff volumes and sediment yields from the mine disturbance area will be reduced during the operational mining period due to the retention and attenuation effects of the sediment control structures and the mine pit. Compared to the pre-mine condition, there will also be a slight reduction in peak flows, runoff volumes and sediment yields after reclamation and removal of the sedimentation ponds due to lower slopes and improved vegetation cover from reclamation. Nevertheless, the changes in peak flows, runoff volumes and sediment concentrations on the South Branch Heart River and on the Heart River will be negligible for all storms due to the large sizes of the contributing watersheds relative to mining disturbance.

2.6.5.2 Effects of Mining and Reclamation Operations on Surface Water Quality

The potential surface water quality effects evaluated for the planned mining and reclamation activities include changes in TDS, changes in pH, and changes in selected chemical characteristics of surface runoff. The mine overburden and interburden are alkaline. Acid generating conditions are not expected to occur in the mine spoils derived from the overburden materials at this site. Nevertheless, during mining operations, the concentrations of dissolved constituents in surface runoff flowing to sedimentation ponds can change due to constituent concentrations in the coal and overburden water and due to rainfall and snowmelt runoff from disturbed areas and overburden stockpiles.

An assessment of the probable changes in concentrations of dissolved solids in surface runoff can be developed by characterizing the likely dissolved constituent concentrations in the sources of surface water draining to the sedimentation ponds at the mine site. The potential changes in water chemistry can be estimated using a mixing analysis based on the relative contribution of each of the sources to surface water. This mixing analysis assumes that the constituents behave conservatively and are not changed due to precipitation, redox, adsorption, or other geochemical processes.

Table 2.6-19~~20~~ shows the median and the average concentrations of selected chemical constituents from four water sources that are considered representative of the water sources that will reach the sedimentation ponds via pit pumpage and disturbed area runoff. Median values are sometimes preferred statistical measures of surface water quality as they are not influenced as much by concentrations during exceptionally low or high flows. The results from SHUN-04, located at the mouth of the South Tributary, are believed to be representative of the water quality of surface runoff from the tributary drainages within the Primary Study Area. The stations on the West Tributary

(SHUN-01 and SHUN-02) would also be expected to have water quality that would be representative of surface runoff from the tributary drainages within the Primary Study Area, but there was no flow at these stations during the first six months of baseline monitoring. Also shown in Table 2.6-19~~20~~ are the median and the average concentrations of constituents in baseline water quality samples from the D-coal seam and the overburden materials and the average concentrations of constituents found in the synthetic precipitation leaching procedure (SPLP) leachate from tested overburden material samples within the Permit Area.

Surface water entering the ponds is expected to have concentrations similar to a mix of pit inflows (combination of water from the coal and overburden materials), surface runoff from overburden stockpiles and exposed overburden materials within the pit as characterized by the SPLP results, and surface runoff from undisturbed areas. Runoff from undisturbed, regraded, and reclaimed areas is expected to be similar to the water quality characteristics at SHUN-04 and was set as 25 percent of the mixed pond water quality. Water quality characteristics at SHUN-04 are also considered to be representative of the water quality in the Class III tributaries to the Heart River. Runoff from topsoil stripped areas and exposed overburden materiasl is expected to be similar to the SPLP results and was set as 25 percent of the mixed pond water quality.

The relative mix of water reaching the ponds from the identified sources will vary with time and with the magnitude of precipitation and snowmelt. However, on an annual basis pit inflows and storm water runoff volumes are expected to be approximately the same, based an estimated annual runoff from disturbed areas of about 3-inches per year. Winter et al. (1984) estimated an annual water yield from undisturbed areas in the vicinity of the site of 1.0 inch. The estimated annual runoff of about 3 inches from disturbed areas was based on the SEDCAD modeling results, which indicate about a 3-fold increase in runoff volumes from disturbed areas during the smaller, more frequent runoff producing precipitation events. The pit inflows from the coal are expected to be comprised of 40 percent of the mixed water based on a coal thickness of approximately 18 feet and hydraulic conductivity of the 20.7 ft/day and an overburden sand thickness of approximately 20 feet and hydraulic conductivity of 1.59 ft/day. The relative pond contribution due to pit inflows from the overburden will vary during the mining sequence but is assumed to be 10 percent for this water quality assessment. The mixed pond water results based on these assumptions are provided in Table 2.6-19~~20~~.

The tributaries to the Heart River are Class III waters, suitable for agricultural, industrial use, stock watering, irrigation, recreation, and aquatic habitat. The estimated Class III criteria are included in

Table 2.6-19~~20~~. Although these criteria can be compared to the mixed pond water results in Table 2.6-19~~20~~, it is important to realize that the results for metals in the mixed pond water represent total concentrations (unless specified otherwise) while the Class III criteria are based on dissolved metals. Furthermore, it is expected that the total metals concentration in any pond water discharge will be reduced in comparison with the Table 2.6-19~~20~~ results due to settling of suspended solids within the pond. On that basis, it is expected that any pond water discharge to surface water or ground water will have lower total metals concentrations than the receiving stream.

Nevertheless, boron, sulfate, and TDS concentrations are projected to be higher in pond water discharge than in the receiving stream and boron, cadmium, copper, and lead in the mixed pond water projection are elevated above the Class III criteria. The estimated boron concentration in mixed pond water of average concentrations slightly exceeds the Class III criteria for boron, but does not when median values are used for the stormwater, coal and overburden samples. Thus, the mixing of pond water with surface water is expected to result in boron concentrations that are below the Class III criteria. The estimated cadmium, copper and lead concentrations in mixed pond water of median and average concentrations exceeds the Class III criteria for each parameter. However, the exceedence was the result of the high concentrations in the single surface water sample collected at station SHUN-04, which was subsequently used to represent of the water quality of surface runoff from the mine area. Furthermore the analysis results for these constituents were for total concentrations while the corresponding Class III criteria are for dissolved concentrations.. Thus, removal of sediments in pond water and mixing with surface water in the receiving stream is not expected to result in concentrations of dissolved cadmium, copper and lead that exceed the Class III criteria.. Sulfate concentrations are relatively low in the surface water so pond water discharges are not expected to result in exceedence of the Class III standard for sulfate.

Once mine water pumping ceases, reclamation topsoiling is completed and vegetation is established on disturbed areas, the dissolved constituent concentrations in surface water draining to sedimentation ponds are expected to return to the pre-mining levels.

In conclusion, surface water quality changes are likely to occur as a result of mining and pond water discharge. These changes may result in slight reductions in total metals concentrations and increases in TDS, sulfate, and boron concentrations. However, the water quality changes are not expected to materially impact the suitability of the water in the receiving stream for the classified uses, including agricultural, wildlife, and aquatic life.

2.6.5.43 Effects of Mining and Reclamation Operations on Recharge Capacity

The disturbance of the land surface by mining and reclamation activities, including the removal of vegetation and the enhanced surface detention storage prior to final grading of mine backfill, can temporarily increase the recharge capacity at the site. Without root penetration, the water in the mine spoils is generally above field capacity, resulting in enhanced recharge relative to the pre-mine or reclaimed vegetated conditions. However, after spoil grading and revegetation and when reclamation standards are attained, the recharge rates at reclaimed areas will return to levels comparable to pre-mining.

2.6.5.4 Effects of Mining and Reclamation Operations on Developed Water Resources

Within the Permit Area, stock ponds or reservoirs were identified as part of baseline studies (Table 2.6-4). All of these developed water resources are assumed to be used for stock watering purposes and are located in drainage ways as described in Section 2.6.2. The ponds and reservoirs are generally fed from precipitation and direct runoff. Ponds and reservoirs within the disturbance area will be removed by mining operations. Water from the ponds or reservoirs will be replaced during reclamation consistent with post-mining land use. Where ponds or reservoirs are replaced, they will be located along drainage ways and fed by precipitation and direct runoff. Design calculations for wetlands and ponds in Appendix 4.1-2 indicate that the watersheds will be of sufficient size to contribute an ample supply of water from normal year precipitation. If the water supply for these ponds is insufficient, various methods will be adopted to replace the water source. These may include the installation of wells with windmill or solar powered pumps to utilize the available ground water resource as described in Section 2.5 Ground Water Hydrology or the use of water supply enhancements such as snow fences and vegetation management. Table 2.6-4 provides a list of identified ponds or reservoirs within the Permit Area and briefly outlines examples of probable hydrologic reclamation actions for those ponds or reservoirs that may be adversely affected by mining.

2.6.5.5 Surface Water Monitoring Plan

Surface water quality and quantity (flow) will be monitored before mining begins, during mining, and during reclamation. ~~monitoring will continue beyond the baseline study period. Monitoring will be limited to locations immediately adjacent to the Permit Area.~~ A monitoring plan is presented below and includes a description of the monitoring locations, frequency of monitoring and monitoring parameters. A summary of the monitoring plan is presented in Table 2.6-21.

2.6.5.5.1 Baseline Monitoring

Surface water quantity and quality monitoring was conducted from September 2006 through December 2009 During the baseline data collection period, surface water quantity and quality monitoring were performed as described previously in Sections 2.6.3.2 and 2.6.4.3, respectively. A schedule of baseline monitoring events is presented in Table 2.6-14. Daily average flows at monitored locations are presented in Appendix 2.6-1 and the results of water quality analyses are presented in Appendix 2.6-4.Monitoring sites for surface water quantity is shown in Figure 2.6-6B and for surface water quality are shown in Figure 2.6-9. Water quality samples were analyzed for the parameters listed in Table 2.6-14. The results of the water quality analyses were summarized in Table 2.6-16.

2.6.5.5.2 Ongoing and Future MonitoringMonitoring Concurrent with Mining

Beginning at least one year prior to land disturbance for mining activities and continuing throughout the active (i.e., non-reclamation) mining period, surface water flow and quality will be monitored along with on-site climatic conditions. Following the baseline study period and extending through mining and into post-mining surface water and climate monitoringThe program will include continuous stage measurements of primary and secondary drainages during freeze-free months, water quality sampling of streams at peak and low flows periods when water is present, and continuous recording of climate data. will include:

Continuous stage measurements at the flume and stilling well locations indicated in Table 2.6-21 during freeze-free months.

Water quality sampling of streams and reservoirs indicated in Table 2.6-21 at peak and low flow periods when water is present. Samples will be analyzed for the parameters required in the regulations for the baseline investigation and indicated in Table 2.6-14.

Continuous recording of climate data at the onsite meteorological station.

Surface water and climate data will be evaluated as part of the annual reporting discussed below, and an alternate (i.e., reduced) list of monitoring locations and parameters may be implemented if warranted and approved by the PSC.

Monitoring of surface runoff from disturbed areas will be in compliance with requirements set forth in Section 69-05.2-16-05 of the Rules and Regulations Governing the Reclamation of Surface Mined Lands and the regulations promulgated under the NDDH's National Pollutant Discharge Elimination System (NPDES). An NPDES permit will be required for this proposed mining activity and an application for that permit will be prepared and filed at a future date. Runoff monitoring locations, frequency, and parameters, and reporting to NDDH will be performed in accordance with an approved NPDES permit.

2.6.5.5.3 Reporting

Results of the monitoring will be presented to PSC in quarterly and annual reports or at another frequency approved by the PSC. Quarterly reporting is proposed to begin with the first quarter following approval of the permit. Annual reporting is proposed to begin at the end of the first calendar year following approval of the permit and at least two quarterly reports. The quarterly reports will summarize the stage and meteorological data observed during the quarter. Annual reports will summarize the stage and meteorological measurements over the entire year and will present the results of the water quality analyses. In addition, the annual reports will describe any proposed modifications to the monitoring plan based on an analysis of the water quality data. These modifications could include changes to monitoring locations, frequency of monitoring, and monitoring parameters.

TABLES

FIGURES

APPENDICES

APPENDIX 2.6-1

SEASONAL VARIATION FOR SURFACE WATER QUANTITY WITHIN THE PRIMARY STUDY AREA

APPENDIX 2.6-2

HISTORICAL WATER CHEMISTRY DATA

APPENDIX 2.6-3

LIMITED SEDIMENT AND PHOSPHOROUS SAMPLES AT FIVE SITES

APPENDIX 2.6-4

SURFACE WATER QUALITY RESULTS