3.0 ARSENIC

Assessment of data from the 2006 SWQB water quality survey in the Cimarron River watershed identified exceedences of the New Mexico water quality standards for arsenic in:

- Cimarron River (Cimarron Village to Turkey Creek)
- Cimarron River (Turkey Creek to Eagle Nest Lake)
- Ute Creek (Cimarron River to headwaters)

Consequently, these waterbodies were listed on the Integrated CWA §303(d)/§305(b) list for arsenic (NMED/SWQB 2010a).

3.1 Target Loading Capacity

The target values for these arsenic TMDLs are based on the dissolved arsenic criteria in 20.6.4.900 NMAC: 2.3 µg/L for domestic water supply, 9.0 µg/L for human health, and 100 µg/L for irrigation. Exceedences for each assessment unit are presented in Table 3.1.

Arsenic is a naturally occurring element widely distributed in the earth's crust. Arsenic occurs naturally in soil and minerals and may enter the air, water, and land from wind-blown dust and may get into water from runoff and leaching. Fish and shellfish can accumulate arsenic; most of this arsenic is in an organic form called arsenobetaine that is much less harmful.

Table 3.1 Dissolved arsenic exceedences

Assessment Unit	Designated Use Affected	Associated Criterion (µg/L)	Exceedence Ratio (# exceedences / total # samples)
Cimarron River (Cimarron Village to Turkey Creek)	DWS	2.3	3/4
Cimarron River (Turkey Creek to Eeagle Nest Lake)	DWS	2.3	3/4
Ute Creek (Cimarron River to headwaters)	DWS	2.3	3/4

Notes: DWS = Domestic Water Supply
µg/L = micrograms per liter

3.2 Flow

Arsenic concentrations can vary as a function of flow, therefore TMDLs are calculated at a specific flow. Streamflow was measured by SWQB during the 2006 sampling season using standard procedures (NMED/SWQB 2007). Flows measured in Ute Creek above US 64 at Ute Park, NM ranged from 0.06 cfs to 3.24 cfs. Water quality standard exceedences *only* occurred during low flows. Therefore, the critical flow value used to calculate the TMDL for Ute Creek was based on a low-flow condition using a 4Q3 regression model. The 4Q3 is the minimum average 4 consecutive day flow that occurs with a frequency of once in 3 years.

It is necessary to estimate a critical flow for a portion of a watershed where there is no active flow gage as in Ute Creek. This can be accomplished by applying one of several different formulas developed by the U.S. Geological Survey (USGS).

It is possible to extrapolate a known discharge duration and/or return interval at a gaged site to an ungaged site by using a drainage-area ratio adjustment. However, this extrapolation is applicable only when the drainage-area ratio between the gaged and ungaged watersheds is between 0.5 and 1.5. In cases where the recommended areal ratio is outside of this range, as is the case between the Cimarron River (gaged site) and Ute Creek (ungaged site), analysis methods described by Waltemeyer (2002) are used to estimate flow. In this analysis, two regression equations for estimating the 4Q3 flow were developed based on physiographic regions of NM (i.e., statewide and mountainous regions above 7,500 feet in elevation). The following regression equation for mountainous regions above 7,500 feet in elevation is based on data from 40 gaging stations with non-zero discharge (Waltemeyer 2002):

$$4Q3 \quad = \quad 7.3287 \times 10^{-5}\ DA^{0.70}\ P_w^{\ 3.58}\ S^{1.35} \qquad \text{(Eq. 3-1)}$$

where,

4Q3 = minimum average four-day, three-year flow (cfs)
DA = Drainage area (mi^2)
P_w = Average basin mean winter precipitation (inches)
S = Average basin slope (percent).

The average standard error of the estimate (SEE) and coefficient of determination are 94 and 66 percent, respectively, for this regression equation (Waltemeyer 2002). The 4Q3 for Ute Creek was estimated using the regression equation for mountainous regions (Eq. 3-1) because the average elevation for this assessment unit is greater than 7,500 feet in elevation (Table 3.2).

Table 3.2 Calculation of 4Q3 Flow

Assessment Unit	Average elevation (ft.)	Drainage area (mi^2)	Mean winter precipitation (in.)	Average basin slope (percent)	4Q3 (cfs)
Ute Creek (Cimarron River to headwaters)	9183	15.754	10.01	0.299	0.378

The 4Q3 value for Ute Creek was converted from cubic feet per second (cfs) to units of million gallons per day (mgd) as follows:

$$0.378\ \frac{ft^3}{\sec} \times 1{,}728 \frac{in^3}{ft^3} \times 0.004329 \frac{gal}{in^3} \times 86{,}400\ \frac{\sec}{day} \times 10^{-6} = 0.244 mgd$$

Streamflow in the Cimarron River was measured by the USGS during the 2006 sampling season using active gages below Eagle Nest Dam (USGS 07206000) and near Cimarron, NM (USGS 07207000). Average daily streamflow in the Cimarron River below Eagle Nest Dam ranged from 0.50 cfs to 44 cfs during the SWQB sampling events. Average daily streamflow near Cimarron, NM ranged from 2.3 cfs to 39 cfs during the SWQB sampling events. Water quality standard exceedences *only* occurred during higher flows. Therefore, the critical streamflow value for this TMDL is not the 4Q3 but the lowest streamflow at which the arsenic standard is exceeded, or the expected flow at which arsenic is equal to 2.3 µg/L. Figure 3.1 depicts the relationship between arsenic and streamflow for the Cimarron River below Eagle Nest Lake (R^2 = 0.57) and Figure 3.2 depicts the relationship between arsenic and streamflow for the Cimarron River near Cimarron, NM (R^2 = 0.90).

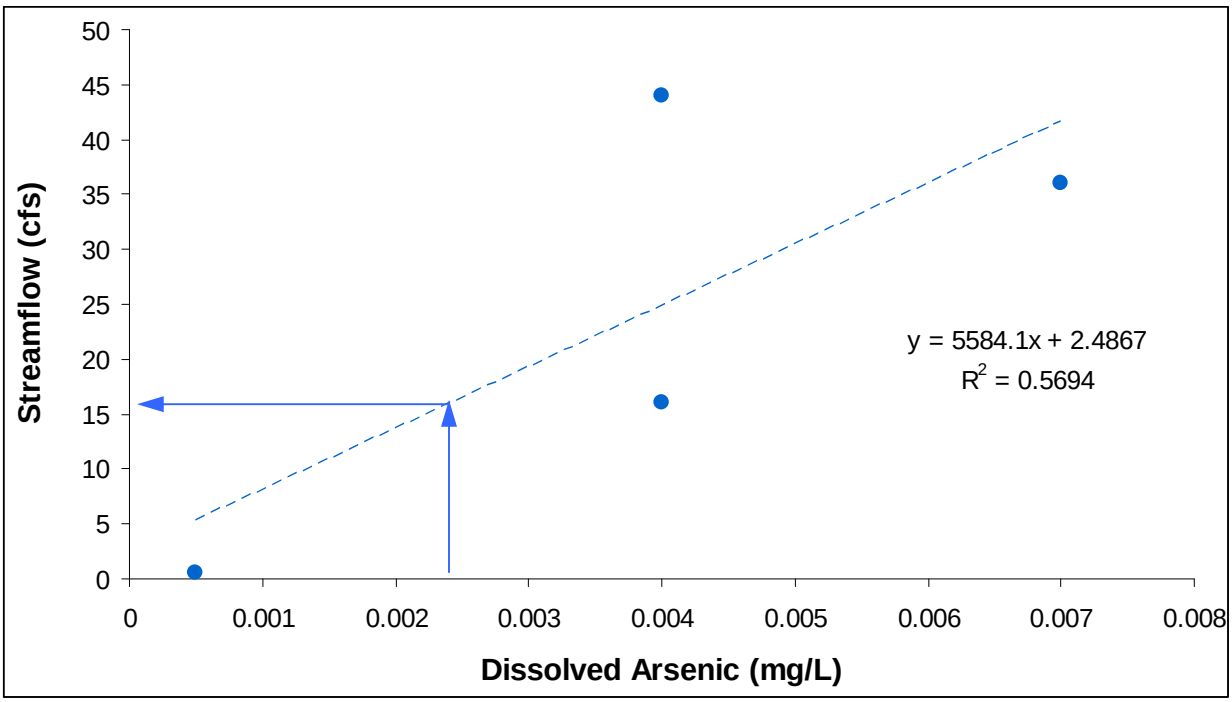

Figure 3.1 Cimarron River below Eagle Nest Lake: Arsenic vs. Streamflow Relationship

The critical flows are based on SWQB data and were calculated using the relationship between arsenic and streamflow presented in Figures 3.1 and 3.2. Using the arsenic-flow relationship and an arsenic standard of 2.3 µg/L (0.0023 mg/L) for the x-variable, the estimated critical flows are:

- Cimarron River (Turkey Creek to Eagle Nest Lake) =
  (5584.1 x 0.0023 mg/L) + 2.4867 ≅ 15.3 cfs
- Cimarron River (Cimarron Village to Turkey Creek) =
  (10802 x 0.0023 mg/L) – 1.0299 ≅ 23.8 cfs

The critical streamflow value for the Cimarron River (Turkey Creek to Eagle Nest Lake) was converted from cubic feet per second (cfs) to units of million gallons per day (mgd) as follows:

$$15.3\,\frac{ft^3}{\sec} \times 1{,}728\,\frac{in^3}{ft^3} \times 0.004329\,\frac{gal}{in^3} \times 86{,}400\,\frac{\sec}{day} \times 10^{-6} = 9.91\,mgd$$

Critical flow for the Cimarron River (Cimarron Village to Turkey Creek) was converted to million gallons per day using the same formula. The resulting critical flows are listed in Table 3.3.

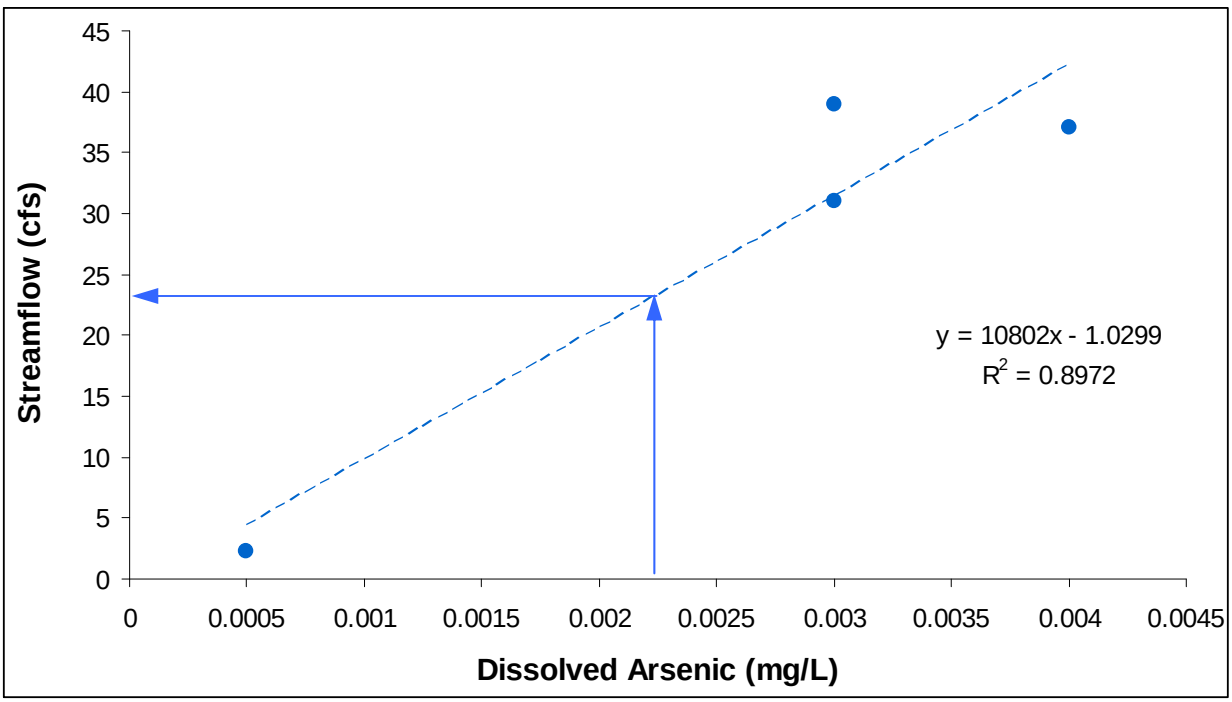

Figure 3.2 Cimarron River near Cimarron, NM: Arsenic vs. Streamflow Relationship

It is important to remember that the TMDL itself is a value calculated at a defined critical condition, and is calculated as part of a planning process designed to achieve water quality standards. Since flows vary throughout the year in these systems, the actual load at any given time will vary based on the changing flow.

3.3 Calculations

A target load for arsenic is calculated based on the critical flow, the current water quality criterion, and a conversion factor (0.00834) that is used to convert µg/L units to lbs/day (see Appendix A for conversion factor derivation). The target loading capacity is calculated using Equation 3-2. The results are shown in Table 3.3.

Critical flow (mgd) x Criterion (µg/L) x 0.00834 = Target Loading Capacity (Eq. 3-2)

Table 3.3 Calculation of target loads for dissolved arsenic

Assessment Unit	Critical Flow (mgd)	Dissolved Arsenic[1] (µg/L)	Conversion Factor	Target Load Capacity[2] (lbs/day)
Cimarron River (Cimarron Village to Turkey Creek)	15.4	2.3	0.00834	0.295
Cimarron River (Turkey Creek to Eagle Nest Lake)	9.91	2.3	0.00834	0.190
Ute Creek (Cimarron River to headwaters)	0.244	2.3	0.00834	0.005

Notes: [1] target values are based on the most conservative criterion applicable to each assessment unit.
[2] values rounded to three significant figures

The measured loads for arsenic were similarly calculated. The arithmetic mean of the data used to determine the impairment was substituted for the criterion in Equation 2. The same conversion factor of 0.00834 was used. Results are presented in Table 3.4.

Table 3.4 Calculation of measured loads for dissolved arsenic

Assessment Unit	Critical Flow (mgd)	Dissolved Arsenic Arithmetic Mean[1] (µg/L)	Conversion Factor	Measured Load[2] (lbs/day)
Cimarron River (Cimarron Village to Turkey Creek)	15.4	3.3	0.00834	0.424
Cimarron River (Turkey Creek to Eagle Nest Lake)	9.91	5.0	0.00834	0.413
Ute Creek (Cimarron River to headwaters)	0.244	3.7	0.00834	0.008

Notes: [1] dissolved arsenic concentration is the arithmetic mean of observed exceedences
[2] values rounded to three significant figures

3.4 Waste Load Allocations and Load Allocations

3.4.1 Waste Load Allocation

There are no active point source dischargers on these AUs. Neither are there any Municipal Separate Storm Sewer System (MS4) storm water permits. However, excess metal levels may be a component of some storm water discharges covered under general NPDES permits, so the load from these dischargers should be addressed.

Storm water discharges from construction activities are transient because they occur mainly during the construction itself, and then only during storm events. Coverage under the National Pollutant Discharge Elimination System (NPDES) Construction General Permit (CGP) for construction sites greater than one acre requires preparation of a Storm Water Pollution Prevention Plan (SWPPP) that includes identification and control of all pollutants associated with the construction activities to minimize impacts to water quality. The current CGP also includes state-specific requirements to implement site-specific interim and permanent stabilization, managerial, and structural solids, erosion, and sediment control Best Management Practices (BMPs) and/or other controls. BMPs are designed to prevent to the maximum extent practicable an increase in sediment load to the water body or an increase in a sediment-related parameter, such as total suspended solids, turbidity, siltation, stream bottom deposits, etc. BMPs also include measures to reduce flow velocity during and after construction compared to pre-construction conditions to assure that waste load allocations (WLAs) or applicable water quality standards, including the antidegradation policy, are met. Compliance with a SWPPP that meets the requirements of the CGP is generally assumed to be consistent with this TMDL.

Storm water discharges from active industrial facilities are generally covered under the current NPDES Multi-Sector General Permit (MSGP). This permit also requires preparation of an SWPPP, which includes specific requirements to limit (or eliminate) pollutant loading associated with the industrial activities in order to minimize impacts to water quality. Compliance with a SWPPP that meets the requirements of the MSGP is generally assumed to be consistent with this TMDL.

It is not possible to calculate individual WLAs for facilities covered by these General Permits at this time using available tools. Loads that are in compliance with the General Permits are therefore currently included as part of the load allocation (LA).

3.4.2 Load Allocation

In order to calculate the LA, the WLA and margin of safety (MOS) were subtracted from the target capacity TMDL following Equation 3-3:

$$WLA + LA + MOS = TMDL \qquad \text{(Eq. 3-3)}$$

The MOS is estimated to be 20 percent of the target load calculated in Table 3.3. Results are presented in Table 3.5. Additional details on the MOS are presented in Section 3.7.

Table 3.5 TMDL for dissolved arsenic

Assessment Unit	WLA (lbs/day)	LA (lbs/day)	MOS (20%) (lbs/day)	TMDL* (lbs/day)
Cimarron River (Cimarron Village to Turkey Creek)	0	0.236	0.059	0.295
Cimarron River (Turkey Creek to Eagle Nest Lake)	0	0.150	0.040	0.190
Ute Creek (Cimarron River to headwaters)	0	0.004	0.001	0.005

Notes: *values rounded to three significant figures

The extensive data collection and analyses necessary to determine background arsenic loads for the Cimarron River watershed were beyond the resources available for this study. It is therefore assumed that a portion of the LA is made up of natural background loads.

The load reductions necessary to meet the target loads were calculated to be the difference between the calculated TMDL (Table 3.3) and the measured loads (Table 3.4), and are shown in Table 3.6. These load reduction tables are presented for informational purposes only. It is important to note that WLAs and LAs are estimates based on a specific flow condition (see Section 3.2). Under differing hydrologic conditions, the loads will change. For this reason the load allocations given here are less meaningful than are the relative percent reductions. Successful implementation of this TMDL will be determined based on achieving the current water quality standards.

Table 3.6 Calculation of load reduction for dissolved arsenic

Assessment Unit	Target Load (lbs/day) *(a)*	Measured Load (lbs/day)	Load Reduction (lbs/day)	Percent Reduction *(b)*
Cimarron River (Cimarron Village to Turkey Creek)	0.236	0.424	0.188	44%
Cimarron River (Turkey Creek to Eagle Nest Lake)	0.150	0.413	0.263	64%
Ute Creek (Cimarron River to headwaters)	0.004	0.008	0.004	50%

Notes: The MOS is not included in the load reduction calculations because it is a set aside value which accounts for any uncertainty or variability in TMDL calculations and therefore should not be subtracted from the measured load.
(a) Target Load = TMDL - MOS
(b) Percent reduction is the percent the existing measured load must be reduced to achieve the TMDL, and is calculated as follows: (Measured Load – Target Load) / Measured Load x 100

3.5 Identification and Description of Pollutant Source(s)

SWQB fieldwork includes an assessment of the probable sources of impairment (Appendix B). The approach for identifying "Probable Sources of Impairment" was recently modified by SWQB to include additional input from a variety of stakeholders including landowners, watershed groups, and local, state, tribal and federal agencies. Probable Source Sheets are filled out by SWQB staff during watershed surveys and watershed restoration activities. The draft probable source list is reviewed and modified, as necessary, with watershed group/stakeholder input during the TMDL public meeting and comment period.

The Probable Source Identification Sheets in Appendix B provide an approach for a visual analysis of a pollutant source along an impaired reach. Although this procedure is subjective, SWQB feels that it provides the best available information for the identification of probable sources of impairment in this watershed. The list of "Probable Sources" is not intended to single out any particular land owner or single land management activity and has therefore been labeled "Probable" and generally includes several sources for each known impairment. Table 3.7 displays probable sources along the reach as determined by field reconnaissance and assessment. Probable sources of arsenic will be evaluated, refined, and changed as necessary through the Watershed-Based Plan (WBP) process.

Table 3.7 Pollutant source summary for Arsenic

Assessment Unit	Pollutant Sources	Magnitude[(a)] (lbs/day)	Probable Sources[(b)] (% from each)
Cimarron River (Cimarron Village to Turkey Creek)	Point: Nonpoint:	n/a 0.424	0% 100% Baseflow depletion from groundwater withdrawls, rangeland grazing, source unknown
Cimarron River (Turkey Creek to Eagle Nest Lake)	Point: Nonpoint:	n/a 0.413	0% 100% Dam or impoundment, other recreational pollution sources, source unknown
Ute Creek (Cimarron River to headwaters)	Point: Nonpoint:	n/a 0.008	0% 100% Rangeland grazing, source unknown

Notes: *(a)* Measured Loads in pounds per day.
(b) From the Integrated CWA 303(d)/305(b) list (NMED/SWQB 2010a). This list of probable sources is based on staff observation and known land use activities in the watershed. These sources are not confirmed nor quantified at this time.

3.6 Linkage of Water Quality and Pollutant Sources

Arsenic is a naturally occurring element found in many of the rocks and minerals that make up the earth's crust. The minerals with the highest arsenic content are realgar and orpiment, both arsenic sulfides, which contain 70% and 60% arsenic by weight, respectively. These minerals are rare. More common arsenic containing minerals include arsenopyrite and pyrite ("fool's

gold"). These two minerals can contain as much as 48% and 5% arsenic by weight, respectively. One of the geologic settings in which these minerals occur is areas where precious metals have been deposited, and both minerals are common in New Mexico. Although the arsenic in these minerals is chemically bound into their structure, it can be introduced into surface water or groundwater through the dissolution of minerals and ores (NMBGMR 2002).

Baldy Mountain, the highest mountain in the *Cimarron Mountains* subrange of the Sangre de Cristo Mountains, is located in the Moreno Valley near Eagle Nest, NM. Baldy Mountain, as well as others mountains in this range, has seen extensive mining over the years. Gold was discovered around 1867 and mining operations began soon after. Miners strip mined areas of the mountain that they thought had gold. One negative result of the extensive mining in the area is that arsenic can be very concentrated in mine tailings, especially in those associated with gold mining operations.

SWQB performed a water quality survey of Eagle Nest Lake in 2005. There were 4 of 6 exceedences of the domestic water supply criterion (2.3 ug/L). Therefore, Eagle Nest Lake is listed as impaired due to arsenic. Since Eagle Nest Lake sits in the Moreno Valley below many of these abandoned mines, it is reasonable to expect that some of the waste products connected with the “gold rush” have found their way into the surface waters of the Moreno Valley and washed into Eagle Nest Lake. In addition, since Eagle Nest Lake supplies the majority of water to the Cimarron River, it is not surprising that the Cimarron River below Eagle Nest Dam is also listed as impaired due to arsenic.

3.7 Margin of Safety

TMDLs should reflect a MOS based on the uncertainty or variability in the data, the point and nonpoint source load estimates, and the modeling analysis. The MOS can be expressed either implicitly or explicitly. An implicit MOS is incorporated by making conservative assumptions in the TMDL analysis, such as allocating a conservative load to background sources. An explicit MOS is applied by reserving a portion of the TMDL and not allocating it to any other sources.

For these arsenic TMDLs, the margin of safety was developed using a combination of conservative assumptions and explicit recognition of potential errors. Therefore, this margin of safety takes into account the following assumptions:

- *Conservative Assumptions*

  Using the critical flow, or “worst case scenario,” to calculate the allowable loads.

- *Explicit recognition of potential errors*

  A level of uncertainty exists in water quality sampling. Techniques used for measuring arsenic concentrations in stream water can lead to inaccuracies in the data. A conservative MOS for this element is **10 percent.**

There is also inherent error in all flow calculations. A conservative MOS for this element is **10 percent.**

Therefore, based on the potentia l errors described ab ove, a cons ervative, explicit MOS of 20% was assigned to the arsenic TMDLs.

3.8 Consideration of Seasonal Variation

Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs take into consideration seasonal variation in watershed conditions and pollutant loading. During the 2006 water quality survey, arsenic exceedences occurred mainly during higher streamflows, which coincides with seasonal water releases from Eagle Nest dam. Higher flows caused by stormwater runoff may also flush more nonpoint source runoff containing sediment and metals. It is possible the criterion may be exceeded under a low flow condition when there is insufficient dilution. Evaluation of seasonal variability for potential nonpoint sources is difficult due to limited available data. Data used in the calculation of this TMDL were collected during the spring, summer, and fall of 2006 in order to ensure coverage of any potential seasonal variation in the system.

3.9 Future Growth

Growth estimates by county are available from the New Mexico Bureau of Business and Economic Research. These estimates project growth to the year 2035. Growth estimates for Colfax County project a 14% growth rate through 2035. However, as of 2008, the largest incorporated town in the county, Raton, had an estimated population of 6,465 people. This showed a decrease of 11.22 percent from the 2000 census population and Raton's population is not expected to have much growth in the future.

According to the data, arsenic loading is mainly from Eagle Nest Lake sourcewater and other diffuse nonpoint sources (i.e. abandoned mines and tailings). Estimates of future growth are not anticipated to lead to a significant increase in metals concentrations that cannot be controlled with best management practice (BMP) implementation in this watershed. However, it is imperative that BMPs continue to be utilized and improved upon in this watershed while adhering to SWPPP requirements related to construction and industrial activities covered under the general permit.