6.0 SELENIUM

During the 2002 SWQB intensive water quality survey in the San Juan River basin, there was one exceedence of the New Mexico water quality standard for total recoverable selenium documented at the sampling station on Gallegos Canyon near the confluence with the San Juan River. SJRIP also provided data from 1994-2003. In total, there were 23 of 30 exceedences of the total recoverable selenium wildlife habitat chronic screening criteria of 0.0075 mg/L (0.005 mg/L x 1.5). Consequently, Gallegos Canyon (San Juan River to Navajo boundary) was listed on the 2004-2006 Clean Water Act Integrated §303(d)/§305(b) list for selenium.

6.1 Target Loading Capacity

Target values for this selenium TMDL will be determined based on 1) the presence of numeric criteria, 2) the degree of experience in applying the indicator, and 3) the ability to easily monitor and produce quantifiable and reproducible results. For this TMDL document, target values for total recoverable selenium are based on numeric criteria. This TMDL is also consistent with New Mexico's antidegradation policy.

According to the New Mexico water quality standards (20.6.4.900.M NMAC), the total recoverable selenium criterion is 0.005 mg/L for wildlife habitat uses. According to the SWQB assessment protocol, impairment is determined by comparing measured concentrations to the chronic screening criteria of 0.0075 mg/L (0.005 mg/L x 1.5) (NMED/SWQB 2004b). This screening criteria was exceeded 23 of 30 times during the 2002 survey and in the 1994-2003 data set from SJRIP (Table 6.1). Concurrently collected TSS and turbidity data reported in Table 6.1 will be discussed in the Linkage(s) section below.

The large majority of the Gallegos watershed (99%) is under the jurisdiction of the Navajo Nation. The Navajo Nation water quality criteria for dissolved and total selenium are 0.05 mg/L and 0.002 mg/L, respectively, for Livestock and Wildlife Watering uses (NNEPA 2004).

Selenium is both an essential and detrimental naturally occurring trace element, predominantly found in black shale derived soils and landscapes. Selenium becomes bioavailable to aquatic biota through surface and groundwater interactions with surrounding geology. Selenium is also hypothesized as contributing to the decline of endangered fishes of the Colorado River Basin because it may inhibit recovery by adversely affecting reproduction and recruitment (see USGS 2004 for full references). Due to the bioaccumulative properties of selenium, USEPA is currently proposing that one component of selenium criteria be expressed as a concentration of the pollutant in fish tissue rather than a concentration in the water (USEPA 2004).

Table 6.1 Total recoverable selenium, TSS, and turbidity concentrations in Gallegos Canyon

Sample Date	Total Recoverable Selenium (mg/L)	TSS (mg/L)	Turbidity (NTU)	Source
2/17/1998	0.015*	3160	2660	SJRIP
3/16/1998	0.017*	340	31	SJRIP
4/20/1998	0.007	756	510	SJRIP
5/12/1998	0.013*	168	93	SJRIP
6/22/1998	0.025*	168	81	SJRIP
8/19/1998	0.010*	2150	1170	SJRIP
9/21/1998	0.013*	1210	585	SJRIP
11/18/1998	0.018*	2220	950	SJRIP
3/7/1999	0.016*	372	240	SJRIP
5/13/1999	0.018*	780	480	SJRIP
8/26/1999	0.010*	3380	1650	SJRIP
11/30/1999	0.017*	362	NA	SJRIP
2/7/2000	0.014*	196	38	SJRIP
5/25/2000	0.007	714	140	SJRIP
8/22/2000	0.007	6260	314000	SJRIP
11/18/2000	0.015*	114	45.4	SJRIP
2/27/2001	0.008*	5810	5920	SJRIP
5/21/2001	0.013*	250	167	SJRIP
8/21/2001	0.013*	1870	1030	SJRIP
2/13/2002	0.016*	56	43.4	SJRIP
3/27/2002	0.014*	560	338	SJRIP
5/7/2002	0.012*	142	25.7	SJRIP
8/21/2002	0.007	4670	3970	SJRIP
10/24/2002	0.008*	1340	1100	SWQB
11/19/2002	0.009*	1210	770	SJRIP
2/19/2003	0.012*	38	47.2	SJRIP
5/27/2003	0.005	118	71	SJRIP
8/28/2003	0.007	4390	4300	SJRIP
11/18/2003	0.008*	1690	1420	SJRIP

NOTES: * Exceedence of chronic screening criterion of 0.0075 mg/L total recoverable selenium.
NTU = Nephelometric turbidity units

6.2 Flow

TMDLs are calculated for the Gallegos Canyon at a specific flow. When available, USGS gages are used to estimate flow. Where gages are absent, geomorphologic cross section field data are collected at each site and flows are modeled or actual flow measurements are taken.

Gallegos Canyon is an ephemeral system. However, there appears to be perennial flow in the lower portion of Gallegos Canyon due to seepage from return flow from irrigated Navajo Agricultural Products Industry (NAPI) fields in the watershed (Photo 6.0). The flow in this

portion is braided and shallow with sandy substrate. It is therefore often not possible to take an accurate flow measurement using standard USGS protocol. Flow at the Gallegos Canyon station during the October 2002 SWQB sampling event was estimated to be 2 cfs at this sampling event based on SWQB staff field notes. In the absence of any other flow information, this value is used in the TMDL calculation.

This flow value for Gallegos Canyon was converted from cfs to units of million gallons per day (mgd) as follows:

$$2\,\frac{ft^3}{\sec} \times 1{,}728\,\frac{in^3}{ft^3} \times 0.004329\,\frac{gal}{in^3} \times 86{,}400\,\frac{\sec}{day} \times 10^{-6} = 1.29\,mgd$$

It is important to remember that the TMDL is a planning tool to be used to achieve water quality standards. Since flows vary throughout the year in all natural surface water systems, the target load will vary based on the changing flow. Management of the load to improve stream water quality should be a goal to be attained. Meeting the calculated target load may be a difficult objective.

Photo 6.0 Gallegos Canyon at confluence with the San Juan River, Oct 2003

6.3 Calculations

A target load for total recoverable selenium is calculated based on a flow, the current water quality criterion, and a conversion factor (8.34) that is a used to convert milligrams per liter (mg/L) units to pounds per day (lbs/day) (see Appendix A for Conversion Factor Derivation). The target loading capacity is calculated using **Equation 1**. The results are shown in Table 6.2.

Critical Flow (mgd) x Standard (mg/L) x 8.34 = Target Loading Capacity (Eq. 1)

Table 6.2 Calculation of target loads for total recoverable selenium

Location	**Flow+ (mgd)**	**Total recoverable selenium (mg/L)**	**Conversion Factor**	**Target Load Capacity (lbs/day)**
Gallegos Canyon	1.29	0.005	8.34	0.054

NOTES: + Since USGS gages were unavailable and direct measurement was not possible, flow was estimated during the 2002 October sampling event.

The measured loads for total recoverable selenium were similarly calculated. The arithmetic mean of the data used to determine the impairment was substituted for the standard in **Equation 1**. The same conversion factor of 8.34 was used. Results are presented in Table 6.3.

Table 6.3 Calculation of measured loads for total recoverable selenium

Pollutant sources	**Flow (mgd)**	**Dissolved Selenium Arithmetic Mean* (mg/L)**	**Conversion Factor**	**Measured Load Capacity (lbs/day)**
Gallegos Canyon	1.29	0.012	8.34	0.129

Notes: * Arithmetic mean of total recoverable selenium concentrations (see Table 6.1).

6.4 Waste Load Allocations and Load Allocations

6.4.1 Waste Load Allocation

There are no point source contributions associated with this TMDL. The WLA is zero.

6.4.2 Load Allocation

In order to calculate the LA, the WLA and MOS were subtracted from the target capacity (TMDL) following **Equation 2**.

$$WLA + LA + MOS = TMDL \qquad \text{(Eq. 2)}$$

The MOS is estimated to be 25% of the target load calculated in Table 6.2. Results are presented in Table 6.4. Additional details on the MOS chosen are presented in Section 6.7 below.

Table 6.4 Calculation of TMDL for total recoverable selenium

Location	WLA (lbs/day)	LA (lbs/day)	MOS (25%) (lbs/day)	TMDL (lbs/day)
Gallegos Canyon	0	0.040	0.014	0.054

The extensive data collection and analyses necessary to determine background total recoverable selenium for the Gallegos Canyon watershed was beyond the resources available for this study. It is therefore assumed that a portion of the load allocation is made up of natural background loads.

The NPS and background load reductions that would be necessary to meet the target loads were calculated to be the difference between the calculated TMDL (Tables 6.4) and the measured load (Table 6.3), and are shown in Table 6.5. These load reduction tables are presented for informational purposes only.

Table 6.5 Calculation of load reduction for total recoverable selenium

Location	TMDL (lbs/day)	Measured Load (lbs/day)	Load Reduction (lbs/day)	Percent Reduction[(a)]
Gallegos Canyon	0.054	0.129	0.075	58%

Notes:
[(a)] Percent reduction is the percent the existing measured load must be reduced to achieve the TMDL, and is calculated as follows: (Measured Load – TMDL) / Measured Load x 100.

6.5 Identification and Description of Pollutant Source(s)

Probable nonpoint pollutant sources that may be contributing to observed total recoverable selenium loads are displayed in Table 6.6.

Table 6.6 Pollutant Source Summary for Total Recoverable Selenium

Pollutant Sources	Magnitude (lbs/day)	Assessment Unit	Potential Sources[(a)]
Point: [(b)]			
Selenium	NA	Gallegos Canyon (San Juan River to Navajo Nation bnd)	0%
Nonpoint: [(c)]			
Selenium	0.129	Gallegos Canyon (San Juan River to Navajo Nation bnd)	100% Irrigated crop production, natural sources

Notes: NA – not applicable
[(a)] From the 2004-2006 Integrated 303(d)/305(b) list. This list of probable sources is based on staff observation and known land use activities in the watershed. These sources are not confirmed or quantified at this time.
[(b)] There are no point sources of selenium in the watershed.
[(c)] Measured load.

6.6 Link Between Water Quality and Pollutant Sources

Where data gaps exist or the level of uncertainty in the characterization of sources is large, the recommended approach to TMDL assignments requires the development of allocations based on estimates utilizing the best available information.

SWQB fieldwork includes an assessment of the potential sources of impairment (SWQB/NMED 1999). The Pollutant Source(s) Documentation Protocol form and Potential Sources Summary Table in Appendix B provide documentation of a visual analysis of probable sources along an impaired reach. Although this procedure is subjective, SWQB feels that it provides the best available information for the identification of potential sources of impairment in this watershed. Table 6.6 (Pollutant Source Summary) identifies and quantifies potential sources of nonpoint source impairments along each reach as determined by field reconnaissance and assessment. It is important to consider not only the land directly adjacent to the impaired assessment unit, but also on the upland and upstream areas in a more holistic watershed approach to implementing this TMDL.

In general, increased metals in the water column can commonly be linked to sediment transport and accumulation, where the metals are a constituent part of the sediment. This does not appear to be the case in the Gallegos Canyon as evidenced by the fact that there is not a relationship between total recoverable selenium and TSS concentrations according to the data used to determine the impairment (Table 6.1, Figure 6.1).

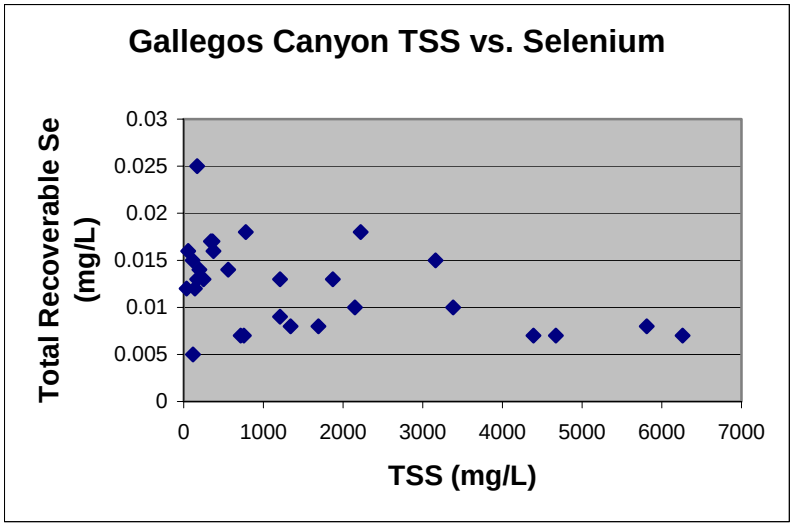

Figure 6.1 Relationship between Total Recoverable Selenium and TSS in Gallegos Canyon

The high sandstone bluffs that parallel the flood plain on the south side of the San Juan River east of Gallegos canyon are often referred to as the Bluffs. The Bluffs are characterized geologically as sedimentary sandstone of the Ojo Alamo Formation, and clays and shales of the Kirtland and Fruitland Formations (Dane and Bachman 1965). The Nacimiento Formation and the Kirtland Shale/Fruitland Formation underlie tile soils and compose the outcrop in most of the upland area south of the San Juan River (Blanchard *et al*. 1993). These deep layers are cut by drainages creating dissected colluvial mesa tops that drop off into narrow steep-walled canyons (Wheelbarger 2000).

All of the shales of Cretaceous age consist at least in part of gray arid black shale and are potential sources of selenium (Blanchard *et al.* 1993). Black shale is comprised of organic-rich, generally dark-colored, fine-grained, sedimentary rock deposited in very low oxygen conditions. Oil and gas are valued resources that originate in black shale, thus explaining the large amount of oil and gas exploration in the San Juan River basin. This type of shale is also the probable source of metals found in some mineral deposits. As such, many black shale sequences are non-point sources for potentially toxic elements such as arsenic, selenium, chromium, and mercury (USGS 2004). Normal aqueous chemical processes, enhanced by seepage from irrigated agriculture in the watershed, are capable of rendering some of the naturally-occurring selenium in the Cretaceous age layers in the watershed available to the stream system.

These landscapes, which occur in the San Juan River basin, are recognized by several federal, tribal, and state land management agencies as a focal point for the need for science information supporting sound land-use policies. This need has risen in prominence due to increased and changing land use demands, and bioavailability issues involving both selenium concentrations and salinity levels in surface and ground water (USGS 2004). Specifically, ground-water return flow from irrigated areas contributes substantially to surface water flow in Gallegos Canyon (Blanchard *et al*. 1993). Seepage of irrigation water from fields in the upland areas east of Gallegos Canyon appears to be the cause of the perennial flow in lower Gallegos Canyon. This

seepage is also likely leaching out and mobilizing the selenium, thus leading to elevated concentrations. Concern for selenium concentrations in water and sediment prompted a USGS 1990-1991 study of Gallegos Canyon, Ojo Amarillo Canyon, and the Hogback Project (Blanchard *et al.* 1993) and a 1993-1995 follow up study (Thomas *et al.*, 1998). Concentrations of selenium larger than established standards and criteria were present in water, bottom sediment, and biota in four areas on these three irrigation projects, including the middle and north ponds in Gallegos Canyon on the Navajo Indian Irrigation Project (NIIP) (Blanchard *et al.* 1993). Soils in the upland area where the NIIP is located typically are derived from eolian and alluvial material, are deep and are well- to excessively- drained. Permeability ranges from moderately rapid to rapid (Blanchard *et al.* 1993). Thomas *et al.* (1998) found that water samples from seeps and tributaries to the San Juan River draining irrigated land developed on Cretaceous soils contained about 10 times more selenium than samples from sites draining irrigated land developed on non-Cretaceous soils.

These finding have helped prioritize locations for proposing and implementing BMPs to address excessive selenium in the San Juan River basin. NIIP as well as the Hogback Irrigation Project have been identified as irrigation sources of salt in the San Juan River Basin, which may in turn contribute to excessive salinity in the Colorado River basin. This concern, and potential solutions that are already being implemented, are being addressed through the Colorado River Basin Salinity Control Program for the San Juan Unit. Additional information can be found at web site http://www.usbr.gov/dataweb/html/san_juan.html.

6.7 Margin of Safety

TMDLs should reflect a MOS based on the uncertainty or variability in the data, the point and NPS load estimates, and the modeling analysis. For this TMDL, there will be no MOS for point sources, since there are none. However, for NPSs the MOS is estimated to be an addition of **25%** for total recoverable selenium in this case. This MOS incorporates several factors:

- Errors in calculating NPS loads

  A level of uncertainty exists in sampling NPSs of pollution. Techniques used for measuring metals concentrations in stream water can lead to inaccuracies in the data. Therefore, a conservative MOS for metals increases the TMDL by **15%.**

- Errors in calculating flow

  Flow estimate was based on one visual estimation October 2002. Accordingly, a conservative MOS increases the TMDL by an additional **10%.**

6.8 Consideration of Seasonal Variation

Data used in the calculation of this TMDL were collected during the spring, summer, fall, and winter between 1998 and 2003 in order to ensure coverage of any potential seasonal variation in

the system. Critical condition was set to the flow estimate determined during the October 2002 SWQB sampling visit.

6.9 Future Growth

Estimations of future growth are not anticipated to lead to a significant increase for total recoverable selenium that cannot be controlled with BMP implementation in this watershed.