EXHIBIT C

KC HARVEY, LLC
SOIL AND WATER RESOURCE CONSULTANTS

May 4, 2006

Mr. Bill DiRienzo
Wyoming Department of Environmental Quality
Water Quality Division
Herschler Building, 4th Floor West
122 West 25th Street
Cheyenne, Wyoming 82002

Subject: Comments pertaining to the derivation of default effluent limits for EC in the Draft Section 20 Agricultural Use Protection Policy.

Dear Mr. DiRienzo:

I respectfully submit for your consideration the following comments regarding the fourth draft of the Section 20 Agricultural Use Protection Policy as it pertains to the derivation of default effluent limits for EC. These comments are being submitted on behalf of Yates Petroleum Company, Williams Production RMT Company, Petro-Canada Resources (USA) Inc., Marathon Oil Company, Lance Oil & Gas Company, Inc., Fidelity Exploration & Production Company, Devon Energy Production Company L.P., Bill Barrett Corporation, and Anadarko Petroleum Corporation. I have submitted additional comments regarding the derivation of SAR limits and the proposed SAR cap to you in a separate letter.

By way of introduction, I am a board-certified professional soil scientist having practiced as an environmental consultant in Montana and Wyoming, and throughout the world, for nearly 25 years. For the past seven years, my practice has focused on water management and soil and water salinity/sodicity issues associated with oil and gas development. I am credited as the first to research, develop, and apply managed irrigation techniques for the beneficial use of coalbed natural gas produced water. I have directed or participated in over 75 separate projects related to produced water management, WPDES permitting, soil and water chemistry investigations, and reclamation for coalbed and conventional natural gas projects in Wyoming, Colorado, and Montana. I have a M.S. degree in land rehabilitation (soil science emphasis) from Montana State University, and a B.S. in Resource Conservation (soil science emphasis) from the University of Montana.

I would like to comment on the proposed changes made to the Agricultural Use Protection Policy by the WDEQ subsequent to the January 26, 2006 meeting of the Water and Waste Advisory Board. My comments will focus on the comments provided by Dr. Larry Munn in his letter to the DEQ dated December 5, 2005. It is my understanding that Dr. Munn's comments resulted in the changes made to the proposed Policy. Specifically, I comment on Dr. Munn's request that the California-based soil salinity tolerance thresholds be used to establish default effluent limits for electrical conductivity (EC) under the Tier 1 process.

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Summary of Findings

The fourth draft of the Agricultural Use Protection Policy describes a 3-tiered decision making process for deriving appropriate effluent limits for EC and SAR whenever a proposed discharge may reach irrigated lands. The Tier 1 process would be followed for deriving "default" limits, and as such, this procedure would require a minimum of background information from the applicant. Specifically, the default EC limits would be based on the species-specific 100 percent yield potential values for soil EC reported by the USDA Agricultural Research Service (ARS) Salt Tolerance Database (USDA ARS, 2006).

Alfalfa is considered to be the most salt sensitive plant irrigated in northeastern Wyoming. Given this, my comments focus on the relevant information regarding alfalfa salinity tolerance. The ramifications of the concepts and data discussed herein for alfalfa can be applied to the more tolerant irrigated forage species commonly found in northeastern Wyoming, for example, western wheatgrass and smooth brome.

A considerable amount of research went into preparing these comments, including three months searching and reviewing the relevant scientific literature, and compiling and analyzing available and relevant soil, plant, and water data. The key conclusions of the literature review and data analysis are presented below and will be substantiated by the discussion that follows.

<u>California Based Salinity Thresholds</u>

- The ARS Salt tolerance database relies on California based salinity thresholds developed to approximate the specific plant, soil and environmental variables associated with that region.
- Regional differences in soil chemistry, climate and agricultural practices are likely to have a profound effect on the applicability of California based salinity threshold data to alfalfa growing in Wyoming.

<u>Chloridic Versus Sulfatic Soils</u>

- The natural soil salinity in the Powder River Basin is dominated by the sulfate ion; California soils are dominated by chloride. This conclusion is supported herein by the literature and by an evaluation of actual soil chemistry data provided by the USDA National Soil Survey Center.
- The term "gypsiferous" refers to sulfatic soils and is applicable to the Powder River Basin of Wyoming. Numerous documents, including the ARS Salt Tolerance Database, indicate that in sulfatic (or "gypsiferous") soils, plants will tolerate about 2 dS/m higher salinity than indicated.

The Influence of Soil Salinity on Alfalfa Yield

- Alfalfa is considered the most salt sensitive plant irrigated in northeastern Wyoming. Conditions required for the growth of alfalfa at 100 percent of its physiological yield potential probably do not exist anywhere in northeastern Wyoming and place doubt on the application of this benchmark value there.

- Sources of research and field guidance outside of California suggest alfalfa has a higher relative 100 percent yield soil EC tolerance than 2 dS/m, perhaps as high as 4 to 8 dS/m.

- Alfalfa yield comparisons between California and Wyoming show actual harvest values independent of soil salinity. Identical yields were reported in Wyoming for soil EC values ranging from 1.8 dS/m to 6.5 dS/m.

Based on the review summarized herein, we respectfully suggest that the WDEQ consider adopting an acceptable average root zone EC threshold of 4 dS/m for protection of alfalfa. This would equate to a default (Tier 1) effluent limit of 2.7 dS/m based on the 1.5 concentration factor cited by the draft Agricultural Use Protection Policy. The EC limits for protecting other species of concern in the Powder River Basin, e.g., western wheatgrass, should also be adjusted accordingly, based on the inherent differences in soil chemistry and climate between the northern Great Plains and the California agricultural areas. These conclusions and recommendations are substantiated by the discussion below.

California-based Salinity Thresholds

The majority of salinity tolerance data generated in the United States have been a product of field and laboratory trials conducted by the U.S. Salinity Laboratory (USSL) in Riverside, California. The salinity tolerance data generated by the USSL were prompted in response to agricultural production in the areas of the San Joaquin and Imperial Valleys of California. In 1977, Maas and Hoffman compiled the California research in a seminal article titled "Crop Salt Tolerance -- Current Assessment," listing salt tolerance levels for various crops. The subsequent year, Francois and Maas (1978) published an indexed bibliography of plant responses to salinity from 1900 to 1977 with 2,357 references to about 1,400 species. These articles serve as the primary references regarding crop tolerance and yield potential of selected crops as influenced by irrigation water (EC_w) or the average root zone soil salinity level (EC_e). This information was updated by Mass (1990). The ARS Salt Tolerance Database relies entirely on the Mass (1990) summary as the primary source of relative salt tolerance levels among crops. With respect to alfalfa, the original salt tolerance listings remain unchanged from the original Mass and Hoffman (1977) article.

The Mass and Hoffman (1977) and Mass (1990) listings of salt tolerance levels include the establishment of the 100 percent yield threshold for soil salinity. This value refers to the maximum allowable average root zone salinity level (EC_e) that results in no yield reduction for crops grown in chloritic soils. The term chloritic soil refers to the dominant salt type found in California soils (see below). For alfalfa, Mass and Hoffman (1977) and Mass (1990) list the 100 percent yield potential for alfalfa grown in chloritic soils as 2.0 dS/m (EC_e). The Mass and

Hoffman (1977) and Mass (1990) assessments also contain a disclaimer that the yield potentials listed should only serve as a guide to relative tolerances among crops, and that the absolute salt tolerance of crops is not simply a function of soil EC but is dependent on "many plant, soil, water, and environmental variables."

Six studies conducted at the US Salinity Laboratory in Riverside, California, served as the foundation for the determination of Maas and Hoffman's 2.0 dS/m threshold value (Gauch and Magistad, 1943; Brown and Hayward, 1956; Bernstein and Ogata, 1966; Bower et al., 1969; Bernstein and Francois, 1973; Hoffman et al., 1975). These studies vary in their methodology, including greenhouse and field experiments, different growth mediums (sand, gravel and soil), various watering regimes (automatic watering, tension-based watering), and multiple sources of chloritic salinity (NaCl, $CaCl_2$, and $MgCl_2$). These studies were designed to assess relative yield values, irrigation leaching fractions, root zone salt profiles, or salinity-ozone interactions. They were not specifically designed to determine a threshold salinity value for alfalfa. Usually, only four salinity levels were tested, with data used to produce a crop yield reduction line.

Furthermore, the source of salinity in the six studies was consistently chloride dominated, with either NaCl or a blend of NaCl, $CaCl_2$, and $MgCl_2$ added to the irrigation water. In Southern California, where these studies occurred, salts found in the soils are largely chloride-dominated. None of these studies were conducted using sulfate-dominated salts, such as are found in Wyoming soils (see below). Such regional differences in soil salinity are likely to have a profound effect on the application of existing salinity threshold data to alfalfa growing in the Northern Great Plains. Recognizing this, Mass (1990), Ayers and Westcot (1985), Hanson et al. (1999), as well as the ARS Salt Tolerance Database, all indicate that plants grown in sulfatic soils will tolerate average root zone EC_e values about 2 dS/m higher than indicated by each of these references. For alfalfa, this would equate to a 100 percent yield threshold of approximately 4 dS/m. This fact is discussed in detail below.

Chloridic Versus Sulfatic Soils

Research efforts of the USSL in California identified adjustments in effective plant salinity tolerance expressed or repressed in the field by physiological responses to climate, cultural practices, soil fertility, irrigation methods, physical condition of the soils and the distribution and speciation of salts within soil profiles. A critical difference between the environmental conditions in California and the northern Great Plains (including northeastern Wyoming) is soil chemistry and the primary salt constituents found in these soils. It is widely accepted that the soils of the agricultural areas of California are dominated by salts where chloride is the dominant anion, and that the soils of the northern Great Plains are dominated by salts where sulfate is the dominant anion. In earlier publications, sulfatic soils are sometimes termed "gypsiferous," referring to the most common sulfate salt found in semi-arid soils -- gypsum (calcium sulfate dehydrate). The correct term used today is sulfatic soils.

To incorporate the variation of salinity tolerance exhibited by plant response to different salt distributions and dominant salt species, the authors of salt tolerance research included a provision for sulfatic soils. Soils may contain amounts of sparingly soluble salts, such as gypsum and other sulfate salts, many times greater than can be held in solution in the field water-content range. Sulfatic soils may appear to be saline when exhaustively extracted in the lab (i.e., saturated paste extract), but the in-situ soil solution may be nonsaline because of the limited solubility of gypsum and other sulfate salts (Bernstein, 1975). Thus, the EC measured in a saturated paste extract is higher than the actual concentration of salts seen by plants in sulfatic soils. It was suggested originally by Bernstein (1962) that plants will tolerate about 2 dS/m higher soil salinity (EC_e) than indicated in sulfatic soils due to this solubility effect. Since calcium sulfate is disproportionately dissolved in preparing saturated-soil extracts, the EC_e of sulfatic soils will range an average of 2 dS/m higher than that of chloritic soils with the same water conductivity at field capacity (Bernstein 1962). Therefore, plants grown in sulfatic soils will tolerate an EC_e of approximately 2 dS/m higher than those grown where chloride is the predominant ion (Maas, 1990). This narrative provision for sulfatic soils is included in the ARS Salt Tolerance Database, and the classic irrigation guidelines presented in Ayers and Wescot (1985).

Sulfatic soils are the rule not the exception in Wyoming and the northern Great Plains. Sulfatic soils identified by salinity tolerance references are characterized by the presence and influence of gypsum, or calcium sulfate dihydrate ($CaSO_4 \cdot 2H_20$), within the soil profile, as well as the geological and climactic prerequisites for sulfatic soil conditions. Soil gypsum may stem from one of several sources. Soils formed from geologic material containing anhydrite or gypsum often contains gypsum. The amount of rainfall and the topographic setting will strongly influence the amount and location of gypsum in the soil (Dixon and Weed, 1989). Accumulations of soluble salts, including sulfates in the surface layers, are characteristic of saline soils of arid and semiarid regions (Brady, 1974), including Wyoming. Research conducted by the U.S. Geological Survey confirms the presence of gypsiferous parent materials in the Powder River Basin (Johnson, 1993). At this point, it is important to differentiate between the soil taxonomic terms "gypsic" or "petrogypsic," which are used to describe significant gypsum accumulation within soil horizons, from the terms "gypsiferous" or "sulfatic" soils which refer to the dominate salt type in soils of Wyoming and the northern Great Plains.

Published research has addressed the issue of prevailing salt distribution and climate influenced salt dominance. In Springer et al. (1999), Curtin et al. (1993) and Trooien (2001), northern Great Plains prairie soil chemistry is comparatively summarized and/or contrasted to soils of California. Research suggests that recommendations developed for the western United States, where chloride is the major anion in soil and water chemistry, may not be appropriate for sulfatic soils (Springer et al., 1999). Trooien (2001) notes that most plant salinity tolerance information is developed in California and that the chemistry of salinity is different in the northern Great Plains (i.e., sulfate dominated salinity). Therefore, Trooien (2001) indicates that salinity thresholds are greater and yield losses are somewhat smaller in the Northern Great Plains compared to those of California (i.e., chloride dominated salinity). Research in Canadian prairie soils by Curtin et al. (1993) and Wentz (2001) suggest that salt tolerance testing at the Swift Current, Saskatchewan, salinity laboratory (and also at the US Salinity Laboratory) has mostly involved the determination of crop responses to chloride salinity. However, there is reason to suspect that responses to sulfate salinity, which is the predominant form of salinity in prairie soils, may differ from those observed in chloride salt systems. Wentz (2001) summarizes that crop tolerances developed for chloride dominated soils, such as those in California, may not be applicable to crops grown on the sulfate dominated soils typically found in western Canada.

Comparison of actual soil analytical data from the NSSC Soil Survey Laboratory, Lincoln, Nebraska, supports the chloride and sulfate salt dominance designations suggested by Springer et al. (1999), Curtin et al. (1993), Trooien (2001), and Wentz (2001). Analyses from the U.S. Soil Survey Laboratory are available online at http://ssldata.nrcs.usda.gov/ and organized by soil pedon. Data from selected counties in Wyoming and California were obtained from the NSSC Soil Survey Laboratory Research Database in order to determine the dominance of chloride or sulfate soil chemistry in the respective regions. Soil chemistry data were downloaded for use in this study for counties of the Powder River Basin in Wyoming (Sheridan, Campbell and Johnson Counties). Soil chemistry data were also downloaded for counties in California where intensive agricultural production takes place (Imperial, Fresno, Kern, Kings and Tulare).

Data pertaining to soil chloride and sulfate in the saturated paste extract are arranged and averaged by county and state in Table 1 below. These values are based on all of the available data provided by the U.S. Soil Survey Laboratory.

Table 1
A Comparison of Average Soil Saturated Paste Extract Sulfate and Chloride Levels from Counties in Wyoming and California.

County	**Average Soil Sulfate Level (meq/L)**	**Average Soil Chloride Level (meq/L)**
Sheridan, WY	14.9	4.1
Campbell, WY	130.4	3.0
Johnson, WY	30.9	1.8
Wyoming Average	**58.7**	**2.9**
Imperial, CA	48.4	295.7
Fresno, CA	98.6	26.3
Kern, CA	44.3	73.0
Kings, CA	110.7	23.9
Tulare, CA	9.3	21.6
California Average	**62.3**	**88.1**

The summary data suggest that the relative proportion of chloride salts in the selected California counties outweigh the proportion of sulfate salts and verify the chloride dominance suggested by the literature summarized above. In northeastern Wyoming, the relative proportion of sulfate salts in selected counties outweigh the proportion of chloride by an order of magnitude and verify the sulfate dominance and sulfatic conditions implied by the literature. Therefore, the recommendation by the ARS Salt Tolerance Database signifying that plants grown in sulfatic soils will tolerate average root zone EC_e values about 2 dS/m higher than indicated, is valid for the Powder River Basin, and probably all of Wyoming. For alfalfa, this would equate to a 100 percent yield threshold of 4 dS/m.

The Influence of Soil Salinity on Alfalfa Yield

As indicated above, the *relative* 100 percent yield potential reported for alfalfa in the ARS Salt Tolerance Database is 2 dS/m (EC_e). As such, alfalfa is regarded in the California-based literature as "moderately sensitive" to salinity. An *absolute* salinity tolerance would reflect predictable inherent physiological responses by plants, but cannot be determined because interactions among plant, salt, water and environmental factors influence the plant's ability to tolerate salt. *Relative* salt tolerance is a value based on the climatic and cultural conditions under which a crop is grown (Maas and Hoffman, 1977). Research generated outside the U.S. Salinity Laboratory in the U.S. and Canada has introduced alternative salinity tolerance values for alfalfa influenced by these climatic and cultural conditions.

In a study based on field trials in western Canada, McKenzie (1988) reported the "relative maximum salinity crops will tolerate when combined with intermittent moisture stress throughout the growing season." McKenzie (1988) places alfalfa within a moderate tolerance category, as opposed to moderate sensitivity, and extends alfalfa's 100 percent yield tolerance to an EC range of 4-8 dS/m, as opposed to 2 dS/m. Similar tolerance descriptors and EC values for alfalfa can be found associated with Britton et al. (1977), who supports moderate salt tolerance and an EC range of 5-10 dS/m for alfalfa. Likewise, Milne and Rapp (1968) present alfalfa with a moderate tolerance and an EC range of 4-8 dS/m. Cavers (2002); Wentz (2001); Schafer (1983); Holzworth and Wiesner (1990) and Dodds and Vasey (1985) also contribute to a departure from the established Maas classification of alfalfa salinity tolerance and threshold values. Bower et al., suggests an alfalfa tolerance somewhat between the previous authors and Maas (1990), suggesting maximum alfalfa yield is obtained when the average EC_e value for the root zone is 3 dS/m. Using salinized field plots in southern Saskatchewan, Holm (1983) reported a small, 0.037 ton/acre, reduction in alfalfa yields resulting from an increase in the surface EC_e (0 to 15 cm sample) from a 0 to 4 dS/m range to a 4 to 8 dS/m range. Holm presented these scales as representative of low and medium EC levels.

Relative salinity tolerances reported outside of peer reviewed literature stem from professional observations and judgments, roundtable discussions, experience in the field, and experience with the region, culture and climate; not from experimental data. Incorporation of field experience, observation, and limited data into supporting documents of the Salt Tolerance Database is acknowledged in Ayers and Wescot (1985). Alternative sources listed herein do not always report EC values in terms of 100 percent yield thresholds for alfalfa, but should not be discounted, as they pertain to what is realistic in the field. As an example, the Montana Salinity Control Association reports forage salt tolerances in terms of marginal establishment levels, not 100 percent yield potentials. Conditions allowing alfalfa to produce at 100 percent of its physiochemical yield potential probably do not exist anywhere within the northern Great Plains.

A suggested field-yield value corresponding to the 100 percent yield of alfalfa has never been reported by authors of salinity literature. Specifically, what yield of alfalfa, in tons per acre, could one expect if it was grown under conditions supporting 100 percent yield? Conditions supporting 100 percent alfalfa yields recommended by the ARS Salt Tolerance Database and its supporting documents would be: a soil EC_e of 2 dS/m or less, an irrigation water EC_w less than or equal to 1.3 dS/m, water contents maintained at field capacity, available N, P and K nutrient levels maximized for alfalfa growth, a sufficiently long growing season, no associated phytotoxicity or pest issues, etc. This data limitation precludes the direct comparison of alfalfa yields generated in an agricultural area to the potential yields theoretically available under optimized conditions. The only available analysis is to compare an alfalfa yield to the average yield generated in its area, or generated between areas.

Using data available from the National Agricultural Statistics Service, selected county agricultural commissioner's data, and the U.S. Census of Agriculture (2002, 1997), irrigated alfalfa yield data were obtained for periods of interest. Alfalfa yield data for Wyoming counties are available from 1959 through 2005, but were averaged from 1970-2005 to reflect the integration of new irrigation technologies. Alfalfa yield data were summarized for the area encompassing the Powder River Basin: Sheridan, Johnson and Campbell counties. Alfalfa yield data for California counties are available from 1980-2004 so the entire dataset was averaged. Alfalfa data were summarized for counties in California related to intensive agriculture: Imperial, Fresno, Kern, Kings and Tulare counties.

Soil salinity data (as measured by EC) collected by the USDA National Soil Survey and analyzed by the National Soil Survey Center (NSSC) Soil Survey Laboratory were also obtained and summarized for the aforementioned counties. Average root zone EC values were calculated to a maximum depth of five feet. The county alfalfa yield and average root zone EC summaries are presented in Table 2 below.

Table 2
Comparison of Average Root Zone Soil Salinity (EC) Values with Historical Alfalfa Yields for Selected Counties in Wyoming and California.

County	Average Root Zone Soil Salinity (EC as dS/m)	Historical Average Alfalfa Yield (tons/acre)
Sheridan, WY	1.5	2.7
Johnson, WY	1.9	2.4
Campbell, WY	2.0	2.4
Wyoming Average	**1.8**	**2.5**
Tulare, CA	2.8	8.4
Kings, CA	6.9	6.9
Kern, CA	4.6	8.0
Fresno, CA	6.7	7.9
Imperial, CA	6.7	7.8
California Average	**5.5**	**8.0**

Values expressed in Table 2 show substantially higher average root zone salinities in California than in Wyoming. Alfalfa yields reported in California are three times greater than those in Wyoming, even though, on average, the soil salinity values are nearly three times higher than those reported for the Wyoming counties. The values generated in this exercise suggest that environmental factors other than salinity, e.g., climate, may be dictating the obtainable degree of alfalfa yield produced. However, the data also suggest that the California-based 100 percent yield threshold of 2 dS/m may not be appropriate for even the chloritic soils of California. For example, the historical average yield of alfalfa in Tulare County is 8.4 tons per acre with a corresponding average root zone EC of 2.8 dS/m. The yield from Tulare County is actually slightly greater than the yields from Fresno and Imperial Counties where the corresponding average root zone EC values are substantially higher at 6.7 and 6.7 dS/m, respectively. Regardless, there does not appear to be a substantial difference in yields reported by the California counties with soil EC values ranging from 2.8 to 6.7 dS/m.

Other field data from Wyoming have been reviewed that also suggest an alternative to the California-based salinity tolerance values. The Use Attainability Analysis (UAA) report for Cottonwood Creek (SWWRC et al., 2002) was downloaded from the Wyoming Department of Quality, Water Quality Division webpage. Cottonwood Creek is located in Hot Springs County within the Bighorn Basin of Wyoming. This is an area of extensive conventional oil and gas production. According to the UAA report, discharge of produced water from the Hamilton Dome oil field to Cottonwood Creek constitutes the majority of flow to the ephemeral stream and constitutes the only irrigation water source for approximately 35 ranching operations. The waters of Cottonwood Creek exhibit an EC_w between 4.1 and 4.5 dS/m. At an average EC_w of 4.3 dS/m, an average root zone soil EC_e value can be calculated using the widely accepted relationship: $EC_e = 1.5\ EC_w$ (Ayers and Wescot, 1985). This relationship is expressed in the draft Section 20 Agricultural Use Protection Policy. From this relationship, an average root zone soil EC value of 6.5 is estimated for the fields irrigated long-term with water from Cottonwood Creek. Average alfalfa hay yields reported in the UAA amount to 2.5 tons per acre. This yield is identical to the average of the three Wyoming counties reported in Table 2 above. This is compelling given that the average soil EC value for the three other Wyoming counties is 1.8 dS/m, while the estimated soil EC for the fields irrigated with water from Cottonwood Creek is 6.5.

Closing Statement

Based on the review summarized herein, we respectfully suggest that the WDEQ consider adopting an acceptable average root zone EC threshold of 4 dS/m for protection of alfalfa. This would equate to a default (Tier 1) effluent limit of 2.7 dS/m based on the 1.5 concentration factor cited by the draft Agricultural Use Protection Policy. Other species of concern, including western wheatgrass, should be given equal consideration due to the inherent differences in soil chemistry between the northern Great Plains and the California agricultural areas for which the ARS Salt Tolerance Database is based. Factors such as extreme climate, periodic drought, soil moisture regime, duration of growing season, soil depth, and fertility limitations can collectively exert an overriding regional influence on the yield potential of forage crops. Based on this, we ask that the WDEQ exercise caution interpreting the applicability of specific salinity tolerances outlined by the ARS Salt Tolerance Database and thoughtfully consider the difficulty in detecting a "measurable" change in plant production due to soil salinity alone.

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Thank you very much for your time and consideration of this review and the recommendations stemming from it. If you, your WDEQ colleagues, or the members of the Water and Waste Advisory Board have any questions or comments regarding our findings, please contact me.

Sincerely,

Kevin C. Harvey, M.Sc., CPSSc.
Principal Soil Scientist

KC HARVEY, LLC
SOIL AND WATER RESOURCE CONSULTANTS

May 4, 2006

Mr. Bill DiRienzo
Wyoming Department of Environmental Quality
Water Quality Division
Herschler Building, 4th Floor West
122 West 25th Street
Cheyenne, Wyoming 82002

Subject: Comments pertaining to the proposed default SAR effluent limit cap of 10 in the Draft Section 20 Agricultural Use Protection Policy.

Dear Mr. DiRienzo:

I respectfully submit for your consideration the following comments regarding the fourth draft of the Section 20 Agricultural Use Protection Policy as it pertains to the derivation of effluent limits for SAR, particularly the proposed SAR cap of 10. These comments are being submitted on behalf of Yates Petroleum Company, Williams Production RMT Company, Petro-Canada Resources (USA) Inc., Marathon Oil Company, Lance Oil & Gas Company, Inc., Fidelity Exploration & Production Company, Devon Energy Production Company L.P., Bill Barrett Corporation, and Anadarko Petroleum Corporation. I have submitted additional comments regarding the derivation of EC limits in a separate letter.

By way of introduction, I am a board-certified professional soil scientist having practiced as an environmental consultant in Montana and Wyoming, and throughout the world, for nearly 25 years. For the past seven years, my practice has focused on water management and soil and water salinity/sodicity issues associated with oil and gas development. I am credited as the first to research, develop, and apply managed irrigation techniques for the beneficial use of coalbed natural gas produced water. I have directed or participated in over 75 separate projects related to produced water management, WPDES permitting, soil and water chemistry investigations, and reclamation for coalbed and conventional natural gas projects in Wyoming, Colorado, and Montana. I have a M.S. degree in land rehabilitation (soil science emphasis) from Montana State University and a B.S. in Resource Conservation (soil science emphasis) from the University of Montana.

I would like to comment on the proposed changes made to the Agricultural Use Protection Policy by the WDEQ subsequent to the January 26, 2006 meeting of the Water and Waste Advisory Board. My comments will focus on the comments provided by Dr. Larry Munn in his letter to the DEQ dated December 5, 2005. It is my understanding that Dr. Munn's comments resulted in the changes made to the proposed Policy. Specifically, I comment on Dr. Munn's proposal that all WPDES default effluent limits for SAR be capped at 10 under the Tier 1 process.

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Summary of Findings

The fourth draft of the Agricultural Use Protection Policy describes a 3-tiered decision making process for deriving appropriate effluent limits for EC and SAR whenever a proposed discharge may reach irrigated lands. The Tier 1 process would be followed for deriving "default" limits, and as such, this procedure would require a minimum of background information from the applicant. The default SAR limits would be extrapolated from the Hanson et al. (1999) chart relating the established EC effluent limit to SAR, up to a maximum default value of 10. The effluent limit for SAR will be determined in conjunction with EC so that the relationship of SAR to EC remains within the "no reduction in rate of infiltration" zone of the Hanson et al. (1999) diagram.

Two key concerns arise from Dr. Munn's letter regarding sodicity and the discharge of CBNG produced water in the Powder River Basin: (1) the potential impacts on the hydraulic function of irrigated soils during produced water discharge; and (2) the potential impacts of residual adsorbed sodium on the hydraulic function of irrigated fields after produced water discharge has ceased and rainfall/snowmelt leaches salts from the upper root zone. It is assumed that these concerns led Dr. Munn and the WDEQ to propose the SAR effluent limit cap of 10 under the Tier 1 process.

In addressing these concerns, I performed a considerable amount of research, including three months searching and reviewing the relevant scientific literature, and compiling and analyzing available and relevant soil, plant, and water data. The key conclusions of the literature review and data analysis are presented below and will be substantiated by the discussion that follows.

<u>Review of Soil Sodicity</u>

- Plant growth problems associated with excess sodium adsorption are in response to negative changes in soil structure resulting in reduced air exchange, water infiltration and hydraulic conductivity.

- The universally applied sodic soil threshold is an exchangeable sodium percentage (ESP) greater than 15.

- SAR is a measure of the sodicity risk in irrigation water. The higher the salinity of irrigation water, the higher the SAR can be without impacting soil structure and impairing soil infiltration and permeability.

<u>The ESP-SAR Relationship for Soils in Northeastern Wyoming</u>

- Using regression analysis, the relationship between ESP and <u>soil</u> SAR was determined for the Powder River Basin (n=382, R^2=.74).

- A 1:1 relationship of <u>soil</u> SAR to <u>water</u> SAR exists for soils in equilibrium with irrigation water. This relationship is widely accepted and confirmed by recent research led by Dr.

James Bauder at Montana State University. The relationship of ESP to soil SAR is therefore equivalent to the relationship of ESP to water SAR.

- Based on the regional specific relationship of ESP and SAR, an effluent limit of SAR = 16 corresponds to an ESP of 10, and provides a 33% margin of safety against the formation of sodic conditions (i.e., exceeding an ESP of 15). The proposed default SAR cap of 10 is, therefore, unnecessarily conservative.

The Effect of Rainwater Leaching on Soils Irrigated with Produced Water

- Concern has been raised that subsequent rainfall/snowmelt leaching of residual soil salinity may lower the electrolyte concentration and naturally raise the ESP past the dispersive sodic soil threshold.

- Research demonstrates that arid land soils can release 0.3 to 0.5 dS/m of Ca and Mg to solution as a result of the dissolution of primary minerals and the inherent calcium carbonate content of surface soils. Shainberg et al. (1981) indicates that these concentrations are sufficient to counter the deleterious effects of exchangeable sodium, even when the soil is leached with rainwater.

A Review of Soil Sodicity

The physical and chemical phenomena associated with soil sodicity are complex. Therefore, a brief summary is provided regarding the soil and water chemistry associated with the physical affects of soil sodicity.

A large body of research concerning sodic, or "black alkali" soils has been generated in response to the negative effects of high sodium concentrations on soils. Toxicity effects of sodium are rarely expressed in forage and grass crops, but do cause injury to selected woody plants (Lilleand et al., 1945; Ayers et al., 1951; Brown et al., 1953). Plant growth problems associated with high concentrations of sodium are generally a response to negative changes in soil structure. Sodic soils are "nonsaline soils containing sufficient exchangeable sodium to adversely affect crop production and soil structure (Soil Science Society of America, 2001)." High levels of adsorbed sodium tend to disperse soil particles thereby sealing the soil. The result can produce clogged soil pores, hard surface crusts, reduced infiltration, reduced permeability, and reduced oxygen diffusion rates, all of which interfere with or prevent plant growth. By definition, sodic soils are those that have an exchangeable sodium percentage (ESP) greater than 15. The universally applied ESP threshold of 15 percent is acknowledged in numerous publications, including Levy et al. (1998), Abrol et al., (1988), Evangelou (1998), McNeal and Coleman (1966), Sparks (1995), Sumner et al. (1998), Shainberg et al. (1971), the Soil Improvement Committee (2002), university extension publications, etc.

Clay minerals are the most physically and chemically reactive components of the sand, silt, and clay matrix in soil. The structural arrangement of clay minerals in soil is akin to a deck of cards; the clay mineral itself can be thought of as the deck, and the cards as individual layers. The properties of the deck depend upon the arrangement of the cards and the electrochemical interlayer forces holding the cards together.

Clay minerals in soils are negatively charged and consequently attract ions with a positive charge such as calcium, magnesium, potassium, and sodium. Positively charged ions are called cations. Each cation competes with others in the soil solution for access to the bonding sites based on its valence and hydrated size. Every soil has a definite capacity to adsorb the positively charged cations. This is termed the cation exchange capacity (CEC). The various adsorbed cations (such as calcium and sodium) can be exchanged one for another and the extent of exchange depends upon their relative concentrations in the soil solution (dissolved), the ionic charge (valence), the nature and amount of other cations, etc. ESP is, accordingly, the amount of adsorbed sodium on the soil exchange complex expressed in percent of the cation exchange capacity in milliequivalents per 100 grams of soil (meq/100 g). Thus,

ESP = (exchangeable sodium / cation exchange capacity) x 100.

Sodic soil conditions arise when greater than 15 percent of the ions bonded to the deck are sodium, which has a +1 valence and a large hydrated radius. When the ESP exceeds 15, the large hydrated sodium ions can wedge in-between the individual cards and cause "swelling" of the deck (Levy et al., 1998). This causes negative effects on the physical structure of the soil. Upon re-wetting, the individual decks may disperse and settle into soil pores, effectively clogging them and reducing the efficiency of air exchange, water infiltration, and permeability (i.e., hydraulic conductivity). In general, soils with moderately high, to high, clay contents are at higher risk.

Excessive adsorbed or exchangeable sodium can result from sustained use of irrigation water that is high in sodium and low in calcium and magnesium. Consequently, the ratio of sodium to calcium and magnesium ions in water is an important property affecting the infiltration and permeability hazard. The water quality index used to measure the hazard related to sodium abundance or sodicity in irrigation water is the sodium adsorption ratio or SAR.

The SAR is the ratio of the dissolved sodium concentration in water divided by the square root of the average calcium plus magnesium concentration. The SAR can be calculated from the sodium, calcium and magnesium concentrations via the formula:

$$SAR = [sodium] / (([calcium] + [magnesium])/2)^{1/2}$$

where the concentrations are in milliequivalents per liter (meq/L).

What is not apparent from the SAR formula is the fact that the higher the salinity of the water, the higher the SAR can be without impacting soil structure and impairing soil infiltration and permeability. Put another way, for a given SAR, infiltration rates generally increase as salinity (measured by the EC) increases. The changes in soil infiltration and permeability occur at varying SAR levels, higher if the salinity is high, and lower if the salinity is low. Therefore, in order to evaluate the sodicity risk of irrigation water, the EC must be considered. To this end, the SAR-EC guidelines presented in Ayers and Westcot (1985) and Hanson et al. (1999) are used to assess the potential sodicity risk of irrigation water.

The ESP-SAR Relationship for Soils in Northeastern Wyoming

In addition to measuring the SAR of irrigation water, one can also measure the SAR of the soil solution via a saturated paste extract (i.e., the dissolved concentrations of sodium, calcium, and magnesium are measured in a saturated paste extract and applied via the SAR formula presented above). The soil SAR was developed to serve as a rapid and relatively inexpensive index of ESP. It is widely accepted that the SAR of the soil in equilibrium with the SAR of the irrigation water is equal to the long-term average SAR of the irrigation water.

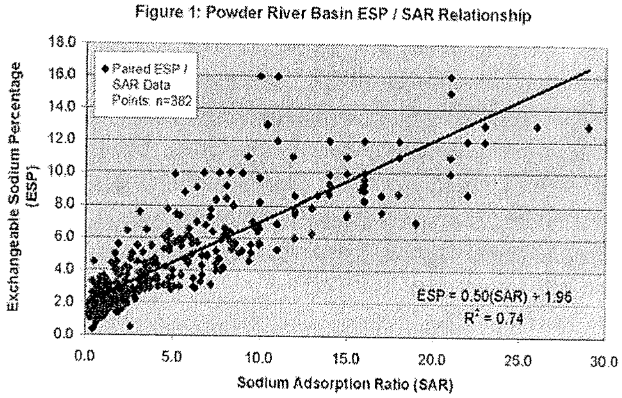
The fourth draft of the Agricultural Use Protection Policy includes a proposed SAR cap of 10 for Tier 1 default effluent limits. To evaluate the appropriateness of the proposed cap, an analysis was performed using 382 ESP-SAR data pairs generated from ongoing soils assessment work in the Powder River Basin of Wyoming (KC Harvey LLC, 2006). This database represents flood plain soils associated with tributaries to the Powder River and the Tongue River, including spreader dike irrigated fields. This database represents baseline soil chemical conditions. In no case were any of these soils irrigated with or influenced by coalbed natural gas produced water. The soil samples from which the analyses were made were collected during soil profile descriptions to five feet, and with a Giddings hydraulic probe up to eight feet in depth. The numerous soil investigations involved were required for various coalbed natural gas water management planning, permitting, and design purposes.

The ESP-SAR data pairs were graphed in Microsoft Excel using simple scatter-plot and trend line analysis. The best fit line resulted in a linear regression which yielded the equation:

ESP = 0.5(SAR) + 1.96, with an R^2 value of 0.74.

The regional-specific "Powder River Basin" relationship, based on 382 soil samples, is shown on Figure 1. According to the Powder River Basin equation, a soil SAR of 26 corresponds to the critical ESP threshold of 15 percent.

Figure 1: Powder River Basin ESP / SAR Relationship



It is widely accepted that the SAR of soil in equilibrium with irrigation water equals the long-term average SAR of irrigation water. Recent Department of Energy funded research directed by Dr. James Bauder at Montana State University (Robinson and Bauder, 2003) confirms this relationship. Their research, which is related to the potential effects of coalbed natural gas produced water on soils, reports that in general, soil solution SAR represents the SAR of the applied water. The 1:1 soil SAR to water SAR relationship allows one to relate the SAR of discharge water to the SAR of the soil in the Powder River Basin ESP-SAR graph and equation described above. For example, after long-term irrigation with water exhibiting an SAR of 15, the equilibrated ESP of the irrigated soil would be approximately 9.5 percent. The proposed SAR cap of 10 would equate to a corresponding ESP of 7. An ESP cap of 7 appears to be unnecessarily conservative given the regional specific relationship of ESP and SAR. While an ESP threshold of 15 is widely accepted to be the point at which clay swelling and dispersion occurs, we respectfully suggest that the WDEQ consider establishing a Tier 1 default SAR effluent limit cap of 16, which corresponds to an ESP of 10. An ESP value of 10 provides a 33 percent margin of safety.

The Effect of Rainwater Leaching on Soils Irrigated with Produced Water

In his December 5, 2005 letter, Dr. Munn indicates his concern about the potential effects of rainwater leaching of fields that had received produced water due to upstream permitted discharges. In particular, what is the effect of leaching on the sodicity status and hydraulic function of soils after discharge and irrigation with produced water ceases? Fortunately, the considerable research on this subject has been well documented in the scientific literature.

Discontinuation of produced water discharge in the Powder River Basin will effectively reduce the EC and SAR of irrigation waters from tributaries and mainstems so long as the surface water is of higher quality than the produced water. In the case of fields that are irrigated opportunistically (e.g., in response to runoff events that are captured behind spreader dike systems), there can be three sources of water supplying soil moisture: (1) meteoric water (rain and snowmelt); (2) natural runoff water; and (3) subirrigation from a shallow aquifer. In the case of rainfall and snowmelt, the EC of these waters will be similar to that of distilled water, i.e., they will exhibit very low dissolved solids. Owing to the dissolution of soluble constituents within the watershed, natural runoff EC values can range up to 5 dS/m or higher. Regarding subirrigation, shallow aquifers can be relatively saline due to the entrainment of dissolved minerals along the groundwater flowpath.

The concern arises from leaching of residual surface soil salinity with rainfall and snowmelt. Intermittent rainfall and snowmelt may lower the electrolyte concentration (i.e., EC) sufficiently to promote clay dispersion, depending on soil properties (Levy et al., 1998). Conversely, when the electrolyte concentration in the soil solution reaches a moderate level (1-2 dS/m), high sodicity levels (ESP between 10 and 30) cause only small to moderate changes in the physical and hydraulic properties of the soils, which are mostly reversible (Levy et al., 1998). Shainberg et al. (1981) showed that a major factor causing differences among various sodic soils in their susceptibility to hydraulic failure when leached with low electrolyte concentrations (i.e., a low EC) was their rate of salt release from mineral dissolution.

Arid land soils can release 0.3 to 0.5 dS/m of calcium and magnesium to solution as a result of the dissolution of plagioclase, feldspars, hornblends and other sparingly soluble minerals within the soil matrix (Rhoades et al. 1968). The solution composition of a calcareous soil at a given ESP in contact with distilled water (i.e., rainwater or snowmelt) can be calculated (Shainberg et al., 1981). As calcium carbonate ($CaCO_3$) dissolves, the EC of the soil solution increases and calcium replaces sodium on exchange sites until the solution is in equilibrium with the cation exchange system and the $CaCO_3$ solid phase. Shainberg et al. (1981) calculated that the EC values of solutions in equilibrium with soils having ESP values of 5, 10, and 20 are 0.4, 0.6, and 1.2 dS/m, respectively. Shainberg et al. (1981) indicates that these concentrations are sufficient to counter the deleterious effects of exchangeable sodium, even when the soil is leached with rainwater.

It is evident that water equilibrated with a calcareous soil can never be a very low salinity (Shainberg et al., 1981). Using the same database discussed above for evaluation of the ESP-SAR relationship in 382 soil samples from the Powder River Basin, we can compute an average percent lime ($CaCO_3$) content in surface soil samples (n=81), which is 5.1 percent. This represents a considerable reserve of calcium. Other sources of calcium include residual gypsum ($CaSO_4$) which we know to be prevalent in Wyoming soils.

Various soil SAR-EC relationships (not to be confused with irrigation water SAR-EC relationships) have been reported in the literature by introducing low electrolyte concentration waters to sodic soils. Felhendler et al. (1974) measured the hydraulic conductivity of two montmorillonitic soils as a function of the SAR and found that both were only slightly affected by the SAR of the percolating solution up to a SAR of 20 as long as the concentration of the percolating solution exceeded 1 dS/m. Shainberg et al. (1981) studied the effects of leaching a 1:1 sand-soil column with distilled water and increasing concentrations of a weak electrolyte solution. His findings concluded that an electrolyte concentration of 0.3 dS/m in the percolating solution was adequate to prevent the adverse effects of a SAR of 15 on the hydraulic conductivity of the soil-sand mixture. These findings are very similar to the conclusions of the U.S. Salinity Laboratory Staff (1954) who used electrolyte concentrations equal to or greater than 0.3 dS/m in their regression analysis to determine the sodic soils threshold of ESP = 15.

As a review, an electrolyte concentration of 0.3 dS/m is the minimum value of calcium and magnesium contributions to soil solution associated solely to arid soil weathering. This suggests that an arid Powder River Basin soil with a SAR of 16 (ESP = 10), will have no sodicity related impacts to the hydraulic conductivity, even when the salt concentration of the irrigation or rainwater is equal to that of distilled water.

Of course, irrigation water in the Powder River Basin has an intrinsic electrical conductivity greater than that of distilled water. Use of surface water for irrigation will actually supplement the inputs of calcium and magnesium from weathering and carbonate dissolution alone.

Using the aforementioned Powder River Basin soils assessment database (KC Harvey LLC, 2006), an average surface soil ECe of 1.64 dS/m was calculated from 81 individual surface soil samples. This value suggests that electrolyte concentrations in surface soils of the Powder River Basin, in equilibrium with mineral dissolution, the salinity of runoff irrigation water, and rainwater/snowmelt, is about 1.6 dS/m, or five times (1.6 dS/m divided by 0.3 dS/m) the concentration required to maintain the hydraulic conductivity of a soil at an ESP of 16.

Closing Statement

Results of the Powder River Basin regression analysis indicates that a relationship between ESP and soil/water SAR exists, which allows the calculation of one parameter from the other. Using the proposed, default ESP cap of 10 percent, the scientific literature indicates that water with a SAR of 16 can be effectively used for irrigation without adverse effects on the physical structure or hydraulic conductivity of Powder River Basin soils during irrigation. Furthermore, it has been shown that inputs of Ca and Mg from the natural dissolution of plagioclase, feldspars, hornblends and other sparingly soluble minerals, especially calcium carbonate and gypsum, will provide an effective buffer to residual soil sodicity after the discontinuation of produced water discharge and the transition back to native irrigation, precipitation, and runoff regimes.

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* * * * *

Thank you very much for your time and consideration of this review and the recommendations stemming from it. If you, your WDEQ colleagues, or the members of the Water and Waste Advisory Board have any questions or comments regarding our findings, please contact me.

Sincerely,

Kevin C. Harvey, M.Sc., CPSSc.
Principal Soil Scientist

EXHIBIT D

Surface Water Monitoring Report

Water Quality Monitoring Stations Including Upstream and Downstream Monitoring Locations

July 2005
To
December 2005

Prepared For:

Wyoming Department of Environmental Quality
Water Quality Division
Herschler Building
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920 E. Sheridan Street
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1.0 INTRODUCTION

This document presents water quality monitoring data associated with designated Class 2AB streams in northeastern Wyoming which receive coal bed methane (CBM) produced water. The monitoring program described within satisfies the Wyoming Pollution Discharge Elimination System (WYPDES) permit reporting requirements for multiple permits and permit holders. Water Quality Monitoring Stations (WQMSs) have been established throughout northeastern Wyoming to conduct systematic water quality monitoring in association with those multiple permits.

WQMS sites are located on streams receiving CBM produced water near their confluence with a larger Class 2AB steam. Associated WQMSs are also located on the Class 2AB waters upstream and downstream of the confluence with a receiving stream. In compliance with WYPDES permits, WQMSs are inspected monthly and sampling is conducted at all three associated stations if a receiving stream flows into a Class 2AB water. Monthly observations are reported semi-annually.

Stream flow measurements are taken on-site, and in-stream samples are collected for laboratory analysis of dissolved calcium, dissolved magnesium, dissolved sodium, sodium adsorption ratio, specific conductance, dissolved chloride, and other parameters as required by individual WYPDES permits.

2.0 SCOPE

This report presents WQMS data from July 2003 through December 2005. Table 1 provides a comprehensive list of WQMS station names, station locations (legal description, township and range, and UTM coordinates), permits covered by each group of associated stations, and permit holders. WQMS project maps have also been developed in association with this study.

Table 1 – Water Quality Monitoring Station Locations Summary

WQMS	QtrQtr	Sec	Twn	Rng	UTM_E_map	UTM_N_map	Associated Permits	Operator
Barber Creek DPR	SWSE	32	51	77	408434.445	4910843.772	WY0051276	LOG
Barber Creek TRIB1*	SWNW	9	50	77	409389.697	4908150.242	WY0052175	LOG
Barber Creek UPR	SWSW	9	50	77	409185.881	4907535.777	WY0050857	WPC
							WY0053171	WPC
							WY0048089	YPC
Beaver Creek DPR	SWNE	20	48	77	408821.500	4885834.841	WY0047881	PEI
Beaver Creek TRIB1	NESE	20	48	77	409419.975	4885351.054	WY0047899	PEI
Beaver Creek UPR	SWSW	20	48	77	408159.980	4885005.024	WY0048143	PEI
							WY0048178	PEI
							WY0048631	PEI
							WY0050130	PEI
							WY0051021	PEI
							WY0038091	WPC
							WY0038423	WPC
							WY0046922	WPC
							WY0049611	WPC
							WY0051519	WPC
							WY0051683	WPC
							WY0041149	YPC
							WY0050806	YPC
							WY0051381	YPC
							WY0052400	YPC
Bitter Creek TRIB1*	SENW	23	58	75	433126.050	4982805.052	WY0049131	JMH
							WY0050024	JMH
							WY0052523	JMH
							WY0050059	SCE
BullStottsUN DPR	SENE	34	53	77	412564.261	4930882.190	WY0051551	PEI
BullStottsUNTRIB1*	NWNE	3	52	77	411971.816	4929958.002		
BullStottsUNTRIB2*	NWNW	2	52	77	412793.506	4929480.113		
BullStottsUNTRIB3*	SWSW	2	52	77	412888.665	4928538.885		
BullStottsUN UPR	NWSE	10	52	77	411897.760	4927288.851		
Burger Draw DPR	NWNW	33	49	77	409123.859	4892436.218	WY0051144	YPC
Burger Draw TRIB1	NWSW	22	56	79	391958.540	4962445.078		
Burger Draw UPR	SWSE	8	48	77	408856.285	4888358.407		
Cottonwood Creek DPR	SESW	2	53	77	413326.181	4938269.212	WY0042064	PEI
Cottonwood Creek TRIB1	SESE	10	53	77	412786.79	4936532.203	WY0052388	LOG
Cottonwood Creek UPR	SESW	11	53	77	413548.372	4936477.558	WY0051870	YPC
Culp Draw DPR	SWSW	20	48	77	408159.980	4885005.024	WY0051390	WPC
Culp Draw TRIB1*	NENE	31	48	77	407614.983	4883022.953	WY0051594	WPC
Culp Draw UPR	NENW	6	47	77	407019.916	4881390.976	WY0053244	WPC
Curtis Draw DPR	NENE	1	46	78	406002.404	4871417.839	WY0043559	JMH
Curtis Draw TRIB1*	SWSE	1	46	78	405492.272	4870421.298		
Curtis Draw UPR	NESE	1	46	78	406128.757	4870906.527		
Dead Horse Creek DPR	SWSE	32	50	77	408410.065	4900831.968	WY0052248	LOG
Dead Horse Creek TRIB1*	NESE	16	49	77	410666.994	4896409.992	WY0049585	PEI

Table 1: Water Quality Monitoring Station Locations Summary - Continued

WQMS	QtrQtr	Sec	Twn	Rng	UTM_E_map	UTM_N_map	Associated Permits	Operator
Dead Horse Creek UPR	SWSW	17	49	77	407776.988	4896295.042	WY0038733	WPC
							WY0048321	WPC
							WY0050709	WPC
							WY0050971	WPC
							WY0051268	WPC
							WY0051462	WPC
							WY0037842	YPC
							WY0048721	YPC
							WY0050598	YPC
							WY0052914	YPC
Dead Horse Creek North DPR	NESE	31	58	75	427410.000	4979524.058	WY0051942	JMH
Dead Horse Creek North TRIB1	SENW	7	57	75	426717.023	4976380.952		
Dead Horse Creek North UPR	SWSE	12	57	76	425346.534	4976340.188		
Deer Creek DPR	NENW	23	53	77	413247.1412	4934647.13	WY0050156	PEI
Deer Creek TRIB1*	SENE	26	53	77	414085.0171	4933745.544		
Deer Creek UPR	NWNE	26	53	77	413785.983	4933003.591		
Deer Gulch DPR	SESW	29	51	77	408064.035	4912396.058	WY0048381	LOG
Deer Gulch TRIB1	SWNW	32	51	77	407854.975	4911395.978		
Deer Gulch TRIB2*	SWNW	32	51	77	407854.975	4911395.978		
Deer Gulch UPR	SWSE	32	51	77	408434.445	4910843.772		
Dry Creek DPR	SENE	32	50	77	408626.308	4901938.263	WY0052728	YPC
Dry Creek TRIB1	NESW	31	50	77	406604.781	4901254.652	WY0052582	
Dry Creek UPR	SENW	5	49	77	407983.806	4899958.668	WY0053406	
Dry Fork Powder River DPR	SWSW	9	44	78	399640.038	4849210.047	WY0044067	WEG
Dry Fork Powder River TRIB1*	NENW	15	44	78	401903.913	4849037.688	WY0044091	WEG
Dry Fork Powder River UPR	NENE	20	44	78	399330.053	4847419.997	WY0048372	WPC
							WY0050687	WPC
							WY0050946	WPC
							WY0051161	WPC
							WY0051241	WPC
							WY0051918	WPC
Flying E Creek DPR	SWNW	28	50	77	409134.893	4903243.169	WY0047317	LOG
Flying E Creek TRIB1	NWSW	28	50	77	409062.673	4903096.892	WY0052639	LOG
Flying E Creek UPR	SESW	28	50	77	409406.344	4902813.515	WY0052787	YPC
							WY0053066	YPC
Fortification Creek DPR	SWSE	16	52	77	410388.737	4925137.313	WY0052809	LOG
Fortification Creek TRIB1*	NENW	6	51	77	416639.311	4919778.324	WY0051993	PCR
Fortification Creek UPR	SESW	16	52	77	409898.953	4925154.190	WY0049999	WPC
Fourmile Creek DPR	NENW	31	48	77	406964.734	4882889.129	WY0048313	LOG
Fourmile Creek TRIB1	SENE	36	48	78	406054.046	4882418.974		
Fourmile Creek TRIB2	SENE	36	48	78	406054.046	4882418.974		
Fourmile Creek UPR	NESE	36	48	78	406173.846	4882049.613		
Horse Creek DLPR	SESW	23	55	71	471306.144	4952764.792	WY0051501	CH4
Horse Creek TRIB1	SWSE	22	55	71	470295.186	4952682.216	WY0052698	JMH

Table 1: Water Quality Monitoring Station Locations Summary - Continued

WQMS	QtrQtr	Sec	Twn	Rng	UTM_E_map	UTM_N_map	Associated Permits	Operator
Horse Creek ULPR	NENE	27	55	71	470690.630	4952269.995	WY0038164	LOG
							WY0048241	LOG
							WY0050181	LOG
							WY0050652	LOG
							WY0038334	PEI
							WY0039624	PEI
							WY0039632	PEI
							WY0039641	PEI
							WY0048224	PEI
							WY0048232	PEI
							WY0047376	SEC
							WY0047384	SEC
							WY0037265	YPC
							WY0037401	YPC
							WY0037753	YPC
							WY0037761	YPC
							WY0048879	YPC
							WY0048950	YPC
							WY0050610	YPC
							WY0052710	WPC
							WY0052957	WPC
Ivy Creek/Joe Creek WQ1*	NENE	35	56	77	414255.745	4959945.965	WY0046051	PEI
Ivy Creek/Joe Creek WQ2*	SWNW	18	56	76	416262.589	4964322.852		
Ivy Creek DPR	SWNW	18	56	76	416262.589	4964322.852	WY0046655	PEI
Ivy Creek TRIB1*	NENE	24	56	77	415792.040	4963415.703		
Ivy Creek TRIB2*	NWSW	18	56	76	416093.375	4964020.076		
Ivy Creek UPR	NENE	35	56	77	414255.745	4959945.965		
Joe Creek WQ1*	NENE	35	56	77	414255.745	4959945.965	WY0046060	PEI
Joe Creek WQ2*	NENE	35	56	77	414255.745	4959945.965		
Powder River DPR	SWSE	32	50	77	408410.065	4900831.968	WY0052736	YPC
Unnamed Eph Trib to PR TRIB1	NWNW	8	49	77	407553.227	4898917.108		
Bugher Draw TRIB2	NWSW	8	49	77	407896.577	4897972.422		
Unnamed Eph Trib to PR TRIB3	SWSW	17	49	77	407776.988	4896295.042		
Juniper Draw TRIB4	NWNW	20	49	77	407515.698	4895761.349		
Powder River UPR	NWNW	33	49	77	409123.859	4892436.218		
Kinney Draw DPR	SESW	16	51	77	409911.000	4915631.995	WY0052167	LOG
Kinney Draw UPR	SENE	20	51	77	408905.998	4914839.996		
Little Willow Creek DPR	NESE	23	45	78	404130.040	4856139.955	WY0044059	WEG
Little Willow Creek TRIB1*	NESW	26	45	78	403660.016	4854620.044		
Little Willow Creek UPR	NWNW	35	45	78	402849.991	4853889.973		
LxBar Creek DPR	NESE	12	57	76	425346.534	4976340.188	WY0050148	CI
LxBar Creek TRIB1*	NWSE	14	57	76	423795.035	4974545.026	WY0039861	JMH
LxBar Creek UPR	SWNW	16	57	76	420208.905	4975100.640	WY0040347	JMH
							WY0041017	JMH
							WY0052256	JMH
							WY0051837	LOG
							WY0053210	LOG
							WY0039055	PEI
							WY0048275	PEI
							WY0048348	YPC
							WY0049646	YPC
							WY0050741	YPC

Table 1: Water Quality Monitoring Station Locations Summary - Continued

WQMS	QtrQtr	Sec	Twn	Rng	UTM_E_map	UTM_N_map	Associated Permits	Operator
OK Creek DPR	SWNE	27	54	77	411924.368	4942152.416	WY0042056	PEI
OK Creek TRIB1*	SESW	26	54	77	413412.953	4941174.619		
OK Creek UPR	SENE	35	54	77	414002.908	4940443.106		
Pumpkin Creek DPR	SENE	24	47	77	406016.428	4875865.505	WY0040045	PEI
Pumpkin Creek TRIB1	NESW	19	47	77	407034.858	4875444.501	WY0048496	PEI
Pumpkin Creek UPR	SWSW	19	47	77	406402.567	4875346.722	WY0048500	PEI
							WY0048518	PEI
							WY0046914	WPC
							WY0038431	YPC
							WY0038784	YPC
							WY0047741	YPC
							WY0050776	YPC
							WY0051438	YPC
							WY0052418	YPC
Rawhide Creek DLPR	NESW	14	52	72	462175.800	4925699.341	WY0039560	CI
Rawhide Creek TRIB1*	SWNE	26	52	72	462211.451	4923084.586	WY0048607	CI
Rawhide Creek ULPR	NESE	26	52	72	462968.392	4922792.951	WY0039288	PEI
							WY0039322	PEI
							WY0046256	PEI
							WY0046264	PEI
							WY0048151	PEI
							WY0048160	PEI
							WY0048194	PEI
							WY0048330	PEI
							WY0039501	WEG
							WY0053163	WPC
							WY0037371	YPC
Robinson Dr DPR	NENW	22	55	77	411661.927	4953556.952	WY0040819	PEI
Robinson Dr TRIB1	NENW	27	55	77	411760.790	4952100.161		
Robinson Dr UPR	NWSE	34	55	77	411899.001	4949691.995		
Rose Draw DPR	SWSW	21	52	77	409319.528	4923647.867	WY0052973	LOG
Rose Draw UPR	NENE	29	52	77	409268.544	4923415.272		
SA Creek DPR	NESE	31	58	75	427410.000	4979524.058	WY0049930	CI
SA Creek TRIB1	NESW	7	57	75	426717.023	4976380.952	WY0041025	JMH
SA Creek UPR	SWNE	12	57	76	425346.534	4976340.188	WY0047627	JMH
							WY0049557	JMH
							WY0049981	JMH
							WY0049221	PEI
							WY0040282	SCE
							WY0046701	SCE
							WY0049514	SCE
							WY0047520	YPC
							WY0047589	YPC
Salt Creek DPR	SENW	13	43	79	395441.015	4838924.041	WY0050695	WPC
Salt Creek TRIB1*	NWNE	22	43	79	392435.796	4837633.899		
Salt Creek UPR	NWSE	15	43	79	392279.559	4838309.969		
Spotted Horse Creek DPR	SENW	31	57	76	416337.038	4969910.976	WY0038351	CH4
Spotted Horse Creek TRIB1	SWNE	7	56	76	416764.988	4966146.981	WY0052680	JMH

Table 1: Water Quality Monitoring Station Locations Summary - Continued

WQMS	QtrQtr	Sec	Twn	Rng	UTM_E_map	UTM_N_map	Associated Permits	Operator
Spotted Horse Creek UPR	NWSW	7	56	76	416116.837	4965455.052	WY0049701	LOG
							WY0049859	LOG
							WY0051829	LOG
							WY0039721	PEI
							WY0048283	PEI
							WY0037362	YPC
							WY0049336	YPC
							WY0050199	YPC
							WY0051306	YPC
							WY0051756	YPC
UNPR TRIB1* (WY0046485)	NENE	27	53	77	412549.712	4932920.753	WY0046485	PEI
UNPR TRIB2* (WY0046485)	SWSE	27	53	77	412179.041	4931759.980		
UNPR TRIB3* (WY0046485)	NENE	34	53	77	412432.665	4931369.909		
UNPR DPR (WY0046787)	NWNE	27	54	77	412158.462	4942642.495	WY0046787	PEI
UNPR TRIB1* (WY0046787)	NWSW	25	54	77	414459.038	4941615.939		
UNPR TRIB2* (WY0046787)	SENE	26	54	77	414045.768	4941984.120		
UNPR TRIB3* (WY0046787)	SWNE	26	54	77	413816.654	4942079.147		
UNPR UPR (WY0046787)	NESW	36	54	77	415009.672	4940188.040		
UNPR DPR (WY0047422)	NENE	27	54	77	412272.233	4942715.764	WY0047422	PEI
UNPR TRIB1* (WY0047422)	SENE	35	54	77	413888.351	4940328.549		
UNPR TRIB2* (WY0047422)	NWSE	2	53	77	413812.853	4938726.456		
UNPR TRIB3* (WY0047422)	NENW	11	53	77	413961.703	4937943.825		
UNPR UPR (WY0047422)	NENW	11	53	77	413529.869	4937797.549		
UNPR DPR (WY0047538)	NWNE	26	53	77	413785.983	4933003.591	WY0047538	PEI
UNPR TRIB1* (WY0047538)	SENE	26	53	77	413995.699	4932479.303		
UNPR UPR (WY0047538)	NWSE	26	53	77	413805.513	4932269.587		
UNPR DPR (WY0047546)	SESW	26	54	77	413412.953	4941174.619	WY0047546	PEI
UNPR TRIB1* (WY0047546)	NWNW	13	53	77	414597.450	4936372.928		
UNPR TRIB2* (WY0047546)	NWNW	12	53	77	414790.650	4937687.711		
UNPR TRIB3* (WY0047546)	SWSW	13	53	77	414390.750	4934929.956		
UNPR UPR (WY0047546)	NENW	23	53	77	413247.146	4934647.102		
UNPR DPR (WY0047554)	NWSE	35	54	77	413700.656	4940069.944	WY0047554	PEI
UNPR TRIB1* (WY0047554)	SENW	1	53	77	415019.764	4938758.176		
UNPR TRIB2* (WY0047554)	NWNW	13	53	77	414597.450	4936372.928		
UNPR UPR (WY0047554)	NENW	11	53	77	413529.869	4937797.549		
UNPR DPR* (WY0051284)	NWSW	19	47	77	406273.854	4875707.039	WY0051284	WPC
UNPR TRIB1* (WY0051284)	SWSW	19	47	78	406620.015	4875005.935		
UNPR UPR (WY0051284)	SESE	24	47	78	405871.463	4875092.573		
UNPR DPR (WY0051357)	SENE	36	48	78	406054.046	4882418.974	WY0051357	WPC
UNPR TRIB1* (WY0051357)	SWNW	7	47	77	406302.952	4879357.394		
UNPR TRIB2* (WY0051357)	SWSE	12	47	78	405676.428	4878511.193		
UNPR UPR (WY0051357)	SWNE	13	47	78	405583.760	4877796.851		
UNPR DPR (WY0051713)	SWSE	8	48	77	408925	4888277	WY0051713	WPC
UNPR TRIB1(WY0051713)	NESW	17	48	77	408318	4887291		
UNPR UPR (WY0051713)	SWSW	20	48	77	408898	4885853		
VanHouten Draw DPR	SWNW	28	49	77	409347.584	4893844.387	WY0051861	LOG
VanHouten Draw TRIB1	SENE	29	49	77	408951.903	4893477.553	WY0050270	PCR
VanHouten Draw UPR	NESE	29	49	77	408861.353	4893220.063	WY0052001	YPC

Table 1: Water Quality Monitoring Station Locations Summary - Continued

WQMS	QtrQtr	Sec	Twn	Rng	UTM_E_map	UTM_N_map	Associated Permits	Operator
Whitetail Creek DPR	NWNE	10	55	71	470125.054	4957326.097	WY0038326	PEI
Whitetail Creek TRIB1*	SESW	10	55	71	469861.993	4956286.959	WY0052116	SAI
Whitetail Creek UPR	SENW	11	55	71	471182.281	4956775.071	WY0052159	SAI
Wild Horse Creek DPR	NWSE	34	55	77	411865.385	4949672.541	WY0040371	LOG
Wild Horse Creek TRIB1	SESE	16	54	77	411065.060	4944516.955	WY0049697	LOG
Wild Horse Creek TRIB2* (WY0050636)	NWNE	36	54	77	415119.772	4940955.205	WY0050636	LOG
Wild Horse Creek UPR	SWSE	16	54	77	410572.360	4944514.858	WY0039853	PCR
							WY0039870	PCR
							WY0050547	PCR
							WY0051985	PCR
							WY0039047	PEI
							WY0039519	PEI
							WY0039616	PEI
							WY0039659	PEI
							WY0039934	PEI
							WY0042102	PEI
							WY0043079	PEI
							WY0043630	PEI
							WY0044342	PEI
							WY0046876	PEI
							WY0046884	PEI
							WY0047058	PEI
							WY0047406	PEI
							WY0047461	PEI
							WY0048216	PEI
							WY0048461	PEI
							WY0048917	PEI
							WY0051012	PEI
							WY0052281	PEI
							WY0052361	PEI
							WY0047643	SEC
							WY0041718	WPC
							WY0048259	WPC
							WY0048691	WPC
							WY0048933	WPC
							WY0048976	WPC
							WY0049549	WPC
							WY0050555	WPC
							WY0050865	WPC
							WY0051691	WPC
							WY0037419	YPC
							WY0037427	YPC
							WY0037818	YPC
							WY0041009	YPC
							WY0042048	YPC
							WY0049271	YPC

Table 1: Water Quality Monitoring Station Locations Summary - Continued

WQMS	QtrQtr	Sec	Twn	Rng	UTM_E_map	UTM_N_map	Associated Permits	Operator
Wild Horse Creek UPR (Cont.)								
							WY0050351	YPC
							WY0050601	YPC
							WY0050989	YPC
							WY0052035	YPC
Notes:								
CH4 - CH4 Energy LLC								
CI - Continental Industries								
DEC - Dolphin Energy Corporation								
JMH - J.M. Huber Corporation								
LOG - Lance Oil and Gas Corporation								
PEI - Pennaco Energy Company								
SAI - Suncor (Natural Gas) America, Inc.								
SEC - Stormcat Energy Corporation								
WEG - Windsor Energy Group								
WPC - Williams Production Company								
YPC - Yates Petroleum Company								

3.0 METHODS

3.1 Flow Measurement

As part of the WQMS monitoring program, streamflow measurements are obtained either via direct measurement or estimated from USGS flow station data. If field conditions are safe, stream flow is measured directly using the method noted in Table 2. If direct measurement of flow cannot be conducted safely at a particular location, USGS data is used to estimate flow values at that site, based on two assumptions:

- Stream flow rates increase as the river flows downstream; and
- Streamflow losses and gains which may occur in the river between the USGS station and the measured tributary are insignificant.

Thus, flow rates on the Powder River can be estimated by adding measured tributary flow to the nearest upstream USGS station or by subtracting measured tributary flow from the nearest downstream USGS station, whichever is appropriate.

Tables 2 through 13a list the WQMS tributaries, measured flow rates by sampling date, and the flow measurement method employed. For purposes of this report, the following acronyms are used:

For the Water Quality Monitoring Stations:

UPR - Powder River upstream of a tributary
DPR - Powder River downstream of a tributary
ULPR - Little Powder River upstream of a tributary
DLPR - Little Powder River downstream of a tributary
TRIB - Tributary prior to confluence with Class 2 Water
UN – Unnamed Tributary to the Powder River

For the USGS Streamflow Monitoring Stations:
(Source: http://water.usgs.gov/cgi-bin/dailyMainW?state=wy&map_type=dvd)

SSX - Powder River at Sussex, WY (USGS Station ID 06343500)
BDB - Powder River above Burger Draw, near Buffalo, WY (USGS Station ID 06313590)
MOH - Powder River at Moorehead, MT (USGS Station ID 06324500)
ARV - Powder River at Arvada, WY (USGS Station ID 06317000)

For the flow measurement methods:
FPR/Global Flow Probe – flow probe
Pygmy – pygmy meter w/star

Refer to Section 3.1 for Flow Calculation Explanation

Table 2 – Beaver Creek Water Quality and Flow Data

Beaver Creek Sampled Station	Date	Calcium, Dissolved mg/L	Chloride, Dissolved mg/L	Magnesium, Dissolved mg/L	Sodium Adsorption Ratio (SAR) unitless	Sodium, Dissolved mg/L	Specific Conductance @25C umhos/cm	Flow Volume MGD	Flow Method
Beaver Creek UPR	7/29/2003	247	316	89	7.3	529	3940	5.60	
Beaver Creek TRIB1	7/29/2003	129	6	32	2.3	114	1320	0.12	
Beaver Creek DPR	7/29/2003	258	309	93	7.1	524	3970	5.72	
Beaver Creek UPR	8/28/2003							NA	
Beaver Creek TRIB1	8/28/2003							No Flow	
Beaver Creek DPR	8/28/2003							NA	
Beaver Creek UPR	9/2/2003							NA	
Beaver Creek TRIB1	9/2/2003							No Flow	
Beaver Creek DPR	9/2/2003							NA	
Beaver Creek UPR	10/16/2003	186	309	81	5.4	349	2790	32.92	
Beaver Creek TRIB1	10/16/2003	23	21	56	15.9	621	2980	0.23	
Beaver Creek DPR	10/16/2003	184	309	80	5.5	354	2830	33.16	
Beaver Creek UPR	11/3/2003	127	204	48	4.3	223	2100	66.60	DPR - Trib1
Beaver Creek TRIB1	11/3/2003	22	27	40	17.2	588	2800	0.44	FPR
Beaver Creek DPR	11/3/2003	121	208	46	4.3	220	2140	67.04	FPR/Pigme stick w/star
Beaver Creek UPR	12/13/2003	161	183	52	4.4	249	2220	139.58	FPR/Globel
Beaver Creek TRIB1	12/13/2003	59	19	67	14.9	704	3610	0.09	FPR/Globel
Beaver Creek DPR	12/13/2003	159	183	52	4.3	243	2240	139.67	UPR + Trib1
Beaver Creek UPR	1/6/2004							NA	
Beaver Creek TRIB1	1/6/2004							No Flow	
Beaver Creek DPR	1/6/2004							NA	
Beaver Creek UPR	2/10/2004							NA	
Beaver Creek TRIB1	2/10/2004							No Flow	
Beaver Creek DPR	2/10/2004							NA	
Beaver Creek UPR	3/4/2004	145	179	50	4.6	253	2280	118.25	SSX
Beaver Creek TRIB1	3/4/2004	69	14	65	9.9	477	2840	0.50	FPR/Globel
Beaver Creek DPR	3/4/2004	146	178	50	4.8	264	2280	118.76	UPR + Trib1
Beaver Creek UPR	4/13/2004	105	166	38	5.0	236	1860	101.57	DPR - Trib1
Beaver Creek TRIB1	4/13/2004	40	18	73	15.9	729	3540	0.53	FPR/Globel
Beaver Creek DPR	4/13/2004	103	166	39	5.0	235	1850	102.10	BDB
Beaver Creek UPR	5/5/2004	111	184	45	5.4	268	2070	85.94	DPR - Trib1
Beaver Creek TRIB1	5/5/2004	29	13	57	16.0	644	3090	0.60	FPR/Globel

Refer to Section 3.1 for Flow Calculation Explanation

Table 2: Beaver Creek Water Quality and Flow Data – Continued

Beaver Creek Sampled Station	Date	Calcium, Dissolved mg/L	Chloride, Dissolved mg/L	Magnesium, Dissolved mg/L	Sodium Adsorption Ratio (SAR) unitless	Sodium, Dissolved mg/L	Specific Conductance @25C umhos/cm	Flow Volume MGD	Flow Method
Beaver Creek DPR	5/5/2004	111	179	45	5.5	274	2070	86.54	BDB
Beaver Creek UPR	6/17/2004	173	629	93	11.5	751	4720	14.75	DPR - Trib1
Beaver Creek TRIB1	6/17/2004	17	13	36	20.5	654	2760	0.76	FPR/Globel
Beaver Creek DPR	6/17/2004	170	589	93	11.6	757	4660	15.51	BDB
Beaver Creek UPR	7/7/2004	95	105	39	4.3	196	1680	38.42	DPR - Trib1
Beaver Creek TRIB1	7/7/2004	14	13	32	20.1	598	2640	1.00	FPR/Globel
Beaver Creek DPR	7/7/2004	95	103	39	4.6	209	1700	39.42	BDB
Beaver Creek UPR	8/16/2004	173	756	95	13.6	899	5260	0.00	DPR - Trib1
Beaver Creek TRIB1	8/16/2004	11	14	26	23.8	637	2620	0.59	FPR/Globel
Beaver Creek DPR	8/16/2004	155	630	90	13.7	868	4920	0.00	BDB
Beaver Creek UPR	9/8/2004	149	540	87	11.0	682	4260	2.57	DPR - Trib1
Beaver Creek TRIB1	9/8/2004	14	15	29	20.4	580	2520	0.66	FPR/Globel
Beaver Creek DPR	9/8/2004	144	494	86	11.2	689	4200	3.23	BDB
Beaver Creek UPR	10/21/2004	130	222	51	6.3	336	2460	47.13	DPR - Trib1
Beaver Creek TRIB1	10/21/2004	27	15	44	16.8	606	2850	0.69	FPR/Globel
Beaver Creek DPR	10/21/2004	127	217	51	6.4	339	2450	47.82	BDB
Beaver Creek UPR	11/9/2004	133	190	53	5.0	270	2270	67.82	DPR - Trib1
Beaver Creek TRIB1	11/9/2004	28	14	45	14.5	533	2860	0.69	FPR/Globel
Beaver Creek DPR	11/9/2004	134	190	55	4.8	262	2300	68.51	BDB
Beaver Creek UPR	12/17/2004	141	218	51	5.7	312	2340	156.96	DPR - Trib1
Beaver Creek TRIB1	12/17/2004	45	17	48	16.1	652	2990	0.71	FPR/Globel
Beaver Creek DPR	12/17/2004	141	221	51	5.8	314	2380	157.67	BDB
Beaver Creek UPR	1/16/2005	159	247	55	5.9	337	2490	ICE	
Beaver Creek TRIB1	1/16/2005	52	14	43	17.7	714	3050	ICE	
Beaver Creek DPR	1/16/2005	157	246	55	6.0	345	2490	ICE	
Beaver Creek UPR	2/7/2005	151	205	55	5.6	314	2390	ICE	
Beaver Creek TRIB1	2/7/2005	44	11	45	14.3	566	2640	ICE	
Beaver Creek DPR	2/7/2005	155	214	57	6.0	344	2540	ICE	
Beaver Creek UPR	3/17/2005	131	254	58	6.8	373	2570	58.95	BDB
Beaver Creek TRIB1	3/17/2005	39	15	57	15.2	638	2930	0.51	FPR
Beaver Creek DPR	3/17/2005	128	240	58	7.0	378	2570	59.46	BDB + Trib1
Beaver Creek UPR	4/12/2005	105	179	43	5.3	255	1920	118.80	BDB
Beaver Creek TRIB1	4/12/2005	20	16	29	11.9	359	3020	2.05	FPR
Beaver Creek DPR	4/12/2005	102	178	43	5.6	267	1970	120.85	BDB + Trib1

Refer to Section 3.1 for Flow Calculation Explanation

Table 2: Beaver Creek Water Quality and Flow Data - Continued

Beaver Creek		Calcium, Dissolved	Chloride, Dissolved	Magnesium, Dissolved	Sodium Adsorption Ratio (SAR)	Sodium, Dissolved	Specific Conductance @25C	Flow Volume	Flow Method
Sampled Station	Date	mg/L	mg/L	mg/L	unitless	mg/L	umhos/cm	MGD	
Beaver Creek UPR	5/17/2005	107	67	37	4.6	218	1710	274.87	BDB
Beaver Creek TRIB1	5/17/2005	48	17	86	15.0	753	3470	0.44	FPR
Beaver Creek DPR	5/17/2005	105	63	37	4.7	222	1720	275.31	BDB + Trib1
Beaver Creek UPR	6/8/2005	115	156	45	4.8	242	1950	65.83	BDB
Beaver Creek TRIB1	6/8/2005	23	14	49	17.1	634	2910	1.38	Pigme Stick
Beaver Creek DPR	6/8/2005	115	151	44	4.9	244	1960	67.21	BDB + Trib1
Beaver Creek UPR	7/18/2005	156	593	97	12.9	836	4620	9.61	BDB - Trib1
Beaver Creek TRIB1	7/18/2005	12	16	29	25.8	728	2790	0.09	Pigme Stick
Beaver Creek DPR	7/18/2005	154	573	97	12.3	790	4580	9.70	BDB
Beaver Creek UPR	8/13/2005	134	484	68	10.0	571	3700	31.22	Pigme Stick
Beaver Creek TRIB1	8/13/2005	88	10	40	7.0	316	2000	0.70	Pigme Stick
Beaver Creek DPR	8/13/2005	132	408	68	9.8	555	3640	31.92	UPR + Trib1
Beaver Creek UPR	9/7/2005	202	683	111	12.2	871	5200	1.07	BDB - Trib1
Beaver Creek TRIB1	9/7/2005	13	14	24	23.6	625	2520	0.49	Pigme Stick
Beaver Creek DPR	9/7/2005	155	485	93	12.3	785	4530	1.55	BDB
Beaver Creek UPR	10/12/2005	144	226	59	5.8	330	2480	116.95	BDB - Trib1
Beaver Creek TRIB1	10/12/2005	27	15	35	17.3	576	2550	0.67	Pigme Stick
Beaver Creek DPR	10/12/2005	142	222	59	6.1	343	2490	117.62	BDB
Beaver Creek UPR	11/8/2005	129	203	57	5.1	278	2290	69.16	BDB - Trib1
Beaver Creek TRIB1	11/8/2005	29	16	38	16.3	568	2640	0.64	Pigme Stick
Beaver Creek DPR	11/8/2005	127	198	57	5.2	282	2310	69.80	BDB
Beaver Creek UPR	12/15/2005	173	189	65	5.0	303	2410	ICE	
Beaver Creek TRIB1	12/15/2005	53	22	54	20.4	881	3620	0.65	Estimate
Beaver Creek DPR	12/15/2005	171	192	66	5.4	331	2470	ICE	

Refer to Section 3.1 for Flow Calculation Explanation

Table 3 – Pumpkin Creek Water Quality and Flow Data

Pumpkin Creek Sampled Station	Date	Calcium, Dissolved mg/L	Chloride, Dissolved mg/L	Magnesium, Dissolved mg/L	Sodium Adsorption Ratio (SAR) unitless	Sodium, Dissolved mg/L	Specific Conductance @25C umhos/cm	Flow Volume MGD	Flow Method
Pumpkin Creek UPR	7/28/2003							NA	
Pumpkin Creek TRIB1	7/28/2003							No Flow	
Pumpkin Creek DPR	7/28/2003							NA	
Pumpkin Creek UPR	8/28/2003							NA	
Pumpkin Creek TRIB1	8/28/2003							No Flow	
Pumpkin Creek DPR	8/28/2003							NA	
Pumpkin Creek UPR	9/2/2003							NA	
Pumpkin Creek TRIB1	9/2/2003							No Flow	
Pumpkin Creek DPR	9/2/2003							NA	
Pumpkin Creek UPR	10/16/2003							NA	
Pumpkin Creek TRIB1	10/16/2003							No Flow	
Pumpkin Creek DPR	10/16/2003							NA	
Pumpkin Creek UPR	11/3/2003	127	206	48	4.2	220	2060	64.29	FPR/Globel
Pumpkin Creek TRIB1	11/3/2003	106	35	102	15.5	931	4790	0.49	FPR/Globel
Pumpkin Creek DPR	11/3/2003	119	208	45	4.1	208	2050	64.78	UPR + Trib1
Pumpkin Creek UPR	12/13/2003	164	183	54	4.2	240	2210	142.81	FPR/Globel
Pumpkin Creek TRIB1	12/13/2003	74	29	84	17.9	946	4570	1.10	FPR/Globel
Pumpkin Creek DPR	12/13/2003	157	172	55	4.7	268	2340	143.91	UPR + Trib1
Pumpkin Creek UPR	1/6/2004	212	325	71	4.6	300	2790	ICE	
Pumpkin Creek TRIB1	1/6/2004	84	33	87	18.9	1040	5010	ICE	
Pumpkin Creek DPR	1/6/2004	209	305	71	4.7	308	2840	ICE	
Pumpkin Creek UPR	2/10/2004	141	190	47	3.8	207	1970	ICE	
Pumpkin Creek TRIB1	2/10/2004	39	24	54	20.2	832	3990	ICE	
Pumpkin Creek DPR	2/10/2004	133	173	46	4.8	250	2100	ICE	
Pumpkin Creek UPR	3/3/2004	147	171	49	4.5	245	2230	129.07	DPR - Trib1
Pumpkin Creek TRIB1	3/3/2004	37	20	54	17.7	722	3470	1.53	FPR/Globel
Pumpkin Creek DPR	3/3/2004	145	166	50	4.8	263	2270	130.59	FPR/Globel
Pumpkin Creek UPR	4/13/2004	115	183	42	5.5	269	2020	98.22	SSX
Pumpkin Creek TRIB1	4/13/2004	153	28	131	14.7	1020	5160	0.05	FPR/Globel
Pumpkin Creek DPR	4/13/2004	111	179	41	5.4	264	2030	98.17	UPR + Trib1
Pumpkin Creek UPR	5/5/2004	112	191	45	5.6	280	2170	85.91	DPR - Trib1

Refer to Section 3.1 for Flow Calculation Explanation

Table 3: Pumpkin Creek Water Quality and Flow Data – Continued

Pumpkin Creek Sampled Station	Date	Calcium, Dissolved mg/L	Chloride, Dissolved mg/L	Magnesium, Dissolved mg/L	Sodium Adsorption Ratio (SAR) unitless	Sodium, Dissolved mg/L	Specific Conductance @25C umhos/cm	Flow Volume MGD	Flow Method
Pumpkin Creek TRIB1	5/5/2004	268	31	168	11.6	986	5890	0.04	FPR/Globel
Pumpkin Creek DPR	5/5/2004	113	192	46	5.7	286	2190	65.94	BDB
Pumpkin Creek UPR	6/17/2004							NA	
Pumpkin Creek TRIB1	6/17/2004							No Flow	
Pumpkin Creek DPR	6/17/2004							NA	
Pumpkin Creek UPR	7/27/2004							NA	
Pumpkin Creek TRIB1	7/27/2004							No Flow	
Pumpkin Creek DPR	7/27/2004							NA	
Pumpkin Creek UPR	8/16/2004							NA	
Pumpkin Creek TRIB1	8/16/2004							No Flow	
Pumpkin Creek DPR	8/16/2004							NA	
Pumpkin Creek UPR	9/16/2004							NA	
Pumpkin Creek TRIB1	9/16/2004							No Flow	
Pumpkin Creek DPR	9/16/2004							NA	
Pumpkin Creek UPR	10/20/2004	134	218	49	5.8	308	2350	54.50	DPR - Trib1
Pumpkin Creek TRIB1	10/20/2004	26	25	48	25.2	934	4010	1.72	FPR/Globel
Pumpkin Creek DPR	10/20/2004	125	203	50	6.8	356	2480	56.22	BDB
Pumpkin Creek UPR	11/8/2004	146	203	55	4.6	256	2280	65.20	DPR - Trib1
Pumpkin Creek TRIB1	11/8/2004	21	26	43	24.1	838	3820	2.00	FPR/Globel
Pumpkin Creek DPR	11/8/2004	132	191	54	5.3	286	2370	67.20	BDB
Pumpkin Creek UPR	12/17/2004	148	224	53	5.4	302	2340	154.30	DPR - Trib1
Pumpkin Creek TRIB1	12/17/2004	22	28	39	24.6	826	3870	2.08	FPR/Globel
Pumpkin Creek DPR	12/17/2004	127	211	47	5.8	300	2440	156.38	BDB
Pumpkin Creek UPR	1/16/2005	165	249	56	5.5	319	2440	ICE	
Pumpkin Creek TRIB1	1/16/2005	30	28	46	27.9	1050	4090	ICE	
Pumpkin Creek DPR	1/16/2005	168	249	56	5.5	324	2440	ICE	
Pumpkin Creek UPR	2/7/2005	162	239	56	5.6	326	2480	ICE	
Pumpkin Creek TRIB1	2/7/2005	27	24	45	24.9	905	3790	ICE	
Pumpkin Creek DPR	2/7/2005	161	235	56	5.7	332	2490	ICE	
Pumpkin Creek UPR	3/17/2005	133	248	56	6.3	344	2490	59.12	USGS-Burger
Pumpkin Creek TRIB1	3/17/2005	35	28	53	25.2	1010	4100	0.34	PIGME METER
Pumpkin Creek DPR	3/17/2005	127	249	55	6.7	357	2520	59.46	USGS-Burger + Trib1
Pumpkin Creek UPR	4/11/2005	115	164	48	5.1	261	1900	125.82	DPR - Trib1
Pumpkin Creek TRIB1	4/11/2005	52	26	85	20.8	1050	4290	2.14	FPR
Pumpkin Creek DPR	4/11/2005	114	161	49	5.6	282	1970	127.96	BDB
Pumpkin Creek UPR	5/17/2005	95	62	33	4.1	184	1550	260.35	DPR - Trib1

Refer to Section 3.1 for Flow Calculation Explanation

Table 3: Pumpkin Creek Water Quality and Flow Data - Continued

Pumpkin Creek		Calcium, Dissolved	Chloride, Dissolved	Magnesium, Dissolved	Sodium Adsorption Ratio (SAR)	Sodium, Dissolved	Specific Conductance @25C	Flow Volume	Flow Method
Sampled Station	Date	mg/L	mg/L	mg/L	unitless	mg/L	umhos/cm	MGD	
Pumpkin Creek TRIB1	5/17/2005	53	23	82	17.5	869	4080	3.33	FPR
Pumpkin Creek DPR	5/17/2005	93	61	34	4.4	194	1610	263.68	BDB
Pumpkin Creek UPR	6/7/2005	113	145	44	4.4	218	1880	81.03	DPR - Trib1
Pumpkin Creek TRIB1	6/7/2005	33	28	80	21.4	999	4400	0.40	FPR
Pumpkin Creek DPR	6/7/2005	112	143	43	4.8	235	1870	81.43	BDB
Pumpkin Creek UPR	7/18/2005							NA	
Pumpkin Creek TRIB1	7/18/2005							No Flow	
Pumpkin Creek DPR	7/18/2005							NA	
Pumpkin Creek UPR	8/8/2005							NA	
Pumpkin Creek TRIB1	8/8/2005							No Flow	
Pumpkin Creek DPR	8/8/2005							NA	
Pumpkin Creek UPR	9/1/2005							NA	
Pumpkin Creek TRIB1	9/1/2005							No Flow	
Pumpkin Creek DPR	9/1/2005							NA	
Pumpkin Creek UPR	10/12/2005	137	175	52	5.3	285	2210	116.10	BDB - Trib1
Pumpkin Creek TRIB1	10/12/2005	24	27	38	29.2	982	3770	1.53	Pigmy stick
Pumpkin Creek DPR	10/12/2005	126	162	50	6.3	331	2280	117.63	BDB
Pumpkin Creek UPR	11/8/2005	143	213	58	4.5	252	2260	87.16	BDB - Trib1
Pumpkin Creek TRIB1	11/8/2005	24	29	40	25.7	882	3830	2.03	Pigmy stick
Pumpkin Creek DPR	11/8/2005	127	201	56	5.7	306	2390	89.19	BDB
Pumpkin Creek UPR	12/8/2005	216	302	79	5.5	371	3150	ICE	
Pumpkin Creek TRIB1	12/8/2005	36	29	44	25.3	960	4150	1.60	Estimate
Pumpkin Creek DPR	12/8/2005	214	313	79	5.8	391	3160	ICE	

Refer to Section 3.1 for Flow Calculation Explanation

Table 4 – SA Creek Water Quality and Flow Data

SA Creek		Calcium, Dissolved	Chloride, Dissolved	Magnesium, Dissolved	Sodium Adsorption Ratio (SAR)	Sodium, Dissolved	Specific Conductance @25C	Flow Volume	Flow Method
Sampled Station	Date	mg/L	mg/L	mg/L	unitless	mg/L	umhos/cm	MGD	
SA Creek UPR	7/27/2003							NA	
SA Creek TRIB1	7/27/2003							No Flow	
SA Creek DPR	7/27/2003							NA	
SA Creek UPR	8/12/2003							NA	
SA Creek TRIB1	8/12/2003							No Flow	
SA Creek DPR	8/12/2003							NA	
SA Creek UPR	9/16/2003							NA	
SA Creek TRIB1	9/16/2003							No Flow	
SA Creek DPR	9/16/2003							NA	
SA Creek UPR	10/11/2003							NA	
SA Creek TRIB1	10/11/2003							No Flow	
SA Creek DPR	10/11/2003							NA	
SA Creek UPR	11/1/2003							NA	
SA Creek TRIB1	11/1/2003							No Flow	
SA Creek DPR	11/1/2003							NA	
SA Creek UPR	12/15/2003							NA	
SA Creek TRIB1	12/15/2003							No Flow	
SA Creek DPR	12/15/2003							NA	
SA Creek UPR	1/2/2004							NA	
SA Creek TRIB1	1/2/2004							No Flow	
SA Creek DPR	1/2/2004							NA	
SA Creek UPR	2/9/2004							NA	
SA Creek TRIB1	2/9/2004							No Flow	
SA Creek DPR	2/9/2004							NA	
SA Creek UPR	3/6/2004	126	108	46	3.5	183	1810	276.90	DPR - Trib1
SA Creek TRIB1	3/6/2004	188	18	263	7.0	638	5020	0.97	FPR/Globel
SA Creek DPR	3/6/2004	126	107	46	3.5	182	1810	277.87	MOH
SA Creek UPR	4/15/2004	107	103	45	3.6	177	1610	164.60	DPR - Trib1
SA Creek TRIB1	4/15/2004	300	25	443	10.7	1240	7600	0.18	FPR/Globel
SA Creek DPR	4/15/2004	107	103	45	3.8	184	1630	164.78	MOH

Refer to Section 3.1 for Flow Calculation Explanation

Table 4: SA Creek Water Quality and Flow Data - Continued

SA Creek		Calcium, Dissolved	Chloride, Dissolved	Magnesium, Dissolved	Sodium Adsorption Ratio (SAR)	Sodium, Dissolved	Specific Conductance @25C	Flow Volume	Flow Method
Sampled Station	Date	mg/L	mg/L	mg/L	unitless	mg/L	umhos/cm	MGD	
SA Creek UPR	5/10/2004	122	207	53	5.8	306	2440	84.59	DPR - Trib1
SA Creek TRIB1	5/10/2004	262	18	381	10.2	1100	7330	0.01	Bucket Test
SA Creek DPR	5/10/2004	124	207	54	5.8	306	2440	84.65	MOH
SA Creek UPR	6/19/2004							NA	
SA Creek TRIB1	6/19/2004							No Flow	
SA Creek DPR	6/19/2004							NA	
SA Creek UPR	7/26/2004							NA	
SA Creek TRIB1	7/26/2004							No Flow	
SA Creek DPR	7/26/2004							NA	
SA Creek UPR	8/1/2004							NA	
SA Creek TRIB1	8/1/2004							No Flow	
SA Creek DPR	8/1/2004							NA	
SA Creek UPR	9/4/2004							NA	
SA Creek TRIB1	9/4/2004							No Flow	
SA Creek DPR	9/4/2004							NA	
SA Creek UPR	10/2/2004							NA	
SA Creek TRIB1	10/2/2004							No Flow	
SA Creek DPR	10/2/2004							NA	
SA Creek UPR	11/10/2004	119	118	56	4.3	225	1950	122.02	DPR - Trib1
SA Creek TRIB1	11/10/2004	114	19	217	10.8	855	4950	0.13	FPR/Globel
SA Creek DPR	11/10/2004	118	118	55	4.3	227	1950	122.15	MOH
SA Creek UPR	12/18/2004	131	118	58	3.8	209	1860	93.56	DPR - Trib1
SA Creek TRIB1	12/18/2004	221	24	316	11.0	1080	6450	0.14	FPR/Globel
SA Creek DPR	12/18/2004	131	119	58	4.0	217	1870	93.70	MOH
SA Creek UPR	1/15/2005							NA	
SA Creek TRIB1	1/15/2005							No Flow	
SA Creek DPR	1/15/2005							NA	
SA Creek UPR	2/8/2005	126	119	52	4.3	228	1920	ICE	
SA Creek TRIB1	2/8/2005	254	21	383	9.6	1040	6540	ICE	
SA Creek DPR	2/8/2005	127	117	53	4.4	234	1940	ICE	
SA Creek UPR	3/22/2005	114	157	57	5.7	298	2100	156.47	DPR - Trib1
SA Creek TRIB1	3/22/2005	233	22	383	10.8	1150	6620	7.69	FPR
SA Creek DPR	3/22/2005	119	157	59	5.4	288	2130	157.69	MOH
SA Creek UPR	4/8/2005	119	158	59	5.2	278	2230	113.24	DPR - Trib1
SA Creek TRIB1	4/8/2005	285	24	449	10.8	1250	7710	0.50	FPR

Refer to Section 3.1 for Flow Calculation Explanation

Table 4: SA Creek Water Quality and Flow Data - Continued

SA Creek		Calcium, Dissolved	Chloride, Dissolved	Magnesium, Dissolved	Sodium Adsorption Ratio (SAR)	Sodium, Dissolved	Specific Conductance @25C	Flow Volume	Flow Method
Sampled Station	Date	mg/L	mg/L	mg/L	unitless	mg/L	umhos/cm	MGD	
SA Creek DPR	4/8/2005	114	156	61	5.3	282	2260	113.74	MOH
SA Creek UPR	5/15/2005	100	29	38	3.8	176	1520	1411.70	DPR - Trib1
SA Creek TRIB1	5/15/2005	164	19	263	7.5	669	5030	10.16	FPR
SA Creek DPR	5/15/2005	104	29	40	3.8	161	1540	1421.90	MOH
SA Creek UPR	6/26/2005	61	16	23	1.2	45	672	1014.64	MOH
SA Creek TRIB1	6/26/2005	246	24	450	11.2	1280	7060	0.06	Pigmy Stick
SA Creek DPR	6/26/2005	60	16	22	1.3	46	672	1014.70	MOH + Trib1
SA Creek UPR	7/19/2005							NA	
SA Creek TRIB1	7/19/2005							No Flow	
SA Creek DPR	7/19/2005							NA	
SA Creek UPR	8/10/2005							NA	
SA Creek TRIB1	8/10/2005							No Flow	
SA Creek DPR	8/10/2005							NA	
SA Creek UPR	9/7/2005							NA	
SA Creek TRIB1	9/7/2005							No Flow	
SA Creek DPR	9/7/2005							NA	
SA Creek UPR	10/13/2005	102		50	4.3	214	1810	168.81	MOH
SA Creek TRIB1	10/13/2005	163		190	7.6	601	4060	0.03	Pigmy Stick
SA Creek DPR	10/13/2005	103		51	4.6	226	1810	169.33	MOH + Trib1
SA Creek UPR	11/9/2005							NA	
SA Creek TRIB1	11/9/2005							No Flow	
SA Creek DPR	11/9/2005							NA	
SA Creek UPR	12/16/2005							NA	
SA Creek TRIB1	12/16/2005							No Flow	
SA Creek DPR	12/16/2005							NA	

Refer to Section 3.1 for Flow Calculation Explanation

Table 5 – Wild Horse Creek Water Quality and Flow Data

Wild Horse Creek		Calcium, Dissolved	Chloride, Dissolved	Magnesium, Dissolved	Sodium Adsorption Ratio (SAR)	Sodium, Dissolved	Specific Conductance @25C	Flow Volume	Flow Method
Sampled Station	Date	mg/L	mg/L	mg/L	unitless	mg/L	umhos/cm	MGD	
Wild Horse Creek UPR	7/27/2003							NA	
Wild Horse Creek TRIB1	7/27/2003							No Flow	
Wild Horse Creek DPR	7/27/2003							NA	
Wild Horse Creek UPR	8/12/2003							NA	
Wild Horse Creek TRIB1	8/12/2003							No Flow	
Wild Horse Creek DPR	8/12/2003							NA	
Wild Horse Creek UPR	9/16/2003							NA	
Wild Horse Creek TRIB1	9/16/2003							No Flow	
Wild Horse Creek DPR	9/16/2003							NA	
Wild Horse Creek UPR	10/11/2003							NA	
Wild Horse Creek TRIB1	10/11/2003							No Flow	
Wild Horse Creek DPR	10/11/2003							NA	
Wild Horse Creek UPR	11/5/2003	154	216	72	5.3	320	2660	98.87	ARV
Wild Horse Creek TRIB1	11/5/2003	58	30	172	14.7	985	5250	0.13	FPR/Globel
Wild Horse Creek DPR	11/5/2003	147	218	69	5.3	312	2590	99.00	UPR + Trib1
Wild Horse Creek UPR	12/11/2003	125	161	48	4.1	212	1970	162.20	ARV
Wild Horse Creek TRIB1	12/11/2003	138	22	203	11.4	901	5450	0.12	FPR/Globel
Wild Horse Creek DPR	12/11/2003	121	158	46	3.9	201	1980	162.31	UPR + Trib1
Wild Horse Creek UPR	1/5/2004							NA	
Wild Horse Creek TRIB1	1/5/2004							No Flow	
Wild Horse Creek DPR	1/5/2004							NA	
Wild Horse Creek UPR	2/18/2004	131	155	47	4.2	221	2050	ICE	
Wild Horse Creek TRIB1	2/18/2004	159	16	154	8.8	648	4550	ICE	
Wild Horse Creek DPR	2/18/2004	143	157	52	4.3	236	2060	ICE	
Wild Horse Creek UPR	3/7/2004	140	147	50	4.3	231	2150	272.75	ARV
Wild Horse Creek TRIB1	3/7/2004	74	10	94	6.9	380	2860	0.60	FPR/Globel
Wild Horse Creek DPR	3/7/2004	139	149	49	4.3	230	2150	273.34	UPR + Trib1
Wild Horse Creek UPR	4/15/2004	113	148	46	4.6	231	1940	86.59	ARV
Wild Horse Creek TRIB1	4/15/2004	125	17	196	11.3	872	5050	0.33	FPR/Globel
Wild Horse Creek DPR	4/15/2004	116	149	47	4.7	235	1940	86.92	UPR + Trib1

Refer to Section 3.1 for Flow Calculation Explanation

Table 5: Wild Horse Creek Water Quality and Flow Data – Continued

Wild Horse Creek		Calcium, Dissolved	Chloride, Dissolved	Magnesium, Dissolved	Sodium Adsorption Ratio (SAR)	Sodium, Dissolved	Specific Conductance @25C	Flow Volume	Flow Method
Sampled Station	Date	mg/L	mg/L	mg/L	unitless	mg/L	umhos/cm	MGD	
Wild Horse Creek UPR	5/25/2004	146	216	61	5.7	325	2610	62.04	ARV
Wild Horse Creek TRIB1	5/25/2004	134	22	272	12.3	1080	6180	0.06	FPR/Globel
Wild Horse Creek DPR	5/25/2004	148	212	62	5.8	332	2630	62.09	UPR + Trib1
Wild Horse Creek UPR	6/18/2004	162	394	97	9.7	631	4020	7.75	ARV
Wild Horse Creek TRIB1	6/18/2004	110	20	279	14.3	1240	6450	0.04	Bucket Test
Wild Horse Creek DPR	6/18/2004	164	395	98	10.1	661	4060	7.75	UPR + Trib1
Wild Horse Creek UPR	7/30/2004	101	76	38	5.9	276	1920	0.00	ARV
Wild Horse Creek TRIB1	7/30/2004	57	10	59	9.7	441	2390	1.52	FPR/Globel
Wild Horse Creek DPR	7/30/2004	98	75	38	6.1	280	1920	0.00	UPR + Trib1
Wild Horse Creek UPR	8/30/2004							No Flow	
Wild Horse Creek TRIB1	8/30/2004	74	11	95	8.5	467	2730	0.001	Bucket Test
Wild Horse Creek DPR	8/30/2004							No Flow	
Wild Horse Creek UPR	9/12/2004							No Flow	
Wild Horse Creek TRIB1	9/12/2004	73	11	111	9.2	534	3190	0.001	Bucket Test
Wild Horse Creek DPR	9/12/2004							No Flow	
Wild Horse Creek UPR	10/25/2004	117	201	62	6.9	371	2570	63.97	ARV
Wild Horse Creek TRIB1	10/25/2004	57	16	116	13.0	745	3790	0.33	FPR/Globel
Wild Horse Creek DPR	10/25/2004	116	206	62	7.0	375	2590	64.31	UPR + Trib1
Wild Horse Creek UPR	11/14/2004	125	179	59	5.3	288	2310	91.13	ARV
Wild Horse Creek TRIB1	11/14/2004	51	16	86	12.7	639	3330	0.28	FPR/Globel
Wild Horse Creek DPR	11/14/2004	123	180	60	5.3	288	2320	91.40	UPR + Trib1
Wild Horse Creek UPR	12/19/2004	137	187	57	5.3	292	2250	93.70	ARV
Wild Horse Creek TRIB1	12/19/2004	92	20	165	13.9	967	4840	0.29	FPR/Globel
Wild Horse Creek DPR	12/19/2004	134	186	57	5.2	286	2250	93.99	UPR + Trib1
Wild Horse Creek UPR	1/18/2005	163	234	61	6.1	361	2570	ICE	
Wild Horse Creek TRIB1	1/18/2005	126	18	173	13.1	963	4800	ICE	
Wild Horse Creek DPR	1/18/2005	161	235	60	6.0	352	2570	ICE	
Wild Horse Creek UPR	2/28/2005	119	199	50	6.0	311	2280	139.59	ARV
Wild Horse Creek TRIB1	2/28/2005	113	11	179	10.5	773	4410	0.45	FPR
Wild Horse Creek DPR	2/28/2005	123	192	52	5.8	304	2310	140.04	UPR + Trib1
Wild Horse Creek UPR	3/22/2005	116	212	56	7.0	365	2450	129.26	ARV
Wild Horse Creek TRIB1	3/22/2005	115	13	138	8.6	581	3370	2.25	FPR

Refer to Section 3.1 for Flow Calculation Explanation

Table 5: Wild Horse Creek Water Quality and Flow Data – Continued

Wild Horse Creek		Calcium, Dissolved	Chloride, Dissolved	Magnesium, Dissolved	Sodium Adsorption Ratio (SAR)	Sodium, Dissolved	Specific Conductance @25C	Flow Volume	Flow Method
Sampled Station	Date	mg/L	mg/L	mg/L	unitless	mg/L	umhos/cm	MGD	
Wild Horse Creek DPR	3/22/2005	120	208	58	7.1	377	2450	131.51	UPR + Trib1
Wild Horse Creek UPR	4/27/2005	119	168	53	7.3	380	2470	208.75	ARV
Wild Horse Creek TRIB1	4/27/2005	99	13	107	7.2	432	2700	3.16	FPR
Wild Horse Creek DPR	4/27/2005	122	169	54	7.0	370	2460	211.91	UPR + Trib1
Wild Horse Creek UPR	5/19/2005	88	52	33	3.7	159	1490	460.81	ARV
Wild Horse Creek TRIB1	5/19/2005	142	16	130	5.6	384	3200	3.34	FPR
Wild Horse Creek DPR	5/19/2005	94	51	36	3.9	177	1520	464.15	UPR + Trib1
Wild Horse Creek UPR	6/16/2005	80	93	33	3.8	162	1360	234.60	ARV
Wild Horse Creek TRIB1	6/16/2005	189	10	128	5.1	369	3050	2.44	FPR
Wild Horse Creek DPR	6/16/2005	79	92	33	3.9	163	1370	232.16	UPR + Trib1
Wild Horse Creek UPR	7/28/2005	192	141	65	4.5	286	2400	18.74	ARV
Wild Horse Creek TRIB1	7/28/2005	127	20	214	12.0	955	5140	0.02	Pigmy Stick
Wild Horse Creek DPR	7/28/2005	190	136	64	4.6	288	2400	18.74	UPR +Trib1
Wild Horse Creek UPR	8/17/2005	143	304	60	8.8	494	3190	7.76	ARV
Wild Horse Creek TRIB1	8/17/2005	73	22	176	13.3	919	5060	0.03	Pigmy Stick
Wild Horse Creek DPR	8/17/2005	139	301	58	8.4	471	3210	7.79	UPR +Trib1
Wild Horse Creek UPR	9/21/2005							No Flow	
Wild Horse Creek TRIB1	9/21/2005	44	19	146	15.8	966	4760	0.57	Pigmy Stick
Wild Horse Creek DPR	9/21/2005							No Flow	
Wild Horse Creek UPR	10/31/2005	108	193	58	6.5	338	2270	60.11	ARV
Wild Horse Creek TRIB1	10/31/2005	90	19	160	12.2	833	4370	0.05	Pigmy Stick
Wild Horse Creek DPR	10/31/2005	107	195	57	6.5	337	2290	60.16	UPR +Trib1
Wild Horse Creek UPR	11/10/2005	112	185	60	5.8	309	2280	84.02	ARV
Wild Horse Creek TRIB1	11/10/2005	89	20	154	11.3	757	4100	0.11	Pigmy Stick
Wild Horse Creek DPR	11/10/2005	113	186	61	5.9	311	2310	84.13	UPR +Trib1
Wild Horse Creek UPR	12/23/2005	152	211	63	6.1	352	2570	ICE	
Wild Horse Creek TRIB1	12/23/2005	146	21	173	10.7	809	4640	0.21	Estimate
Wild Horse Creek DPR	12/23/2005	152	208	63	6.0	348	2580	ICE	

Refer to Section 3.1 for Flow Calculation Explanation

Table 6 – Horse Creek Water Quality and Flow Data

Horse Creek		Calcium, Dissolved	Chloride, Dissolved	Magnesium, Dissolved	Sodium Adsorption Ratio (SAR)	Sodium, Dissolved	Specific Conductance @25C	Flow Volume	Flow Method
Sampled Station	Date	mg/L	mg/L	mg/L	unitless	mg/L	umhos/cm	MGD	
Horse Creek ULPR	7/25/2003							NA	
Horse Creek TRIB1	7/25/2003							No Flow	
Horse Creek DLPR	7/25/2003							NA	
Horse Creek ULPR	8/9/2003							NA	
Horse Creek TRIB1	8/9/2003							No Flow	
Horse Creek DLPR	8/9/2003							NA	
Horse Creek ULPR	9/19/2003							NA	
Horse Creek TRIB1	9/19/2003							No Flow	
Horse Creek DLPR	9/19/2003							NA	
Horse Creek ULPR	10/10/2003							NA	
Horse Creek TRIB1	10/10/2003							No Flow	
Horse Creek DLPR	10/10/2003							NA	
Horse Creek ULPR	11/8/2003							NA	
Horse Creek TRIB1	11/8/2003							No Flow	
Horse Creek DLPR	11/8/2003							NA	
Horse Creek ULPR	12/16/2003							NA	
Horse Creek TRIB1	12/16/2003							No Flow	
Horse Creek DLPR	12/16/2003							NA	
Horse Creek ULPR	1/1/2004							NA	
Horse Creek TRIB1	1/1/2004							No Flow	
Horse Creek DLPR	1/1/2004							NA	
Horse Creek ULPR	2/13/2004							NA	
Horse Creek TRIB1	2/13/2004							No Flow	
Horse Creek DLPR	2/13/2004							NA	
Horse Creek ULPR	3/31/2004	90	34	49	7.0	331	2240	0.65	DPR - Trib1
Horse Creek TRIB1	3/31/2004	160	12	143	4.9	356	3020	0.25	FPR/Globel
Horse Creek DLPR	3/31/2004	106	29	69	6.2	336	2430	0.70	FPR/Globel
Horse Creek ULPR	4/12/2004							NA	
Horse Creek TRIB1	4/12/2004							No Flow	
Horse Creek DLPR	4/12/2004							NA	

Refer to Section 3.1 for Flow Calculation Explanation

Table 6: Horse Creek Water Quality and Flow Data – Continued

Horse Creek		Calcium, Dissolved	Chloride, Dissolved	Magnesium, Dissolved	Sodium Adsorption Ratio (SAR)	Sodium, Dissolved	Specific Conductance @25C	Flow Volume	Flow Method
Sampled Station	Date	mg/L	mg/L	mg/L	unitless	mg/L	umhos/cm	MGD	
Horse Creek ULPR	5/13/2004							NA	
Horse Creek TRIB1	5/13/2004							No Flow	
Horse Creek DLPR	5/13/2004							NA	
Horse Creek ULPR	5/24/2004							NA	
Horse Creek TRIB1	5/24/2004							No Flow	
Horse Creek DLPR	5/24/2004							NA	
Horse Creek ULPR	6/14/2004							NA	
Horse Creek TRIB1	6/14/2004							No Flow	
Horse Creek DLPR	6/14/2004							NA	
Horse Creek ULPR	7/4/2004							NA	
Horse Creek TRIB1	7/4/2004							No Flow	
Horse Creek DLPR	7/4/2004							NA	
Horse Creek ULPR	7/31/2004							NA	
Horse Creek TRIB1	7/31/2004							No Flow	
Horse Creek DLPR	7/31/2004							NA	
Horse Creek ULPR	8/7/2004							NA	
Horse Creek TRIB1	8/7/2004							No Flow	
Horse Creek DLPR	8/7/2004							NA	
Horse Creek ULPR	9/3/2004							NA	
Horse Creek TRIB1	9/3/2004							No Flow	
Horse Creek DLPR	9/3/2004							NA	
Horse Creek ULPR	10/21/2004							NA	
Horse Creek TRIB1	10/21/2004							No Flow	
Horse Creek DLPR	10/21/2004							NA	
Horse Creek ULPR	11/10/2004							NA	
Horse Creek TRIB1	11/10/2004							No Flow	
Horse Creek DLPR	11/10/2004							NA	
Horse Creek ULPR	12/14/2004							NA	
Horse Creek TRIB1	12/14/2004							No Flow	
Horse Creek DLPR	12/14/2004							NA	
Horse Creek ULPR	1/14/2005							NA	
Horse Creek TRIB1	1/14/2005							No Flow	

Refer to Section 3.1 for Flow Calculation Explanation

Table 6: Horse Creek Water Quality and Flow Data - Continued

Horse Creek Sampled Station	Date	Calcium, Dissolved mg/L	Chloride, Dissolved mg/L	Magnesium, Dissolved mg/L	Sodium Adsorption Ratio (SAR) unitless	Sodium, Dissolved mg/L	Specific Conductance @25C umhos/cm	Flow Volume MGD	Flow Method
Horse Creek DLPR	1/14/2005							NA	
Horse Creek ULPR	2/6/2005							NA	
Horse Creek TRIB1	2/6/2005							No Flow	
Horse Creek DLPR	2/6/2005							NA	
Horse Creek ULPR	3/4/2005							NA	
Horse Creek TRIB1	3/4/2005							No Flow	
Horse Creek DLPR	3/4/2005							NA	
Horse Creek ULPR	4/8/2005							NA	
Horse Creek TRIB1	4/8/2005							No Flow	
Horse Creek DLPR	4/8/2005							NA	
Horse Creek ULPR	5/6/2005							NA	
Horse Creek TRIB1	5/6/2005							No Flow	
Horse Creek DLPR	5/6/2005							NA	
Horse Creek ULPR	6/14/2005	237	14	197	6.0	517	4050	2.15	Pigmy Stick
Horse Creek TRIB1	6/14/2005	114	48	77	9.3	524	3050	0.21	Pigmy Stick
Horse Creek DLPR	6/14/2005	104	51	68	9.5	505	2950	2.36	ULPR + Trib1
Horse Creek ULPR	7/3/2005							NA	
Horse Creek TRIB1	7/3/2005							No Flow	
Horse Creek DLPR	7/3/2005							NA	
Horse Creek ULPR	8/9/2005							NA	
Horse Creek TRIB1	8/9/2005							No Flow	
Horse Creek DLPR	8/9/2005							NA	
Horse Creek ULPR	9/8/2005							NA	
Horse Creek TRIB1	9/8/2005							No Flow	
Horse Creek DLPR	9/8/2005							NA	
Horse Creek ULPR	10/9/2005							NA	
Horse Creek TRIB1	10/9/2005							No Flow	
Horse Creek DLPR	10/9/2005							NA	
Horse Creek ULPR	11/5/2005							NA	
Horse Creek TRIB1	11/5/2005							No Flow	
Horse Creek DLPR	11/5/2005							NA	
Horse Creek ULPR	12/13/2005							NA	
Horse Creek TRIB1	12/13/2005							No Flow	
Horse Creek DLPR	12/13/2005							NA	

Refer to Section 3.1 for Flow Calculation Explanation

Table 7 – Deer Gulch Water Quality and Flow Data

Deer Gulch Sampled Station	Date	Calcium, Dissolved mg/L	Chloride, Dissolved mg/L	Magnesium, Dissolved mg/L	Sodium Adsorption Ratio (SAR) unitless	Sodium, Dissolved mg/L	Specific Conductance @25C umhos/cm	Flow Volume MGD	Flow Method
Deer Gulch UPR	10/21/2003							NA	
Deer Gulch TRIB1	10/21/2003							No Flow	
Deer Gulch DPR	10/21/2003							NA	
Deer Gulch UPR	11/4/2003	127	216	52	4.8	255	2220	74.96	DPR - Trib1
Deer Gulch TRIB1	11/4/2003	24	37	28	31.6	961	4200	2.25	FPR/Globel
Deer Gulch DPR	11/4/2003	122	202	50	5.5	286	2350	77.00	FPR/Globel
Deer Gulch UPR	12/3/2003	156	196	59	4.6	265	2260	ICE	
Deer Gulch TRIB1	12/3/2003	43	33	41	28	1070	4500	0.32	FPR/Pigme stick w/star
Deer Gulch DPR	12/3/2003	157	196	58	4.6	266	2280	ICE	
Deer Gulch UPR	1/5/2004	228	330	80	6.1	420	3570	ICE	
Deer Gulch TRIB1	1/5/2004	23	39	37	35.8	1190	4840	ICE	
Deer Gulch DPR	1/5/2004	223	307	79	6	413	3480	ICE	
Deer Gulch UPR	2/26/2004	120	93	42	4.3	213	1840	ICE	
Deer Gulch TRIB1	2/26/2004	20	27	26	28.6	818	3600	ICE	
Deer Gulch DPR	2/26/2004	110	107	39	4.7	227	1880	ICE	
Deer Gulch UPR	3/5/2004							NA	
Deer Gulch TRIB1	3/5/2004							No Flow	
Deer Gulch DPR	3/5/2004							NA	
Deer Gulch UPR	4/14/2004							NA	
Deer Gulch TRIB1	4/14/2004							No Flow	
Deer Gulch DPR	4/14/2004							NA	
Deer Gulch UPR	5/6/2004							NA	
Deer Gulch TRIB1	5/6/2004							No Flow	
Deer Gulch DPR	5/6/2004							NA	
Deer Gulch UPR	6/18/2004							NA	
Deer Gulch TRIB1	6/18/2004							No Flow	
Deer Gulch DPR	6/18/2004							NA	
Deer Gulch UPR	7/30/2004							NA	
Deer Gulch TRIB1	7/30/2004							No Flow	
Deer Gulch DPR	7/30/2004							NA	
Deer Gulch UPR	8/16/2004							NA	

Refer to Section 3.1 for Flow Calculation Explanation

Table 7: Deer Gulch Water Quality and Flow Data – Continued

Deer Gulch		Calcium, Dissolved	Chloride, Dissolved	Magnesium, Dissolved	Sodium Adsorption Ratio (SAR)	Sodium, Dissolved	Specific Conductance @25C	Flow Volume	Flow Method
Sampled Station	Date	mg/L	mg/L	mg/L	unitless	mg/L	umhos/cm	MGD	
Deer Gulch TRIB1	8/16/2004								
Deer Gulch DPR	8/16/2004							No Flow	
Deer Gulch UPR	9/4/2004							NA	
Deer Gulch TRIB1	9/4/2004							NA	
Deer Gulch DPR	9/4/2004							No Flow	
Deer Gulch UPR	10/4/2004							NA	
Deer Gulch TRIB1	10/4/2004							NA	
Deer Gulch DPR	10/4/2004							No Flow	
Deer Gulch UPR	11/9/2004							NA	
Deer Gulch TRIB1	11/9/2004							NA	
Deer Gulch DPR	11/9/2004							No Flow	
Deer Gulch UPR	12/16/2004							NA	
Deer Gulch TRIB1	12/16/2004							NA	
Deer Gulch DPR	12/16/2004							No Flow	
Deer Gulch UPR	1/17/2005							NA	
Deer Gulch TRIB1	1/17/2005							NA	
Deer Gulch DPR	1/17/2005							No Flow	
Deer Gulch UPR	2/8/2005							NA	
Deer Gulch TRIB1	2/8/2005							NA	
Deer Gulch DPR	2/8/2005							No Flow	
Deer Gulch UPR	3/24/2005							NA	
Deer Gulch TRIB1	3/24/2005							NA	
Deer Gulch DPR	3/24/2005							No Flow	
Deer Gulch UPR	4/13/2005							NA	
Deer Gulch TRIB1	4/13/2005							NA	
Deer Gulch DPR	4/13/2005							No Flow	
Deer Gulch UPR	5/4/2005							NA	
Deer Gulch TRIB1	5/4/2005							NA	
Deer Gulch DPR	5/4/2005							No Flow	
Deer Gulch UPR	6/12/2005							NA	
Deer Gulch TRIB1	6/12/2005							NA	
Deer Gulch DPR	6/12/2005							No Flow	
Deer Gulch UPR	7/1/2005							NA	
Deer Gulch TRIB1	7/1/2005							NA	
								No Flow	

Refer to Section 3.1 for Flow Calculation Explanation

Table 8 – Flying E Creek Water Quality and Flow Data

Flying E Creek Sampled Station	Date	Calcium, Dissolved mg/L	Chloride, Dissolved mg/L	Magnesium, Dissolved mg/L	Sodium Adsorption Ratio (SAR) unitless	Sodium, Dissolved mg/L	Specific Conductance @25C umhos/cm	Flow Volume MGD	Flow Method
Flying E Creek UPR	7/28/2003							NA	
Flying E Creek TRIB1	7/28/2003							No Flow	
Flying E Creek DPR	7/28/2003							NA	
Flying E Creek UPR	8/28/2003							NA	
Flying E Creek TRIB1	8/28/2003							No Flow	
Flying E Creek DPR	8/28/2003							NA	
Flying E Creek UPR	9/16/2003							NA	
Flying E Creek TRIB1	9/16/2003							No Flow	
Flying E Creek DPR	9/16/2003							NA	
Flying E Creek UPR	10/21/2003							NA	
Flying E Creek TRIB1	10/21/2003							No Flow	
Flying E Creek DPR	10/21/2003							NA	
Flying E Creek UPR	11/4/2003							NA	
Flying E Creek TRIB1	11/4/2003							No Flow	
Flying E Creek DPR	11/4/2003							NA	
Flying E Creek UPR	12/9/2003							NA	
Flying E Creek TRIB1	12/9/2003							No Flow	
Flying E Creek DPR	12/9/2003							NA	
Flying E Creek UPR	1/5/2004							NA	
Flying E Creek TRIB1	1/5/2004							No Flow	
Flying E Creek DPR	1/5/2004							NA	
Flying E Creek UPR	2/14/2004							NA	
Flying E Creek TRIB1	2/14/2004							No Flow	
Flying E Creek DPR	2/14/2004							NA	
Flying E Creek UPR	3/5/2004							NA	
Flying E Creek TRIB1	3/5/2004							No Flow	
Flying E Creek DPR	3/5/2004							NA	
Flying E Creek UPR	4/14/2004							NA	
Flying E Creek TRIB1	4/14/2004							No Flow	
Flying E Creek DPR	4/14/2004							NA	

Refer to Section 3.1 for Flow Calculation Explanation

Table 8: Flying E Creek Water Quality and Flow Data - Continued

Flying E Creek		Calcium, Dissolved	Chloride, Dissolved	Magnesium, Dissolved	Sodium Adsorption Ratio (SAR)	Sodium, Dissolved	Specific Conductance @25C	Flow Volume	Flow Method
Sampled Station	Date	mg/L	mg/L	mg/L	unitless	mg/L	umhos/cm	MGD	
Flying E Creek UPR	5/16/2004							NA	
Flying E Creek TRIB1	5/16/2004							No Flow	
Flying E Creek DPR	5/16/2004							NA	
Flying E Creek UPR	6/18/2004							NA	
Flying E Creek TRIB1	6/18/2004							No Flow	
Flying E Creek DPR	6/18/2004							NA	
Flying E Creek UPR	7/30/2004							NA	
Flying E Creek TRIB1	7/30/2004							No Flow	
Flying E Creek DPR	7/30/2004							NA	
Flying E Creek UPR	8/16/2004							NA	
Flying E Creek TRIB1	8/16/2004							No Flow	
Flying E Creek DPR	8/16/2004							NA	
Flying E Creek UPR	9/4/2004							NA	
Flying E Creek TRIB1	9/4/2004							No Flow	
Flying E Creek DPR	9/4/2004							NA	
Flying E Creek UPR	10/25/2004	116	141	49	5.9	301	2240	105.98	BDB
Flying E Creek TRIB1	10/25/2004	41	103	4	9.7	243	1250	0.37	FPR/Globel
Flying E Creek DPR	10/25/2004	116	140	49	6.0	304	2210	106.35	UPR + Trib1
Flying E Creek UPR	11/9/2004	127		55	5.1	276	2290	56.22	BDB
Flying E Creek TRIB1	11/9/2004	49		4	5.8	158	986	0.39	FPR/Globel
Flying E Creek DPR	11/9/2004	123		54	5.1	270	2270	56.61	UPR + Trib1
Flying E Creek UPR	11/19/2004	119		53	6.1	317	2380	NA	BDB
Flying E Creek TRIB1	11/19/2004	48		3	6.0	160	901	NA	FPR/Globel
Flying E Creek DPR	11/19/2004	110		45	6.0	297	2150	NA	UPR + Trib1
Flying E Creek UPR	12/16/2004	121		46	5.4	276	2200	157.67	BDB
Flying E Creek TRIB1	12/16/2004	75		5	7.3	244	1350	0.37	FPR/Globel
Flying E Creek DPR	12/16/2004	120		46	5.5	278	2210	158.05	UPR + Trib1
Flying E Creek UPR	12/27/2004	156		61	6.8	397	2720	168.01	BDB
Flying E Creek TRIB1	12/27/2004	112		5	5.5	221	1420	0.16	FPR/Globel
Flying E Creek DPR	12/27/2004	154		59	6.8	393	2730	168.17	UPR + Trib1
Flying E Creek UPR	1/17/2005	158		56	6.1	348	2560	ICE	
Flying E Creek TRIB1	1/17/2005	156		4	4.4	203	1500	ICE	

Refer to Section 3.1 for Flow Calculation Explanation

Table 8: Flying E Creek Water Quality and Flow Data – Continued

Flying E Creek		Calcium, Dissolved	Chloride, Dissolved	Magnesium, Dissolved	Sodium Adsorption Ratio (SAR)	Sodium, Dissolved	Specific Conductance @25C	Flow Volume	Flow Method
Sampled Station	Date	mg/L	mg/L	mg/L	unitless	mg/L	umhos/cm	MGD	
Flying E Creek DPR	1/17/2005	156		55	6.0	344	2550	ICE	
Flying E Creek UPR	2/28/2005	121		49	6.5	337	2430	56.23	BDB
Flying E Creek TRIB1	2/28/2005	65		7	9.9	314	1630	0.25	FPR
Flying E Creek DPR	2/28/2005	118		48	6.6	334	2430	56.48	UPR + Trib1
Flying E Creek UPR	3/23/2005	115		54	7.3	378	2470	91.78	BDB
Flying E Creek TRIB1	3/23/2005	73		6	9.2	306	1550	1.17	FPR
Flying E Creek DPR	3/23/2005	117		55	7.5	392	2450	92.95	UPR + Trib1
Flying E Creek UPR	4/13/2005	99		44	5.6	265	2010	109.87	BDB
Flying E Creek TRIB1	4/13/2005	97		5	6.9	258	1490	1.28	FPR
Flying E Creek DPR	4/13/2005	102		45	5.9	284	2000	111.16	UPR + Trib1
Flying E Creek UPR	5/19/2005	95		36	4.4	198	1510	266.68	BDB
Flying E Creek TRIB1	5/19/2005	56		5	4.6	133	920	0.89	FPR
Flying E Creek DPR	5/19/2005	90		32	4.0	175	1500	267.57	UPR + Trib1
Flying E Creek UPR	6/16/2005	102		43	5.8	278	2010	69.60	BDB
Flying E Creek TRIB1	6/16/2005	120		5	5.7	233	1600	0.58	Pigmy Stick
Flying E Creek DPR	6/16/2005	101		43	5.8	276	2010	69.22	BDB + Trib1
Flying E Creek UPR	7/28/2005	96		84	13.6	757	4000	12.28	BDB
Flying E Creek TRIB1	7/28/2005	347		61	1.1	88	2120	0.01	Pigmy Stick
Flying E Creek DPR	7/28/2005	99		83	13.6	755	4000	12.29	BDB + Trib1
Flying E Creek UPR	8/13/2005							NA	
Flying E Creek TRIB1	8/13/2005							No Flow	
Flying E Creek DPR	8/13/2005							NA	
Flying E Creek UPR	9/20/2005	33		55	20.9	845	3830	0.18	BDB
Flying E Creek TRIB1	9/20/2005	18		12	33.0	735	2760	0.43	Pigmy Stick
Flying E Creek DPR	9/20/2005	46		39	16.0	614	2980	0.61	BDB + Trib1
Flying E Creek UPR	10/30/2005	115		56	6.2	325	2370	113.10	BDB
Flying E Creek TRIB1	10/30/2005	114		6	4.8	195	1430	0.49	Pigmy Stick
Flying E Creek DPR	10/30/2005	110		54	6.4	328	2290	113.59	BDB + Trib1
Flying E Creek UPR	11/7/2005	123		61	6.4	345	2280	90.02	BDB
Flying E Creek TRIB1	11/7/2005	116		6	5.1	207	1370	0.47	Pigmy Stick
Flying E Creek DPR	11/7/2005	119		59	6.4	340	2240	90.48	BDB + Trib1
Flying E Creek UPR	12/15/2005	174		72	6.2	385	2740	ICE	
Flying E Creek TRIB1	12/15/2005	89		7	8.0	289	1580	0.73	Pigmy Stick
Flying E Creek DPR	12/15/2005	171		69	6.3	387	2700	ICE	

Refer to Section 3.1 for Flow Calculation Explanation

Table 9 – Fourmile Creek Water Quality and Flow Data

Fourmile Creek		Calcium, Dissolved	Magnesium, Dissolved	Sodium Adsorption Ratio (SAR)	Sodium, Dissolved	Specific Conductance @25C	Flow Volume	Flow Method
Sampled Station	Date	mg/L	mg/L	unitless	mg/L	umhos/cm	MGD	
Fourmile Creek UPR	7/28/2003						NA	
Fourmile Creek TRIB1	7/28/2003						No Flow	
Fourmile Creek DPR	7/28/2003						NA	
Fourmile Creek UPR	8/28/2003						NA	
Fourmile Creek TRIB1	8/28/2003						No Flow	
Fourmile Creek DPR	8/28/2003						NA	
Fourmile Creek UPR	9/2/2003						NA	
Fourmile Creek TRIB1	9/2/2003						No Flow	
Fourmile Creek DPR	9/2/2003						NA	
Fourmile Creek UPR	10/14/2003						NA	
Fourmile Creek TRIB1	10/14/2003						No Flow	
Fourmile Creek DPR	10/14/2003						NA	
Fourmile Creek UPR	11/3/2003						NA	
Fourmile Creek TRIB1	11/3/2003						No Flow	
Fourmile Creek DPR	11/3/2003						NA	
Fourmile Creek UPR	12/9/2003						NA	
Fourmile Creek TRIB1	12/9/2003						No Flow	
Fourmile Creek DPR	12/9/2003						NA	
Fourmile Creek UPR	1/5/2004						NA	
Fourmile Creek TRIB1	1/5/2004						No Flow	
Fourmile Creek DPR	1/5/2004						NA	
Fourmile Creek UPR	2/10/2004						NA	
Fourmile Creek TRIB1	2/10/2004						No Flow	
Fourmile Creek DPR	2/10/2004						NA	
Fourmile Creek UPR	3/3/2004						NA	
Fourmile Creek TRIB1	3/3/2004						No Flow	
Fourmile Creek DPR	3/3/2004						NA	
Fourmile Creek UPR	4/2/2004						NA	
Fourmile Creek TRIB1	4/2/2004						No Flow	
Fourmile Creek DPR	4/2/2004						NA	

Refer to Section 3.1 for Flow Calculation Explanation

Table 9: Fourmile Creek Water Quality and Flow Data – Continued

Fourmile Creek		Calcium, Dissolved	Magnesium, Dissolved	Sodium Adsorption Ratio (SAR)	Sodium, Dissolved	Specific Conductance @25C	Flow Volume	Flow Method
Sampled Station	Date	mg/L	mg/L	unitless	mg/L	umhos/cm	MGD	
Fourmile Creek UPR	5/8/2004						NA	
Fourmile Creek TRIB1	5/8/2004						No Flow	
Fourmile Creek DPR	5/8/2004						NA	
Fourmile Creek UPR	6/3/2004						NA	
Fourmile Creek TRIB1	6/3/2004						No Flow	
Fourmile Creek DPR	6/3/2004						NA	
Fourmile Creek UPR	7/6/2004						NA	
Fourmile Creek TRIB1	7/6/2004						No Flow	
Fourmile Creek DPR	7/6/2004						NA	
Fourmile Creek UPR	8/3/2004						NA	
Fourmile Creek TRIB1	8/3/2004						No Flow	
Fourmile Creek DPR	8/3/2004						NA	
Fourmile Creek UPR	9/1/2004						NA	
Fourmile Creek TRIB1	9/1/2004						No Flow	
Fourmile Creek DPR	9/1/2004						NA	
Fourmile Creek UPR	10/8/2004						NA	
Fourmile Creek TRIB1	10/8/2004						No Flow	
Fourmile Creek DPR	10/8/2004						NA	
Fourmile Creek UPR	10/19/2004						NA	
Fourmile Creek TRIB1	10/19/2004						No Flow	
Fourmile Creek DPR	10/19/2004						NA	
Fourmile Creek UPR	11/18/2004	123	50	5.7	299	2250	56.22	DPR - Trib1
Fourmile Creek TRIB1	11/18/2004	30	84	14.4	679	3320	0.01	Bucket Test
Fourmile Creek DPR	11/18/2004	125	51	5.6	296	2270	56.23	BDB
Fourmile Creek UPR	12/13/2004						NA	
Fourmile Creek TRIB1	12/13/2004						No Flow	
Fourmile Creek DPR	12/13/2004						NA	
Fourmile Creek UPR	1/28/2005						NA	
Fourmile Creek TRIB1	1/28/2005						No Flow	
Fourmile Creek DPR	1/28/2005						NA	
Fourmile Creek UPR	2/9/2005						NA	
Fourmile Creek TRIB1	2/9/2005						No Flow	

Refer to Section 3.1 for Flow Calculation Explanation

Table 9: Fourmile Creek Water Quality and Flow Data - Continued

Fourmile Creek		Calcium, Dissolved	Magnesium, Dissolved	Sodium Adsorption Ratio (SAR)	Sodium, Dissolved	Specific Conductance @25C	Flow Volume	Flow Method
Sampled Station	Date	mg/L	mg/L	unitless	mg/L	umhos/cm	MGD	
Fourmile Creek DPR	2/9/2005						NA	
Fourmile Creek UPR	3/2/2005						NA	
Fourmile Creek TRIB1	3/2/2005						No Flow	
Fourmile Creek DPR	3/2/2005						NA	
Fourmile Creek UPR	4/10/2005	112	49	6.0	302	2200	95.52	BDB - FPR
Fourmile Creek TRIB1	4/10/2005	44	118	13.9	779	3980	2.08	FPR
Fourmile Creek DPR	4/10/2005	110	49	6.2	309	2230	97.59	BDB
Fourmile Creek UPR	5/2/2005	88	40	6.9	318	2250	139.10	BDB - FPR
Fourmile Creek TRIB1	5/2/2005	18	52	18.9	699	3180	0.50	FPR
Fourmile Creek DPR	5/2/2005	96	39	6.7	309	2250	139.60	BDB
Fourmile Creek UPR	6/8/2005						NA	
Fourmile Creek TRIB1	6/8/2005						No Flow	
Fourmile Creek DPR	6/8/2005						NA	
Fourmile Creek UPR	7/6/2005	120	65	6.8	371	2690	43.19	BDB - Trib1
Fourmile Creek TRIB1	7/6/2005	18	50	17.3	629	2800	0.11	Pigmy Stick
Fourmile Creek DPR	7/6/2005	118	64	7.2	392	2710	43.30	BDB
Fourmile Creek UPR	8/9/2005	150	93	13.2	834	4930	8.40	BDB - Trib1
Fourmile Creek TRIB1	8/9/2005	13	42	26.4	869	3380	0.74	Pigmy Stick
Fourmile Creek DPR	8/9/2005	150	93	13.6	864	4900	9.14	BDB
Fourmile Creek UPR	9/6/2005	195	108	12.3	863	5170	0.66	BDB - Trib1
Fourmile Creek TRIB1	9/6/2005	17	68	24.7	1020	4290	0.63	Pigmy Stick
Fourmile Creek DPR	9/6/2005	193	107	12.3	861	5140	1.29	BDB
Fourmile Creek UPR	10/14/2005	129	50	5.2	276	2170	137.62	BDB - Trib1
Fourmile Creek TRIB1	10/14/2005	68	184	13.9	971	5130	0.04	Pigmy Stick
Fourmile Creek DPR	10/14/2005	130	51	5.3	283	2170	137.66	BDB
Fourmile Creek UPR	11/1/2005						NA	
Fourmile Creek TRIB1	11/1/2005						No Flow	
Fourmile Creek DPR	11/1/2005						NA	
Fourmile Creek UPR	12/24/2005						NA	
Fourmile Creek TRIB1	12/24/2005						No Flow	
Fourmile Creek DPR	12/24/2005						NA	

Refer to Section 3.1 for Flow Calculation Explanation

Table 10 – Spotted Horse Creek Water Quality and Flow Data

Spotted Horse Creek		Calcium, Dissolved	Chloride, Dissolved	Magnesium, Dissolved	Sodium Adsorption Ratio (SAR)	Sodium, Dissolved	Specific Conductance @25C	Flow Volume	Flow Method
Sampled Station	Date	mg/L	mg/L	mg/L	unitless	mg/L	umhos/cm	MGD	
Spotted Horse Creek UPR	7/27/2003							NA	
Spotted Horse Creek TRIB1	7/27/2003							No Flow	
Spotted Horse Creek DPR	7/27/2003							NA	
Spotted Horse Creek UPR	8/12/2003							NA	
Spotted Horse Creek TRIB1	8/12/2003							No Flow	
Spotted Horse Creek DPR	8/12/2003							NA	
Spotted Horse Creek UPR	9/16/2003							NA	
Spotted Horse Creek TRIB1	9/16/2003							No Flow	
Spotted Horse Creek DPR	9/16/2003							NA	
Spotted Horse Creek UPR	10/11/2003							NA	
Spotted Horse Creek TRIB1	10/11/2003							No Flow	
Spotted Horse Creek DPR	10/11/2003							NA	
Spotted Horse Creek UPR	11/1/2003							NA	
Spotted Horse Creek TRIB1	11/1/2003							No Flow	
Spotted Horse Creek DPR	11/1/2003							NA	
Spotted Horse Creek UPR	12/14/2003							NA	
Spotted Horse Creek TRIB1	12/14/2003							No Flow	
Spotted Horse Creek DPR	12/14/2003							NA	
Spotted Horse Creek UPR	1/2/2004							NA	
Spotted Horse Creek TRIB1	1/2/2004							No Flow	
Spotted Horse Creek DPR	1/2/2004							NA	
Spotted Horse Creek UPR	2/9/2004							NA	
Spotted Horse Creek TRIB1	2/9/2004							No Flow	
Spotted Horse Creek DPR	2/9/2004							NA	
Spotted Horse Creek UPR	3/6/2004							NA	
Spotted Horse Creek TRIB1	3/6/2004							No Flow	
Spotted Horse Creek DPR	3/6/2004							NA	
Spotted Horse Creek UPR	4/14/2004							NA	
Spotted Horse Creek TRIB1	4/14/2004							No Flow	
Spotted Horse Creek DPR	4/14/2004							NA	
Spotted Horse Creek UPR	5/10/2004							NA	

Refer to Section 3.1 for Flow Calculation Explanation

Table 10: Spotted Horse Creek Water Quality and Flow Data – Continued

Spotted Horse Creek Sampled Station	Date	Calcium, Dissolved mg/L	Chloride, Dissolved mg/L	Magnesium, Dissolved mg/L	Sodium Adsorption Ratio (SAR) unitless	Sodium, Dissolved mg/L	Specific Conductance @25C umhos/cm	Flow Volume MGD	Flow Method
Spotted Horse Creek TRIB1	5/10/2004							No Flow	
Spotted Horse Creek DPR	5/10/2004							NA	
Spotted Horse Creek UPR	6/1/2004							NA	
Spotted Horse Creek TRIB1	6/1/2004							No Flow	
Spotted Horse Creek DPR	6/1/2004							NA	
Spotted Horse Creek UPR	7/26/2004							NA	
Spotted Horse Creek TRIB1	7/26/2004							No Flow	
Spotted Horse Creek DPR	7/26/2004							NA	
Spotted Horse Creek UPR	8/1/2004							NA	
Spotted Horse Creek TRIB1	8/1/2004							No Flow	
Spotted Horse Creek DPR	8/1/2004							NA	
Spotted Horse Creek UPR	9/4/2004							NA	
Spotted Horse Creek TRIB1	9/4/2004							No Flow	
Spotted Horse Creek DPR	9/4/2004							NA	
Spotted Horse Creek UPR	10/2/2004							NA	
Spotted Horse Creek TRIB1	10/2/2004							No Flow	
Spotted Horse Creek DPR	10/2/2004							NA	
Spotted Horse Creek UPR	11/10/2004							NA	
Spotted Horse Creek TRIB1	11/10/2004							No Flow	
Spotted Horse Creek DPR	11/10/2004							NA	
Spotted Horse Creek UPR	12/18/2004	134	191	58	5.4	300	2290	93.54	DPR - Trib1
Spotted Horse Creek TRIB1	12/18/2004	44	30	103	21.6	1140	4850	0.16	FPR
Spotted Horse Creek DPR	12/18/2004	133	191	58	5.4	299	2310	93.70	MOH
Spotted Horse Creek UPR	1/15/2005							NA	
Spotted Horse Creek TRIB1	1/15/2005							No Flow	
Spotted Horse Creek DPR	1/15/2005							NA	
Spotted Horse Creek UPR	2/8/2005							NA	
Spotted Horse Creek TRIB1	2/8/2005							No Flow	
Spotted Horse Creek DPR	2/8/2005							NA	
Spotted Horse Creek UPR	3/22/2005							NA	
Spotted Horse Creek TRIB1	3/22/2005							No Flow	
Spotted Horse Creek DPR	3/22/2005							NA	
Spotted Horse Creek UPR	4/9/2005							NA	

Refer to Section 3.1 for Flow Calculation Explanation

Table 10: Spotted Horse Creek Water Quality and Flow Data - Continued

Spotted Horse Creek		Calcium, Dissolved	Chloride, Dissolved	Magnesium, Dissolved	Sodium Adsorption Ratio (SAR)	Sodium, Dissolved	Specific Conductance @25C	Flow Volume	Flow Method
Sampled Station	Date	mg/L	mg/L	mg/L	unitless	mg/L	umhos/cm	MGD	
Spotted Horse Creek TRIB1	4/9/2005							No Flow	
Spotted Horse Creek DPR	4/9/2005							NA	
Spotted Horse Creek UPR	5/19/2005	92	49	35	3.9	172	1600	1014.50	MOH - Trib1
Spotted Horse Creek TRIB1	5/19/2005	188	22	303	6.8	644	5040	0.15	FPR
Spotted Horse Creek DPR	5/19/2005	94	49	36	3.9	178	1610	1014.70	MOH
Spotted Horse Creek UPR	6/26/2005	131	39	49	2.0	106	1370	1115.00	MOH - Trib1
Spotted Horse Creek TRIB1	6/26/2005	111	23	307	9.8	887	5120	3.07	Pigmy Stick
Spotted Horse Creek DPR	6/26/2005	129	40	49	2.0	104	1380	1118.10	MOH
Spotted Horse Creek UPR	7/19/2005							NA	
Spotted Horse Creek TRIB1	7/19/2005							No Flow	
Spotted Horse Creek DPR	7/19/2005							NA	
Spotted Horse Creek UPR	8/11/2005							NA	
Spotted Horse Creek TRIB1	8/11/2005							No Flow	
Spotted Horse Creek DPR	8/11/2005							NA	
Spotted Horse Creek UPR	9/7/2005							NA	
Spotted Horse Creek TRIB1	9/7/2005							No Flow	
Spotted Horse Creek DPR	9/7/2005							NA	
Spotted Horse Creek UPR	10/13/2005	102		50	4.3	214	1810	168.81	ARV
Spotted Horse Creek TRIB1	10/13/2005	163		190	7.6	601	4060	0.03	Pigmy Stick
Spotted Horse Creek DPR	10/13/2005	103		51	4.6	226	1810	168.84	ARV +Trib1
Spotted Horse Creek UPR	11/9/2005							NA	
Spotted Horse Creek TRIB1	11/9/2005							No Flow	
Spotted Horse Creek DPR	11/9/2005							NA	
Spotted Horse Creek UPR	12/16/2005							NA	
Spotted Horse Creek TRIB1	12/16/2005							No Flow	
Spotted Horse Creek DPR	12/16/2005							NA	

Refer to Section 3.1 for Flow Calculation Explanation

Table 11 – Barber Creek Water Quality and Flow Data

Barber Creek		Calcium, Dissolved	Magnesium, Dissolved	Sodium Adsorption Ratio (SAR)	Sodium, Dissolved	Specific Conductance @25C	Flow Volume	Flow Method
Sampled Station	Date	mg/L	mg/L	unitless	mg/L	umhos/cm	MGD	
Barber Creek UPR	3/5/2004						NA	
Barber Creek TRIB1	3/5/2004						No Flow	
Barber Creek DPR	3/5/2004						NA	
Barber Creek UPR	4/14/2004						NA	
Barber Creek TRIB1	4/14/2004						No Flow	
Barber Creek DPR	4/14/2004						NA	
Barber Creek UPR	5/6/2004						NA	
Barber Creek TRIB1	5/6/2004						No Flow	
Barber Creek DPR	5/6/2004						NA	
Barber Creek UPR	6/18/2004						NA	
Barber Creek TRIB1	6/18/2004						No Flow	
Barber Creek DPR	6/18/2004						NA	
Barber Creek UPR	7/30/2004						NA	
Barber Creek TRIB1	7/30/2004						No Flow	
Barber Creek DPR	7/30/2004						NA	
Barber Creek UPR	8/16/2004						NA	
Barber Creek TRIB1	8/16/2004						No Flow	
Barber Creek DPR	8/16/2004						NA	
Barber Creek UPR	9/5/2004						NA	
Barber Creek TRIB1	9/5/2004						No Flow	
Barber Creek DPR	9/5/2004						NA	
Barber Creek UPR	10/4/2004						NA	
Barber Creek TRIB1	10/4/2004						No Flow	
Barber Creek DPR	10/4/2004						NA	
Barber Creek UPR	11/9/2004						NA	
Barber Creek TRIB1	11/9/2004						No Flow	
Barber Creek DPR	11/9/2004						NA	
Barber Creek UPR	12/16/2004						NA	
Barber Creek TRIB1	12/16/2004						No Flow	
Barber Creek DPR	12/16/2004						NA	
Barber Creek UPR	1/17/2005						NA	
Barber Creek TRIB1	1/17/2005						No Flow	
Barber Creek DPR	1/17/2005						NA	
Barber Creek UPR	2/5/2005						NA	

Refer to Section 3.1 for Flow Calculation Explanation

Table 11: Barber Creek Water Quality and Flow Data - Continued

Barber Creek		Calcium, Dissolved	Magnesium, Dissolved	Sodium Adsorption Ratio (SAR)	Sodium, Dissolved	Specific Conductance @25C	Flow Volume	Flow Method
Sampled Station	Date	mg/L	mg/L	unitless	mg/L	umhos/cm	MGD	
Barber Creek TRIB1	2/5/2005						No Flow	
Barber Creek DPR	2/5/2005						NA	
Barber Creek UPR	3/20/2005						NA	
Barber Creek TRIB1	3/20/2005						No Flow	
Barber Creek DPR	3/20/2005						NA	
Barber Creek UPR	4/4/2005						NA	
Barber Creek TRIB1	4/4/2005						No Flow	
Barber Creek DPR	4/4/2005						NA	
Barber Creek UPR	5/16/2005						NA	
Barber Creek TRIB1	5/16/2005						No Flow	
Barber Creek DPR	5/16/2005						NA	
Barber Creek UPR	6/12/2005						NA	
Barber Creek TRIB1	6/12/2005						No Flow	
Barber Creek DPR	6/12/2005						NA	
Barber Creek UPR	7/5/2005						NA	
Barber Creek TRIB1	7/5/2005						No Flow	
Barber Creek DPR	7/5/2005						NA	
Barber Creek UPR	8/17/2005	174	59	6.7	398	2910	47.83	BDB
Barber Creek TRIB1	8/17/2005	22	12	27.2	636	2610	0.04	FPR/Globel
Barber Creek DPR	8/17/2005	179	62	6.9	419	2930	47.87	UPR+Trib1
Barber Creek UPR	9/20/2005						NA	
Barber Creek TRIB1	9/20/2005						No Flow	
Barber Creek DPR	9/20/2005						NA	
Barber Creek UPR	10/31/2005						NA	
Barber Creek TRIB1	10/31/2005						No Flow	
Barber Creek DPR	10/31/2005						NA	
Barber Creek UPR	11/7/2005						NA	
Barber Creek TRIB1	11/7/2005						No Flow	
Barber Creek DPR	11/7/2005						NA	
Barber Creek UPR	12/12/2005						NA	
Barber Creek TRIB1	12/12/2005						No Flow	
Barber Creek DPR	12/12/2005						NA	

Refer to Section 3.1 for Flow Calculation Explanation

Table 12 – Culp Draw Water Quality and Flow Data

Culp Draw		Calcium, Dissolved	Magnesium, Dissolved	Sodium Adsorption Ratio (SAR)	Sodium, Dissolved	Specific Conductance @25C	Flow Volume	Flow Method
Sampled Station	Date	mg/L	mg/L	unitless	mg/L	umhos/cm	MGD	
Culp Draw UPR	11/8/2004						NA	
Culp Draw TRIB1	11/8/2004						No Flow	
Culp Draw DPR	11/8/2004						NA	
Culp Draw UPR	12/17/2004						NA	
Culp Draw TRIB1	12/17/2004						No Flow	
Culp Draw DPR	12/17/2004						NA	
Culp Draw UPR	1/16/2005						NA	
Culp Draw TRIB1	1/16/2005						No Flow	
Culp Draw DPR	1/16/2005						NA	
Culp Draw UPR	2/7/2005						NA	
Culp Draw TRIB1	2/7/2005						No Flow	
Culp Draw DPR	2/7/2005						NA	
Culp Draw UPR	3/17/2005						NA	
Culp Draw TRIB1	3/17/2005						No Flow	
Culp Draw DPR	3/17/2005						NA	
Culp Draw UPR	4/11/2005						NA	
Culp Draw TRIB1	4/11/2005						No Flow	
Culp Draw DPR	4/11/2005						NA	
Culp Draw UPR	5/17/2005						NA	
Culp Draw TRIB1	5/17/2005						No Flow	
Culp Draw DPR	5/17/2005						NA	
Culp Draw UPR	6/7/2005						NA	
Culp Draw TRIB1	6/7/2005						No Flow	
Culp Draw DPR	6/7/2005						NA	
Culp Draw UPR	7/18/2005						NA	
Culp Draw TRIB1	7/18/2005						No Flow	
Culp Draw DPR	7/18/2005						NA	
Culp Draw UPR	8/8/2005						NA	
Culp Draw TRIB1	8/8/2005						No Flow	
Culp Draw DPR	8/8/2005						NA	
Culp Draw UPR	9/5/2005						NA	
Culp Draw TRIB1	9/5/2005						No Flow	

Refer to Section 3.1 for Flow Calculation Explanation

Table 12: Culp Draw Water Quality and Flow Data - Continued

Culp Draw		Calcium, Dissolved	Magnesium, Dissolved	Sodium Adsorption Ratio (SAR)	Sodium, Dissolved	Specific Conductance @25C	Flow Volume	Flow Method
Sampled Station	Date	mg/L	mg/L	unitless	mg/L	umhos/cm	MGD	
Culp Draw DPR	9/5/2005						NA	
Culp Draw UPR	10/12/2005						NA	
Culp Draw TRIB1	10/12/2005						No Flow	
Culp Draw DPR	10/12/2005						NA	
Culp Draw UPR	11/8/2005						NA	
Culp Draw TRIB1	11/8/2005						No Flow	
Culp Draw DPR	11/8/2005						NA	
Culp Draw UPR	12/6/2005	182	72	7.4	468	3260	ICE	
Culp Draw TRIB1	12/6/2005	60	56	23.5	1050	4250	see Table 12a	Estimate (ice)
Culp Draw DPR	12/6/2005	181	73	7.5	470	3250	ICE	
Culp Draw UPR	12/24/2005	135	50	5.0	267	2120	ICE	
Culp Draw TRIB1	12/24/2005	30	25	28.0	856	3560	see Table 12a	Estimate (ice)
Culp Draw DPR	12/24/2005	121	46	5.3	270	2160	ICE	

* Flow data obtained by sampling technician in the field

Table 12a - Flow Monitoring for Culp Draw

Operator	Permit Name	Permit Number	Seasonal Flow limit (mgd) applicable Jan, Feb, May, June, Nov. and Dec.	Nov 2005 (mgd)	Dec 2005 (mgd)
WPC	SG Palo Section 31	WY0051594	1.29	0.104	0.763

Refer to Section 3.1 for Flow Calculation Explanation

Table 13 – Unnamed Trib PR 51713 Water Quality and Flow Data

Unnamed Trib PR 51713		Calcium, Dissolved	Magnesium, Dissolved	Sodium Adsorption Ratio (SAR)	Sodium, Dissolved	Specific Conductance @25C	Flow Volume	Flow Method
Sampled Station	Date	mg/L	mg/L	unitless	mg/L	umhos/cm	MGD	
UNPR 51713 UPR	3/20/2005						NA	
UNPR 51713 TRIB1	3/20/2005						No Flow	
UNPR 51713 DPR	3/20/2005						NA	
UNPR 51713 UPR	4/11/2005						NA	
UNPR 51713 TRIB1	4/11/2005						No Flow	
UNPR 51713 DPR	4/11/2005						NA	
UNPR 51713 UPR	5/17/2005						NA	
UNPR 51713 TRIB1	5/17/2005						No Flow	
UNPR 51713 DPR	5/17/2005						NA	
UNPR 51713 UPR	6/8/2005						NA	
UNPR 51713 TRIB1	6/8/2005						No Flow	
UNPR 51713 DPR	6/8/2005						NA	
UNPR 51713 UPR	7/18/2005						NA	
UNPR 51713 TRIB1	7/18/2005						No Flow	
UNPR 51713 DPR	7/18/2005						NA	
UNPR 51713 UPR	8/8/2005						NA	
UNPR 51713 TRIB1	8/8/2005						No Flow	
UNPR 51713 DPR	8/8/2005						NA	
UNPR 51713 UPR	9/1/2005						NA	
UNPR 51713 TRIB1	9/1/2005						No Flow	
UNPR 51713 DPR	9/1/2005						NA	
UNPR 51713 UPR	10/12/2005						NA	
UNPR 51713 TRIB1	10/12/2005						No Flow	
UNPR 51713 DPR	10/12/2005						NA	
UNPR 51713 UPR	11/8/2005						NA	
UNPR 51713 TRIB1	11/8/2005						No Flow	
UNPR 51713 DPR	11/8/2005						NA	
UNPR 51713 UPR	12/6/2005	193	76	6.7	434	3210	ICE	
UNPR 51713 TRIB1	12/6/2005	18	23	32.4	883	3460	See Table 13a.	Estimate
UNPR 51713 DPR	12/6/2005	181	75	7.8	493	3370	ICE	

Refer to Section 3.1 for Flow Calculation Explanation

Table 13a – Flow Monitoring for Unnamed Trib PR 51713

Operator	Permit Name	Permit Number	Seasonal Flow limit (mgd) applicable Jan, Feb, May, June, Nov and Dec	Nov 2005 (mgd)	Dec 2005 (mgd)
WPC	SG Palo Prospect Section 18	WY0051713	1.29	0.038	0.343

3.2 Sampling, Analysis, and Quality Assurance

All monitoring data reported herein are acquired in accordance with the established Quality Assurance Plan of CBM Associates, Inc. This includes, but is not limited to, adherence to CBM Associates, Inc. Standard Operating Procedures (SOPs) regarding field sampling protocols, equipment calibration and maintenance, field data recording, sample handling, sample chain of custody, and laboratory procedures.

Mainstem WQMS sites, downstream of influent tributaries, are located below the mixing zone for mainstem and tributary waters to ensure a representative water quality sample as required by the WDEQ. All water samples for laboratory analysis are maintained between 0°C and 4°C from the time of collection to the time of laboratory analysis. Samples remain in the custody of the sampler until released to the laboratory or to a qualified intermediary, and chain of custody records are maintained for each sample from the time of collection to the time of sample disposal after analysis and reporting.

All chemical analyses are performed by laboratories certified by the National Environmental Laboratory Accreditation Council (NELAC) for the analysis of water and wastewater and by the USEPA and the states of Wyoming and Montana for drinking water. All analyses are performed in accordance with the following established methodologies:

Parameter	Method
Calcium, dissolved	EPA 200.7
Chloride, dissolved	EPA 300.0
Magnesium, dissolved	EPA 200.7
Sodium, dissolved	EPA 200.7
Specific Conductance	ASTM 2510 B

4.0 RESULTS

4.1 Raw data

Water quality and flow data are presented in Tables 2 through 13a. Table 14 lists the inspection dates for tributaries that did not discharge during the sampling period.

4.2 Graphical Overviews of Selected Data

WQMS data from tributaries exhibiting consistent measurable flow provide the most reliable data regarding the chemistry and quality of water entering the mainstem Class 2AB streams, as well as potential changes downstream upon mixing. Graphical representations of data for consistently flowing tributaries and associated upstream and downstream stations on the Class 2AB streams are presented here.

Table 14: Tributaries Exhibiting "No Discharge" or "Dry" Conditions and Dates Visited

OP_LyBarCK_Multi_TRIB1	OP_BisonCK_Multi_TRIB1	OP_FortificationCK_Multi_TRIB1	OP_DeadHorseCK_North_Multi_TRIB1	OP_DeadHorseCK_Multi_TRIB1	OP_DryForkPR_Multi_TRIB1	OP_RawhideCK_Multi_TRIB1	OP_LillWillowCK_Multi_TRIB1	OP_SaltCK_Multi_TRIB1	OP_VanHoutenDraw_TRIB1	OP_UnnamedTribPR_5357_TRIB1	OP_UnnamedTribPR_51384_TRIB1	OP_CurtisDraw_Multi_TRIB1	OP_WhitetailCk_Multi_TRIB1	OP_RobinsonCK_Multi_TRIB1	OP_BullSkullUN_TRIB1	OP_CottonwoodCk_TRIB1	OP_DryCk_TRIB1	OP_BurgerDw_TRIB1	OP_CaballoCK_Multi_TRIB1	OP_RoseDw_UPR/DPR	OP_JuniperDw_TRIB1	OP_KinneyDw_TRIB1
7/27/03	7/30/03	NA	NA	7/26/03	NA	*NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
8/12/03	8/13/03	8/25/03	NA	8/26/03	NA	*NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
9/15/03	9/15/03	9/3/03	NA	9/2/03	NA	*NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
10/11/03	10/12/04	10/23/03	NA	10/16/03	NA	*NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
11/11/03	11/1/03	11/2/03	NA	11/5/03	11/13/03	*NA	11/13/03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
12/15/03	12/15/03	12/15/03	NA	12/5/03	12/18/05	*NA	12/18/03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1/2/04	1/2/04	1/5/04	NA	1/5/04	1/30/04	*NA	1/30/04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2/8/04	2/8/04	2/12/04	NA	2/14/04	2/4/04	*NA	2/4/04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3/8/04	3/6/04	3/6/04	NA	3/5/04	3/3/04	*NA	3/30/04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4/18/04	4/18/04	4/12/04	NA	4/14/04	4/20/04	*NA	4/20/04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5/10/04	5/10/04	5/13/04	NA	5/5/04	5/25/04	*NA	5/25/04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6/1/04	6/1/04	6/14/04	NA	6/16/04	6/20/04	6/14/04	6/20/04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7/26/04	7/26/04	7/13/04	NA	7/6/04	7/20/04	7/4/04	7/20/04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
8/1/04	8/1/04	8/13/04	NA	8/3/04	8/4/04	8/17/04	8/4/04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
9/4/04	9/4/04	9/11/04	NA	9/5/04	9/5/04	9/3/04	9/5/04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
10/21/04	10/1/04	10/4/04	NA	10/21/04	10/13/04	10/2/04	10/13/04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
11/13/04	11/13/04	11/9/04	NA	11/9/04	11/17/04	11/10/04	11/17/04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
12/15/04	12/15/04	12/16/04	NA	12/13/04	12/17/04	12/14/04	12/17/04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1/15/05	1/15/05	1/15/05	NA	1/16/05	1/18/05	1/15/05	1/18/05	1/16/05	NA	NA	1/15/05	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2/8/05	2/8/05	2/5/05	NA	2/7/05	2/23/05	2/6/05	2/27/05	2/5/05	NA	NA	2/7/05	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3/1/05	3/1/05	3/16/05	NA	3/18/05	3/3/05	3/3/05	3/3/05	3/5/05	3/19/05	3/17/05	3/7/05	3/17/05	3/4/05	NA	3/23/05	NA	NA	NA	NA	NA	NA	NA
4/8/05	4/5/05	4/4/05	NA	4/10/05	4/5/05	4/8/05	4/5/05	4/12/05	4/10/05	4/17/05	4/11/05	4/11/05	4/8/05	NA	4/25/05	NA	NA	NA	NA	NA	NA	NA
5/15/05	5/15/05	5/5/05	NA	5/2/05	5/15/05	5/16/05	5/15/05	5/17/05	5/1/05	5/17/05	5/17/05	5/16/05	5/5/05	NA	5/4/05	NA	NA	NA	NA	NA	NA	NA
6/25/05	6/26/05	6/10/05	NA	6/6/05	6/24/05	6/9/05	6/24/05	5/5/05	6/6/05	6/7/05	6/7/05	6/7/05	6/3/05	6/15/05	6/12/05	NA	NA	NA	NA	NA	NA	NA
7/13/05	7/13/05	7/7/05	7/19/05	7/6/05	7/19/05	7/2/05	7/19/05	7/1/05	7/5/05	7/18/05	7/16/05	7/18/05	7/2/05	7/1/05	7/1/05	NA	NA	NA	NA	NA	NA	NA
8/10/05	8/10/05	8/7/05	8/10/05	8/8/05	8/31/05	8/9/05	8/31/05	8/6/05	8/6/05	8/13/05	8/5/05	8/8/05	5/9/05	8/31/05	8/15/05	8/14/05	8/13/05	NA	NA	NA	NA	NA
9/24/05	9/7/05	9/19/05	9/7/05	9/5/05	9/27/05	9/9/05	9/27/05	9/3/05	9/5/05	9/1/05	9/5/05	9/5/05	9/3/05	9/7/05	9/8/05	9/21/05	9/5/05	NA	NA	NA	NA	NA
10/10/05	10/9/05	10/25/05	10/9/05	10/11/05	10/18/05	10/9/05	10/18/05	10/21/05	10/11/05	10/12/05	10/12/05	10/12/05	10/9/05	10/10/05	10/31/05	10/19/05	10/30/05	10/31/05	10/30/05	NA	10/30/05	NA
11/4/05	11/9/05	11/12/05	11/9/05	11/7/05	11/7/05	11/5/05	11/8/05	11/6/05	11/9/05	11/8/05	11/6/05	11/8/05	11/5/05	11/5/05	11/10/05	11/7/05	11/7/05	11/8/05	11/11/05	11/7/05	11/7/05	NA
12/16/05	12/15/05	12/13/05	12/15/05	12/7/05	12/14/05	12/13/05	12/14/05	12/14/05	12/7/05	12/8/05	12/5/05	12/15/05	12/16/05	12/14/05	12/9/05	12/9/05	12/15/05	12/15/05	12/14/05	12/15/05	12/15/05	12/15/05

NA - Not Applicable due to Permit sign date or Outfall connectivity required
*NA - Access to trib unaccessible due to landowner issues

4.2.1 Beaver Creek

Dissolved chloride, sodium adsorption ratio (SAR), and specific conductance (SC) levels are plotted in the time series shown in Figures 1, 2, and 3. TRIB1, UPR, and DPR data are plotted on the same graph to show the relationships of tributary water quality to that of the mainstem.

Chloride concentrations observed at the Beaver Creek TRIB1 monitoring station (6 - 27 mg/L) are lower than those seen at the UPR (67-756 mg/L) and DPR (63-630 mg/L) stations.

SAR levels at the Beaver Creek TRIB1 station range between 2.3 to 25.8. UPR and DPR SAR values range between 4.3 -13.6 and 4.3 – 13.7, respectively. SC values at the TRIB1 station range between 1,320 – 3,620 μmhos/cm. UPR and DPR SC values range between 1,680 – 5,260 and 1,700 – 4,920 μmhos/cm, respectively. SAR and SC values at the UPR and DPR overlap and are lower than the TRIB values suggesting that there is little to no impact on downstream mainstem water chemistry.

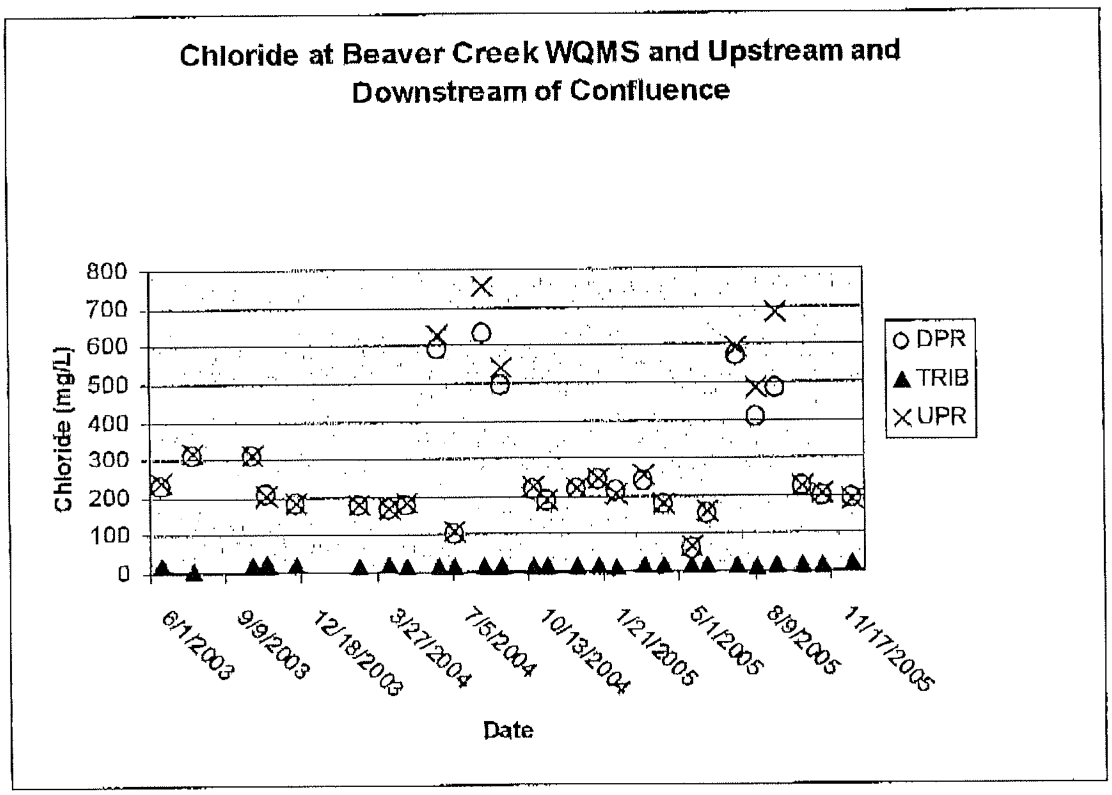

Figure 1 – Time Series of Dissolved Chloride at Beaver Creek TRIB1, UPR, and DPR

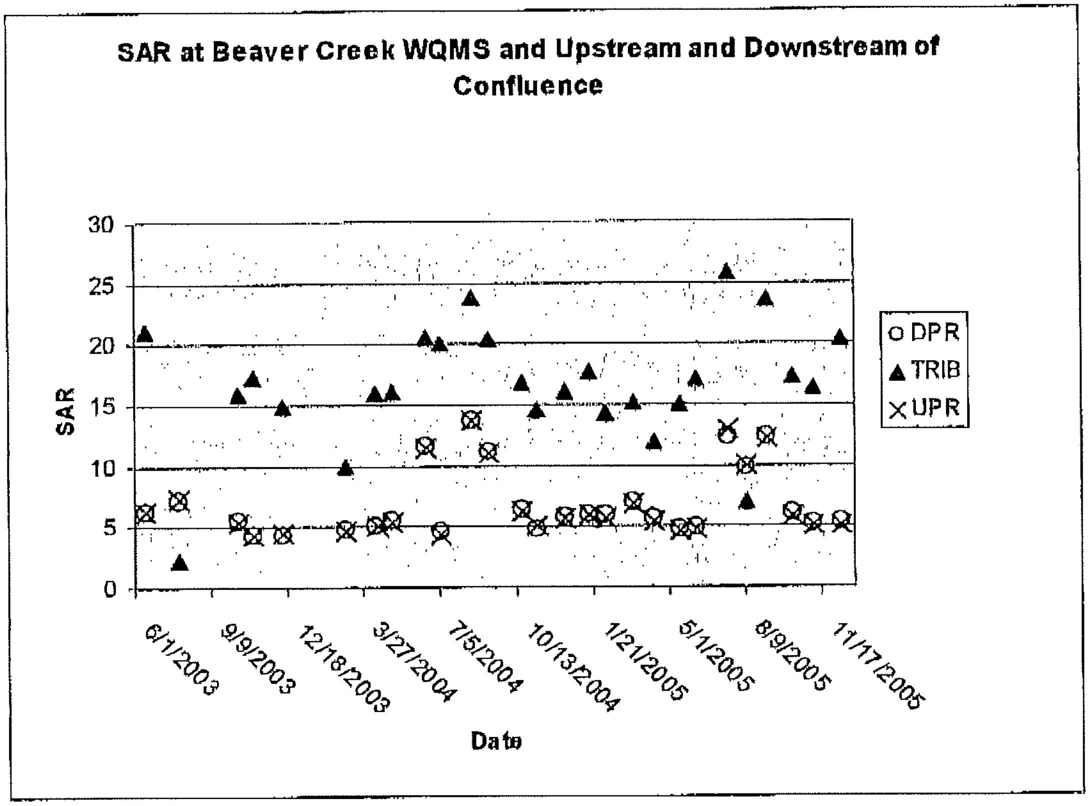

Figure 2 – Time Series of Sodium Adsorption Ratio at Beaver Creek TRIB1, UPR, and DPR

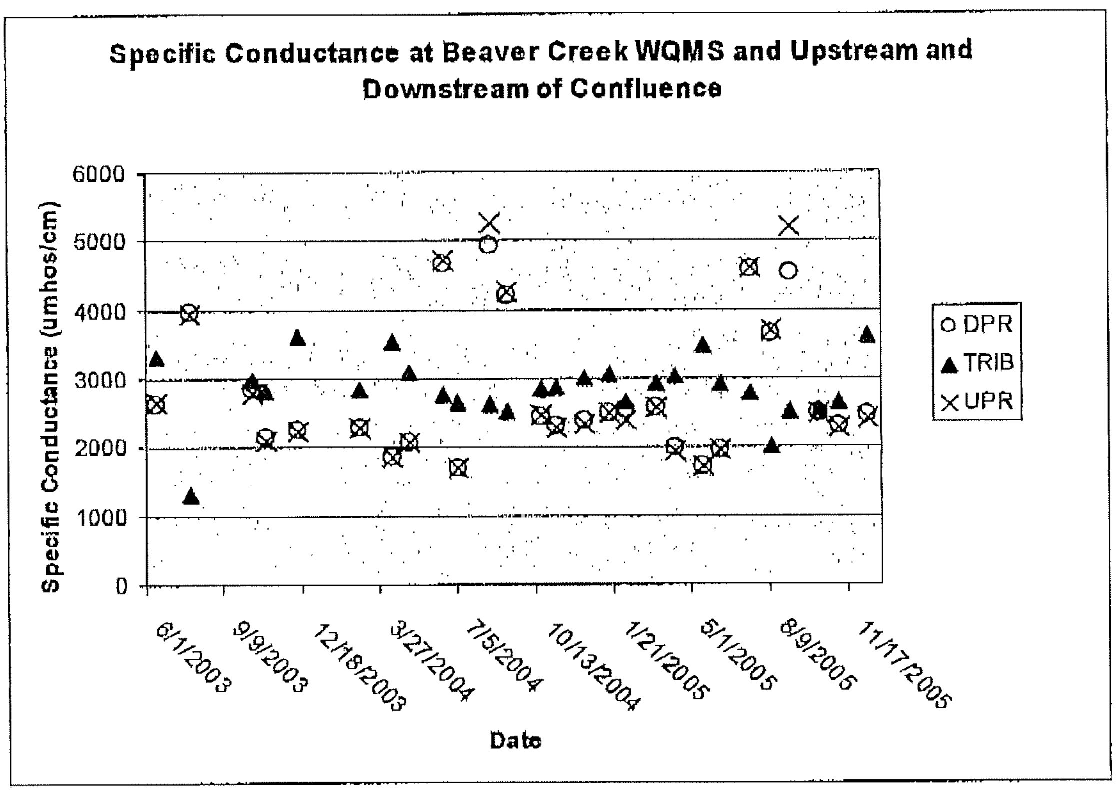

Figure 3 – Time Series of Specific Conductance at Beaver Creek TRIB1, UPR, and DPR

4.2.2 Pumpkin Creek

Measured parameters including dissolved chloride, SAR, and SC are plotted in the time series shown in Figures 4, 5 and 6. TRIB1, UPR, and DPR data are plotted on the same graph to show the relationships of the tributary water quality to that of the mainstem.

Chloride concentrations observed at the Pumpkin Creek TRIB1 monitoring station (20 - 35 mg/L) are lower than those seen at the UPR (62 - 325 mg/L) and DPR (61 - 305 mg/L) stations.

SAR concentrations at the TRIB1 station range from 11.6 to 29.2. UPR and DPR SAR values range between 3.8 - 6.3 and 4.1 - 6.8, respectively. SC values at the TRIB1 station range between 3,470 – 5,890 µmhos/cm. UPR and DPR SC values range between 1,550 – 2,790 and 1,610 – 2,520 µmhos/cm, respectively. SAR and SC values at the UPR and DPR overlap and are lower than the TRIB values suggesting that there is little to no impact on downstream mainstem water chemistry.

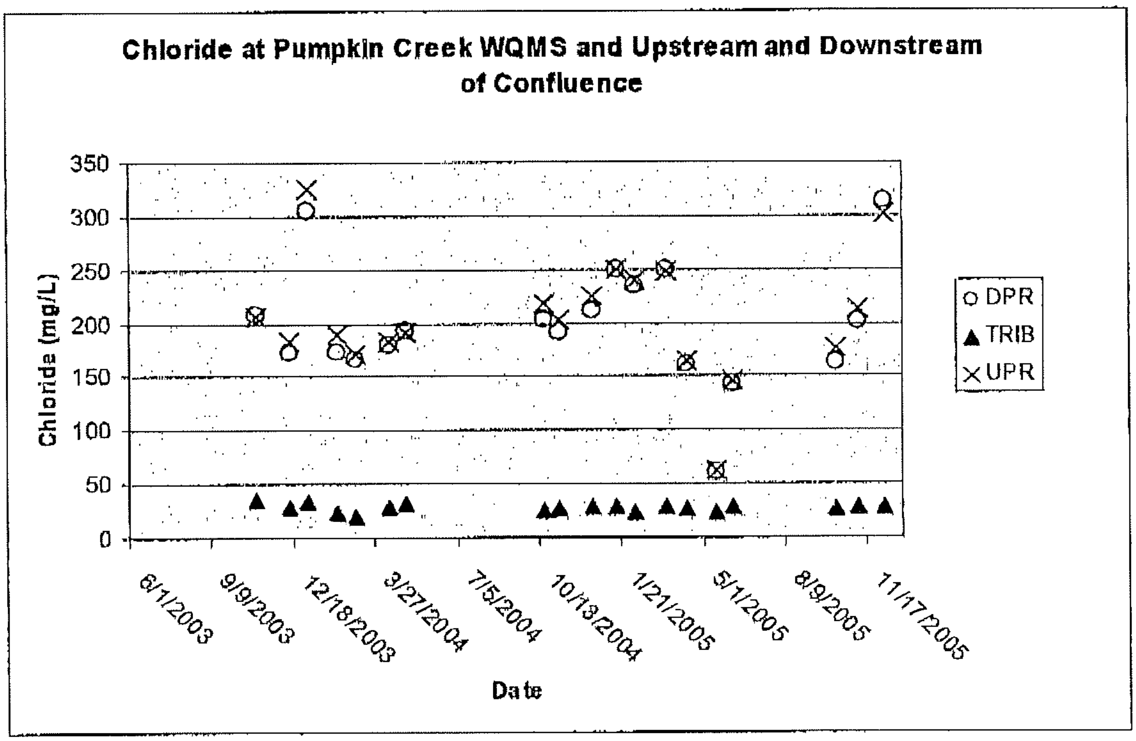

Figure 4 – Time Series of Dissolved Chloride at Pumpkin Creek TRIB1, UPR, and DPR

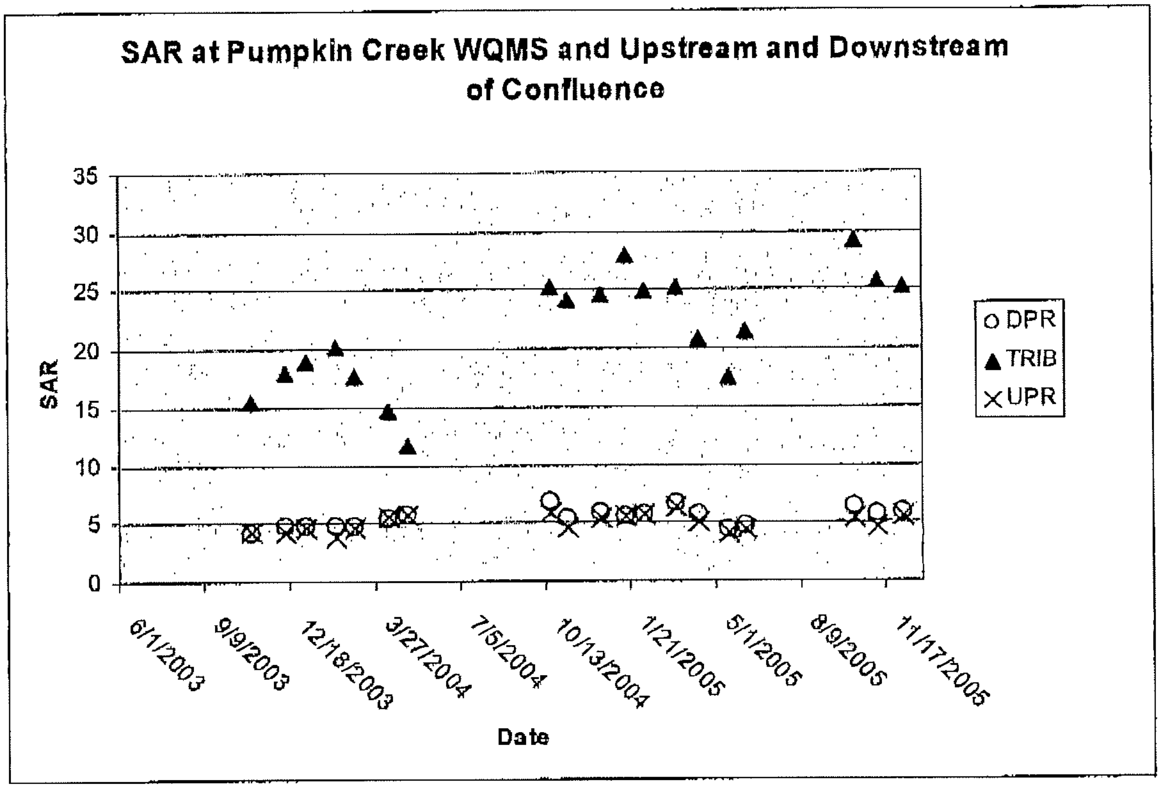

Figure 5 – Time Series of Sodium Adsorption Ratio at Pumpkin Creek TRIB1, UPR, and DPR

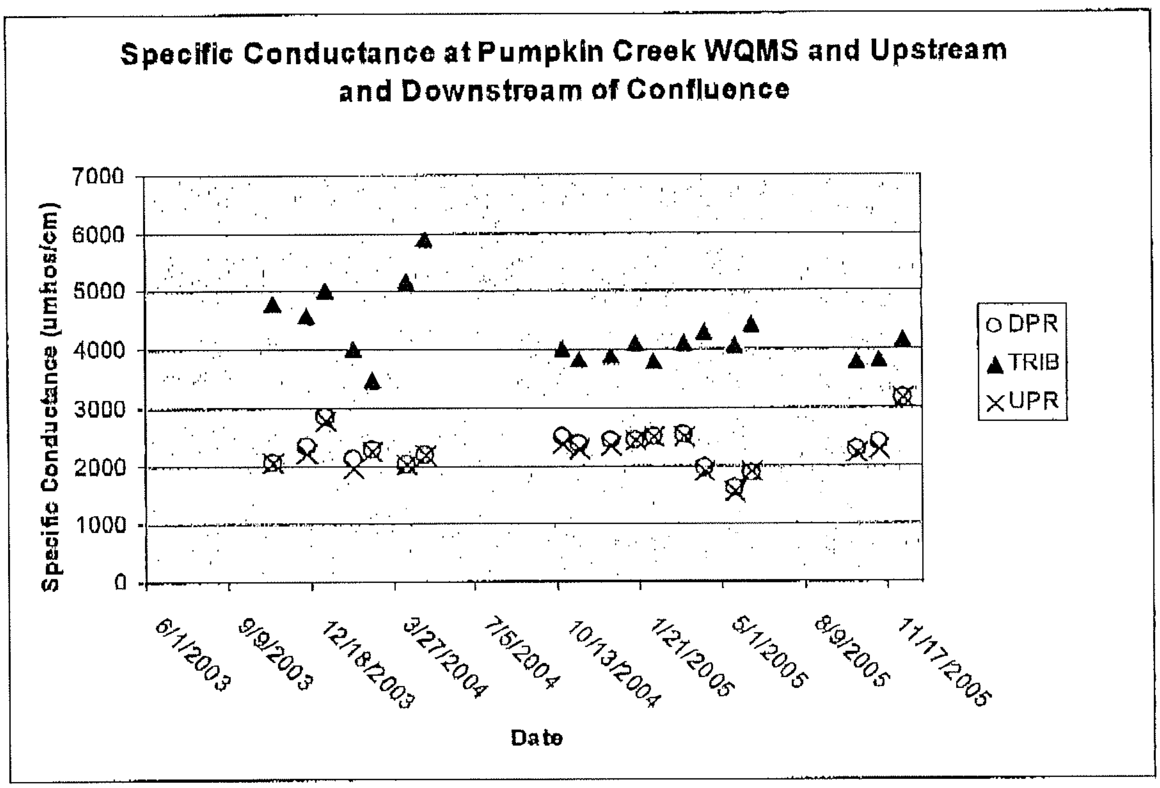

Figure 6 – Time Series of Specific Conductance at Pumpkin Creek TRIB1, UPR, and DPR

4.2.3 SA Creek

Measured parameters including dissolved chloride, SAR, and SC are plotted in the time series shown in Figures 7, 8 and 9. The three sampling locations, TRIB1, UPR, and DPR, are plotted on the same graph to show the relationships of the tributary water quality to that of the mainstem.

Chloride concentrations observed at the SA Creek TRIB1 monitoring station (18 - 25 mg/L) are equal to or lower than those seen at the UPR (16-207 mg/L) and DPR (16-207 mg/L) stations.

SAR values at the TRIB1 station ranged between 7.0 – 11.2, with ranges of 1.2 – 5.8 and 1.3 – 5.8 for the UPR and DPR stations, respectively. SC values at the TRIB1 monitoring station ranged between 4060 – 7710 µmhos/cm, with ranges of 672 – 2440 µmhos/cm at both the UPR and DPR stations. SAR and SC values at the UPR and DPR overlap and are lower than the TRIB values suggesting that there is little to no impact on downstream mainstem water chemistry.

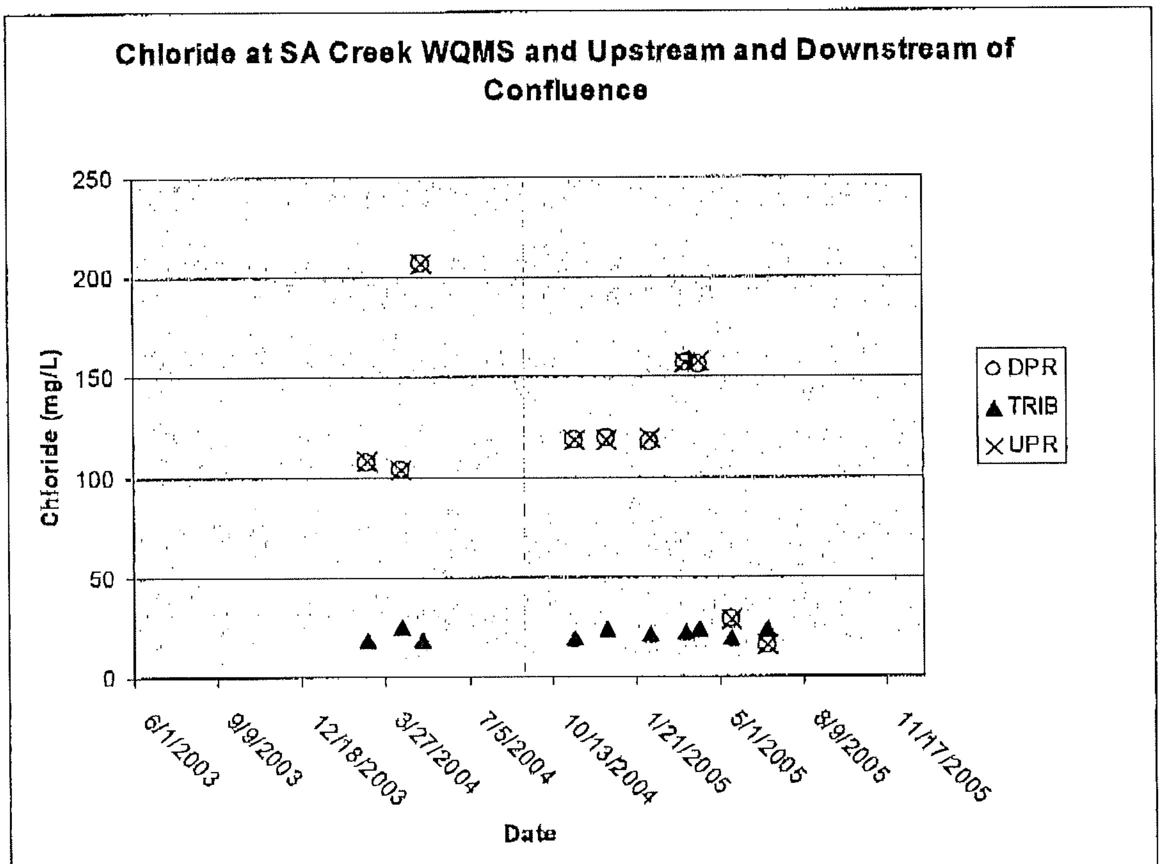

Figure 7 – Time Series of Dissolved Chloride at SA Creek TRIB1, UPR, and DPR

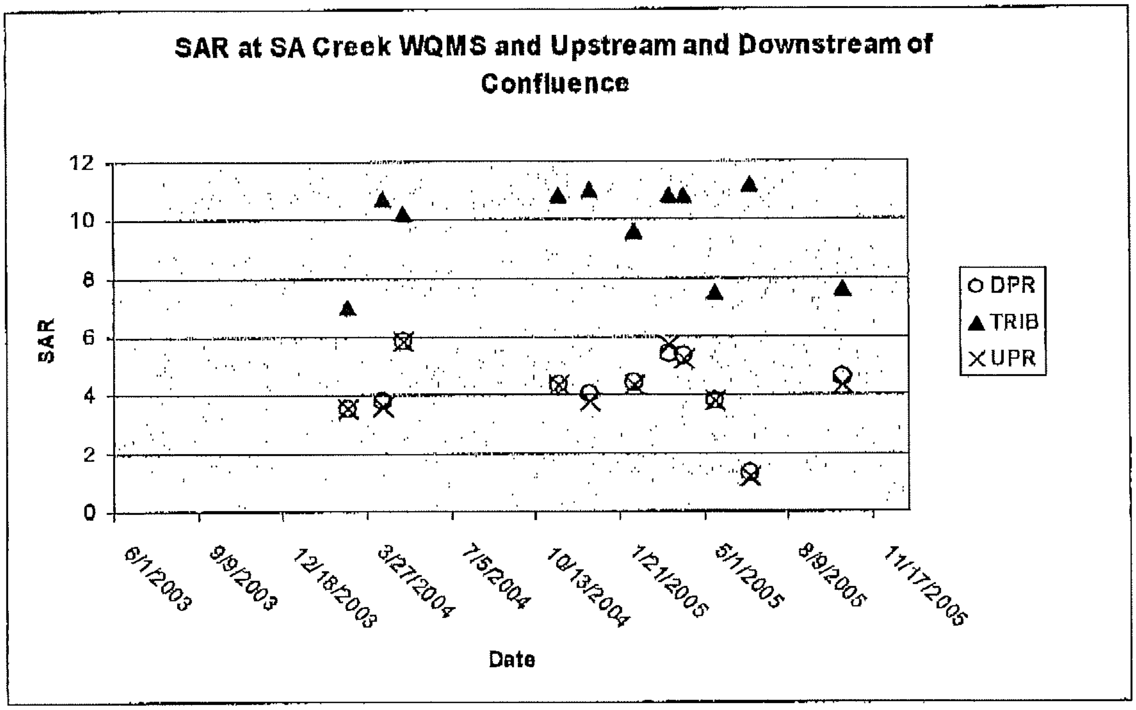

Figure 8 – Time Series of Sodium Adsorption Ratio at SA Creek TRIB1, UPR, and DPR

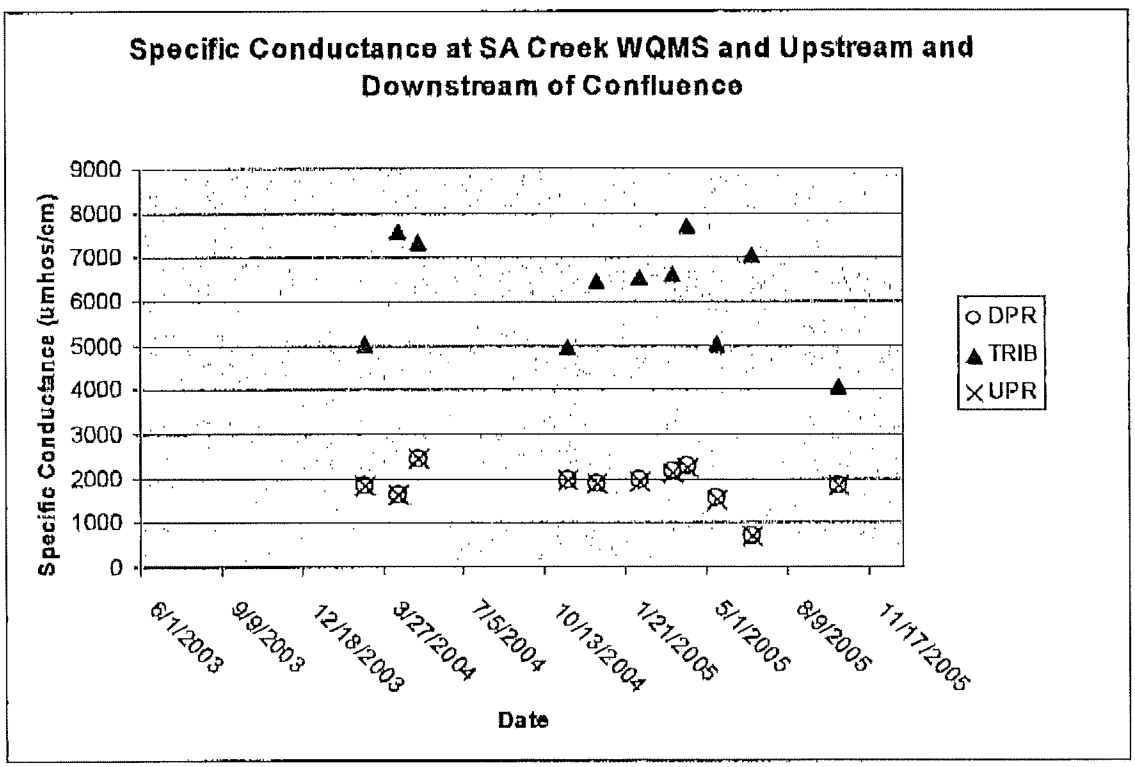

Figure 9 – Time Series of Specific Conductance at SA Creek TRIB1, UPR, and DPR

4.2.4 Wild Horse Creek

Measured parameters including dissolved chloride, SAR, and SC are plotted in the time series shown in Figures 10, 11 and 12. The three sampling locations, TRIB1, UPR, and DPR, are plotted on the same graph to show the relationships of the tributary water quality to that of the mainstem.

Chloride concentrations observed at the Wild Horse Creek TRIB1 monitoring station (10 - 30 mg/L) are lower than those seen at the UPR (52-394 mg/L) and DPR (51-395 mg/L) stations.

SAR value ranges were 5.1 – 15.8, 3.7 – 9.7, and 3.9 – 10.1 for TRIB1, UPR, and DPR stations, respectively. SC value ranges were 2390 – 6450 µmhos/cm, 1360 – 4020 µmhos/cm, and 1370 – 4060 µmhos/cm for TRIB1, UPR, and DPR stations, respectively. SAR and SC values at the UPR and DPR overlap and are lower than the TRIB values suggesting that there is little to no impact on downstream mainstem water chemistry.

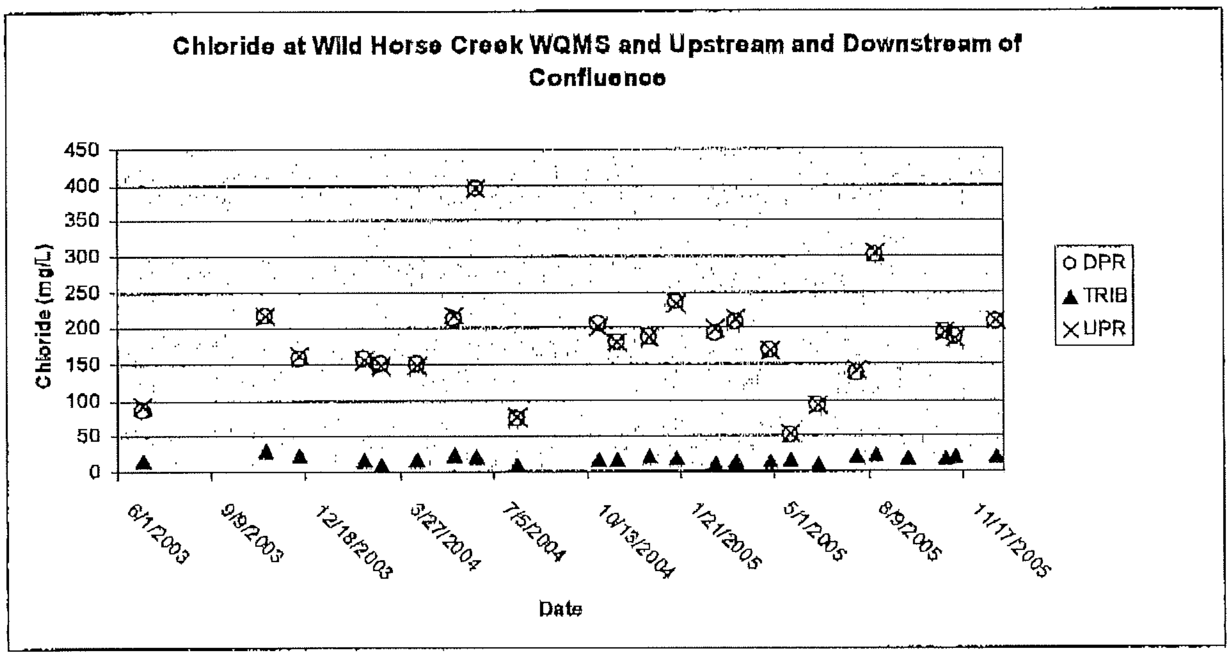

Figure 10 – Time Series of Dissolved Chloride at Wild Horse Creek TRIB1, UPR, and DPR

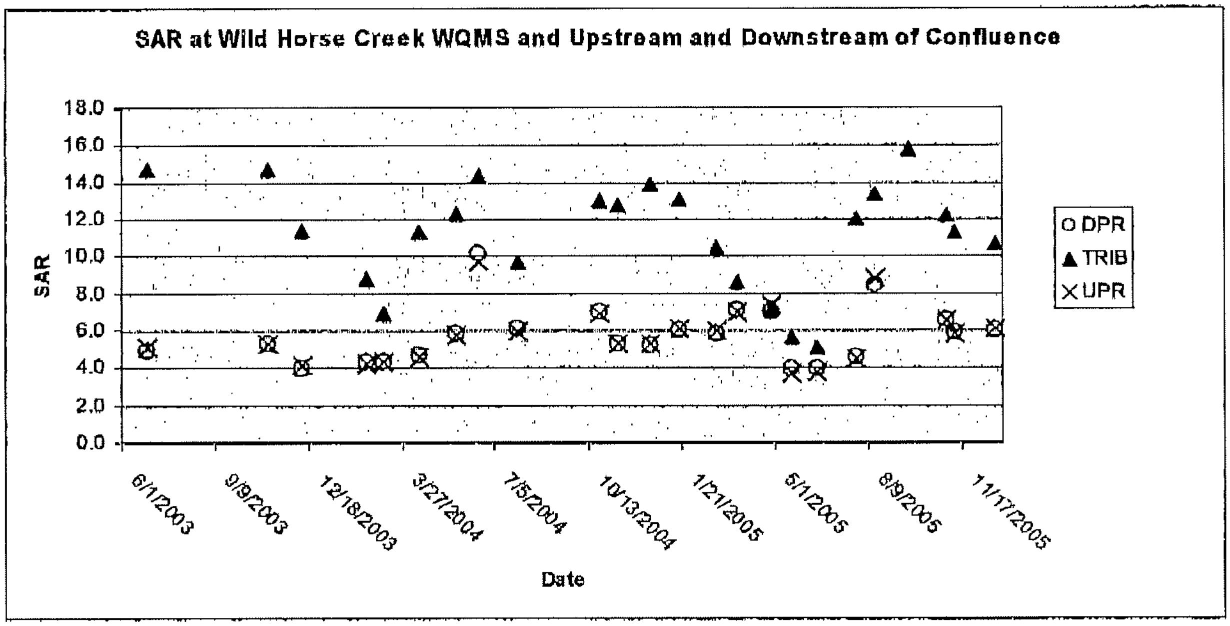

Figure 11 – Time Series of Sodium Adsorption Ratio at Wild Horse Creek TRIB1, UPR, and DPR

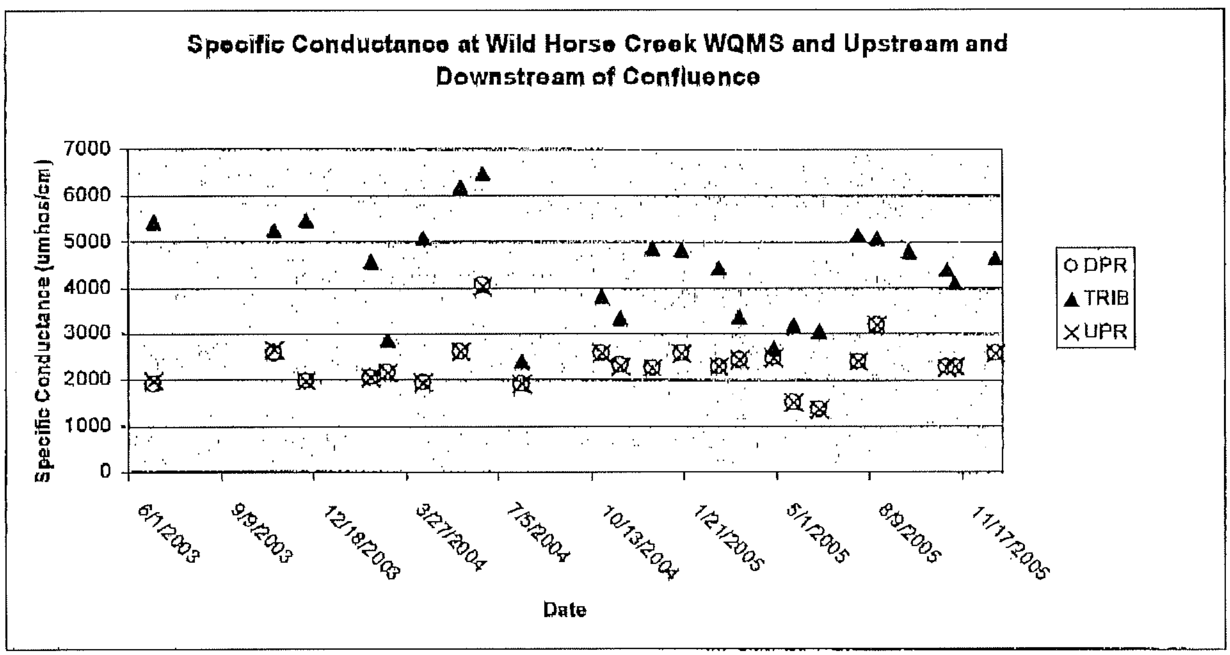

Figure 12 – Time Series of Specific Conductance at Wild Horse Creek TRIB1, UPR, and DPR

4.2.5 Flying E Creek

SAR and SC values from Flying E Creek are plotted in the time series shown in Figures 13 and 14. The three sampling locations, TRIB1, UPR, and DPR, are plotted on the same graph to show the relationships of the tributary water quality to those of the mainstem.

SAR value ranges were 1.1 – 33.0, 4.4 – 20.9, and 4.0 – 16.0 respectively for the TRIB1, UPR, and DPR stations. SC value ranges were 901 – 2760 μmhos/cm, 1510 – 4000 μmhos/cm, and 1500 – 4000 μmhos/cm for the TRIB1, UPR, and DPR stations, respectively. SAR and SC values at the UPR and DPR overlap and are lower than the TRIB values suggesting that there is little to no impact on downstream mainstem water chemistry.

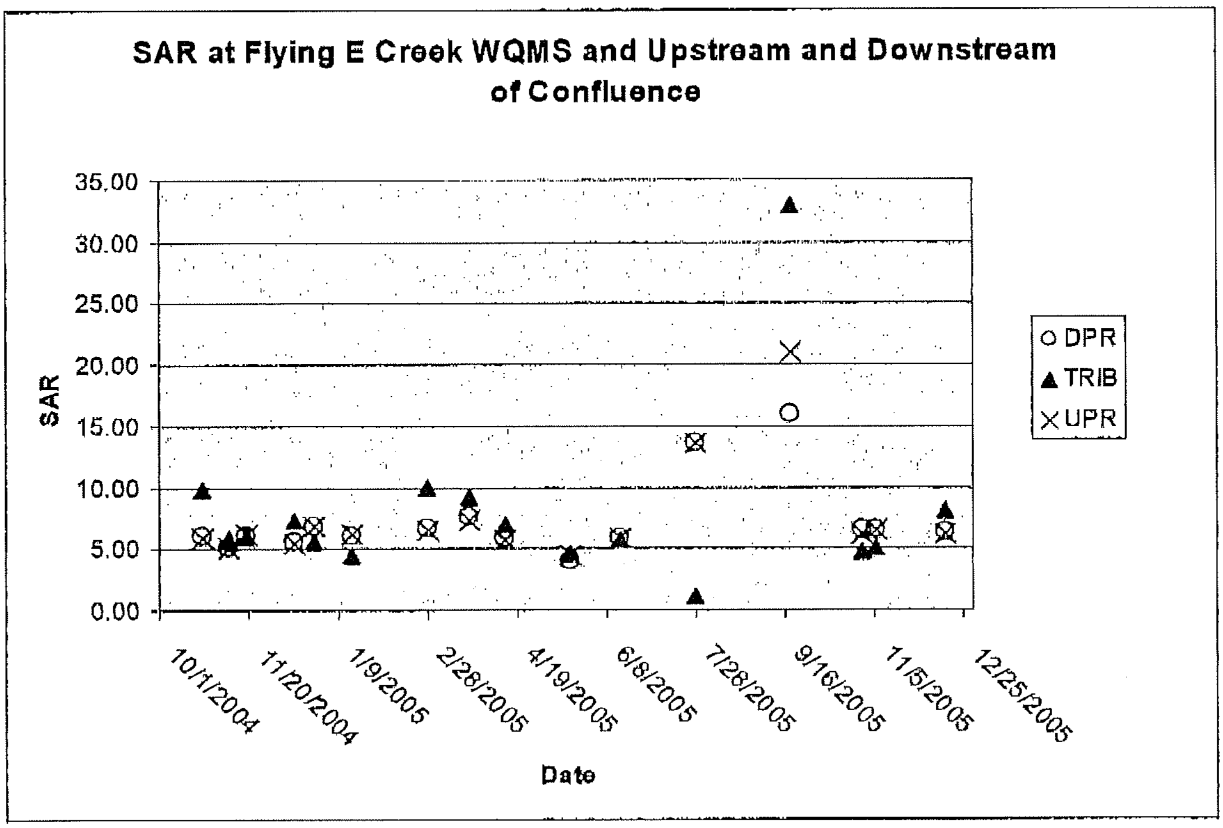

Figure 13 – Time Series of Sodium Adsorption Ratio at Flying E Creek TRIB1, UPR, and DPR

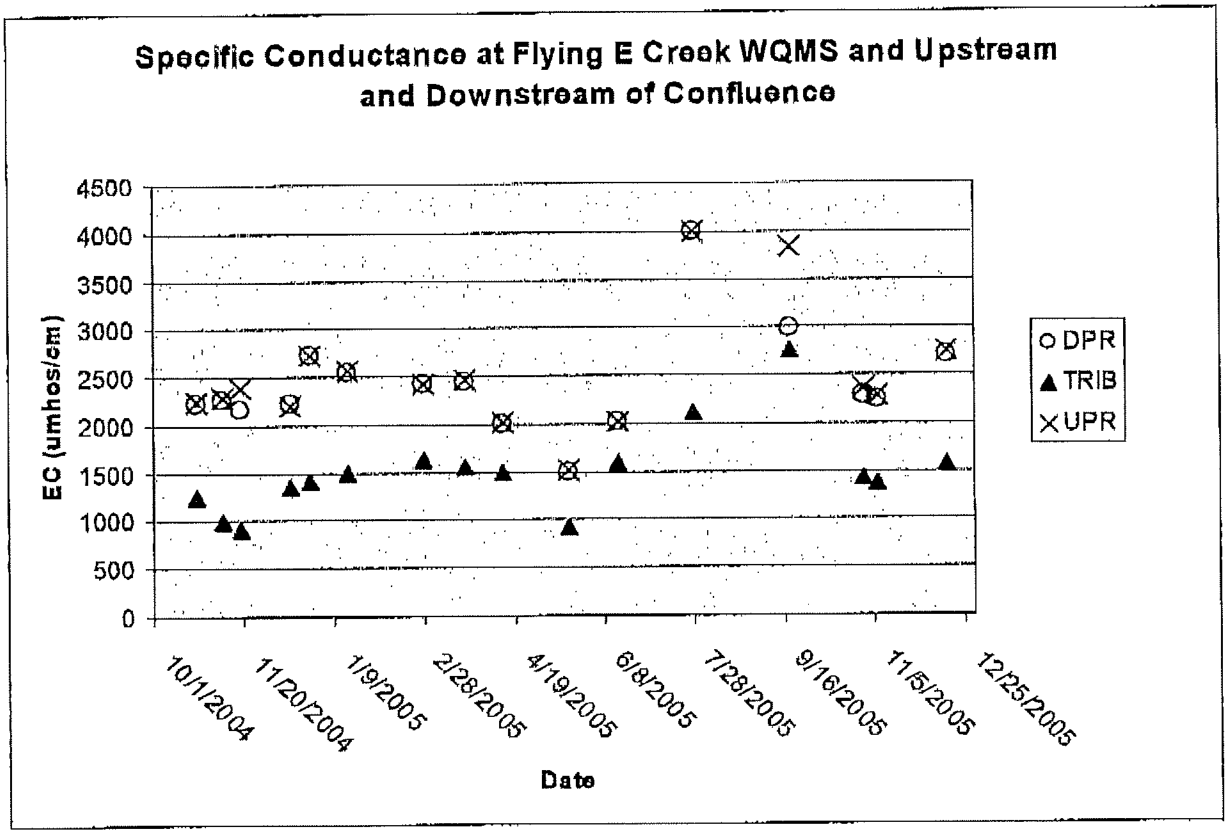

Figure 14 – Time Series of Specific Conductance at Flying E Creek TRIB1, UPR, and DPR

5.0 SUMMARY AND CONCLUSIONS

This report presents data from Water Quality Monitoring Stations (WQMSs) throughout northeastern Wyoming covering a period from July 2003 through December 2005. The presented data and analyses satisfy the reporting requirements for multiple WYPDES permits. Results are graphed for five tributaries, Beaver Creek, Pumpkin Creek, SA Creek, Wild Horse Creek, and Flying E Creek including upstream and downstream locations on the mainstem Class 2 receiving stream. EC and SAR values upstream and downstream from the tributary confluences tend to plot closely, overlapping in many instances and are lower than those found at the TRIB1 stations. Chloride concentrations at UPR monitoring stations consistently overlap DPR results. These data indicate that the mainstem water quality is not significantly affected by tributary in-flows for the tributaries monitored in the WQMS program. Tables 2-13a list tributaries that flowed during the course of this study. Table 14 lists tributaries which did not flow during the same time period.

EXHIBIT E

Department of Environmental Quality

To protect, conserve and enhance the quality of Wyoming's environment for the benefit of current and future generations.

Dave Freudenthal, Governor

John Corra, Director

September 13, 2006

Pumpkin Creek Watershed Permitting
Stakeholder Committee Participant

RE: RESPONSE TO PUBLIC COMMENTS RELATED TO PUMPKIN CREEK WATERSHED GENERAL PERMIT – WYG280000

Dear Participants:

The Water Quality Division (WQD) has reviewed and considered the public comments submitted for the draft Pumpkin Creek General Permit, which was advertised in public notice February of this year. Thank you for your participation in the development of this general permit. Listed below are WQD's responses to the comments received. The permit was issued on September 11, 2006.

Revisions were made to the permit, in response to comments received during the public notice period, as well as during the final Pumpkin Creek Watershed stakeholders meeting in April of 2006, and are described below.

Pumpkin Creek Watershed-Based Permit

RESPONSE TO COMMENTS

	Commentor	Affiliation
1	Tim Barber	Yates Petroleum
2	Jill Morrison	Powder River Basin Resource Council
3	Karl Taboga	CBM Associates (on behalf of Lance Oil and Gas Co.)
4	John Robitaille	Petroleum Association of Wyoming
5	Bill Wichers	Wyoming Game and Fish Department
6	Steve Jones	Wyoming Outdoor Council

Please note that commentors are identified by ID number (in parenthesis) at the end of each comment. Some comments, while not identical, were considered sufficiently similar to be addressed by a single comment and response. Comments of this type are identified by multiple ID numbers in parenthesis following the comment.

The Pumpkin Creek permitting permit is being modified from the version that appeared in public notice to incorporate the following changes

1. *To allow operators the option (under newly-included Category ID) of treating CBM effluent prior to discharge, as long as the type of treatment selected does not contribute to or cause the treated discharge to exceed the effluent limits being established in the permitting permit.*

2. *To change Category II reservoir containment requirements. Originally, to meet the criteria for this discharge category, operators had to demonstrate that, in addition to all estimated CBM effluent, the reservoir could contain stormwater runoff from a 100 year, 24 hour precipitation event. The criteria has been changed to include all reservoirs that can contain all estimated effluent in addition to stormwater runoff from a 50 year, 24 hour precipitation event.*

3. *Verbal comments were made to the WYPDES Program during the public notice that led to the discovery of irrigation on South Prong, Pumpkin Creek. Effluent limits and requirements protective of irrigation uses originally established only on North Prong, Pumpkin Creek are now extended to include all discharges occurring upstream of the irrigation diversions on South Prong, Pumpkin Creek.*

4. *Language clarifying whole effluent toxicity testing requirements was included. However, these changes did not alter the intent or requirements surrounding whole effluent toxicity testing. (limit changed to NOEC at 100% effluent concentration).*

5. *Sections of the permit that establish requirements regarding headcut identification, monitoring and mitigation were changed. Operators are no longer required to perform a pre-NOI submittal headcut inventory. Upon consideration of the original headcut identification requirements, it was determined that the WYPDES Program had no regulatory authority to enforce the original requirements. However, language requiring operators to monitor and mitigate identified headcuts remains.*

Comments

1. Comment: Category II discharges to reservoirs require containment of the 100 year [storm] event. Yates feels strongly that there should be a category with relaxed effluent limits that takes into account that water will be stored in reservoirs as opposed to the Category I where the reservoirs can overtop produced water under dry conditions, albeit with more conservative limits. (1) (3) (4)

Response: The effluent limits established for Category I discharges under the Pumpkin Creek General Permit consider antidegradation, as is required by Chapter 1 of the Wyoming Water Quality Rules and Regulations for all discharges with the potential to impact higher-class waters on a persistent, significant, or frequent basis. As produced water contained within reservoirs classified as Category I under the Pumpkin Creek General Permit may be discharged from the reservoir either as the result of overtopping during precipitation events, or as the result of a reservoir discharge that may be allowed under the parallel Powder River assimilative capacity process, it is appropriate to establish effluent limits protective of the Powder River for this category of discharges. It is important to note that Powder River protection for constituents other than SAR and EC is incorporated into the effluent limits established for Category I discharges.

By comparison, discharges classified as Category II are to reservoirs that prohibit discharge from the reservoir unless the reservoir fills and overtops in response to a 100 year, 24 hour storm event. This requirement ensures that discharges under Category II of the Pumpkin Creek General Permit do not impact the Powder River on a frequent, persistent, or significant basis. Therefore, the effluent limits established for discharges under Category II of the Pumpkin Creek General Permit do not consider antidegradation.

However, in response to comments received during the public notice period, and requests made by various watershed-permitting committee stakeholders, the WYPDES Program has re-evaluated the reservoir containment *requirements associated with Category II discharges under the Pumpkin Creek General Watershed-Based Permit, and made the following change:*

> *Criteria for Category II reservoirs of all types has been changed to allow reservoirs able to contain runoff from the 50 year, 24 hour precipitation event in addition to all estimated CBM effluent to apply for coverage under this discharge category. In reviewing precipitation data from the National Oceanographic and Atmospheric Administration (NOAA), it became apparent that utilization of 50 year, 24 hour runoff containment requirements instead of 100 year, 24 hour containment requirements was only slightly less conservative (50 year, 24 hour precipitation events in the Powder River drainage average 3.6 inches per year, while 100 year, 24 hour precipitation events in the Powder River drainage average 4.0 inches per year), while still providing landowners and operators a reduction in containment requirements as requested.*

Sufficient information that would allow the WYPDES Program to evaluate potential cumulative impacts that could result from requiring containment of lesser precipitation events was not available.

2. Comment: We believe that landowners have been very clear during the Watershed Based Permitting Process that they are not in favor of this [the 100 year, 24 hour precipitation] redundant capacity. Many landowners have expressed concern that they would rather see those upland areas retain the ephemeral flow regime, which would be better served by use of reservoirs that can overtop during storm/snowmelt events of any size. (1) (3) (4)

Response: The WYPDES Program did receive a number of verbal comments from landowners regarding this issue. The WYPDES Program has considered this comment and agree to change the storm water runoff containment requirement for this discharge category to a 50 year, 24 hour precipitation event. The purpose of this requirement is to ensure protection o f receiving streams while providing flexibility to the operators in management of produced water. Since the effluent limits for this discharge category are based on protection of the immediate receiving stream instead of protection of water quality within the Powder River, the 50 year, 24 hour containment requirement is necessary to ensure that the produced water does not impact the Powder River on a frequent, persistent, or significant basis. It should be noted that these containment requirements do not apply to every reservoir within the Pumpkin Creek drainage, operators still have the ability to apply for discharges into reservoirs that do not meet the 50 year, 24 hour precipitation event containment criteria under Category I of the Pumpkin Creek General Permit.

3. Comment: We further believe that it has been very adequately demonstrated that mixing across a given area of even very small events and the background landscape influences upon water coming out of a reservoir are such strong influences upon water chemistry that the produced water's chemical signature is essentially lost in mixing and from water contacting soils. (1) (3) (4)

Response: While it is true that operators have submitted this kind of data with permit applications, the data in question typically only considers the discharge from the facility in question, and does not present a cumulative analysis for all potential reservoir discharges within the drainage. If additional information is submitted to the WYPDES Program in the future that adequately addresses cumulative impact from reservoirs of this type, the WYPDES Program will evaluate the data at that time and determine if the general permit (once appropriate notification procedures have been followed) can be altered.

4. Comment: A (likely unintended) consequence of providing such conservative containment requirements for this Category [II] will be that many operators will not seek this permit option for operational or landowner concerns. Since there is little Regulatory benefit for building reservoirs in the Category I permit, there will be less storage and more direct discharge to the drainage. (1)

Response: Where possible, the WYPDES Program's intent is to allow operators having the ability to comply with the containment requirements under Category II less stringent effluent limits due to the remote and unlikely potential for such discharges to impact the Powder River. Operators will still be interested in utilizing reservoirs *under Category I in order to meet requirements being established under the parallel Powder River assimilative capacity process. Under this process, there will be periods during the year when direct discharges into stream channels will either be prohibited or very limited due to the lack of assimilative capacity. In addition, operators with small leaseholdings may not "own" many credits under the assimilative capacity process and desire to use reservoirs as a means of conserving assimilative capacity credits.*

5. Comment: Industry has cooperatively prepared studies that show how quickly Ammonia (sic) degrades in the natural landscape and has conducted sampling at CBNG outfalls for TAN [total ammonia nitrogen]. This natural attenuation of Ammonia (sic) at outfalls and in the stream channel seems to have been disregarded in the calculations for this discharge category (Category I). (1) (3)

Response: The WYPDES Program wishes to thank industry for initiating the sampling and data collection effort related to ammonia. In a previous draft of the Pumpkin Creek General Permit, an ammonia limit was established for all Category I discharges, and the ammonia limits were year-round. Based upon information provided by the operators regarding ammonia attenuation, the WYPDES Program revised the Pumpkin Creek watershed general permit that was advertised in public notice to include effluent limits for ammonia in Category IA only (outfalls located within one stream mile of the Powder River), and only for a portion of the year. Because ammonia toxicity is dependent upon temperature and pH, the wasteload allocation performed during the development of the Pumpkin Creek General Permit demonstrated that ammonia was a "pollutant of non-concern" except during warm weather.

In order to further reduce this "zone of ammonia attenuation", the WYPDES Program would require a more extensive dataset than the one that was provided. A more extensive dataset that considers adequate seasonal variation would also be necessary because ammonia exhibits changes in toxicity and attenuation due to changes in temperature and pH.

In addition, the data provided indicated that attenuation in the reservoirs may not in all cases reduce total ammonia concentrations below the established effluent limits.

6. Comment: How does this permit actually protect the existing uses on Four Mile (sic) and Pumpkin Creek? Specifically regarding soil, vegetation, grazing land, livestock, wildlife, and aquatic uses? (2)

Response: The effluent limits established in the permits are intended to protect existing uses on Pumpkin Creek. Please see the General Permit for CBM Discharge, Pumpkin Creek drainage Fact Sheet for more information.

8. Comment: Limits on SAR and EC for these areas should be set no higher than 6 and 1300, respectively. (2)

Response: The SAR and EC limits established within the Pumpkin Creek general permit appropriately protect irrigation uses identified within the drainage.

9. Comment: Category II and III storage designated for containment up to 100 year flood event should present evidence that water Mixing Calculations (sic) from this co-mingling of CBM discharge and storm water will be protective of down stream resources, including soils and vegetation. (2)

Response: Due to the overwhelming nature of such an event, it is the Division's opinion that reservoir discharges from Category II and III reservoirs will be indistinguishable from the extremely large volume of storm water runoff.

10. Comment: Storm event confirmation should be verified independently by DEQ/WQD. Presently, the providing of evidence for overtopping is completely the responsibility of the operator. (2)

Response: The WYPDES Program uses meteorological information available from the NOAA website to verify such events.