Appendix C
Long-term Monitoring Plan for Water Resources

Appendix C

Greater Natural Buttes Project Area
Natural Gas Development Project
Long-term Monitoring Plan for Water Resources

C1.0 Introduction

In response to public comments received on the Greater Natural Buttes Draft Environmental Impact Statement (EIS), the Bureau of Land Management (BLM) developed this long-term monitoring plan for water resources within the Greater Natural Buttes Project Area (GNBPA).

C1.1 Objectives

The Long-term Monitoring Plan for Water Resources (Plan) is designed to guide the determination of impacts to water resources due to implementation of the agency preferred alternative. Data collected under this Plan can be used to identify and evaluate any direct, indirect, and cumulative impacts that may occur as project-related development proceeds, as well as identify the need for any additional investigations or environmental protection measures that may be necessary to address such impacts.

Potential unanticipated impacts and their causes include:

- Impacts to surface water from leaks or accidental spills of fuels, lubricants, drilling fluids, hydraulic fracturing fluids, condensate, high gravity oil, or other fluids from evaporation ponds, production wells, reserve pits, or other project facilities;
- Impacts to groundwater from leaks or accidental spills of fuels, lubricants, drilling fluids, hydraulic fracturing fluids, condensate, high gravity oil, or other fluids from evaporation ponds, production wells, reserve pits, or other project facilities;
- Increased turbidity or suspended sediment in surface waters due to surface disturbance associated with construction, operation, and final reclamation, which could lead to increased water temperatures and adverse effects on cold water game-fish and aquatic life (Utah designated beneficial use Class 3A) in Willow Creek and Bitter Creek;
- Increased salinity in surface waters due to inadequate implementation or maintenance of erosion control practices, which could contribute to further impairment of Willow Creek for agriculture (Utah designated beneficial use Class 4) associated with Total Dissolved Solids (TDS) concentrations;
- Increased sedimentation, salinity, or turbidity in surface waters due to inadequate implementation or maintenance of erosion control practices, which could adversely affect designated beneficial uses of the White River and its tributaries;
- Decreased flows from springs near development areas due to modification of aquifer characteristics by drilling operations; and
- Changes in groundwater levels in water supply wells near development areas due to withdrawals of groundwater or modification of aquifer characteristics by drilling operations.

C1.2 Existing Monitoring Programs and Requirements

Several agency programs are in place that require monitoring of water resources in the GNBPA. The following list provides a brief description of each of these programs and their existing monitoring and reporting requirements.

- **Disposal Wells:** Permitting of existing and proposed injection wells for the disposal of produced water in the GNBPA is being conducted under the United States Environmental Protection Agency's (USEPA's) Underground Injection Control (UIC) program. As part of the permitting requirements, a monitoring plan is being implemented to collect data on water levels and water quality from monitoring wells constructed in the vicinity of injection activities. Under this existing plan, data is being collected to assess the impact of injection activities on the Birds Nest Aquifer. In addition, any new injection wells would be evaluated and the existing plan updated to assess the impacts of new injection activities on the Birds Nest Aquifer. The monitoring plan for the disposal wells tracks the horizontal movement of injected fluids.
- **Public Water Supply:** Under the Safe Drinking Water Act, the USEPA requires routine monitoring of public water systems. The Bonanza Public Water Supply obtains water from alluvial wells adjacent to the White River, upstream of the GNBPA. Although the system operator would be required to conduct routine monitoring of a broad range of constituents within the water supply source, it is recommended that limited monitoring of this source be conducted as outlined in this plan.
- **Evaporation Ponds:** The proponent (Kerr-McGee Oil & Gas Onshore LP) operates existing produced water evaporation facilities within the GNBPA. Two ponds are located at each of three adjacent facilities; each pond is double lined with a leak detection system that drains to sumps at the four corners of the pond. These facilities are permitted with the State of Utah, and monitoring of water levels within the leak detection system is conducted weekly and reported to the state quarterly.

The Plan for the GNBPA would not include any additional monitoring activities that would overlap with or duplicate the activities under these existing monitoring programs.

C1.3 Development of Detailed Plans and Plan Review

Once the Record of Decision for the Greater Natural Buttes area gas development project is signed, the operators would develop a comprehensive Quality Assurance Project Plan (QAPP), which would include a comprehensive Sampling and Analysis Plan. These plans would be developed based upon a 5-year plan of development updated annually by the operators and would be updated annually based on monitoring results and any change in development plans for the proposed project. The QAPP would be reviewed and approved by the BLM with input from other agencies as appropriate.

The QAPP would be developed using USEPA guidance (USEPA 2001) and would be designed to document the planning, implementation, and assessment procedures for the project, including sampling methods, laboratory procedures, data management and analysis, and reporting. The QAPP would ensure data quality meets the required formats and standards necessary for incorporation into the current Utah Division of Water Quality database. This step is necessary to ensure that the data collected would provide reliable detection of impacts to water resources in or downstream of the GNBPA.

The QAPP would be prepared prior to any sample collection, including baseline sampling, and prior to commencement of the project. Implementation of the QAPP would provide information for the BLM to identify, evaluate, document, and monitor direct, indirect, and cumulative impacts to water resources. It also would provide the BLM with the tools necessary to determine appropriate response and mitigation measures in the unlikely event of impacts to water resources.

This Plan would be reviewed annually as part of the annual reporting process for potential modifications to monitoring station locations, frequency of measurement and sampling, methods of analysis, maintenance of records and databases, and procedures for data interpretations and decision-making. Any plan modifications would be documented in the QAPP for BLM approval to ensure that the effectiveness of monitoring and the management decisions resulting from it would be maintained. These reviews would be documented in the annual reports,

C1.4 Plan Organization

This Plan is focused on surface water, springs, and groundwater monitoring within the GNBPA and is accordingly subdivided into major sections to address these resources. Chapter 2.0 presents a summary of the setting and baseline data for water resources in the GNBPA, and Chapter 3.0 presents the parameters to be analyzed in samples collected under this plan. Chapter 4.0 presents the monitoring locations for surface water sampling, and Chapter 5.0 discusses spring monitoring locations. Chapter 6.0 presents the locations and rationale for groundwater monitoring. Finally, Chapter 7.0 discusses the monitoring data reporting process, Chapter 8.0 presents additional monitoring and potential mitigation that could be employed to address observed impacts to water resources, and Chapter 9.0 lists the references used in this monitoring plan.

C2.0 Characteristics of the Project Area

C2.1 Water Resources within the GNBPA

The GNBPA is located in the lower White River Basin, an area of semi-arid mesas and plateaus that have been deeply dissected by drainages. The White River is a perennial stream that drains an area of approximately 5,120 square miles. The river flows east to west within the GNBPA and flows into the Green River near the northwest corner of the GNBPA. Tributaries to the White River within or near the GNBPA include Bitter Creek, Asphalt Wash, Coyote Wash and its tributaries, Sand Wash, Cottonwood Wash, and Willow Creek (**Figure C-1**). Bitter Creek is perennial over the lower 2 miles of its drainage due to discharge from the only spring known to occur within the GNBPA; otherwise, tributaries to the White River are ephemeral.

Groundwater occurs within eight aquifers underlying the GNBPA as identified in the Draft EIS:

- Shallow alluvial aquifers (also includes Uinta Formation);
- Birds Nest Aquifer (Green River Formation);
- Douglas Creek Aquifers (Green River Formation);
- Mesaverde Aquifer; and
- Dakota Aquifer;
- Morrison Aquifer;
- Entrada Aquifer; and
- Glen Canyon Aquifer.

The shallow alluvial aquifers are of limited aerial extent and occur along major drainages in the GNBPA, especially the White River. The other seven aquifers occur in consolidated sedimentary deposits at increasing depths beneath the GNBPA. The last four aquifers (Dakota, Morrison, Entrada, and Glen Canyon) comprise the Dakota-Glen Canyon aquifer system.

C2.2 Baseline Surface Water Data

Recent surface water flow and water quality data are available for the White River from the following locations (**Figure C-1**):

- Upstream of the GNBPA: White River near Watson (U.S. Geological Survey [USGS] 09306500; map number SW-1)
- Downstream of the GNBPA: White River near Ouray (USGS 09306900; map number SW-3)

- Downstream of the GNBPA: White River near Ouray at Utah State Route 88 (Utah Department of Environmental Quality [UDEQ] Station 4933520; at mouth of White River)

The USGS gage upstream near Watson (SW-1 on **Figure C-1**) currently is operational and used for periodic water quality sampling. This station is 8 to 10 river-miles upstream of the GNBPA and has been operational since the 1950s. The USGS downstream station near the mouth of the river (SW-3) was operated from August 1969 through September 1986. Currently, additional water quality monitoring downstream occurs at the UDEQ station identified in the USEPA STORET database (4933520). This station has sporadic data available into 2006.

Also within the GNBPA, other surface flow and water quality data were retrieved periodically for 2 to 6 years (i.e., in the late 1970s and early 1980s) at the following locations:

- Cottonwood Wash (USGS 09306855; map number SW-9)
- Coyote Wash (USGS 09306878; map number SW-10)
- Sand Wash (USGS 09306870 and 09306872; near the mouth of the wash and above the mouth of Upper Sand Wash)
- Bitter Creek (USGS 09306850; map number SW-5)

The only impaired waterbody near the GNBPA is Willow Creek. A small portion of the Willow Creek watershed is within the GNBPA. It is a perennial stream impaired by elevated TDS concentrations with designated beneficial uses that include secondary contact recreation, cold-water game-fish and aquatic life, and agriculture (Utah Administrative Code 2007). Historical data for Willow Creek has been collected at two locations near Ouray: USGS Station 09308000 (downstream of confluence with Hill Creek on **Figure C-1**) for water years 1975 through 1983 and UDEQ Station 4933500 (near SW-7) for data into 2006.

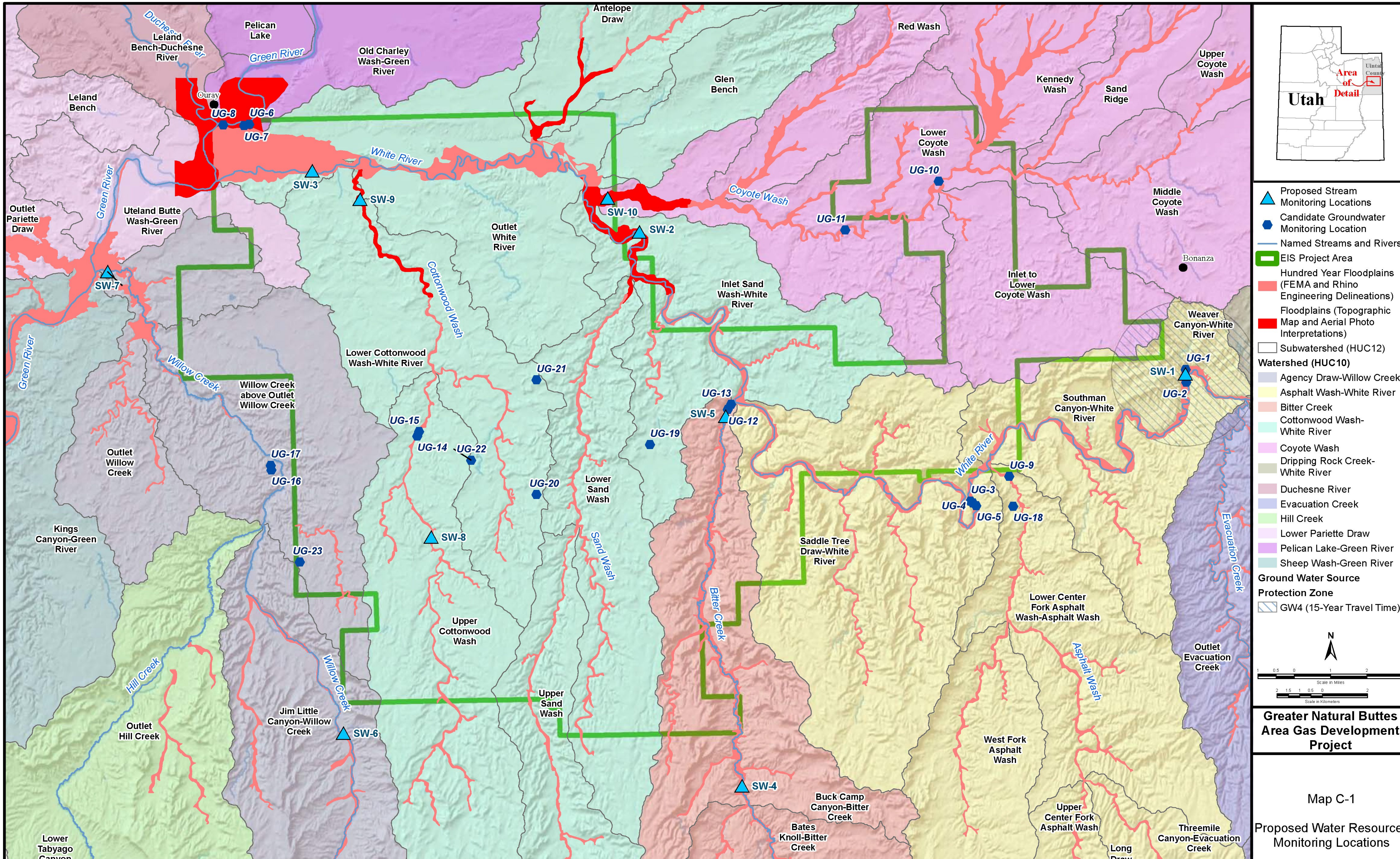
Analytes at these stations typically reflect USGS/UDEQ water quality constituent analyses, including water temperature, turbidity, dissolved oxygen, pH, specific conductance, ammonia, nitrate plus nitrite, orthophosphate, hardness, calcium, magnesium, sodium, sodium adsorption ratio, potassium, chloride, sulfate, carbonate, bicarbonate, TDS, total suspended solids or suspended sediment, boron, iron, manganese, and others. More extensive metals and metalloid analyses are included at Bitter Creek and Willow Creek. USGS analyses for Bitter and Willow creeks also include a large suite of organic and other constituents, such as aldrin, dieldrin, phenolic compounds, heptachlor, PCBs, 2,4-D, 2,4,5-T, gross beta radioactivity, radium-226.

Temperature and precipitation data currently are monitored at Ouray (Ouray 4NE, Station 426568), Jensen (Station 424342), Rangely, Colorado (Rangely 1E, Station 056832), and Dinosaur National Monument, Colorado (Station 052286). These stations fall in a range of elevations generally somewhat lower than the GNBPA, but would be used for general temperature and precipitation data. Daily data and longer-term statistical summaries available for these stations from the Western Regional Climate Center (WRCC) website (wrcc@dri.edu) would be incorporated into the monitoring plan database.

A substantial amount of water quality data is available from USGS sources within the GNBPA. Some of these data represent earlier periods of development in the area, typically from the late 1970s and mid-1980s; however, relatively current surface water data (flow and water quality) are available for the White River, which is the major surface waterbody in the GNBPA. With the exception of organic compounds, which were never measured at any of the stations, the existing water quality data adequately characterizes inorganic constituents.

C2.3 Baseline Groundwater Data

Groundwater levels and water quality data were collected by the USGS at 10 wells within the GNBPA during the late 1970s and early 1980s. Most of these wells were completed in shallow alluvial aquifers. Water levels


Greater Natural Buttes Area Gas Development Project
Map C-1
Proposed Water Resources Monitoring Locations
Utah
Area of Detail
Uintah County
Proposed Stream Monitoring Locations
Candidate Groundwater Monitoring Location
Named Streams and Rivers
EIS Project Area
Hundred Year Floodplains (FEMA and Rhino Engineering Delineations)
Floodplains (Topographic Map and Aerial Photo Interpretations)
Subwatershed (HUC12)
Watershed (HUC10)
Agency Draw-Willow Creek
Asphalt Wash-White River
Bitter Creek
Cottonwood Wash-White River
Coyote Wash
Dripping Rock Creek-White River
Duchesne River
Evacuation Creek
Hill Creek
Lower Pariette Draw
Pelican Lake-Green River
Sheep Wash-Green River
Ground Water Source Protection Zone
GW4 (15-Year Travel Time)
N
Scale in Miles
Scale in Kilometers
Ouray
Bonanza
Green River
White River
Duchesne River
Coyote Wash
Willow Creek
Cottonwood Wash
Sand Wash
Bitter Creek
Asphalt Wash
Evacuation Creek
Hill Creek
SW-1
SW-2
SW-3
SW-4
SW-5
SW-6
SW-7
SW-8
SW-9
SW-10
UG-1
UG-2
UG-3
UG-4
UG-5
UG-6
UG-7
UG-8
UG-9
UG-10
UG-11
UG-12
UG-13
UG-14
UG-15
UG-16
UG-17
UG-18
UG-19
UG-20
UG-21
UG-22
UG-23
Leland Bench-Duchesne River
Pelican Lake
Old Charley Wash-Green River
Antelope Draw
Glen Bench
Red Wash
Kennedy Wash
Sand Ridge
Upper Coyote Wash
Leland Bench
Lower Coyote Wash
Middle Coyote Wash
Outlet Pariette Draw
Uteland Butte Wash-Green River
Outlet White River
Inlet Sand Wash-White River
Inlet to Lower Coyote Wash
Weaver Canyon-White River
Lower Cottonwood Wash-White River
Willow Creek above Outlet Willow Creek
Southman Canyon-White River
Outlet Willow Creek
Lower Sand Wash
Kings Canyon-Green River
Saddle Tree Draw-White River
Upper Cottonwood Wash
Lower Center Fork Asphalt Wash-Asphalt Wash
Outlet Evacuation Creek
Upper Sand Wash
Jim Little Canyon-Willow Creek
Outlet Hill Creek
West Fork Asphalt Wash
Buck Camp Canyon-Bitter Creek
Bates Knoll-Bitter Creek
Upper Center Fork Asphalt Wash
Threemile Canyon-Evacuation Creek
Long Draw
Lower Tabyago Canyon

were measured monthly, and between one to seven water quality samples were retrieved over the years, depending on the well. Groundwater quality analyses were similar to those examined for surface water samples, but usually involved a somewhat smaller suite of constituents. As with surface water baseline data, the existing groundwater baseline data adequately characterizes inorganic constituents but additional monitoring is needed to characterize baseline organic water quality.

Chemical quality of water from alluvial wells ranges from 440 to 27,800 milligrams per liter (mg/L) of dissolved solids. Groundwater from the alluvial aquifers is very alkaline, and the alluvial aquifers contain very hard water. During periods of low flow in the White River (the primary recharge source), the dissolved solids concentration is almost 1,000 mg/L and is slightly saline (Lindskov and Kimball 1984). In general, alluvial aquifer groundwater is not suitable for public supply, but may have value for other uses, such as irrigation, stock water, and limited domestic supply.

C3.0 Sampling Parameters

All water samples collected under this monitoring plan would be analyzed for the parameters presented in **Table C-1**. In addition, field parameters would be collected at all locations where samples are collected. All reference points for the stations would be surveyed to a reference elevation and location, and survey data would be entered into the database. All field equipment (electrodes and meters) would be checked for function and calibrated to known reference solutions at the start of each day of sampling and checked again at the end of the day. The detection limit for all parameters would be reported and entered in a project database.

The list of parameters would be reviewed as part of the annual review process and modified as necessary to collect the required data to address site-specific knowledge gained during the monitoring program. Flows or water levels at each site would be directly measured at the time each sample is collected. Depending on the magnitude of flow or the depth of water, measurements would be taken using the most appropriate method.

Table C-1 Parameters and Water Quality Constituents for Long-Term Monitoring

Field and General Water Quality Parameters	Major Cations and Anions	Trace Elements[1]	Organics[2]	Others
• Total Alkalinity • Temperature (ºC) • Specific Conductance • pH • Dissolved Oxygen • Turbidity[3] • Hardness • Total Dissolved Solids • Suspended Sediment[3] • Water Level (for wells)[4] • Flow Rate (for streams and springs)	• Bicarbonate • Calcium • Carbonate • Chloride • Magnesium • Potassium • Sodium • Sulfate	• Aluminum • Arsenic • Barium • Boron • Cadmium • Chromium • Iron • Lead • Manganese • Mercury • Nickel • Selenium • Silver • Zinc • Radionuclides	• Volatile Organic Compounds (VOCs) by USEPA Method 8260 (Method includes benzene, toluene, ethylbenzene, xylenes) • Semi-volatile organic compounds (SVOCs) by USEPA Method 8270 • Total Petroleum Hydrocarbons - EPA Method 8015 Modified	• Ammonia • Nitrate+nitrite, total • Phosphorus

[1] As total concentrations.
[2] Additional spill response monitoring and reporting would be conducted according to SPCC plans developed for the project and as required by agency with spill oversight authority.
[3] For surface water samples.
[4] Water levels will be measured prior to sampling the well and recorded to the nearest one hundredth of a foot.

C4.0 Surface Water Monitoring

Ten stream stations are recommended as potential monitoring locations along perennial and ephemeral stream reaches, as listed in **Table C-2** and shown in **Figure C-1**. Monitoring locations, sampling methods, and sampling procedures would be defined in the QAPP to be submitted by the operators and approved by the BLM (see Section C1.3). Monitoring would be conducted quarterly. Flow and water quality data for the White River near Watson, Utah (SW-1) would be retrieved as part of the program and incorporated into the monitoring plan database. As mentioned in Section C2.2, there are two historical STORET database sites in or adjacent to the GNBPA. The USGS site on the lower White River (SW-3) has been selected as the proposed monitoring location because it has more continuous data available. Outside of the GNBPA, the proposed station on lower Willow Creek is at or near the UDEQ sampling location (4933500).

Table C-2 Proposed Surface Water Monitoring Locations

Station Name	Map Identifier[1]	Access	Characteristics Relative to GNBPA	Monitoring Rationale
White River near Watson, Utah	SW-1	Utah State Route 45	Upstream perennial	Upstream of the GNBPA on the major perennial waterbody; at an existing USGS monitoring site with historical upstream data
White River at Glen Bench Road	SW-2	Glen Bench Road	Central perennial	Location central to the GNBPA; would help distinguish inputs from Sand Wash, Bitter Creek, Asphalt Wash, and activities outside the GNBPA
White River at mouth near Ouray	SW-3	White River South Road and/or Utah State Route 88	Downstream perennial	Downstream of the GNBPA on major perennial waterbody; former USGS monitoring site with historical data; would help distinguish inputs from Coyote Wash, Cottonwood Wash, and activities outside the GNBPA
Upper Bitter Creek	SW-4	East Bench Road to local road	Upstream perennial	Upstream of the GNBPA on a cold-water stream known for large salinity contributions to the White River.
Lower Bitter Creek[2]	SW-5	Bitter Creek Road	Downstream perennial	Downstream of the only spring within the GNBPA; downstream station on a cold-water perennial known for large salinity contributions to the White River.
Upper Willow Creek	SW-6	Utah State Route 88 to local ranch road along creek	Upstream perennial	Upstream on an impaired cold water stream; would help provide background data on salinity, turbidity, and sediment contributed by the Green River formation
Lower Willow Creek	SW-7	Utah State Route 88 to improved gravel road	Downstream perennial	Downstream on impaired cold-water stream
Middle Cottonwood Wash	SW-8	Glen Bench Cutoff Road	"Upstream" ephemeral	Most extensively disturbed sub-basin in the GNBPA; would serve as an upstream location, although other developments exist further upstream of the GNBPA; even less flow is likely further upstream
Lower Cottonwood Wash	SW-9	White River South Road	Downstream ephemeral	Most extensively disturbed sub-basin in the GNBPA; would track any contributions to the White River from Cottonwood Wash
Lower Coyote Wash	SW-10	Glen Bench Road	Downstream ephemeral	Downstream of existing developments both within and outside of the GNBPA; major background contributor of salinity and sediment to the lower White River

[1] See **Figure C-1**.

[2] See the text discussion regarding the spring on lower Bitter Creek

Three candidate stream monitoring stations have been identified on ephemeral stream reaches within the GNBPA: an upstream and downstream station on Cottonwood Wash and a downstream station on Coyote Wash (**Figure C-1**). These stations initially would be inspected for their suitability as monitoring locations and integrated into the program on a trial basis. If other locations along the washes are found to be more suited to flow and water quality monitoring, the stations could be moved provided suitable representation on each stream is maintained.

The Cottonwood Wash sub-basin would undergo the most extensive disturbance of any of the White River tributaries from the proposed development. Monitoring of this sub-basin would give useful information for other ephemeral tributaries. Extensive industrial disturbance exists outside the GNBPA on Coyote Wash, and a relatively small amount of disturbance would occur in that basin from the proposed development. However, due to extensive badlands terrain, Coyote Wash is a major contributor of background sediment concentrations in the lower White River (Seiler and Tooley 1982); hence, Coyote Wash is recommended as a surface water monitoring location. Both of these tributaries enter the White River downstream of the proposed river monitoring site at Glen Bench Road. Sampling these two washes would help explain any water quality differences in the river between the Glen Bench site (SW-2 on **Figure C-1**) and the proposed monitoring site near the river mouth (SW-3). If monitoring were to indicate the need for additional sampling locations on these streams or others, they could be added through the review process.

Because of the data gaps in existing monitoring data, additional baseline monitoring would precede the onset of construction activities in the GNBPA that would include the monitoring locations in **Table C-2** and parameters discussed in Chapter 3.0. On perennial streams, data collection for baseline monitoring would occur in at least two quarters (up to four quarters if project timing allows), and all water quality constituents (**Table C-1**) would be analyzed during each quarter. The monitoring staff would consult with the USEPA and the BLM prior to undertaking data collection to further verify the data to be collected, particularly for the list of organic constituents that may be expanded for baseline purposes. Two baseline sampling events also would be attempted at ephemeral stream stations as identified in **Table C-2**. These efforts would be opportunistically timed for data retrieval at upstream and downstream pairs on each stream. Parameters and water quality constituents to be analyzed would include those determined for the perennial streams.

C5.0 Spring Monitoring

Only one spring has been documented in the GNBPA, located in the bed of Bitter Creek approximately 2 miles upstream from the confluence with the White River. This feature has been identified through a USGS investigation in the 1980s (Holmes and Kimball 1987). At the time of the USGS investigation, flow in this spring was approximately 360 gallons per minute; no other data are known from this feature. Additional searches for spring occurrences using aerial photos, queries to the BLM, and searches in the Utah Division of Water Rights database did not reveal additional spring features in the GNBPA.

The present approach for obtaining flow and water quality information for this spring would be to assume that stream data collected approximately 1.5 miles downstream (the lower Bitter Creek station identified in **Table C-2**) is dominated by flow from the spring. Further field inspections would be conducted during both the baseline and long-term monitoring to verify this assumption. If investigations indicate that separate data are needed for the spring, then an additional monitoring station would be added at its location.

C6.0 Groundwater Monitoring

Groundwater monitoring would be conducted at locations within aquifers that are likely to yield freshwater resources in the GNBPA. As noted in Section C2.1, eight aquifers were identified as underlying the GNBPA. The following discussion provides the rationale for selection of aquifers that would be monitored based on the potential for development of groundwater resources.

C6.1 Alluvial Aquifer Monitoring

Alluvial aquifers within the GNBPA consist of shallow, unconsolidated water-bearing deposits of limited aerial extent that occur along major drainages. Depth to water generally ranges from about 5 feet along the White River to approximately 20 feet along Bitter Creek (Holmes and Kimball 1987). These alluvial deposits and aquifers primarily occur along the larger streams in or near the GNBPA, such as the Green River, White River, Bitter Creek, and Willow Creek. Smaller areas of alluvial aquifers also occur along lesser streams such as Cottonwood Creek and Coyote Wash. The average thickness of alluvial fill in the Bitter Creek and Willow Creek drainages is on the order of 100 feet, whereas the average thickness along the White River is approximately 30 feet (Holmes and Kimball 1987).

The Bonanza Public Water Supply obtains water from several shallow alluvial wells less than 50 feet deep drilled into the alluvium adjacent to the White River. The wells originally were drilled in the 1940s to provide water to gilsonite mining operations. Since the water diversion is in the alluvium of the White River, the water quality in the wells is overwhelmingly dominated by the White River. As shown on **Figure C-1**, the wells are located next to the river upstream of the GNBPA. A 2-mile radius drinking water source protection zone (DWSPZ) has been established around the wells under the UDEQ, Division of Drinking Water, Source Protection Program. The DWSPZ extends into the GNBPA, although the lateral extent of the alluvial aquifer from which water is drawn is limited to the valley bottom within close proximity to the river and does not extend into the GNBPA.

Although the shallow alluvial aquifers are limited in aerial extent and have varying water quality, wells within these aquifers would be the most likely candidates for monitoring in the GNBPA, especially those associated with the Green and White rivers. Monitoring of these aquifers would help identify contamination impacts due to gas well drilling and production that would require mitigation measures to protect the resource. Therefore, water level and water quality data from alluvial wells within the GNBPA would be gathered for monitoring from the list of potential wells provided in **Table C-3**. Monitoring locations and sampling procedures would be defined in the QAPP as described in Section C1.3. Monitoring would be conducted on a quarterly basis.

Table C-3 Potential Monitoring Wells in the GNBPA

Utah Right Number or USGS ID Number	Map Identifier[1]	Approximate Location	Permit Holder	Well Depth or Water Zone Interval (feet)	Aquifer
Shallow Alluvial Aquifers					
49-173	UG-1	Various Locations NE Sec 2, T10S, R24E	Barber Asphalt	<50	White River Alluvium
49-222	UG-2	Various Locations Sec 2, T10S, R24E (Bonanza Water Supply sample at tap)	American Gilsonite	<50	White River Alluvium
395554109172701	UG-3	SWNWSE Sec 23, T10S, R23E	USGS	38	White River Alluvium
395554109172702	UG-4	SWNWSE Sec 23, T10S, R23E	USGS	17	White River Alluvium
395554109172703	UG-5	SWNWSE Sec 23, T10S, R23E	USGS	18	White River Alluvium
49-2325	UG-6	NE Sec 33, T8S, R20E	Buggsy's Water Service	40	Green River Alluvium
49-2324	UG-7	NE Sec 33, T8S, R20E	Buggsy's Water Service	48	Green River Alluvium
49-2231	UG-8	NW Sec 33,T8S, R20E	Nile Chapman	75	Green River Alluvium
395628109162901	UG-9	NWNENE Sec 24, T10S, R23E	USGS	44	Asphalt Wash Alluvium
49-266	UG-10	NE, Sec 10, T9S, R 23E	Mark M. Hall	15	Coyote Wash Alluvium
49-2266	UG-11	NW Sec 17, T9S, R23E	Questar	50	Coyote Wash Alluvium
395801109245802	UG-12	NESENE Sec 10, T10S, R22E	USGS	15	Bitter Creek Alluvium

Table C-3 Potential Monitoring Wells in the GNBPA

Utah Right Number or USGS ID Number	Map Identifier[1]	Approximate Location	Permit Holder	Well Depth or Water Zone Interval (feet)	Aquifer
395801109245801	UG-13	NESENE Sec 10, T10S, R22E	USGS	36	Bitter Creek Alluvium
395722109344902	UG-14	SWSESW Sec 8, T10S, R21E	USGS	38	Cottonwood Wash Alluvium
395722109344901	UG-15	SWSESW Sec 8, T10S, R21E	USGS	21	Cottonwood Wash Alluvium
395633109384602	UG-16	SESWNW Sec 15, T10S, R20E	USGS	42	Willow Creek Alluvium
395633109384601	UG-17	SESWNW Sec 15, T10S, R20E	USGS	76	Willow Creek Alluvium
Green River Aquifer					
395034109342501	UG-18	SWNESW Sec 24, T10S, R23E	USGS	4852	Green River Formation
49-252	UG-19	NE Sec 17, T10S, R22E	BLM	1560-1850	Green River Formation
49-990	UG-20	NE Sec 23, T10S, R21E	Target Trucking	1570-2000	Green River Formation
49-3	UG-21	NE Sec 2, T10S, R21E	Dekalb AG	2460-2540	Green River Formation
Not Determined	UG-22	SENE Sec 16, T10S, R21E	Not Identified	1342, 1900, 2530-2650, 3300-3520	Green River Formation
49-234	UG-23	NW Sec 35, T10S, R20E (Seep Ridge)	BLM	1700-2500	Green River Formation

[1] See **Figure C-1**.

In addition to shallow alluvial aquifers, the Uinta Formation, of Tertiary age, is exposed at the surface within the GNBPA and the surrounding region (Price and Miller 1975). This formation consists of thinly bedded shale, siltstone, and fine-grained sandstone with interbedded claystone and limestone. The formation generally is not water-bearing in most locations due to drainage by deeply incised streams. For this reason, the Uinta Formation aquifers are not proposed for monitoring in this plan.

The wells in **Table C-3** were identified from the Utah Division of Water Rights database and from a USGS monitoring well network in the GNBPA. It currently is not known if access would be granted to the wells for sampling or if the wells are in suitable condition to be sampled; however, a suitable subset of these wells would be selected to adequately monitor the alluvial aquifers upgradient and downgradient of proposed development activities. If a suitable number of existing alluvial wells cannot be identified for monitoring, new monitoring wells would be installed.

C6.2 Consolidated Aquifer Monitoring

Seven of the eight aquifers underlying the GNBPA are located within consolidated sedimentary formations.

<u>Birds Nest Aquifer; Green River Formation</u>

Monitoring of the Birds Nest Aquifer is being conducted under the USEPA UIC program to observe the effects of ongoing and future injection of produced water into the aquifer. Major points of the SWD monitoring plan include the following:

- Construction of five monitoring wells;
- Collection of water samples for chemical analysis on an annual basis to differentiate between injection water (>800 mg/L sulfate) and natural Birds Nest aquifer formation water (<50 mg/L sulfate) and to document any potential changes in water chemistry caused by the injection wells in this area;

- Measurement of static fluid levels using a tapeline water level meter on a quarterly basis to evaluate potential pressure influences from the injection wells;
- Measurement of bottom hole temperature on an annual basis to evaluate potential temperature affects caused by the injection wells; and
- Definition of a compliance boundary based on stabilized, isolated, and representative Birds Nest Aquifer water samples collected during the completion of all SWD wells, the five monitor wells, and during the plugging and abandonment operations of inactive producing wells located in the immediate area.

The area of the Birds Nest Aquifer outside of the area identified in the monitoring plan required for the salt water disposal (SWD) well permits approved under the USEPA UIC program would be monitored under this Plan by coordinating with the ongoing Utah Geological Survey (UGS) basin-wide study of the aquifer. If appropriate, portions of the UGS study pertinent to the GNBPA would be continued under this Plan through the life of the project.

<u>Douglas Creek Aquifer, Green River Formation</u>

In the GNBPA, water-bearing zones in the Douglas Creek Aquifer generally occur at depths greater than 1,500 feet below ground surface, depending on the structural position of the well. The water-bearing units within the aquifer are of limited lateral and vertical extent and have not been developed for beneficial use within the GNBPA. In addition to the aquifer being located deeper than is practical to drill a typical water supply well, the Green River Formation may contain appreciable amounts of hydrocarbons. Numerous fields in the Uinta Basin produce oil and natural gas from this formation, including possible production zones within the GNBPA. Therefore, it is unlikely that this aquifer will be developed as a source of water.

However, a few wells previously drilled for natural gas have been converted to water wells. One source of water (likely from the Douglas Creek Aquifer) is a water well at Seep Ridge in the northwest quarter of Section 35, T10S, R20E (UG-23 on **Figure C-1**). According to data collected from the Utah Division of Oil, Gas, and Mining (UDOGM) database, this well was converted to a water well in 1960 and produces water from a perforated interval from 2,500 to 2,510 feet below ground surface. The well has been sampled for water quality analysis as part the Utah Geological Survey Uinta Basin Baseline Water Quality Study (Wallace 2011). A review of UDOGM oil and gas data files and the Utah Division of Water Rights database indicated several wells drilled for oil and gas in the 1950s and 1960s that identified water-bearing intervals, but it is not known whether wells other than the Seep Ridge well (originally the Uintah #2) were ever converted to water wells, and if converted, are still operable. Recent water quality data indicates that TDS of water from the Seep Ridge well is 3,056 milligrams per liter (Wallace 2011).

Given the potential for converted gas wells in the Douglas Creek Aquifer to become water supply wells within the GNBPA, this aquifer would be monitored as part of this overall Plan. Existing wells in the aquifer would be monitored, including baseline monitoring, and additional monitoring would be included, as appropriate, in the event that wells are opportunistically converted from gas wells to water supply wells. Baseline water quality and water level measurements would be obtained, followed by long-term monitoring that would continue through the life of the project. The existing wells in the Douglas Creek Aquifer that would be included in this Plan are identified in **Table C-3**.

<u>Mesaverde Aquifer and Dakota – Glen Canyon Aquifer System</u>

The Mesaverde Aquifer and the Dakota – Glen Canyon aquifer system (consisting of the Morrison, Entrada, and Glen Canyon aquifers) generally consist of deeper sandstones interbedded with shales and siltstones. The Mesaverde Aquifer and portions of the Dakota – Glen Canyon aquifer system are targets of the development proposed in the GNBPA. In addition, these aquifers provide little to no discharge to streams and no withdrawals are made from them for beneficial uses in the GNBPA or the surrounding region. Also, these deeper aquifers regularly have TDS values exceeding 25,000 mg/L (Cashion 1967). For these reasons, monitoring of these deeper aquifers is not proposed under this Plan.

C7.0 Data Reporting

All water resources monitoring by the operators would be conducted under the supervision of a qualified hydrologist. Quarterly monitoring results would be entered into a database and summarized quarterly. Data and quarterly summaries would be delivered to the BLM Vernal Field Office, the Utah Division of Water Quality, and UDOGM. In addition, the operators prepare and submit an annual monitoring report of monitoring activities to the BLM and other agency stakeholders. At a minimum, this report would contain a description of the monitoring results that identifies (by location) observed trends in water quality, any identified potential impacts to water quality, flow conditions, changes in depth to groundwater, recommendations for changes to the Plan, and recommendations for mitigation measures to reduce any impacts observed.

The hydrologist for the operators responsible for implementation of the Plan may recommend changes based on the data collected, the locations of active construction, and other project-specific variables. However, these changes should meet the monitoring objectives described in Section C1.1 and defined in the QAPP. These changes could include relocation, addition, or substitutions of monitoring locations; addition of monitoring parameters; and an increase of monitoring frequency if evidence suggests this is necessary. All recommended changes and an explanation for the requested change would be submitted to the BLM and approved prior to implementation.

A final report would be completed at the conclusion of the project. This report would summarize the entire monitoring program and include a final assessment of all sites monitored throughout the project. All monitoring reports would be submitted to the BLM, Utah Division of Water Quality, and UDOGM, and would be made available to the public upon request.

C8.0 Mitigation

The Plan would identify the extent and magnitude of impacts to water resources that actually may result from construction and operation of the proposed development. As stated in the Introduction, the major potential impacts to surface water and groundwater would include water quality degradation from leaks or accidental spills; increased sedimentation, turbidity, or salinity in surface waters; and reduced spring flows or groundwater levels. A number of established programs and measures are in place to reduce or mitigate these anticipated impacts; however, if unforeseen incidents generated impacts, the BLM or other agencies (with appropriate jurisdiction on private and/or state lands) would work with the operators to further remedy effects on water resources. Mitigation would be directly undertaken in some cases, while in other cases it may be preceded by additional diagnostic monitoring and/or inspection at a greater level of detail, leading to implementation of more focused mitigation actions or requirements.

During the development of the QAPP, interpretive approaches would be identified that would activate mitigation or additional monitoring. For example, measures of water quality “exceedances” could include drinking water standards if applicable, constituent levels guided by statistical tests (Sanders et al. 1987; MacDonald et al. 1991; USEPA 1997; Griffith et al. 2001; Helsel and Hirsch 2002), or other significant departures from values or trends known to characterize background conditions within the GNBPA (Boyle et al. 1984; Lindskov and Kimball 1984; Liebermann et al. 1989; Seiler and Tooley 1982). Similarly, any changes in streamflows, spring flow, or groundwater levels would be examined through established, documented approaches to data interpretations.

If any of the water quality constituents or flow-related parameters listed in **Table C-1** were found to depart beyond established “action” levels, the operators would inform the BLM, UDEQ, and UDOGM in writing. Upon agency review, additional means of identifying the source(s) of any effects would be undertaken as necessary. Mitigation measures would be identified for implementation by the operator, as appropriate. Additional monitoring provisions may be required under such circumstances.

The following examples present impacts on water resources that may be identified through the Plan, and the corresponding monitoring or mitigation measures that could be implemented in response. More specific monitoring and mitigation responses would be identified by agencies on a case-by-case basis for implementation by the operator.

- **Increased Concentrations of Turbidity, Suspended Sediment, or Salinity Concentrations**
  - Review and modify best management practices (BMPs) used during road, well pad, and pipeline construction to control runoff and erosion, and reduce sediment delivery to streams.
  - Employ more intensive erosion and sediment controls and enact more frequent inspection and maintenance activities at well pads, along access roads, and at stream crossings during operations.
  - Identify and increase road treatments (paving, stabilizing, or surface treating) at critical sections of main trunk roads and other access roads.
  - Improve the selection, implementation, and maintenance of road drainage practices such as ditches, culverts, reinforced shallow crossings, and drainage turnouts.
  - Enact more conservative slope limits, greater stream/riparian zone buffer distances, and more stringent revegetation standards for proposed well pads, roads, and/or pipelines.
  - Perform a geomorphic reconnaissance and stabilize accelerated erosion of streambanks, nickpoints, headcuts, piping, and/or rills.

- **Increased Concentrations of Inorganic Constituents, including Metals**
  - Review the dust suppression program, including the types of chemical agents used, and modify it if necessary.
  - Review and modify BMPs used during road, well pad, and pipeline construction to control runoff and erosion, and reduce sediment delivery to streams.
  - Employ more intensive erosion and sediment controls and enact more frequent inspection and maintenance activities at well pads, along access roads, and at stream crossings during operations.
  - Identify and increase road treatments (paving, stabilizing, or surface treating) at critical sections of main trunk roads and other access roads.
  - Improve the selection, implementation, and maintenance of road drainage practices such as ditches, culverts, reinforced shallow crossings, and drainage turnouts.
  - Enact more stringent slope limits and greater stream/riparian zone buffer distances for proposed well pads, roads, and/or pipelines.
  - In cases of increased concentrations of selenium, boron, TDS, or other inorganic chemical constituents in surface water or groundwater, collaborate with the Utah Division of Water Quality and the UDOGM to determine the source of the increase and whether oil and gas development has contributed to the increase. If there is reasonable indication that project-related activities have contributed to increased concentrations, implement appropriate BMPs and response measures to mitigate the identified source and/or pathway.

- **Contamination with Petroleum and other Organic Constituents**
  - Review the cementing program for well completion, including audits of cement bond records for wells near the impacted streams.
  - Conduct inspections of facilities that may be leaking, including reserve pits, storage tanks, evaporation ponds, aboveground piping, and process units.

- Require complete remediation of any observed spills or leaks encountered during the inspections at well pads, storage tanks, evaporation ponds, aboveground piping, and process units.
- Review truck loading procedures for produced water and petroleum products.
- Require compensation to the well owner/water user and disclose the contamination of the impacted well, spring, or surface water to the USEPA, Bureau of Indian Affairs, and UDEQ.

- **Reduced Flow in Bitter Creek Spring**
  - Assess whether a reduction in spring flow is from seasonal fluctuation, drought, or the possible result of drilling activities.
  - Identify source area of the spring using appropriate methods (e.g., tracer study), when feasible.
  - Review the cementing program for well completion, including review of cement bond logs for wells drilled near the spring.
  - Require compensation be made to users of the impacted spring.

- **Reduced Water Levels in Wells**
  - Identify whether the reduced water levels are substantial and affect the availability of water (e.g., significantly increased pumping costs or a water level decline below the pump intake).
  - Review the cementing program for well completion, including review of cement bond logs for wells drilled near the impacted water sources.
  - Evaluate the effects of water supply wells on existing water sources.
  - Require that compensation be made to users of impacted wells.
  - Implement further conservation or water re-use procedures to reduce withdrawals from water supply wells near, or hydrologically connected to, impacted wells.
  - Use alternate approved sources of water (e.g., use a different supply well or access an approved surface water supply).

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