Powder River Basin

Coalbed Natural Gas
Interagency Working Groups
Wildlife, Aquatics , and Hydrology
Research Meeting

Program Guide

December 2-3, 2009
Holiday Inn, Sheridan, Wyoming

About the Interagency Working Groups

The Powder River Basin (PRB) contains millions of acres of public land in northeastern Wyoming and southeastern Montana. The Basin holds an extensive natural gas resource associated with the regional coal deposits.

Development of coalbed natural gas (CBNG) on federal lands requires a lease issued from the Bureau of Land Management (BLM) and approval of an application for permit to drill along with associated permits, approvals or reviews from the Montana Department of Environmental Quality or the Wyoming Department of Environmental Quality, and from other State and Federal agencies.

The PRB Interagency Working Group (PRB IWG) was established as the forum for government agencies to address and discuss issues of common concern to all parties involved in permitting and monitoring of CBNG development. Additionally, attention will be given to those issues that may result in cross-border effects requiring close coordination among the State and Federal agencies in Montana and Wyoming, and with Tribal governments. Through this cooperative management effort, each agency will achieve greater operational efficiency, enhance resource protection and better serve the public.

Vision

To work together to protect the air, water, land, fish, wildlife, plants and cultural resources in the PRB for current and future generations while providing for natural gas development to address the nation's energy needs.

Mission Statement

- Develop coordinated and complimentary best management practices, guidelines and programs related to CBNG activities to conserve and protect resources.
- Monitor the impact of CBNG activities and assess the effectiveness of mitigating measures.
- Provide for environmentally sound energy development.
- Develop and integrate the databases and scientific studies needed for effective resource management and planning.
- Promote compatibility in the application of each agency's mission.

Acknowledgements

Thank you to all of the people who have contributed to the research, monitoring, funding, and cooperation on all of the projects that will be presented during this meeting. Further appreciation goes out to all of the speakers, moderators, technical support, sponsors, and contributors, without whom this conference would not be possible.

Sponsors

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Agenda

Wednesday December 2nd

8:00-9:00 Registration/Coffee

9:00-9:15 Welcome: Dale Tribby (BLM-Miles City) and Windy Davis (Montana Fish, Wildlife, and Parks)

Session 1 - Moderator- Brad Schmitz (Montana Fish, Wildlife and Parks)

9:15-9:40 **An ecological evaluation of the effects from Fidelity's MPDES discharges to aquatic life in the Tongue River**, Benjamin Parkhurst*(HAF, INC.) and David Pillard (AECOM Environment)

9:40-10:05 **Identifying the cause of laboratory whole effluent toxicity to *Ceriodaphnia dubia* from Fidelity's CBNG produced water discharges and assessing the potential effects in the Tongue River**, David Pillard* (AECOM Environment) and Benjamin Parkhurst (HAF, INC.)

10:05-10:25 **Characterization of biological communities in streams of the Powder River structural basin, Wyoming and Montana, 2005-2008**, David Peterson* and Katherine Foster (USGS)

10:25-10:40 Break-

10:40-11:05 **A discussion of the available data and methods that may be used to calculate a sodium bicarbonate water quality standard in the Powder/Tongue watershed of Montana and Wyoming**, Aida Farag*, David Harper (USGS), Trevor Selch and Don Skaar (Montana Fish, Wildlife and Parks)

11:05-11:30 **Bicarbonate interactions and effects with diel variations in metals concentrations in the Powder River Basin,** Rod McNeil*(Montana DEQ)

11:30-12:00 Panel Discussion (Parkhurst, Pillard, Peterson, Farag, McNeil)

12:00-1:30 Lunch (On your own)

Wednesday Afternoon -Concurrent Sessions

Session 2-**Side A**- Tom Bills (BLM, Buffalo)-

1:30-1:55 **West Nile virus ecology in sagebrush habitat and impacts on greater sage grouse populations**, David Naugle* and Brett Walker (University of Montana)

1:55-2:20 **Using solar powered GPS/Satellite transmitters on greater sage-grouse in northeastern Wyoming: An overview of objectives and preliminary results**, Chad Olson*, Matt Dzialak, Larry Hayden-Wing, and Jeff Winstead (Hayden-Wing Associates, LLC)

2:20-2:45 **Coda NetLauncher: A mobile tool for capturing Greater Sage-Grouse (*Centrocercus urophasianus*)**, Andrew Sutphin*, Tom Maechtle, Linette Sutphin, Tyler Emme, and John Fredland (Big Horn Environmental Consultants)

2:45-3:00 Break-

3:00-3:25 **Analyzing impacts of CBNG development on nesting raptors,** Courtney Frost* (BLM, Buffalo)

3:25-3:50 Herptile monitoring in the PRB, Bryce Maxell* (Montana Natural Heritage Program)

Session 2-**Side B**- Moderator- Kathy Brus (BLM, Buffalo)

1:30-1:55 **Modeling habitat availability in a Great Plains river system to assess the effects of energy development-related flow augmentation**, Anna Senecal* (Wyoming Game and Fish Department) and Wayne Hubert (USGS Wyoming Cooperative Fish and Wildlife Research Unit)

1:55-2:20 **Object oriented classification of riparian and aquatic habitats along a section of the Powder River in north central Wyoming using Quickbird and Aerocam Imagery,** Robert McDougal* (USGS) and Gretchen Meyer (BLM, Cheyenne)

2:20-2:45 **Evaluation of conceptual and quantitative models of groundwater impacts after 10 years of CBM development in the Powder River Basin, southeastern Montana**, Andrew Bobst*, John Wheaton, and Elizabeth Meredith (Montana Bureau of Mines and Geology)

2:45-3:00 Break-

3:00-3:25 **Considerations for evaluating coalbed methane infiltration pond sites based on site studies in the Powder River basin of Montana and Wyoming**, John

Wheaton*, Andrew Bobst, and Elizabeth Meredith (Montana Bureau of Mines and Geology)

3:25-3:50 **Regional Groundwater Monitoring in the Powder River Basin, Wyoming,** Chris Williams* (BLM, Buffalo)

3:50-4:15 Panel Discussion (Bobst, Wheaton, Williams)

Adjourn for the day

Thursday December 3rd

8:00-8:30 Registration/Coffee

Session 3- Moderator- David Wood (BLM, Montana State Office, Billings)

8:30-8:55 **Monitoring coal-bed methane development effects on surface-water quality of the Tongue and Powder Rivers**, Kyle Blasch* and Steve Sando (USGS, Montana Water Science Center)

8:55-9:20 **Fortification Creek and development of coalbed methane,** Jim Verplancke*, Annie Irwin, and Jennifer Spegon (BLM, Buffalo)

9:20-9:45 **Identifying disturbance mechanisms influencing resource selection by elk in a natural gas development field**, Clay Buchanan* and Jeffrey Beck (University of Wyoming)

9:45-10:00 Break-

10:00-10:25 **Sage grouse population dynamics: how important are individual vital rates for population growth?,** Rebecca Taylor*, Scott Mills, David Naugle (University of Montana) and Brett Walker (Colorado Division of Wildlife)

10:25-10:50 **Sage-grouse and energy development: a synthesis of biological knowledge,** David Naugle* (University of Montana), Kevin Doherty (Wyoming Audobon), Brett Walker (Colorado Division of Wildlife), Matt Holloran (), and Holly Copeland ()

10:50-11:15 **Identifying thresholds of persistence in a shrinking landscape: impacts of human disturbance in greater sage-grouse nesting grounds**, Jason Tack* (University of Montana)

11:15-11:40 Panel Discussion (Taylor, Naugle, Tack, Olson, Maechtle)

11:40-12:00 Wrap Up

Abstracts

ABSTRACTS ARE IN ALPHABETICAL ORDER BY LAST NAME OF PRESENTER

Monitoring Coal-Bed Methane Development Effects on Surface-Water Quality of the Tongue and Powder Rivers

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During coal-bed methane (CBM) extraction in the Tongue and Powder River Basins of northeastern Wyoming and southeastern Montana, large volumes of groundwater, high in salt and sodium, are produced and a portion is discharged into the streams. Downstream irrigators rely on water from the Tongue and Powder Rivers for cultivation of hay and other crops. The U.S. Geological Survey has been monitoring surface-water quality in the Tongue and Powder River Basins sporadically since the 1970s and more consistently since about 2000. Recently, the USGS began a study to analyze streamflow and water-quality data for trends over time and with location in the Tongue and Powder River Basins. Water-quality trends at approximately 20 streamflow-gaging stations, located mostly in Montana, will be analyzed using two methods: Estimate Trend (ESTREND) and Quality of Water Trend (QWTREND). Twenty-four different water quality parameters will be considered in the analysis. This trend analysis will provide information to water users and land and water managers so they can make effective resource management decisions regarding agricultural water use and effects of CBM development. Furthermore, this analysis will help identify the location and significance of any changes in water quality, and any need for remedial measures.

Evaluation of Conceptual and Quantitative Models of Groundwater Impacts after 10 Years of CBM Development in the Powder River Basin, Southeastern Montana

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The Powder River Basin in southeastern Montana is a semi-arid region with an agricultural-based economy that is dependent on the availability of groundwater. The first coalbed methane (CBM) production in the Basin was during April, 1999. CBM development requires the removal and management of large quantities of water from the coalbeds. These same coalbeds are aquifers and commonly provide a reliable source of domestic and livestock water in areas away from major streams. Due to the conflicting interests in the groundwater, conceptual and quantitative models have been developed to evaluate the potential impacts to water availability (e.g. Wheaton and Metesh, 2002; and Myers, 2009). The differences in these models make it clear that long-term monitoring of actual impacts is needed to determine which assumptions are valid.

The Montana regional CBM groundwater monitoring program includes inventories of groundwater resources and regular monitoring at 234 wells, 15 springs, and 2 streams. Additional data are collected from CBM wells, domestic wells and livestock wells. Monitored aquifers include coalbeds, adjacent sandstone units, and alluvium (Meredith and others, 2009). This program is providing potentiometric and water-quality data, and will continue to be active through the duration of CBM production and post-production groundwater recovery.

Monitoring records show that after 10 years of CBM production, hydrostatic levels within the producing area have been lowered to near the top of coalbeds. The 20-foot hydrostatic-drawdown contour extends a maximum of 1.5 miles from CBM development. Since CBM wells are now beginning to reach the end of economic production and are being abandoned , it appears that these impacts are similar to the maximum drawdown that will occur. In areas where CBM wells have been shut-in, recovery of hydrostatic water levels has been rapid, with 73-82 percent recovery occurring after 5-7 years (Meredith and others., 2009).

Monitoring records show little drawdown in aquifers other than the coals. This supports the concept that the confining units typically limited drawdown to the coalbeds. Major faults (those having the greatest vertical offset of beds) act as flow barriers and exert a strong control on areal extent of groundwater drawdown. Faults having less offset may not be barriers.

Identifying disturbance mechanisms influencing resource selection by elk in a natural gas development field

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Human disturbances, such as energy development are known to affect ungulate behavior and resource selection. Within the next several years, approximately 2,000 coalbed natural gas (CBNG) wells may potentially be drilled (0.32 km^2 [80 acre] spacing) in the Fortification Creek Area (FCA) of northeastern Wyoming. The FCA is a Wyoming big sagebrush (*Artemisia tridentata wyomingensis)*-dominated system of approximately 500 km^2 that provides year-round habitat for a reintroduced population of ~230 elk (*Cervus elaphus*). Without proper mitigation, the herd may be limited to an undeveloped wilderness study area which has the predicted capability to maintain 46–64 elk. Our study seeks to identify disturbance mechanisms that influence elk resource selection in the FCA. We began capturing elk in spring 2008 to attach GPS collars to provide relocations over 4 years. Our study objectives focus on identifying disturbance mechanisms (e.g., sound levels, traffic volume, gas field infrastructure) that may influence elk habitat selection to identify appropriate mitigation techniques. To reach these objectives we are measuring habitat characteristics and anthropogenic disturbances. These data will be used to model a resource selection probability function for each elk. Predictor variable coefficients averaged across individual elk will be used to develop a population level model. Identified shifts in resource selection will be related to body condition, survival, and population productivity to elucidate CBNG development effects on elk population dynamics. At the conclusion of our study, we will provide techniques to mitigate detrimental disturbance mechanisms to sustain a healthy elk population while maintaining economically viable CBNG extraction.

A Discussion of Available Data and Methods that May be Used to Calculate a Sodium Bicarbonate Water Quality Standard in the Powder/Tongue Watershed of Montana and Wyoming.

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Production water from coal bed natural gas extraction may contain multiple constituents. However, of the major ions associated with produced waters (Na^+, Ca^{2+}, Mg^{2+}, K^+, Cl^-, HCO_3^-, SO_4^{2-}), only chloride has an established aquatic life criteria (USEPA 1988). Mount et al. (1997) defined sodium bicarbonate in coal bed natural gas production water as the salt most likely to be toxic to aquatic life. Montana Fish, Wildlife, and Park, and the US Geological Survey have been working cooperatively for several years to conduct research and gather the necessary data that may be used to derive water quality criteria should managers decide to implement such a standard. Water of the Tongue and Powder Rivers in Montana and Wyoming were reconstituted in the laboratory and locations along tributaries and on the mainstem of these rivers were used as field sites. The series of acute and chronic experiments conducted in the laboratory should adequately address requirements defined by the US EPA for the establishment of a water quality criteria. Experiments were performed with multiple fish species and at least one species of planktonic crustaceans, benthic crustaceans, insect, non-insect phylum, and others. We will discuss the specific requirements, the experiments that were conducted, and suggested calculations.

Analyzing impacts of CBNG development on nesting raptors

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What can the Buffalo BLM raptor nest database tell us about impacts of CBNG development on nesting raptors? Buffalo BLM has been gathering survey data for raptor nests within 0.5 miles of proposed and approved plans of development since 2003. This talk will focus on findings of preliminary analyses of this dataset that were performed by two Chicago Botanic Garden interns who worked at Buffalo BLM in the summer of 2009, Hannah Specht and Will Tyson. Topics will include survey methodology, structure of the database, results of analyses designed to determine how development may affect nest activity, hypotheses regarding identified trends, recommended improvements to the survey methodology, and potential management implications. Preliminary analyses of the dataset included temporal comparisons of the density of wells around active and inactive nests, average distance to nearest well between active and inactive nests, proportion of active nests, and total number of active nests. Results of these analyses were species-specific. A discussion regarding trends that have been identified, hypotheses about factors that may be contributing to these trends, recommendations for improvements in the survey protocol, and management implications of the preliminary findings will conclude the presentation.

Object Oriented Classification of Riparian and Aquatic Habitats along a Section of the Powder River in North Central Wyoming Using Quickbird and Aerocam Imagery

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The production of Coal Bed Methane (CBM) and associated discharge of high total dissolved solids (TDS) ground water to the surface have been shown to have adverse effects on riparian and aquatic habitats in the Powder River Basin of Wyoming and Montana. In addition, several species of invasive plants have been identified in the study area that are detrimental to the existing ecosystem. By using remotely sensed imagery it is possible to map various plant species and aquatic and riparian habitat over large areas, and to detect changes over time.

To map and classify approximately 75 km of the Powder River, seven full scenes and one partial scene of Quickbird satellite data were acquired from Digital Globe® in 2007. The multispectral images were pan-sharpened to a spatial resolution of 60 cm using the Quickbird panchromatic band. Several band combinations including true-color and color infrared (CIR) were used to show relative water depth and identify instream features such as pools, riffles, and runs. Each of the scenes were analyzed and segmented using the object oriented software from Definiens®, eCognition®. After the segmentation process was completed each image was classified to identify areas of interest such as botanic invasive species, relative water depth, and various riparian vegetation types. In addition to the Quickbird Imagery, several scenes of AeroCam high resolution imagery (.25 m) were analyzed using a similar methodology as described above.

The purpose of this effort was to establish a multi-scaled methodology for mapping instream and riparian habitat. By using imagery of different spatial scales, coarser imagery covering larger areas were refined with the higher resolution data. The resulting classified maps can be used by land management agencies to make informed decisions on land use related to oil and gas development, invasive species, and native habitat.

Bicarbonate interactions and effects with diel variations in metals concentrations in the Powder River Basin

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As Montana works to assess the need for a bicarbonate standard, the interactions of bicarbonate on the inorganic constituents of tributaries and their joint effects entering the main stem of the rivers is being investigated. In addition to concerns raised by direct toxicity testing conducted by Dr. Aida Faraq, for sodium bicarbonate itself, solubility analysis of tributaries entering the Powder was undertaken to look at the potential for carbonate salts displacement/precipitation and the potential for metals toxicity associated with these solubility shifts.

Piper and Durov diagramming will be used to illustrate the predictive value of these techniques as to what locations may bear closer monitoring scrutiny and the likely effects based on contributions from tributaries along the main stem of the river.

Data was collected from all USGS, STORET and Montana DEQ record reporting stations on the Powder and Tongue rivers over the past 50 years, to initially look at time trends in Piper/Durov diagrams. In addition, each group of tributaries in a segment of the main stem of the rivers was compared with the inorganic chemistry of the tributaries within the segment.

The influence of diel variation in metals concentrations from USGS datum will be described, in conjunction with the localized shifts in bicarbonate concentration. Certain metals such as boron are also high in CBM discharge waters and may play an influential role with inorganic solubility's at elevated pH's.

West Nile virus ecology in sagebrush habitat and impacts on greater sage-grouse populations

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Emerging infectious diseases can act as important new sources of mortality for wildlife. West Nile virus (Flaviviridae, *Flavivirus*) has emerged as a potential threat to greater sage-grouse (*Centrocercus urophasianus*) populations since 2002. We review the ecology of West Nile virus in sagebrush (*Artemisia* spp.) ecosystems of western North America, summarize the influence of the virus on sage-grouse mortality and survival, use demographic models to explore potential impacts on population growth, and recommend strategies for managing and monitoring such impacts. The virus was an important new source of mortality in low and mid-elevation sage-grouse populations range-wide from 2003–2007. West Nile virus can simultaneously reduce juvenile, yearling, and adult survival—three vital rates important for population growth in this species, and persistent low-level West Nile virus mortality and severe outbreaks may lead to local and regional population declines. West Nile virus mortality in simulations was projected to reduce population growth (i.e., finite rate of increase, λ) of susceptible populations by an average of 0.06–0.09/yr. However, marked spatial and annual fluctuations in nest success, chick survival, and other sources of adult mortality are likely to mask population-level impacts in most years. Impacts of severe outbreaks may be detectable from lek-count data, but documenting effects of low to moderate mortality will require intensive monitoring of radio-marked birds. Resistance to West Nile virus-related disease appears to be low and is expected to increase slowly over time. Eliminating mosquito breeding habitat from anthropogenic water sources is crucial for reducing impacts. Better data are needed on geographic and temporal variation in infection rates, mortality, and seroprevalence range-wide. Small, isolated, and peripheral populations, particularly those at lower elevations, and those experiencing large-scale increases in distribution of surface water may be at higher risk.

Sage-grouse and energy development: a synthesis of biological knowledge

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Abstract.—Rapidly expanding energy development in western North America poses a major new challenge for conservation of greater sage-grouse (*Centrocercus urophasianus*). We reviewed the scientific literature documenting biological responses of sage-grouse to development, quantified changes in landscape features detrimental to sage-grouse that result from development, examined the potential for landscape-level expansion of energy development within sage-grouse range, and outlined recommended landscape-scale conservation strategies. Shrub lands developed for energy production contained twice as many roads and power lines, and where ranching, energy development, and tillage agriculture coincided, human features were so dense that every 1 km^2 could be bounded by a road and bisected by a power line. Sage-grouse respond negatively to three different types of development and conventional densities of oil and gas wells far exceed the species' threshold of tolerance. These patterns were consistent among studies regardless of whether they examined lek dynamics or demographic rates of specific cohorts within populations. Severity of current and projected impacts indicates the need to shift from local to landscape conservation. The immediate need is for planning tools that overlay the best remaining areas for sage-grouse with the extent of current and anticipated development. This will allow stakeholders to consider a hierarchy of set-aside areas, lease consolidations, and more effective best-management practices as creative solutions to reduce losses. Multiple stressors including energy development must be managed collectively to maintain sage-grouse populations over time in priority landscapes.

Using solar-powered GPD/satellite transmitters on Greater sage-grouse (*Centrocercus urophasianus*) in northeastern Wyoming: An overview of objectives and preliminary results

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Global Positioning System (GPS) PTT transmitters are a powerful tool for understanding landscape-level resource selection by wildlife, particularly species capable of long-distance movements. Although used widely on other bird species, GPS transmitters were too heavy to be used on Greater Sage-grouse (*Centrocercus urophasianus)* until recently. Beginning in 2008, female sage-grouse were equipped with 30-g solar powered ARGOS/GPS PTT transmitters with the objective of collecting information on seasonal habitat-use and movement patterns of grouse in and around oil and gas development in Sheridan County, Wyoming. Transmitters recorded 3-15 locations/day/bird depending on the season. We received >96% of expected GPS fixes and there were no known cases of transmitter failure. We recorded a total of 40,041 and 19,262 GPS locations among 40 and 19 radio-tagged birds in 2008 and 2009 (to-date), respectively. The maximum three-hour step length was 14.0 km and the maximum distance from capture location was 32.3 km. The mean, median, and maximum home range (MCP 100%) was 5,627 ha (SD ± 6,825, n = 34), 2,816 ha, and 27,705 ha, respectively, for 2008. Breeding rates and nest success appeared normal for radio-tagged birds; nest initiation rate was 96.3% and 100% and nest success was 41.4% and 45.5% in 2008 and 2009, respectively. We suggest estimates derived from GPS-tagged birds of nest initiation are likely to be higher and of nest success to be lower because of the improved ability of detecting short-lived nesting attempts and in some cases nests that fail during egg-laying. We also discuss survival estimates.

An Ecological Evaluation of the Effects from Fidelity's MPDES Discharges to Aquatic Life in the Tongue River

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Fidelity Exploration and Production Company (Fidelity) discharges untreated water from coal-bed natural gas (CBNG) wells to the Tongue River in Montana. While fathead minnows always pass the acute WET test requirements, *Ceriodaphnia dubia* regularly fail. To determine if these discharges cause significant adverse effects to aquatic life in the Tongue River, we evaluated (1) effluent toxicity to *C. dubia*, *Daphnia magna* and fathead minnow, (2) instream toxicity to *C. dubia* and *D. magna*, (3) benthic macroinvertebrates, (4) periphyton, and (5) water quality.

In the effluent toxicity tests, effects on *C. dubia* survival only were observed at ≥85% effluent. No effects on survival of *D. magna* or fathead minnows were observed in 100% effluent. In the ambient toxicity tests, no effects on survival of *C. dubia* or *D. magna* were observed in river water samples. For benthic macroinvertebrates, no consistent upstream-downstream trends were observed in the types of species, numbers of taxa, densities, MMI scores or individual MMI metrics. For periphyton, no evidence of adverse effects to periphyton was apparent. Bicarbonate and TDS concentrations and conductivity levels showed an upstream to downstream increase. No significant relationships, however, were present between bicarbonate and TDS concentrations or conductivity and MMI scores or individual MMI metrics. All of the evidence collected, effluent toxicity, ambient toxicity, benthic macroinvertebrates, periphyton and water quality, indicate that Fidelity's CBNG effluents are not having adverse ecological effects to the benthic macroinvertebrate and periphyton communities in the Tongue River.

Characterization of Biological Communities in Streams of the Powder River Structural Basin, Wyoming and Montana, 2005-2008

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Within the Powder River Basin Interagency Working Group (IWG) framework, the Aquatic Task Group (ATG) has studied potential effects of coalbed natural gas (CBNG) on aquatic ecological resources. The ATG developed a monitoring plan to meet two main objectives: (1) establish current conditions for aquatic biota and their habitat and (2) determine existing and potential effects of CBNG-produced water on aquatic life. In order to address objective 1, an aquatic ecology study of streams in the Powder River Basin was conducted by the U.S. Geological Survey during 2005-08, in cooperation with other IWG agencies. Samples and measurements of habitat and macroinvertebrate, algal, and fish communities were collected from sites located on the main-stem Tongue and Powder Rivers, and on various tributaries. Results from a provisional report will be described.

Preliminary results indicate macroinvertebrate communities showed similarity at the river-basin scale. Macroinvertebrate communities at sites with mountainous headwaters and snowmelt driven hydrology, such as Clear Creek, showed similarities with communities from the main-stem Tongue River. Algal communities also showed similarities at the river-basin scale, despite differences in community composition between years. The native fish communities of the Powder River appear to be largely intact although some non-native species were present. The number and relative abundance of introduced fish species was higher in the Tongue River drainage than elsewhere, in part due to the effects of Tongue River Reservoir.

Identifying the Cause of Laboratory Whole Effluent Toxicity to *Ceriodaphnia dubia* from Fidelity's CBNG Produced Water Discharges and Assessing Potential Effects in the Tongue River

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Fidelity Exploration and Production Company (Fidelity) discharges untreated water from coal-bed natural gas (CBNG) wells to the Tongue River in Montana. Whole effluent toxicity (WET) tests with fathead minnows (*Pimephales promelas*) have always passed permit limits (LC_{50} >100% produced water), but *Ceriodaphnia dubia* tests regularly fail. An extensive series of toxicity identification evaluation (TIE) studies were conducted over several months to determine the cause of toxicity, including Phase I studies and additional investigations designed to isolate and confirm the cause of toxicity. Addition of methane to mock effluents did not consistently increase *C. dubia* mortality, nor did complete removal of methane eliminate toxicity. Toxicity of TDS mock effluents was usually the same or greater than toxicity in the effluent, suggesting that TDS alone, and in particular bicarbonate, was responsible for the observed toxicity. The likelihood of TDS as a causative agent was supported by the fact that *Daphnia magna* never showed significantly reduced survival in CBNG effluent. Variability in *C. dubia* survival among tests, even when TDS concentrations were similar, is believed to be due to small but significant differences in organism condition at test termination, thus blurring the lines between dead and live organisms. Tests on water collected from the Tongue River immediately downstream of an outfall were not acutely toxic, reflecting substantial instantaneous dilution. In addition, an assessment of aquatic communities in the Tongue River did not identify any significant negative effects from Fidelity's CBNG effluents.

Modeling habitat availability in a Great Plains river system to assess the effects of energy development-related flow augmentation

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Wyoming's Powder River has been touted as the last remnant of a pristine Great Plains river system. The biologic integrity of basin may be at risk, however, due to the rampant development of coalbed natural gas (CNG) throughout northeastern Wyoming. Production of CNG requires the removal of groundwater associated with coal seams. Management options for CNG product water include direct discharge to surface water bodies. Concern exists regarding the potential for steady influxes of relatively high-quality water to alter the stochastic nature of the Powder River. In light of these concerns, research was conducted regarding the potential effects of increased flow due to CNG product water on the summer, low-flow habitat for native and introduced fishes. The fish assemblages and habitat for discreet habitat types were described during the summer of 2008 and loaded into a GIS. A cluster analysis was conducted to identify groupings, or guilds, of fishes based on their habitat associations. Habitat suitability functions for each guild were derived using logistic regression. Resultant suitability curves, geo-spatial mapping data, and hydrologic habitat attributes were used to predict available instream habitat across variable flows using a meso-habitat scale instream flow model. Modeling indicated that preservation of the natural range of flows is necessary to sustain Powder River fishes and that alteration in summer flows may affect both habitat and fish assemblages.

Coda Netlauncher- A mobile tool for capturing Greater sage-grouse (*Centrocercus urophasianus*)

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Researchers from Big Horn Environmental Consultants (BHEC) captured Greater sage-grouse *(Centrocercus urophasianus)* in the Powder River Basin, and the southern Bighorn Mountains of Wyoming in 2008 and 2009 using a CODA® Netlauncher. BHEC modified the netlauncher to fit into the front receiver of a pick-up truck or on the front of an All Terrain Vehicle. A 30'x 30' net was deployed from the netlauncher over the target using expanding gas from a blank .308 cartridge that propelled four weights which carry the net. Making the netlauncher mobile expanded our trapping opportunities, allowing us to capture birds on a year-round basis, and away from leks. Thirty-six sage-grouse were captured out of forty-four attempts. Success rate was 0.82 birds per capture attempt, with no injuries to any birds. Capture success relied heavily on several factors including: grouse behavior, flock size, vegetation, wind and slope. We will discuss equipment modification specifics and field observations potentially influencing trapping success.

Identifying thresholds of persistence in a shrinking landscape: impacts of human disturbance in greater sage-grouse nesting grounds.

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Sage-grouse leks have evolved at the epicenter of high quality breeding habitat. Historic conversion of western rangelands to tillage agriculture greatly reduced the quantity of sagebrush habitats, and sage-grouse populations. Infrastructure associated with energy development is a contemporary anthropogenic stressor that has additive deleterious effects on sage-grouse abundance, reproductive fitness, and lek persistence. We analyzed lek and human disturbance data to model relationships between lek persistence and lek abundance, and the intensity of human disturbance in sagebrush landscapes. We used all known leks that have been surveyed in Montana, North Dakota, South Dakota, Alberta and Saskatchewan (n = 1,843) to quantify human disturbance variables within 1.0- , 5.3- , 6.8- , and 12.3 km of leks using oil and gas well-sites, agricultural landcover, roads, and other habitat layers. Using logistic regression, we then compared levels of disturbance between leks that have gone inactive and leks that remain active. Active leks were defined as having > 1, 10, 17, and 25 displaying males in the most recent counts to examine thresholds of occurrence for multiple definitions of lek activity. Findings suggest that the number of displaying males is constrained by the amount of disturbance surrounding leks at multiple scales out to 12.3km. Also, models describing lek occurrence differ in structure and effect size when evaluating occurrence at larger leks. We will discuss how managers can use this information to accommodate development while reducing impacts to sage-grouse populations.

Sage grouse population dynamics: how important are individual vital rates for population growth?

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Choosing a management action to enhance sage grouse populations depends on two key pieces of information: first, how does the management action influence a specific vital rate; and second, how much does that vital rate influence population growth. The relative influence of each vital rate on sage grouse population growth has not previously been determined. We conducted a meta-analysis of sage grouse population growth rates, to determine how much each component vital rate contributes to the rate of population growth. Specifically, we compiled estimates of 32 vital rates, range wide, and for each rate, we estimated the overall mean and process variance of the rate among populations. We then used these rates to construct a two stage Lefkovich matrix, which formed the basis for our analytical elasticity analyses and life stage simulation analyses (LSA). Elasticity analyses indicated that both hen survival rates and the vital rates associated with first nest attempts were far more important than vital rates associated with renesting attempts. LSA further indentified particular rates of importance, based on the range of variability that has been captured by studies to date. Certain vital rates (e.g. juvenile survival) have not often been measured, and others (e.g. chick survival) have been quantified by so many non-comparable metrics that few of the published estimates were usable in this meta-analysis. Future research is needed to quantify the natural range of variability in these vital rates.

Fortification Creek and Development of Coal Bed Methane

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Jim Verplancke a BLM Natural Resource Specialist and Biologist for coal-bed methane development in the
Fortification Creek area will provide an overview of disturbance from coal-bed methane development planned in the Fortification Creek area. He will discuss potential methods of protection and restoration which are currently in the planning stages for Fortification Creek. The purpose of the presentation is to encourage discussion of reclamation potential. Jim will solicit questions from the audience. Ideas generated may be considered for reclamation and restoration projects by the Buffalo Field Office.

Jennifer Spegon is working at the Buffalo Field Office and is a graduate student with Nicholas School of the Environment. Jennifer is conducting a master's project in environmental restoration focused on reclamation and restoration of coal-bed methane development in the Powder River Basin. Jennifer has requested to present a survey, in the form of a questionnaire, to attendees at the symposium in Sheridan. Jennifer would like to present the survey as early in the meeting as possible. A copy of the introductory letter, informed consent letter, and a copy of the questionnaire (per University IRB guidelines) will be e-mailed to the host of the symposium for potential entry into attendee workbooks or other printed material.

Considerations for Evaluating Coalbed Methane Infiltration Pond Sites Based on Site Studies in the Powder River Basin of Montana and Wyoming

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Significant volumes of ground water are produced in association with coalbed-methane (CBM) production in the Powder River Basin in Montana and Wyoming. This water must be managed in a manner that is both economical and sensitive to the semi-arid agricultural area of southeastern Montana and northeastern Wyoming. Infiltration ponds are one of the primary methods of handling production water and have been in use in Montana and Wyoming for several years. A solid conceptual framework of the parameters that control water quality and flow allows for the selection of infiltration pond sites that maximize impoundment life and minimize impacts.

Advantages offered by ponds include a low initial capital investment and recharge of the shallow groundwater system, which makes the production water available for future uses. However, as the infiltrated water moves through the shallow weathered bedrock, a series of chemical reactions typically take place (primarily dissolution and oxidation), which temporarily increases the total dissolved solids (TDS). This change is detected primarily as increases in dissolved Mg, Na, and SO_4. As the available salts are removed along the groundwater flow path through the bedrock, the concentrations of dissolved constituents in the groundwater tend to decrease.

The fate and transport of the dissolved salts is controlled to a great extent by the rate of infiltration and the duration of saturated flow from the ponds. The rate of infiltration can be severely reduced as the clays in the pond floor and underlying material are exposed to the high-SAR produced water, which causes dispersion and reduced vertical hydraulic conductivity. Order-of-magnitude decreases in vertical hydraulic conductivity have been observed, which directly affect water management through the pond. First, decreased infiltration will effectively decrease the volume of water that can be managed via an individual pond. Secondly, the mobilized salts may be effectively sequestered by reduced groundwater flow, substantially reducing the temporal and geographic extent of impacts.

On the basis of these results, the MDEQ, MBOGC, and MT-BLM have developed a single set of impoundment siting and monitoring criteria. This single set of criteria should allow for efficient permitting of impoundments, while minimizing the potential for adverse environmental impacts.

Regional Groundwater Monitoring in the Powder River Basin, Wyoming

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The Powder River Basin Final Environmental Impact Study (PRB FEIS) completed in 2003, predicted that there would be local groundwater changes associated with coalbed natural gas (CBNG) production. The Bureau of Land Management (BLM) is tracking these changes by collecting water level and gas pressure data in 111 monitoring wells in the PRB. The Wyoming State Geological Survey (WSGS) in cooperation with the BLM recently published a report presenting the initial compilation and analysis of the well data collected between 1993 and 2006. During this time period, CBNG operations in the PRB produced a total of 174 billion gallons of groundwater at rates of up to 77.3 million gallons per day. The BLM deep monitoring well network is measuring drawdown in the various coal zones as this water production progresses. Also, water level data being collected in adjacent sandstone aquifers can be used to evaluate potential leakage to the coal zones. The WSGS report concluded that groundwater extraction by CBNG operations from coal units in the PRB is depressing groundwater levels locally and that the CBNG impacts on groundwater levels in the upper member of the Fort Union Formation are slightly less than the drawdowns that were predicted by the PRB FEIS for the year 2006. Further work will be conducted to examine and extend these conclusions by incorporating and analyzing recent data and by examining well specific water production data. We will present a summary of the analyses conducted to date and examples of analyses that are in progress at the BLM.

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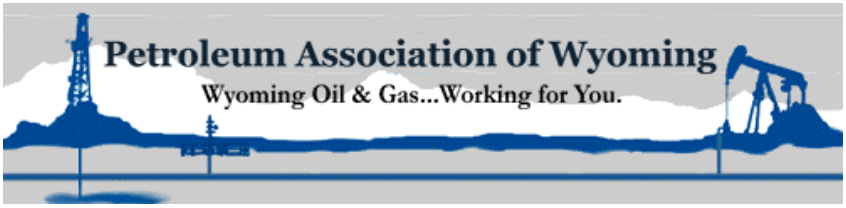
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