

**Recently-completed and ongoing USGS investigations in the Williston Basin
February, 2018**

USGS Office Abbreviations:

CERC, Columbia Environmental Research Center; **CERSC**, Central Energy Resources Science Center; **CGGSC**, Crustal Geophysics and Geochemistry Science Center; **CMERSC**, Central Mineral and Environmental Resources Science Center; **COWSC**, Colorado Water Science Center; **DSC**, Dakota Science Center; **EERSC**, Eastern Energy Resources Science Center; **EROS**, Earth Resources Observation and Science Center; **ERP**, Energy Resources Program; **GECS**, Geosciences and Environmental Change Science Center; **IDWSC**, Idaho Water Science Center; **LSC**, Leetown Science Center; **NPWRC**, Northern Prairie Wildlife Research Center; **NOROCK**, Northern Rocky Mountain Science Center; **OWSC**, Oklahoma Water Science Center; **ORWSC**, Oregon Water Science Center; **WY-MTWSC**, Wyoming-Montana Water Science Center

Project number	Mission Area(s)	Start year	End year	Project title	USGS author(s)/contact(s)	Published paper, data source, etc.	Relevant information	Keywords	Linkage to other research topics	URL to project	URL to product(s)
Topic 1. Understanding the Scale and Nature of UOG Resources											
1.1	Energy and Minerals	2013	2016	Isotope geochemistry and provenance of the Bakken Formation	Leonid Neymark, CMERSC; Chris Holm-Denoma, CMERSC; Wayne Premo, GECS; Rick Moscati, CGGSC; Zell Peterman, CGGSC	Analytical work completed. Report writing next.	Determine the provenance of the Devonian-Mississippian Bakken Formation by dating of detrital zircon using LAICPMS and analyzing Sr and Nd isotopes in whole-rock samples.	Bakken, Provenance, Detrital Zircon, Rb-Sr and Sm-Nd isotope geochemistry, U-Pb zircon geochronology	2.5.1 and 2.5.2		
Topic 2. Water Quality											
Topic 2.1. Multi-Research Topic - overarching studies with multiple sub-components											
Topic 2.2. Groundwater											
2.2.1	Water	2013	2014	Williston Basin Baseline Groundwater-Quality Assessment - Upper Fort Union	Peter McMahon, COWSC; Rod Caldwell, WY-MTWSC; Joel Galloway, DSC; Greg Delzer, DSC	Journal article published.	Characterize baseline water-quality conditions in the Upper Fort Union aquifer within the Williston Basin, Montana and North Dakota.	Energy Development, Williston Basin, Water Quality, Baseline	3		http://pubs.er.usgs.gov/publication/70141030
2.2.2	Water	2014	2015	Groundwater Quality Assessment of the Standing Rock Reservation in North and South Dakota	Joel Galloway, DSC; Josh Valder, DSC	Data collected.	The primary purpose is to provide an initial assessment of the groundwater quality on the Standing Rock Reservation, particularly to develop baseline information related to future energy development activities in the area. A secondary purpose of this study is to establish selected wells for an ambient water-quality sampling program on the Standing Rock Reservation.	Baseline, Water Quality, Tribal, Groundwater, Williston Basin, Energy Development, Hydraulic Fracturing	3		
Topic 2.3. Surface Water											
Topic 2.4. Groundwater and Surface Water											
2.4.1	Water	2003	2014	Delineation of brine contamination in and near the East Poplar oil field, Fort Peck Indian Reservation, northeastern Montana	Joanna Thamke, WY-MTWSC; Zell Peterman, CGGSC; Bruce Smith, CGGSC; Todd Preston, NOROCK	USGS OFR 2006-1216; USGS OFR 2010-1326, USGS SIR 2014-5024.	Assessment of brine contamination to the shallow aquifers and surface water. Uses combination of hydrology, geochemistry, and geophysics to delineate areas of groundwater contamination.	Energy Development, Williston Basin, Brine Contamination, Groundwater, Surface Water, East Poplar oil field, Fort Peck Indian Reservation	3, 6	http://wy-mt.water.usgs.gov/projects/east_poplar/in dex.html	http://pubs.er.usgs.gov/publication/wri034214 http://pubs.usgs.gov/of/2006/1216/

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											http://pubs.usgs.gov/of/2010/1326/ http://pubs.usgs.gov/sir/2014/5024/
2.4.2	Water	2010	present	Delineation of brine contamination in and near the City of Poplar and East Poplar oil field, Fort Peck Indian Reservation, northeastern Montana	Joanna Thamke, WY-MTWSC; Zell Peterman, CGGSC; Bruce Smith, CGGSC; Todd Preston, NOROCK	One journal article published, the other is in review. Data release being prepared. SIR in preparation.	Delineation of brine contamination to shallow aquifers in and near the City of Poplar and East Poplar oil field. Uses combination of hydrology, geochemistry, and geophysics to define extent of contamination.	Energy Development, Williston Basin, Brine Contamination, Groundwater, City of Poplar, East Poplar oil field, Fort Peck Indian Reservation	3, 6	http://wy-mt.water.usgs.gov/pr ojects/east_po plar/in dex.html	http://aapgbull.geoscienceworld.org/content/100/10/1619/article-info
2.4.3	Water	2013	present	Analyses of water-quality data and resources on the Fort Berthold Reservation, North Dakota	Joel Galloway, DSC	Publication in preparation.	Analyses of water-quality data and resources on the Fort Berthold Reservation, North Dakota.	Fort Berthold, Water Quality	3, 6		
Topic 2.5. Produced Water											
2.5.1	Energy and Minerals, Water	2012	2016	Baseline Chemical and Isotopic Data for Produced Water from the Bakken Formation, Williston Basin	Zell Peterman, CGGSC; Rod Caldwell, WY-MTWSC; Joel Galloway, DSC	Data available at http://mt.water.usgs.gov/	Characterize Bakken Formation water.	Energy Development, Williston Basin, Bakken Formation, Strontium Isotopes	3, 6		http://energy.usgs.gov/EnvironmentalAspects/EnvironmentalAspectsofEnergyProductionandUse/ProducedWaters.aspx#3822349-data

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2.5.2	Energy And Minerals, Water	2013	2017	Isotopic Indications of Fluid Flow in the Bakken Formation, Williston Basin	Zell Peterman and Kiyoto Futa, CCGSC; Thomas Oliver, CERSC; Joanna Thamke, WY-MT WSC	Journal article published.	Sr isotopic characterization of pore salts in members of the Bakken Formation to evaluate flow amount units.	Energy Development, Williston Basin, Bakken Formation Flow	3, 6		http://www.aapg.org/publications/news/explorer/emphasis/articleid/10195/saline-water-in-bakken-where-did-it-come-from https://pubs.er.usgs.gov/publication/70190270
2.5.3	Energy And Minerals, Water	2014	2015	Refined Methodology and Safety Analysis for the Collection of Produced Waters: Field Evaluation in the Williston Basin	Rod Caldwell, WY-MTWSC; Tanya Gallegos, ERP; Greg Delzer, DSC		Characterization of produced waters from the Bakken and Three Forks fm. Comparison of waters sampled from wells and separator.	Produced Water, Field Protocol Evaluation, Bakken Formation, Three Forks Formation		Workplan methods eval v 3-21	
2.5.4	Environmental Health			Characterize waste materials generated by UOG development (liquids, solids, and atmospheric emissions).	Bill Orem, EERSC; Matthew Varonka, OWSC	Journal article submitted to Applied Geochemistry					

Topic 3. Water Availability

Topic 3.1. Multi-Research Topic Proposal(s)

Topic 3.2. Groundwater

3.2.1	Water	2012	2019	Williston and Powder River basins groundwater availability	Joanna Thamke and Tim Bartos, WY-MTWSC; Andrew Long and Kyle Davis, DSC	Bednar, 2013, South Dakota School of Mines Thesis; Aurand, 2013, South Dakota School of Mines Thesis; USGS SIR 2014-5047; USGS SIR 2014-5055. Model report in review; data release in review;	Groundwater budget, hydrogeologic framework, Conceptual model prepared. Groundwater availability determined for current and projected energy development.	Energy Development, Williston Basin, Powder River Basin, Groundwater Availability	2	http://mt.water.usgs.gov/projects/WaPR/	http://pubs.er.usgs.gov/publication/sir20145047 http://pubs.er.usgs.gov/publication/sir20145055
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						Professional Paper in preparation.					

Topic 3.3. Surface Water

Topic 3.4 Groundwater and Surface Water

3.4.1	Ecosystems, Water	2010	2017	Water Balances for Energy Resource Production	Seth Haines and Brian Varela, CERSC; Joanna Thamke, WY-MTWSC	USGS Fact Sheet 2014-3010; USGS OFR 2015-1117; USGS Fact Sheet 2017-3044	Water availability, resource assessment methods, water and proppant (sand) quantities.	Energy Development, Williston Basin, Groundwater, Surface Water	2, 6	http://energy.usgs.gov/fs/2014/v/Environmenta/Aspects/EnvironmentalAspectsofEnergyProductionandUse/ProducedWaters.aspx	http://pubs.usgs.gov/fs/2014/3010/ https://pubs.er.usgs.gov/publication/ofr20151117 https://pubs.er.usgs.gov/publication/fs20173044
3.4.2	Water	2013	2014	Quantifying water-use requirements for the variable conditions and processes associated with hydraulic fracturing within North Dakota, South Dakota, and Montana	Kyle Blasch, IDWSC; Roy Sando, WY-MTWSC	Information presented at Feb 2016 National Groundwater Association meeting.	Quantifying water-use requirements for the variable conditions and processes associated with hydraulic fracturing within North Dakota, South Dakota, and Montana	Energy development, Williston Basin, Bakken Formation, Three Forks Formation, Hydraulic Fracturing, Water-Use Requirements	2, 6		
3.4.3	Water	2014	2019	Method Development to Estimate National Water Use Associated with Unconventional Oil and Gas – Phase 1	Joanna Thamke, Roy Sando, Ryan McShane, Theo Barnhart, WY-MTWSC; Janet Carter, Kathleen Rowland, Greg Delzer, Robert Lundgren, and Josh Valder, DSC	USGS Fact Sheet 2016-3032; SIR and Data Release in preparation.	Obtain and analyze water use data for direct (e.g., well drilling, hydraulic fracturing, dust suppression) and indirect uses (e.g., municipalities and crew camps) related to UOG development in the Williston Basin from 2005-2015. Develop water-use coefficients and consumptive-use coefficients for UOG processes for broader application. Assist stakeholders in projecting water use requirements and availability associated with future UOG development.	Water use, Williston Basin, Direct Use, Indirect Use, National Water-Use Assessment	2, 6	http://sd.water.usgs.gov/projects/UOG/UOG.html	https://pubs.er.usgs.gov/publication/fs20163032

Topic 4. Air Quality and Greenhouse Gas Emissions

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Topic 5. Effects on Human Health and Communities											
Topic 6. Ecological Effects											
6.1.1	Ecosystems	2008	2014	Brine Contamination to Prairie Potholes from Energy Development in the Williston Basin	Robert Gleason, NPWRC; Joanna Thamke, WY-MTWSC; Brian Tangen, NPWRC; Todd Preston, NOROCK; Bruce Smith, CGGSC	USGS SIR 2014-5017; USGS FS 2011-3047; Applied Geochemistry, August 24, 2012; USGS OFR 2012-1149; Preston, 2011, Montana State University Thesis.	Water-quality impacts of brine spills, spatial data on wells, decision analysis findings.	Energy Development, Williston Basin, Brine Contamination, Prairie Potholes, Wetlands, Groundwater	2		http://pubs.usgs.gov/sir/2014/5017/ http://pubs.usgs.gov/fs/2011/3047/ http://pubs.usgs.gov/of/2012/1149/
6.1.2	Environmental Health	2015	present	Understanding Potential Risks to Water Resources and Environmental Health Associated with Wastes from Unconventional Oil and Gas Development	Isabelle Cozzarelli, NRP; Katie Skalak, NRP; Joanna Thamke, WY- MTWSC	Cozzarelli, Isabelle M., K. J. Skalak, D. B. Kent, Mark A. Engle, A. Benthem, A. C. Mumford, K. Haase et al., 2017, Environmental signatures and effects of an oil and gas wastewater spill in the Williston Basin, North Dakota: Science of the Total Environment, v. 579, p. 1781–1793.	Characterizing source materials from active drilling sites, study historical and recent leaks and spills of brine wastewaters in the Williston Basin.	Brine spills, wastewater, surface water quality, biological effects, water quality methods development, radium,	2	http://toxics.usgs.gov/investigations/uog/	http://pubs.usgs.gov/fs/2014/3104/
6.1.3	Ecosystems	2015	2017	Information on spills from unconventional oil and gas from four states.	Kelly Maloney, LSC	Maloney, K.O., et al., 2017, Unconventional oil and gas spills: Materials, volumes, and risks to surface waters in four states of the U.S.: Science of the Total Environment, v. 581–582, p. 369–377. Patterson, L.A., et al., 2017, Unconventional Oil and Gas Spills: Risks,	The study compiled and analyzed detailed data on spills (volumes, materials, causes) resulting from unconventional oil and gas development in Colorado, New Mexico, North Dakota and Pennsylvania from state data sources.	Shale oil and gas; Hydraulic fracturing; Extraction; Spill rates; Wells; Colorado; New Mexico; North Dakota; Pennsylvania; Setback regulations;			http://www.sciencedirect.com/science/article/pii/S0048969716328327 http://pubs.acs.org/doi/abs/10.1021/acs.est.6b05749

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						Mitigation Priorities, and State Reporting Requirements: Environmental Science & Technology, v. 51, p. 2563–2573.					
Topic 6.2. Spatial Data Sets and GIS											
6.2.1	Ecosystems	2011	2012	A GIS-Based Vulnerability Assessment of Brine Contamination to Aquatic Resources from Oil and Gas Development in Eastern Sheridan County, MT	Todd M. Preston, NOROCK; Joanna N. Thamke, WY-MTWSC	Article published in Science of the Total Environment.	Vulnerability assessment methods.	Energy Development, Williston Basin, Vulnerability Assessment, Brine Contamination, Aquatic Resources	2		http://dx.doi.org/10.1016/j.scitotenv.2013.09.027
6.2.2	Ecosystems	2014	2015	A Web-Based Tool to Evaluate Potential Saline Contamination to Aquatic Resources in the Williston Basin from Energy Development	Todd M. Preston, NOROCK	Article published in Science of the Total Environment.	Integrate several datasets into a cohesive data product allowing federal, state, tribal, and others to visualize the spatial distribution of factors relevant to brine contamination and determine potential vulnerability.	Energy Development, Williston Basin, Vulnerability Assessment, Brine Contamination, Aquatic Resources	2		http://dx.doi.org/10.1016/j.scitotenv.2014.11.054
6.2.3	Ecosystems	2012	2015	Monitoring and modeling wetland chloride concentrations	Max Post van der Burg, NPWRC; Brian Tangen, NPWRC; Robert Gleason, NPWRC; Jill Frankforter, WY-MTWSC	Article published in the Journal of Environmental Management.	Impacts of brines on wetland surface water chemistry.	Energy Development, Williston Basin, Brine Contamination, Prairie Potholes, Wetlands	2		http://dx.doi.org/10.1016/j.jenvman.2014.10.028
6.2.4	Ecosystems	2013	2015	Presence and Abundance of Non-Native Species Related to Energy Development in Montana and North Dakota	Todd M. Preston, NOROCK; Rick Sojda, NOROCK	Article published in Environmental Monitoring and Assessment.	The effects of energy development on the presence and abundance of noxious weeds.	Energy Development, Williston Basin, Invasive Species, Noxious Weeds			http://www.ncbi.nlm.nih.gov/pubmed/25797884
6.2.5	Ecosystems	2012	present	Investigating the biological impacts of brine contamination	Todd M. Preston, NOROCK	Article in Review with the Journal of Freshwater Ecology.	Biological impacts of brine contamination.	Energy Development, Williston Basin, Brine Contamination, Biological	2		

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				on wetlands of the Prairie Pothole Region: Developing maps depicting conditions in the ecosystems.				Impacts, Prairie Potholes, Wetlands			
6.2.6	Ecosystems	2014	present	Updating, gathering, and serving datasets relevant to oil and gas development and fish and wildlife management within the Williston Basin and Bakken Formation	Todd M. Preston, NOROCK		Updating, gathering, and serving datasets relevant to energy development and natural resources to ScienceBase and a NOROCK server.	Energy development, Williston Basin, Bakken Formation, Water Quality, Hydraulic Fracturing, GIS, Data Server, Webman	2, 3		
6.2.7	Ecosystems	2014	2016	Evaluating recent and future land-use changes related to energy development in the Williston Basin and Bakken Formation	Todd M. Preston, NOROCK	Article has been published in Science of the Total Environment.	Determine the acreage of different land-use classifications converted to current and future oil and gas development	Energy Development, Williston Basin, Bakken Formation, Land Use	2, 3		
6.2.8	Ecosystems	2013	2016	Comprehensive Wetland Assessment and Monitoring Program within the Lostwood Complex of Northeast Montana and Northwest North Dakota.	Todd M. Preston, NOROCK; Rick Sojda, NOROCK	Phase 1. Internal final report submitted to U.S. Fish & Wildlife Service. Phase 2. Sampling.	Use previously determined vulnerability assessment methods for Waterfowl Production Areas in the Lostwood National Wildlife Refuge Complex.	Energy Development, Williston Basin, Waterfowl Production Areas, Brine Contamination, Vulnerability Assessment	2		
6.2.9	Ecosystems	2012	2015	Effects of oil and gas development on grassland birds.	Doug Johnson, NPWRC	Article has been published in Biological Conservation.	Biological impacts of energy development	Grassland birds, Oil and Gas Development			https://pubs.er.usgs.gov/publication/70157525
6.2.10	Ecosystems	2014	present	Modeling avian abundance or occupancy	Max Post van der Burg, NPWRC		Develop a Bayesian hierarchical model to assess relationships between bird abundance and patterns of oil development. More specifically, relate cumulative oil development to population growth rates of	Energy Development, Williston Basin, Avian, Migratory Birds			

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							various migratory birds using Breeding Bird Survey data, and then using those trends to predict future changes.				
6.2.11	Ecosystems	2016	2017	Develop grassland bird habitat suitability models in relation to energy development in the Williston Basin	Todd Preston, NOROCK; Rachel Bolus, NOROCK	Developing code and acquiring land cover changes.	Develop grassland bird habitat suitability models using USGS GAP species and habitat data in conjunction with land cover data derived from 6.2.7	Grassland birds, habitat suitability, energy development, land cover change			

Topic 6.3. Toxicity Studies

6.3.1	Ecosystems Environmental Health	2013	present	Effects of salinity on aquatic resources, acute	Aida Farag, CERC; Dave Harper, CERC		Potential effects of saline waters from energy activities on aquatic resources.	Saline, Brine, Toxicity, Lethal, Sublethal, Energy Development, Williston Basin, Water Quality, Baseline	2, 3, 5		
6.3.2	Ecosystems Environmental Health	2014	present	Effects of salinity on aquatic resources, chronic	Aida Farag, CERC; Dave Harper, CERC		Potential effects of saline waters from energy activities on aquatic resources.	Saline, Brine, Toxicity, Lethal, Sublethal, Energy Development, Williston Basin, Water Quality, Baseline	2, 3, 5		
6.3.3	Ecosystems Environmental Health	2015	present	Field and laboratory assessments of toxicity to multiple species	Aida Farag, CERC; Dave Harper, CERC; Ning Wang, CERC		This work evaluates the toxicity of major ions of concern (including and beyond chloride) to a range of taxa of interest, including the influence of the base water on the toxicity of major ion mixtures. The project is building upon the above listed 6.3.1 projects and additional major ion toxicity projects being conducted at CERC. We have begun with laboratory experiments that simulate various background waters and will work to expand and generate information for a range of taxa using a combination of (1) laboratory toxicity experiments of field-collected waters or field-	Saline, Brine, Toxicity, Lethal, Sublethal, Energy Development, Williston Basin, Water Quality, Baseline	2,3,5		http://www.sciencedirect.com/science/article/pii/S0048969716326201

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							collected sediments, (2) laboratory toxicity experiments of reconstituted waters, (3) in situ toxicity experiments, and (4) community surveys and rapid bioassessments of biota. The current funding will be focused on field assessment of a spill site and further investigating the suitability of simulated background waters for multiple species.				
6.3.4	Water, Ecosystems	2015	2016	Phased Investigation of effects of Unconventional Oil and Gas Development in the Williston Basin on Water Quality, Amphibians, and their Habitats	Chauncey Anderson, ORWSC; Blake Hossack, NOROCK; Bill Battaglin, COWSC		Potential effects of saline waters and sediment quality from energy activities on amphibian toxicity. Funding from USGS ARMI program. Links with bioassays of native amphibian eggs with sediments from Goose Lake pond sites across a gradient of contamination. Also in coordination with NRP/Toxics Project on water quality at legacy sites.	Saline, Brine, Toxicity, Energy Development, Williston Basin, Water Quality, Amphibians	2,5	http://armi.usgs.gov/	
6.3.5	Ecosystems	2015	2016	Effects of brine contamination on amphibians	Blake Hossack, NOROCK; Holly Puglis, CERC; Bill Battaglin, COWSC; Chauncey Anderson, ORWSC;	Article has been published in Environmental Pollution.	We used laboratory experiments to compare survival of larval Boreal Chorus Frogs reared on brine-contaminated sediments vs. uncontaminated sediments.	Saline, Brine, Toxicity, Lethal, Sublethal, Energy Development, Williston Basin, Water Quality, Baseline	2,3,5		https://doi.org/10.1016/j.envpol.2017.08.070
6.3.6	Ecosystems	2017	2020	Linking sublethal effects of brine contamination to aquatic populations and communities.	Blake Hossack (NOROCK), Brian Tornabene (U. Montana PhD student)		Project in development. The main theme is to develop/evaluate measures of sublethal stress (physiological) from brine contamination that predict fitness. The student will also look at the effects of contamination on parasite communities and disease.	Saline, Brine, Toxicity, Energy Development, Williston Basin, Water Quality, Amphibians, Disease, Sublethal Stress	2, 3, 5		
6.3.7	Ecosystems	Mid-2016	Multi-year	An assessment of effects of oil and gas production on water	Walt Sadinski, UMESC	Began field work in 2017	Initial sampling of water quality in 50 or more DOI wetlands in relation to distance from well	Oil and gas production, Bakken Formation, North Dakota, DOI wetlands,			

