


Witness/Exhibit List
Cindy Myers, Intervener for Hydrocarbon Pipeline HP14-001

| Date | Exhibit Number | Document Description | Witness | Offer | Admit | Deny |
|-----------------------------------|----------------|---|----------------|-------|-------|------|
| 04-20-15 | Cindy 1 | Cindy Myers Testimony, SD PUC HP14-001 | Cindy Myers,RN | | | |
| 04-20-15 | Cindy 2 | Paul Seamans Statement re. Missouri River Water Systems | | | | |
| 04-20-15 | Cindy 3 | Map: Missouri River Water Systems  | | | | |
| 04-20-15 | Cindy 4 | John Stansbury Study, "Analysis of Worst-Case Spills From the Proposed Keystone XL Pipeline". 4A-Summary, 4B-excerpts by Dr Stansbury | | | | |
| 04-20-15 | Cindy 5 | https://youtu.be/9Dw7a7YSnH0 Dr Stansbury Interview | | | | |
| 04-20-15 | Cindy 6 | Arden Davis Testimony SD PUC docket HP14-001 | | | | |
| 04-20-15 | Cindy 7 | Madden Testimony, SD PUC docket HP09-001 | | | | |
| 04-20-15 07-24-15 (revised) | Cindy 8 | FSEIS Keystone XL Pipeline, http://keystonepipeline-xl.state.gov/finalseis/index.htm 3.3, 3.13, 4.3, 4.13, Appendix I, Appendix P, Appendix Q | | | | |
| 04-20-15 | Cindy 9 | http://insideclimatenews.org/news/20022015/yellowstone-rupture-probe-stalled-pipeline-restart-plan-moving-forward Montana's Department of Environmental Quality | | | | |
| 04-20-15 | Cindy11 | TransCanada's discovery responses 11-A, 11-B, 11-C | | | | |
| 04-20-15 | Cindy12 | http://thinkprogress.org/climate/2014/10/21/3582480/north-dakota-spill-one-year-later/ | | | | |
| 04-20-15 | Cindy13 | http://www.deq.mt.gov/statesuperfund/silvertipoilspill/default.mcp | | | | |
| 04-20-15 | Cindy14 | http://www.mlive.com/news/grand-rapids/index.ssf/2014/11/2010_oil_spill_cost_enbridge_1.html | | | | |
| 04-20-15 | Cindy15 | http://www.yorknewstimes.com/editorial/the-keystone-xl-pipeline-is-dead/article_b8df8d1e-6e6c-11e4-8232-e32899788eb6.html#.VGvEjBln1QA.email | | | | |
| 04-20-15 | Cindy16 | http://www.denverpost.com/news/ci_26800380/dead-babies-near-oil-drilling-sites-raise-questions | | | | |

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| 04-20-15 | Cindy17 | http://blog.keloland.com/issues/blog/2009/11/02/madden-report-misses-distress-among-keystone-pipeline-neighbors/#.VPAIDQfZ5ms.email | | | | |
| 04-20-15 | Cindy18 | http://m.billinggazette.com/news/state-and-regional/montana/article_c39e74b3-08ec-5fce-8d18-4085c5c03ed2.html?mobile_touch=true | | | | |
| 04-20-15 | Cindy19 | http://bigstory.ap.org/article/03d148c1029a4fe69ccfe60ad9e6f94e/yellowstone-oil-spills-fuel-arguments-over-keystone-line | | | | |
| 04-20-15 | Cindy20 | http://mediamatters.org/blog/2015/01/26/yellowstone-oil-spill-missing-from-keystone-xl/202266 | | | | |
| 04-20-15 | Cindy21 | http://www.thewildlifeneews.com/2015/01/26/pipeline-rupture-under-yellowstone-river/ | | | | |
| 04-20-15 | Cindy22 | http://water.epa.gov/drink/contaminants/index.cfm#List | | | | |
| 04-20-15 | Cindy23 | http://mediamatters.org/blog/2015/01/26/yellowstone-oil-spill-missing-from-keystone-xl/202266 | | | | |
| 04-20-15 | Cindy24 | http://m.missoulian.com/news/opinion/columnists/oil-and-water-don-t-mix/article_3c09934b-435e-5a43-a41b-e14646fc2d12.html?mobile_touch=true | | | | |
| 04-20-15 | Cindy25 | http://www.spokesman.com/stories/2015/jan/24/new-spill-into-yellowstone-river-prompts-pipeline/ | | | | |
| 04-20-15 | Cindy26 | http://mobile.nytimes.com/aponline/2015/01/20/us/ap-us-pipeline-spill.html?referrer=&_r=0 | | | | |
| 04-20-15 | Cindy27 | http://www.netzero-news.net/news/read/category/Top%20News/article/the_associated_press-montana_oil_spill_renews_worry_over_safety_of_old-ap#.VMGpUACr_U.facebook | | | | |
| 04-20-15 | Cindy28 | http://bigstory.ap.org/article/659021779c4f4cefb0393e5006c16af5/montana-oil-spill-renews-worry-over-safety-old-pipelines | | | | |
| 04-20-15 | Cindy29 | http://insideclimatenews.org/news/20150121/ice-hinders-cleanup-yellowstone-oil-pipeline-spill?utm_source=Inside+Climate+News&utm_campaign=3e1c34ad09-Weekly+Newsletter+1+25+2015+1+23+2015&utm_medium=email&utm_term=0_29c928ffb5-3e1c34ad09-327495949 | | | | |
| 04-20-15 | Cindy30 | Brad Vann, Environmental Scientist, EPA, Region 7, email quotes | | | | |
| 04-20-15 | Cindy31 | Keystone "Oil Pipeline for Emergency Responders" Pamphlet 1533-1538 | | | | |
| 04-20-15 | Cindy32 | SD PUC Amended Final Decision and Order; Notice of Entry HP09-001 | | | | |
| 04-20-15 | Cindy33 | Missouri River and tributaries, trace upstream, USGS http://nationalmap.gov/streamer/dataService/dataService.a | | | | |

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| | | shx/report?ID=20025251&traceDir=up&HUCs=&lat=44.50007083273387&lon=-94.57467128066176&elevFt=1030.469163&baseMap=terrainBaseMap&xmin=-10524714&ymin=5536454&xmax=-10510466&ymax=5539947&reportType=maponly&session_id=222255224634&caller=streamer | | | | |
| 04-20-15 | Cindy34 | http://www.vancouverobserver.com/news/first-nations-cancer-linked-oil-sands-toxins-wild-food-study | | | | |
| 04-20-15 | Cindy35 | http://www.vancouverobserver.com/news/alberta-doctor-tells-us-canada-lying-about-tar-sands-health-effects | | | | |
| 04-20-15 | Cindy36 | http://m.billinggazette.com/news/state-and-regional/montana/cancer-causing-agent-detected-in-water-after-pipeline-spill/article_c39e74b3-08ec-5fce-8d18-4085c5c03ed2.html?utm_source=facebook&utm_medium=social&utm_campaign=curated&utm_content=BGKKarenS&mobile_touch=true | | | | |
| 04-20-15 | Cindy37 | http://www.usnews.com/news/us/articles/2015/01/21/city-tries-to-repair-contaminated-water-system-after-spill | | | | |
| 04-20-15 | Cindy38 | http://m.missoulain.com/news/state-and-regional/yellowstone-river-sonar-shows-breached-pipeline-is-exposed-on-riverbed/article_aa9290f2-f997-52f1-9aa5-4f7d426b1f57.html?mobile_touch=true | | | | |
| 04-20-15 | Cindy39 | Acute Health Effects of the Enbridge Oil Spill https://snt150.mail.live.com/mail/ViewOfficePreview.aspx?messageid=mgv68drsZw5BGEemw75afaHg2&folderid=flzg-Wn7trtkiY3oFCUuZJ7Q2&attindex=4&cp=-1&attdepth=4&n=59596253 | | | | |
| 04-20-15 | Cindy40 | MSDS Naphtha https://snt150.mail.live.com/mail/ViewOfficePreview.aspx?messageid=mgv68drsZw5BGEemw75afaHg2&folderid=flzg-Wn7trtkiY3oFCUuZJ7Q2&attindex=2&cp=-1&attdepth=2&n=56189677 | | | | |
| 04-20-15 | Cindy41 | API, Diluted Bitumen Information | | | | |
| 04-20-15 | Cindy42 | SDCL, 49-41 B-22 | | | | |
| 04-20-15 | Cindy43 | http://goo.gl/0GxqoM Video interview of TransCanada's Jeff Rauh and Andrew Craig | | | | |
| 04-20-15 | Cindy44 | PUC staff discovery responses 44-A, 44-B | | | | |
| 04-20-15 | Cindy45 | Map of KXL route in SD | | | | |
| 04-20-15 | Cindy46 | http://bismarcktribune.com/news/state-and-regional/unusual-alliance-on-oil-spill-cleanup-near-tioga/article_75164d8e-4b8f-11e4-bf7b-93e46e70604c.html | | | | |
| 04-20-15 | Cindy47 | Toxicology and Applied Pharmacology, Volume 276, Issue 2, April 15 (2014), pages 83-94 Current understandings and perspectives on non-cancer health | | | | |

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| | | effects of benzene: A global concern. | | | | |
| 04-20-15 | Cindy48 | HHS Public Access, Advances in Understanding Benzene Health Effects and Susceptibility, Published in final edited form as: Annu Rev Public Health. 2010 ; 31: 133–148.doi:10.1146/annurev.publhealth.012809.103646. | | | | |
| 04-20-15 | Cindy49 | NIH Public Access, Systems biology of human benzene exposure, Published in final edited form as: Annu Rev Public Health. 2010 ; 31: 133–148. doi:10.1146/annurev.publhealth.012809.103646. Systems biology of human benzene exposure | | | | |
| 04-30-15 | Cindy50 | ATSDR, “Public Health Statement for Benzene” | | | | |
| 04-30-15 | Cindy51 | Wikipedia, IARC Group I Carcinogens | | | | |
| 07-05-15 | Cindy52 | Paul Seamans statement re. Condition #40, PVC pipe/BTEX | | | | |
| 07-23-15 | Cindy | http://www.edmontonjournal.com/business/Company+investigating+pipeline+break/11222747/story.html “Nexen spill discovered by worker walking by” “Company investigating why pipeline break technology did not work.” By Bill Mah, Edmonton Journal July 17, 2015 | | | | |
| 07-23-15 | Cindy | C Myers Surrebuttal Testimony in response to Kearney’s Rebuttal re. Madden Analysis (Filed with PUC) | | | | |
| 07-23-15 | Cindy | Kevin Schlosser Statements (attached) | | | | |
| 07-23-15 | Cindy | Carol Moyer Statements (attached) | | | | |
| 07-29-15 | 6015 | SD Water Treatment Plants, Phone Visits (attached) | | | | |
| 07-29-15 | 6016 | FSEIS Index (found on-line) | | | | |

**BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA**

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|-----------------------------------|---|----------------------------------|
| IN THE MATTER OF THE PETITION OF |) | Docket 14-001 |
| TRANSCANADA KEYSTONE PIPELINE, |) | |
| LP FOR ORDER ACCEPTING |) | TESTIMONY OF CINDY MEYERS |
| CERTIFICATION OF PERMIT ISSUED IN |) | |
| DOCKET HP09-001 TO CONSTRUCT THE |) | |
| KEYSTONE XL PIPELINE |) | |

Statement for the South Dakota Public Utilities Commission (“PUC”)

My name is Cindy Myers, R.N. My address is 87925 468th Ave., PO Box 104, Stuart, NE 68780.

This testimony is submitted regarding Amended Conditions: 2, 34, 35, 36, 40, 46 and Finding of Facts: 41, 50, 107 of the Amended Final Decision and Order in HP 09-001.

Introduction

Benzene, a potent carcinogen, has increasingly become the most threatening of all environmental toxins. Cancer is primarily an environmental disease. Allowing one of the largest pipelines filled with the world’s dirtiest oil, under the most extreme pressure to funnel benzene and other toxins into South Dakota is a major public health threat. The lifeblood of South Dakota, the Missouri River, which supplies water to over 50% of the state must be protected. The pristine High Plains Aquifer in Tripp County will have this mega toxic infrastructure immersed in water which supplies a municipal well and several private wells. Water protection and Medical Response Planning are not sufficiently considered for this project.

SDCL 49-41 B-22 states: The applicant for a facility construction permit has the burden of proof to establish that:

“The facility will not substantially impair the health, safety or welfare of the inhabitants.”

TransCanada Keystone Pipeline, LP (“TransCanada”) has failed to meet this burden of proof. TransCanada has failed the most important condition of this application: the health, safety and welfare of South Dakotans. I ask the PUC to put aside economic benefits for a foreign company and instead think about what is in the best interest of the good people of South Dakota.

Testimony

As a Registered Nurse, I believe two issues are of paramount importance in ensuring the health, safety, and welfare of South Dakota's residents: (1) clean drinking water, and (2) medical preparedness. If the PUC approves the proposed KXL Pipeline, I believe the health, safety, and welfare of citizens will be impaired or at risk.

Toxicity

Benzene is a potent carcinogen. According to E.P.A. standards, the maximum contamination goal in water is zero. The allowable limit in drinking water is only 5 parts per billion! This is so dilute, you can't taste, see or smell this toxic amount in drinking water. It can only be discovered by testing. Therefore, it would be possible to drink benzene unknowingly. Benzene is a component of oil and the diluent used to thin heavy tar sands oil. We don't know the exact amount because this information is kept from the public by TransCanada, even though such minute amounts of benzene can have major adverse health effects.

NAPHTHA is the primary diluent for bitumen. It is a brew of chemicals, including benzene. Up to 50% of the tar sands product is diluent, meaning 10,000,00 gallons a day of this poison would be gushing through South Dakota daily through a 36 inch pipe under extremely high pressure. NAPHTHA is a known carcinogen, but also capable of causing birth defects and reproductive harm. Scientists and medical professionals in Utah are connecting benzene to a host of severe medical diagnoses, thinking benzene, toluene, and xylenes cross the placental barrier, resulting in dead babies and birth defects.

TransCanada admits: "Benzene can result in health impacts from short-term exposure or long-term exposure." But according to John Stansbury, Ph.D., Associate Professor of Environmental/Water Resources Engineering at U.N.L., TransCanada has failed to adequately study benzene: "If the leak does go undetected for 90 days as the TransCanada document reports, a groundwater user could be exposed to unacceptable concentrations of benzene for a significant period of time. There should have been a human health risk assessment that would have estimated the increased risk of cancer, but there isn't any such assessment. They simply indicate that there could be a significant, undetected release of benzene which could be consumed by human receptors and leave it at that."

The 2010 permit clearly indicates concern about chemicals in the KXL product: BTEX (benzene, toluene, ethyl benzene, xylene). The 2010 permit directs: "At least forty-five days prior to construction, Keystone shall publish a notice in each newspaper of general circulation in each county through which the Project will be constructed advising landowners and public water supply systems of this condition."

Dr. Cleve Trimble is a Nebraska physician concerned about health impacts from the unknown chemical composition and the difficulty in providing treatment.

Aquifers

This massive toxic infrastructure is routed to go straight through the Ogallala Aquifer in Tripp County. This is a major health threat to people drinking from the several private wells and public water system drinking water from that source. Condition of Permit #35 states “The evidence in the record demonstrates that in some reaches of the Project in southern Tripp County, the High Plains Aquifer is present at or very near ground surface and is overlain by highly permeable sands permitting the uninhibited infiltration of contaminants.” Residents are not even informed if they live in a “high consequence area” and risks associated with that designation.

I live where the first KXL route was to cross in Nebraska. That route was moved because of the high water table and sandy soil, similar to the situation in Tripp County which is also underlain by the Ogallala Aquifer. If this was reason to change the route in Nebraska, how come it is still acceptable in South Dakota?

Neither TransCanada nor SD have plans to do prophylactic analyses for the very potential undetected leaks, choosing only to do analyses “in the event of a release.” TransCanada ran the route straight through the Ogallala Aquifer to get the shortest route to the Bakken Oil, telling me: “Meeting the proposed project’s purpose and need, including the extent to which additional infrastructure (pipeline) is necessary to access Bakken crude oil.” The priority here should be the people who drink water in Tripp County.

TransCanada admits other aquifers may not be identified until construction, implying that a thorough pre-evaluation of route has not been accomplished. Oil migrates deep into the ground. In the wheat field near Tioga, ND, 50 feet of soil was required to be removed to evacuate all the spilled oil.

Waterways

TransCanada plans to route KXL through major river valleys in South Dakota: Little Missouri, Cheyenne and White River. These waterways feed into the life blood of South Dakota, the Missouri River. Intakes from the Cheyenne and Missouri Rivers provide drinking water to many cities and reservations across the state, stretching from the Pine Ridge Reservation in western SD to Sioux Falls near the state’s eastern border.

We know the tar sands spill into Michigan’s Kalamazoo River spread several miles downstream. Visible oil from the 2011 Silvertip pipeline break into the Yellowstone River was found 70 miles downstream. An oil sheen was seen an estimated 100 miles downriver three days after the Jan 2012 pipeline break in the Yellowstone River near Glendive, MT. What we don’t know and see is exactly how far and where the benzene plumes migrate to down the rivers.

Arden Davis and John Stansbury both estimate hundreds of miles. The Department of State's environmental study, relied on by South Dakota, only takes into consideration the impact of spills 10 miles downstream.

| Waterway Crossing | Distance to Missouri River | Public Water Intake | Distance from KXL to Water Intake |
|--------------------------|-----------------------------------|----------------------------|--|
| Cheyenne River | 89.5 miles | Cheyenne Reservation | 50-60 miles, est. |
| Cheyenne River | 89.5 miles | OSRWSS | 89.5, est. |
| Cheyenne River | 89.5 miles | Chamberlain | 156 miles, est. |
| White River | 82.4 miles | Yankton | 222 miles, est |
| White River | 82.4 miles | Sioux Falls | unknown location |

Health Impact Assessment

The Commission's 2010 permit relies on the federal EIS, prepared by the Department of State.

SDCL 49-41 B-21: "Environmental impact statement. Prior to the issuance of a permit, the commission may prepare or require the preparation of an environmental impact statement that complies with the provisions of chapter 34A-9"

The federal EIS, required for a cross-border Presidential permit, is not sufficient to adequately address concerns pertinent to South Dakota, particularly health concerns

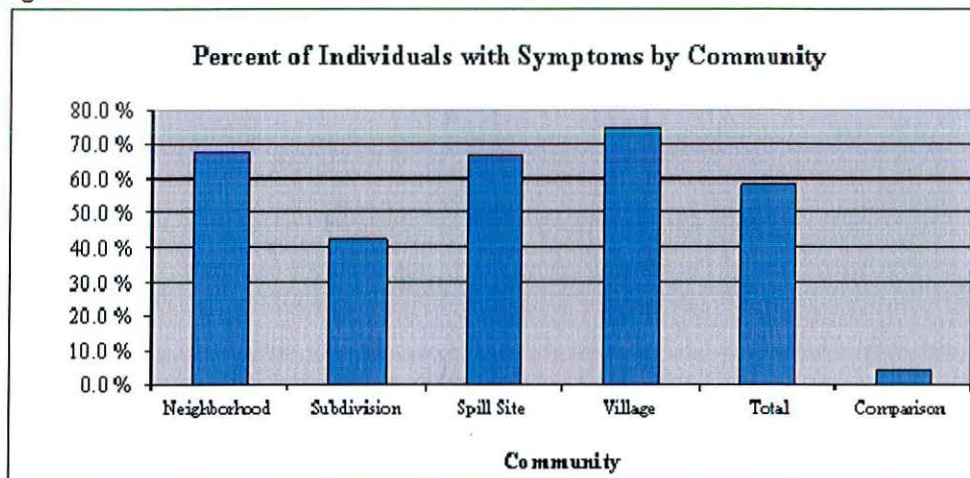
The FSEIS has several chapters. There are chapters exclusively for wildlife, fisheries and threatened and endangered species. There is even a chapter just about terrestrial vegetation, but....there is not even one chapter devoted to how KXL will impact people! The federal study does not include a health impact assessment and the state of SD did not do a health impact assessment.

Medical Preparedness

Tar sands oil spills into Michigan's Kalamazoo River and into the community of Mayflower, Arkansas have demonstrated that medical communities must be prepared to respond to major oil spills and the specifics of benzene toxicity. Emergency response is mentioned in the 2010 permit, implying a response plan for cleaning up spills, but this does not describe an emergency medical response plan.

Acute Health Effects of the Enbridge Oil Spill (Kalamazoo) Michigan Department of Health identified 320 (58%) of 550 individuals with adverse health effects from four community surveys along the impacted waterways.

Figure 3



TransCanada's pamphlet "Oil Pipeline for Emergency Responders", contains absolutely no information geared toward health care providers. It simply says to "Monitor for I-EL, H S and benzene if possible". What lay person knows what that means? Are first responders equipped to test for benzene in the air?

TransCanada declares "Public disclosure of the emergency response plan could commercially disadvantage keystone." Not preparing the medical community for tar sands oil spills could physically disadvantage South Dakotans.

TransCanada has not communicated with Indian Health Services or South Dakota health care facilities medical information such as specifics about tar sands oil product, KXL spill scenarios, and staff education and training for effective treatment of people exposed to benzene. Treating adverse health effects from massive benzene toxicity is not usual for most health professionals.

The "Draft" TransCanada-Keystone Emergency Response Plan in the FSEIS, Appendix Q does not include medical response planning, only a place to list the nearest hospital.

I visited with Kevin Schlosser, Emergency Management Coordinator Avera McKennan in Sioux Falls (Assists Avera St. Mary's, Pierre, SD) He has not seen a Safety Data Sheet, SDS, describing chemicals involved in tar sands oil. He would like to know "What are we dealing with? What is the time-frame? When would it would reach us (in the water). I have not seen any of that. For decontamination purposes and for treating patients, we rely on a SDS. If they would provide a SDS, it would be kept in the Emergency Department to have readily available."

Kevin is not aware of education or training to prepare medical communities to affectively respond to major oil spills. TransCanada directed me to the FSEIS when I asked about an MSDS. The FSEIS gave samples of an MSDS, but stated they do not represent the actual product that would flow through the proposed Keystone XL pipeline. TransCanada has responded "TransCanada is not a medical provider and does not provide medical

information. The local medical authority has jurisdiction during an incident or emergency.”

Contamination of Public Water Intakes

GLENDIVE MONTANA, January 2015

“Breach in pipeline found; cancer-causing agent detected in water “
--- Billings Gazette

What happened in Glendive MT, could happen in SD. After an oil pipeline spilled miles upstream, benzene was found to be up to triple the mcl in the public water system. The residents weren’t warned not to drink the water until two days later! Because water treatment plants do not remove benzene, water plants must be shut down.

Are Water Treatment Plants Prepared in SD?

I contacted three water treatment plants using Missouri River water. Two plants responded they were unaware of any emergency plan in response to a tar sands oil spill directly or indirectly affecting the Missouri. One plant stated the Bureau of Reclamation would notify them if an oil spill threatened the water supply. Another plant stated DNR usually sends out information, but “haven’t heard a word from them” when asked what he knew about tar sands spillage into water. One plant thought benzene analysis was done quarterly and another plant thought benzene analysis was done yearly. The third plant did say a spill kit (for water analyses) is available for emergencies.

Dr. Madden Testimony

Testimonial analysis by Dr. Madden is woefully inadequate to meet SDCL 49-41 B-22. which requires the project must protect the health, safety and welfare of SD residents. He is not a medical doctor, but an economist

| INDUSTRY | SOURCE OF ECONOMIC IMPACTS | DIRECTION OF IMPACT | NET IMPACT |
|----------|-----------------------------------|---------------------|------------|
| HEALTH | Revenue | Positive | Positive |
| | Labor Costs | None Significant | |
| | Displacement of Traditional Users | None | |

Conclusion

Who is responsible for the health,safety and welfare of SD citizens? TransCanada responded these concerns were addressed by the commission, but the law clearly states the applicant is responsible.

SDCL 49-41 B-22 states: The applicant for a facility construction permit has the burden of proof to establish that:

“The facility will not substantially impair the health, safety or welfare of the inhabitants.”

TransCanada has not met the burden of proof establishing this project will not impair the health, safety or welfare of the good people of South Dakota and the many other US citizens living downstream.

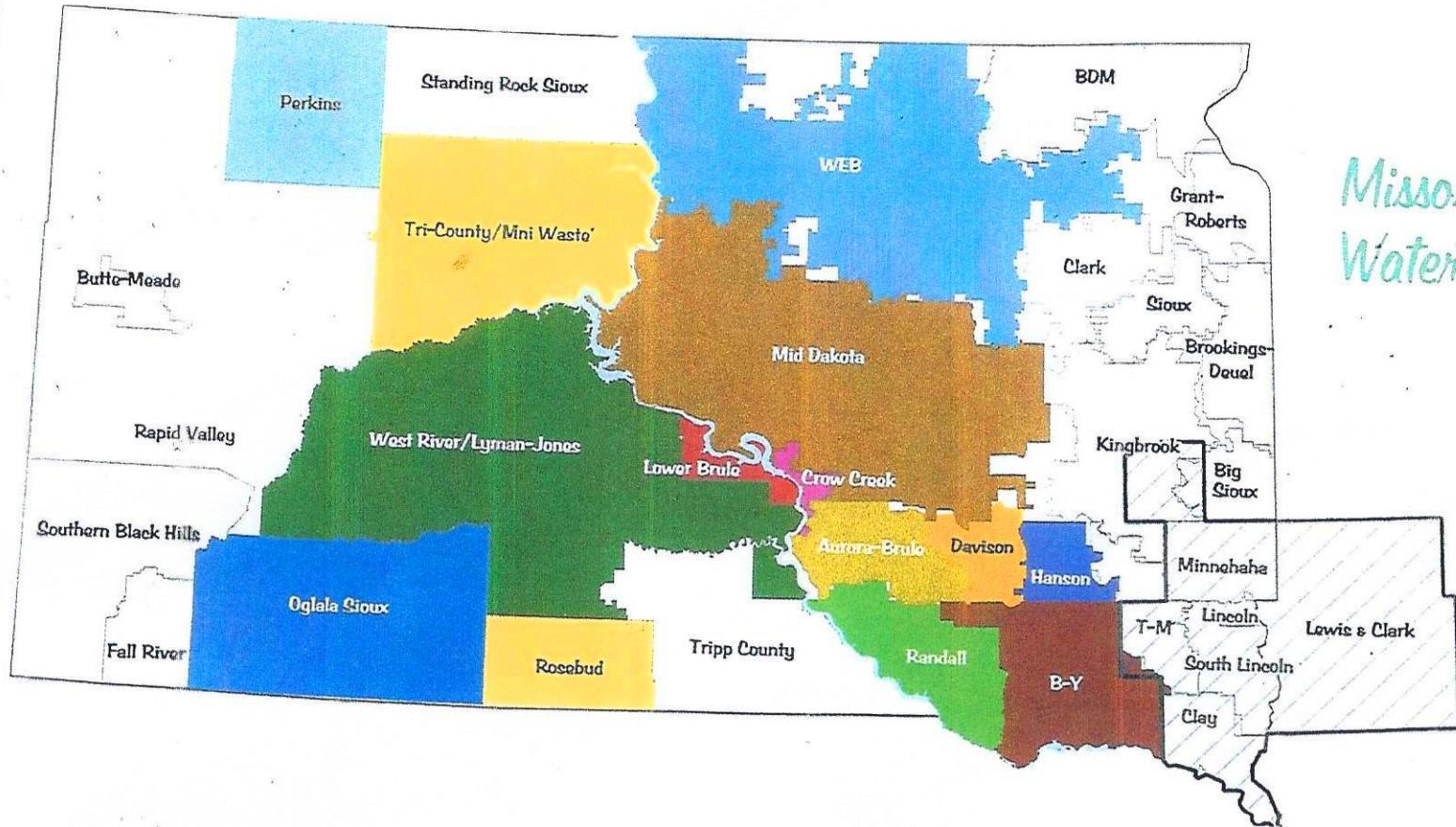
TransCanada affirmed to me “Keystone has not asserted that the project would have ‘no impact on the health, safety and welfare of SD’”.

CINDY MYERS, R.N.

April 2, 2015

Paul Seamans:

I have added up the counties populations of the rural water systems that rely on Missouri River water. It is hard to get an exact count because a lot of the water districts don't always follow county lines. I came up with an approximate 2010 census figure of 500,000 people that rely on Missouri River water. The 2010 census figures for South Dakota's population is 814,000. The percentage of South Dakota's population that gets their water from the Missouri would equal around 61%. The 2014 estimates have South Dakota's population at 853,000 and a large portion of that growth is in the Sioux Falls metro area so this figure would be closer to 64%. I think a person is real safe in saying that at least half of South Dakota relies on the Missouri River for their drinking water, in all actuality it is probably closer to two thirds.



Missouri River Water Systems

Analysis of Frequency, Magnitude and Consequence of Worst-Case spills from the Proposed Keystone XL Pipeline

John Stansbury, Ph.D., P.E.

Executive Summary

TransCanada is seeking U.S. regulatory approval to build the Keystone XL pipeline from Alberta, Canada to Texas. The pipeline will transport diluted bitumen (DilBit), a viscous, corrosive form of crude oil across Montana, South Dakota, Nebraska, Kansas, Oklahoma and Texas. As part of the regulatory process, the National Environmental Policy Act (NEPA) requires an assessment of the potential environmental impacts of a pipeline spill. The Clean Water Act (CWA) also requires TransCanada to estimate the potential worst-case discharge from a rupture of the pipeline and to pre-place adequate emergency equipment and personnel to respond to a worst-case discharge and any smaller spills. The Keystone XL environmental assessment documents (e.g., Draft Environmental Impact Assessment) as well as the environmental impacts documents for the previously built Keystone pipeline, can be found on the US State Department web site. It is widely recognized that the environmental assessment documents for the Keystone XL pipeline are inadequate, and that they do not properly evaluate the potential environmental impacts that may be caused by leaks from the pipeline (e.g., USEPA 2011a). The purpose of this paper is to present an independent assessment of the potential for leaks from the pipeline and the potential for environmental damage from those leaks.

The expected frequency of spills from the Keystone XL pipeline reported by TransCanada (DNV, 2006) was evaluated. According to TransCanada, significant spills (i.e., greater than 50 barrels (Bbls)) are expected to be very rare (0.00013 spills per year per mile, which would equate to 11 significant spills for the pipeline over a 50 year design life). However, TransCanada made several assumptions that are highly questionable in the calculation of these frequencies. The primary questionable assumptions are: (1) TransCanada ignored historical data that represents 23 percent of historical pipeline spills, and (2) TransCanada assumed that its pipeline would be constructed so well that it would have only half as many spills as the other pipelines in service (on top of the 23 percent missing data), even though they will operate the pipeline at higher temperatures and pressures and the crude oil that will be transported through the Keystone XL pipeline will be more corrosive than the conventional crude oil transported in existing pipelines. All of these factors tend to increase spill frequency; therefore, a more realistic assessment of expected frequency of significant spills is 0.00109 spills per year per mile (from the historical data (PHMSA, 2009)) resulting in 91 major spills over a 50-year design life of the pipeline.

The CWA requires that TransCanada estimate the “worst-case spill” from the proposed pipeline (ERP, 2009). TransCanada’s calculation of the worst-case spill from the proposed Keystone XL pipeline was not available at the time of this assessment, so an assessment of the methods used by TransCanada for the existing Keystone pipeline and a comparison of the results of those methods with the methods recommended in this analysis were made. The worst-case spill volume at the Hardisty Pumping Station on the Keystone (the original pipeline will be referred to as simply the Keystone pipeline while the proposed pipeline is the Keystone XL pipeline) pipeline predicted using methods recommended in this analysis was 87,964 barrels

(Bbl), while the worst-case spill predicted using TransCanada's methods was 41,504 Bbl (ERP, 2009). The difference is a factor of more than 2 times. The primary difference between the two methods was the expected time to shut down the pumps and valves on the pipeline. TransCanada used 19 minutes (TransCanada states that it expects the time to be 11.5 minutes for the Keystone XL pipeline). Since a very similar pipeline recently experienced a spill (the Enbridge spill), and the time to finally shut down the pipeline was approximately 12 hours, and during those 12 hours the pipeline pumps were operated for at least 2 hours, it is clear that the assumption of 19 minutes or 11.5 minutes is not appropriate for the shut-down time for the worst-case spill analysis. Therefore, worst-case spill volumes are likely to be significantly larger than those estimated by TransCanada. The worst-case spill volumes from the Keystone XL pipeline for the Missouri, Yellowstone, and Platte River crossings were estimated by this analysis to be 122,867 Bbl, 165,416 Bbl, and 140,950 Bbl, respectively. In addition, this analysis estimated the worst-case spill for a subsurface release to groundwater in the Sandhills region of Nebraska to be 189,000 Bbl (7.9 million gallons).

Among numerous toxic chemicals that would be released in a spill, the benzene (a human carcinogen) released from the worst-case spill into a major river (e.g., Missouri River) could contaminate enough water to form a plume that could extend more than 450 miles at concentrations exceeding the Safe Drinking Water Act Maximum Contaminant Level (MCL) (i.e., safe concentration for drinking water). Therefore, serious impacts to drinking water intakes along the river would occur. Contaminants from a release at the Missouri or Yellowstone River crossings would enter Lake Sakakawea in North Dakota where they would adversely affect drinking water intakes, aquatic wildlife, and recreation. Contaminants from a spill at the Platte River crossing would travel downstream unabated into the Missouri River for several hundred miles and affect drinking water intakes for hundreds of thousands of people in cities like Lincoln, NE; Omaha, NE; Nebraska City, NE; St. Joseph, MO; and Kansas City, MO, as well as aquatic habitats and recreational activities. In addition, other constituents from the spill would pose serious risks to aquatic species in the river. The Missouri, Yellowstone, and Platte Rivers all provide habitat for threatened and endangered species including the pallid sturgeon, the interior least tern, and the piping plover. A major spill in one of these rivers could pose a significant threat to these species.

The benzene released by the worst-case spill to groundwater in the Sandhills region of Nebraska would be sufficient to contaminate 4.9 billion gallons of water at concentrations exceeding the safe drinking water levels. This water could form a plume 40 feet thick by 500 feet wide by 15 miles long. This plume, and other contaminant plumes from the spill, would pose serious health risks to people using that groundwater for drinking water and irrigation.

Introduction

TransCanada is seeking U.S. regulatory approval to build the Keystone XL pipeline from Alberta, Canada to Texas. The pipeline will transport diluted bitumen (DilBit), a viscous, corrosive form of crude oil across Montana, South Dakota, Nebraska, Kansas, Oklahoma, and Texas. As part of the regulatory process, TransCanada is required by the National Environmental Policy Act (NEPA) to evaluate the potential environmental impacts of a pipeline spill. The Clean Water Act (CWA) also requires TransCanada to estimate the potential worst-case discharge from a rupture of the pipeline and to pre-place adequate emergency equipment

and personnel to respond to a worst-case discharge and any smaller spills. The Keystone XL environmental assessment documents (e.g., Draft Environmental Impact Assessment) as well as the environmental impacts documents for the previously built Keystone pipeline, can be found on the US State Department web site. It is widely recognized that the environmental assessment documents for the Keystone XL pipeline are inadequate, and that they do not properly evaluate the potential environmental impacts that may be caused by leaks from the pipeline (e.g., USEPA, 2011a). The purpose of this paper is to present an independent assessment of the potential for leaks from the pipeline and the potential for environmental damage from those leaks.

In addition to evaluating potential environmental damage from pipeline leaks, TransCanada is required by law to pre-position emergency equipment and personnel to respond to any potential spill. This paper does not address these requirements. However, an independent assessment of TransCanada's emergency response plans for the previously built Keystone pipeline was done by Plains Justice (Blackburn, 2010). This document clearly shows that the emergency response plan for the Keystone pipeline is woefully inadequate. Considering that the proposed Keystone XL pipeline will cross much more remote areas (e.g., central Montana, Sandhills region of Nebraska) than was crossed by the Keystone pipeline, there is little reason to believe that the emergency response plan for Keystone XL will be adequate.

Since spills from these pipelines will occur, and since they will be extremely difficult and expensive to clean up (likely tens to hundreds of millions of dollars), it is imperative that TransCanada be required to be bonded for these clean-up costs before any permits are granted. This proposed requirement is supported by the recent Enbridge spill, where a smaller crude-oil pipeline leak released crude oil into a tributary of the Kalamazoo River, and early clean-up costs, as reported in Enbridge's annual report, have exceeded \$500 million (Enbridge, 2011).

Worst-Case Spill

One of the requirements of the CWA is to calculate the worst-case potential spill from the pipeline. An assessment of the potential worst-case spill from the Keystone pipeline was conducted by TransCanada; however, some of the methods and assumptions in that assessment are in question. The primary focus of this paper is to provide an independent assessment of the worst-case spill from the Keystone XL pipeline and to compare that to the assessment done by TransCanada.

Spill frequency

To support understanding of the potential impacts due to releases from the pipeline, an assessment of the likely frequency of spills from the pipeline is made. TransCanada calculated the likely frequency of a pipeline spill for the Keystone XL pipeline in the Draft Environmental Impact Statement (ENTRIX, 2010) using statistics from the Pipeline and Hazardous Materials Safety Administration (PHMSA). Nation-wide statistics from PHMSA for spills from crude oil pipelines show 0.00109 significant (i.e., greater than 50 Bbl) spills per mile of crude oil pipelines per year. When this rate is applied to the Keystone XL pipeline with a length of 1,673 miles, the

expected frequency of spills is 1.82 spills per year ($0.00109 \text{ spills/mi} \times 1,673 \text{ mi}$). Adjusting the nation-wide PHMSA data to only include data from the states through which the Keystone XL pipeline will pass results in a frequency of 3.86 spills per year for the pipeline length (ENTRIX, 2010). The state-specific data are more applicable to the Keystone location; however, the smaller state-specific data base might over-estimate spill frequency. Therefore, the frequency of 1.82 per year is adopted as the best available value for this assessment. Assuming a design life of 50 years for the pipeline, 1.82 spills per year results in 91 expected significant spills (i.e., greater than 50 barrels) for the Keystone Pipeline project. According to the TransCanada Frequency-Volume Study of the Keystone Pipeline (DNV, 2006), 14 percent of the spills would likely result from a large hole (i.e., greater than 10 inches in diameter). Using the 14 percent value, the 91 expected spills during a 50-year lifetime for the pipeline would result in 13 major spills (i.e., from holes larger than 10 inches in the pipeline).

However, TransCanada diverged from historical data and modified the estimate of the expected frequency of spills from the pipeline (DNV, 2006). The company's primary rationale for reducing the frequency of spills from the pipeline was that modern pipelines are constructed with improved materials and methods. Therefore, TransCanada assumed that pipelines constructed with these new improved materials and methods are likely to experience fewer leaks. The revised expected frequency for spills was reported in the Frequency-Volume Study (DNV, 2006) to be 0.14 spills/year over the 1,070 miles from the Canadian border to Cushing, OK. This value was adjusted to 0.22 spills per year for the total 1,673 miles of pipeline, including the Gulf Coast Segment (ENTRIX, 2010). Using the 0.22 spills/year, TransCanada predicted 11 spills greater than 50 barrels would be expected over a 50-year project life.

This reduced frequency estimated by TransCanada is probably not appropriate for a couple of reasons. First, the study of the revised frequency ignored some of the historical spill data; i.e., the spill cause category of "other causes" in the historical spill data set (DNV, 2006). The "other causes" category was assigned for spills with no identified causes. Since this category represents 23 percent of the total spills, this is a significant and inappropriate reduction from the spill frequency data. In addition, the assumed reduction in spill frequency resulting from modern pipeline materials and methods is probably overstated for this pipeline. TransCanada used a reduction factor of 0.5 in comparison to historical data for this issue. That is, according to TransCanada, modern pipeline construction materials and methods would result in half as many spills as the historical data indicate. However, the PHMSA data used in the TransCanada report were from the most recent 10 years. Therefore, at least some of the pipelines in the analysis were modern pipelines. That is, the initial frequency estimate was calculated in part with data from modern pipelines; therefore, a 50 percent reduction of the frequency estimates is highly questionable based on the data set used. More importantly, DilBit, the type of crude oil to be transported through the Keystone XL pipeline will be significantly more corrosive and abrasive than the conventional crude oil transported in most of the pipelines used in the

historical data set. The increased corrosion and abrasion are due to 15 – 20 times the acidity (Crandall, 2002), 5 – 10 times the sulfur content (Crandall, 2002), and much higher levels of abrasive sediments (NPRA, 2008) compared to conventional crude oil. In addition, the high viscosity of DilBit requires that the pipeline be operated at elevated temperatures (up to 158°F for DilBit and ambient temperature for conventional oil) and pressures (up to 1440 psi for DilBit and 600 psi for conventional oil) compared to conventional crude oil pipelines (ENTRIX, 2010). Since corrosion and pressure are the two most common failure mechanisms resulting in crude oil releases from pipelines (DNV, 2006), increased corrosion and pressure will likely negate any reduced spill frequency due to improvement in materials and methods. Although pipeline technology has improved, new pipelines are subject to proportionally higher stress as companies use this improved technology to maximize pumping rates through increases in operational pressures and temperatures, rather than to use this improved technology to enhance safety margins.

Also, TransCanada relies heavily on “soft” technological improvements, such as computer control and monitoring technology, rather than only on “hard” improvements, such as improved pipe fabrication technology. Whereas “hard” technological improvements are built into pipelines, “soft” improvements require an ongoing commitment of monitoring and maintenance resources, which should not be assumed to be constant over the projected service life of the pipeline, and are also subject to an ongoing risk of error in judgment during operations. As demonstrated by the spill from Enbridge’s pipeline into the Kalamazoo River, as pipelines age maintenance costs increase, but pipeline company maintenance efforts may be insufficient to prevent major spills, especially if operators take increased risks to maintain return on investment. Moreover, TransCanada assumes that future economic conditions will allow it to commit the same level of maintenance resources from its first year to its last year of operation. Given future economic uncertainty, this is not a reasonable assumption. It is reasonable to assume that decades from now TransCanada or a future owner will likely fail to commit adequate maintenance resources, fail to comply with safety regulations, or take increased operational risks during periods of lower income. Overtime, PHMSA should assume that the risk of spill from the Keystone XL Pipeline will increase due to weakening of “soft” technological enhancements. Over the service life of the pipeline it is not reasonable to rely on TransCanada’s “soft” technological improvements to the same extent as built-in “hard” improvements.

The TransCanada spill frequency estimation consistently stated the frequency of spills in terms of spills per year per mile. This is a misleading way to state the risk or frequency of pipeline spills. Spill frequency estimates averaged per mile can be useful; e.g., for extrapolating frequency data across varying pipeline lengths. However, stating the spill frequency averaged per mile obfuscates the proper value to consider; i.e., the frequency of a spill somewhere along the length of the pipeline. Stating the spill frequency in terms of spills per mile is comparable

to acknowledging that although some 33,000 deaths from automobile accidents occur annually in the U.S., the average annual fatality rate across 350 million people is only 0.000094; therefore, fatalities from automobile accidents are so rare as to be unimportant. In other words, it is of little importance to know the risk (frequency) of a release in any particular mile segment (frequency per mile); rather it is important to know the risk of a release from the pipeline. As shown above, the expected number of spills for the pipeline over the pipeline lifetime ranges between 11 and 91 spills, depending on the data and assumptions used.

In summary, there is no compelling evidence to reduce the frequency of spills because of modern materials and methods. The increased corrosiveness and erosiveness of the product being transported will likely cancel any gains due to materials and methods improvements and soft technological safeguards will likely become less effective over time. Moreover, the modified frequency stated by TransCanada should not have been reduced by omitting an important failure category. The frequency of spills should have been stated as frequency of spills across the pipeline length per year and per pipeline lifetime. Therefore, the best estimate for spill frequency is the value from the PHMSA historical data set resulting in 1.82 spills/yr or 91 significant spills over the pipeline lifetime. Table 1 compares the predicted number of spills over the lifetime of the pipeline computed from TransCanada's assumptions and from historical data.

Table 1: Predicted Number of Spills from Keystone XL Pipeline Over a 50-Year Lifetime.

| | TransCanada Estimate | Estimates Using Historical Data |
|--------------------------------------|------------------------|---------------------------------|
| Spills per year per mile | 0.00013 ^(a) | 0.00109 ^(a) |
| Pipeline spills per year | 0.22 ^(b) | 1.82 ^(b) |
| Pipeline spills per 50-year lifetime | 11 ^(c) | 91 ^(c) |
| Pipeline spills from > 10 inch hole | 1.54 ^(d) | 12.74 ^(d) |

(a) ENTRIX, 2010

(b) spills/year-mile * 1673 miles

(c) spills/year * 50 years of pipeline lifetime

(d) spills/lifetime * 14percent spills from > 10 inch hole

Most Likely Spill Locations

Crude oil could be spilled from any part of the pipeline system that develops a weakness and fails. Likely failure points include welds, valve connections, and pumping stations. A vulnerable location of special interest along the pipeline system is near the side of a major stream where the pipeline is underground but at a relatively shallow depth. At these locations, the pipeline is susceptible to high rates of corrosion because it is below ground (DNV, 2006). Since the pipeline is below ground, small initial leaks due to corrosion-weakened pipe would potentially go undetected for extended periods of time (e.g., up to 90 days) (DNV, 2006) providing conditions for a catastrophic failure during a pressure spike. In these locations,

pressures would be relatively high due to the low elevation near the river crossing. In addition, major leaks at these locations are likely to result in large volumes of crude oil reaching the river.

In addition to river crossings, areas with shallow groundwater overlain by pervious soils (such as the Sandhills region in Nebraska) where slow leaks could go undetected for long periods of time (e.g., up to 90 days) (DNV, 2006), pose risks of special concern.

Worst Case Spill Volume

The volume of a spill is calculated in two parts: the pumping rate volume and the drain-down volume. The pumping rate volume is the volume of crude oil that is pumped from the leaking pipe during the time between the pipe failure and stoppage of the pumps. The time to shut down the pumps after a leak can be divided into two phases: the time to detect the leak, and the time to complete the shut-down process. The pumping rate volume also depends on the size of the hole in the pipe and the pressure in the pipe. The drain-down volume is the volume of crude oil that is released after the pumps are stopped, as the crude oil in the pipe at elevations above the leak drains out. The following sections explain how the pumping rate volume, the drain-down volume, and the total spill volume are calculated.

Pumping Rate Volume

The pumping rate volume is calculated as:

$$PRV = PR * (DT + SDT)$$

Where:

PRV = pumping rate volume (Bbl)

PR = pumping rate (Bbl/min)

DT = detection time (time required to detect and confirm a leak and order pipeline shut-down (min))

SDT = shut-down time (time required to shut down pumps and to close valves (min))

TransCanada's Frequency-Volume Study (DNV, 2006) states that detection of a leak in an underground pipeline section can range from 90 days for a leak less than 1.5 percent of the pipeline flow rate to 9 minutes for a leak of 50 percent of the pipeline flow rate. The 90-day time to detection is for a very slow leak that would not be detected by the automatic leak detection system. The 9 minute time to detection is for a leak that is large enough to be readily detected by the leak detection system. However, this time estimate is questionable because, as has been shown by experience, it is difficult for the leak detection system to distinguish between leaks and other transient pressure fluctuations in a pipeline transporting high viscosity materials such as DilBit. For example, in the Enbridge pipeline spill, signals from the leak detection system were misinterpreted, and up to 12 hours elapsed between the time of the

leak and final pipeline shut-down (Hersman, 2010). During the 12-hour period between the initial alarm and the final shut-down, the pipeline pumps were operated intermittently for at least two hours. It should be noted that the location of the Enbridge spill was a populated area where field verification of the leak should have been quick and easy. Indeed, local residents called 911 complaining about petroleum odors (likely from the leak) 10 hours before the pipeline was shut down. In the case of the Keystone XL pipeline, leaks could occur in remote areas (e.g., central Montana, or the Sandhills region of Nebraska) where direct observation would only occur by sending an observer to the suspected site; this could take many hours.

TransCanada states that the time to complete the pipeline shut-down sequence is 2.5 minutes (ERP, 2009). Therefore, using TransCanada's time estimates, for a 1.5 percent leak, the total time between leak initiation and shut-down could be up to 90 days, and for a large (>50 percent) leak, the total time between leak initiation and shut-down would be 11.5 minutes (ERP, 2009).

However, given the difficulty for operators to distinguish between an actual leak and other pressure fluctuations, the shut-down time for the worst case volume calculation should not be considered to be less than 30 minutes for a leak greater than 50 percent of the pumping rate. This would allow for 4 alarms (5 minutes apart) to be evaluated by operators and a 5th alarm to cause the decision to shut down. In addition, the time to shut down the systems (pumps and valves) would require another 5 minutes. The assumption that the decision to shut the pipeline down can be made after a single alarm, as is suggested by TransCanada (ERP, 2009) is unreasonable considering the difficulty in distinguishing between a leak and a pressure anomaly. The ability to make the decision to shut down the pipeline after 5 alarms is likely a reasonable "best-case" assumption. However, this "best-case" does not describe the "worst case" conditions that are being assessed here. Rather, the worst case should consider confusing and confounding circumstances where a shut-down decision is not clear and where the leak site is remote and not verifiable in a short time period. The total time is then considered to be between 30 minutes (a best-case scenario) and 12 hours (the time for the Enbridge final shut-down) from leak initiation to shut-down. Considering that the Keystone XL pipeline will cross extremely remote areas and that verification of a leak could take many hours, a shut-down time of 2 hours (i.e., the time the pumps were operated during the Enbridge shutdown process) is a reasonable time for the worst-case analysis.

Therefore, for the worst-case spill for a large leak, a shut-down time of 2 hours is assumed. With a maximum pumping rate of 900,000 Bbl/d, and a shut-down time of 2 hours, the pumping rate volume is 75,000 Bbl ($900,000 \text{ Bbl/d} \times 1 \text{ d}/24 \text{ hr} \times 2 \text{ hr}$). This pumping rate volume (75,000 Bbl) is used in the calculation of the total worst-case spill volume for all high-rate leaks (i.e., greater than 50 percent flow-rate).

The worst-case spill for a small leak could occur where the pipeline is buried and in a remote location (such as central Montana or the Sandhills region of Nebraska), and where

direct observation would be infrequent. According to TransCanada documents (DNV, 2006), a slow leak of less than 1.5 percent of the pumping rate could go undetected for up to 90 days. However, since pipeline inspections are scheduled every few weeks, it is likely that the oil would reach the surface and be detected before the entire 90 days elapsed. Assuming that the pipeline is buried at a depth of 10 feet and that the 1.5 percent leak (75,802 ft³/d) is on the bottom of the pipe, oil would fill the pore spaces in the soil mostly in a downward direction, but it would also be forced upward toward the surface. Assuming that the oil initially fills a somewhat conical volume that extends twice as far below the pipeline as above it, the oil would emerge at the surface within about one day (volume of a cone 30 feet deep with a base diameter of 30 feet is 7,068 ft³). Therefore, the leak would likely be detected in 14 days during the next inspection (assuming bi-weekly inspections). A 1.5 percent spill at a pumping rate of 900,000 Bbl/d over 14 days would result in a release of 189,000 Bbl (7.9 million gallons).

Table 2: Pumping Rate Volume for Various Sized Leaks

| Leak as percent of Pumping Rate ^(a) | Detection and Shut-Down Time | Pumping Rate Volume ^(d) |
|--|------------------------------|------------------------------------|
| <1.5percent | 14 days ^(b) | 189,000 Bbl |
| 100percent | 2 hours | 75,000 Bbl |
| 100percent | 11.5 minutes ^(c) | 7,188 Bbl |

(a) Design pumping rate for Keystone XL = 900,000 Bbl/d. Calculation of worst-case spill requires 100 percent of pumping rate.

(b) Time between pipeline inspections.(DNV, 2006)

(c) TransCanada's assumed shut-down time (ERP, 2009)

Drain-Down Volume

The drain-down volume is the volume in the pipe between the leak and the nearest valve or the nearest high point. Some oil in locally isolated low spots will tend to remain in the pipe. TransCanada arbitrarily assigned a drain-down factor of 0.6 for the Keystone XL pipeline, meaning that 40 percent of the oil in the draining pipeline at elevations above the leak will be captured in low spots. However, since siphon effects will tend to move much of the oil even in local low spots, the 40 percent retention factor is likely too high for a worst-case analysis. PHMSA regulations require valves to be placed on either side of a major water crossing. If these valves are working, they should limit the amount of crude oil that drains from the pipeline to the amount that is between the valves. However, to calculate a worst case spill, the volume should be calculated assuming that at least some of the valves fail (recall the failures of the safety devices in the recent Gulf oil spill). If the valves fail, the drain-down volume would be limited by the major high elevation points on either side of the leak, with a reasonable adjustment for residual crude oil remaining in the pipeline. For this worst-case analysis, a reasonable estimate for residual crude oil remaining in the pipeline is assumed at 20percent of the total volume of oil at elevations above the leak. All of these parameters are site-specific; therefore, for this assessment, the worst case drain-down volumes will be calculated for several

of the river crossings of the Keystone XL pipeline, including the Missouri, Yellowstone, and Platte Rivers.

The drain-down volume is calculated using:

$$DDV = PLDV * DF$$

Where:

DDV = Drain Down volume (Bbl)

PLDV = Pipeline Drain Volume (Bbl) (volume of pipeline either side of the leak to next valve or high elevation point)

DF = Drainage Factor (80percent)

Worst-Case Release Calculation for the Missouri River Crossing

The Missouri River crossing is located at mile post (MP) 89 along the Keystone XL pipeline. The upstream valve is located at MP84, and the downstream valve is located at MP 91. The river is at an elevation of 2,035 feet. Figure 1 shows the elevation profile of the crossing at the Missouri River. Since there are no major high elevations between the river and the valve at MP 84, it is likely that nearly all of the oil in the pipeline between the valve and a hypothetical leak at the river will be siphoned or drained via gravity. If the valve at MP 84 fails, all of the oil in the pipeline between that point and the next valve (MP 81.5) could drain since the pipeline rises gradually in elevation between MP 84 and MP 81 (elevation of 2,225 feet). If the valve on the downstream side of the crossing (MP 91) fails, oil in the pipeline up to the major high point at MP 93 could drain to the hypothetical leak at the river crossing.

There are several scenarios that could affect the drain-down volume. In the worst-case scenario both valves could fail, and the drain-down volume would then be the cross-sectional area of the pipe, times the length of pipeline draining times 80 percent. For this scenario, the length of pipe is 11.5 miles (MP 81.5 to MP 93). The cross-sectional area of the 36 inch pipe is 7.07 ft². Thus the drain-down volume is 3.43x10⁵ ft³ (61,164 Bbls, 2.57 million gallons). However it is highly unlikely that both valves will fail at the same time.

A second scenario would occur if both valves operated correctly but the siphon effect removed the oil from the high point downstream of the valve at MP 84. Under this scenario, the length of drained pipe is 7 miles, and the resulting drain-down volume is 2.09x10⁵ ft³ (37,230 Bbls, 1.56 million gallons).

A third scenario would occur if both valves operated correctly, and the siphon effect did not remove the oil between the high point at MP 86.5 and the valve at MP 84. In this scenario, the length of drained pipe is 4.5 miles (valve at MP 91 to the high point at MP 86.5), and the drain-down volume is 1.34x10⁵ ft³ (23,934Bbls, 1.01 million gallons).

A fourth scenario would occur if one of the valves fails. To be conservative, the valve closest to the river will be the assumed failed valve. In this scenario, the drain-down distance

would be 9 miles (between the valve at MP 84 and the high point at MP 93). The resulting drain-down volume would be $2.69 \times 10^5 \text{ ft}^3$ ($9 \text{ mi} * 5,280 \text{ ft/mi} * 7.07 \text{ ft}^2 * 0.8$) (47,867 Bbl, 2.01 million gallons).

While the first scenario is very unlikely, valve failure is a reasonable consideration in the worst-case spill analysis. So for the purposes of this analysis the fourth scenario, where one of the valves fails, is used to calculate the worst-case spill drain-down volume for the Missouri River crossing site. Therefore, using the fourth drain-down scenario, the drain-down volume is 47,867Bbls. Adding the pumping rate volume of 75,000 Bbl, the worst-case release volume for the Missouri River crossing is 122,867 Bbl (5.16 million gallons).

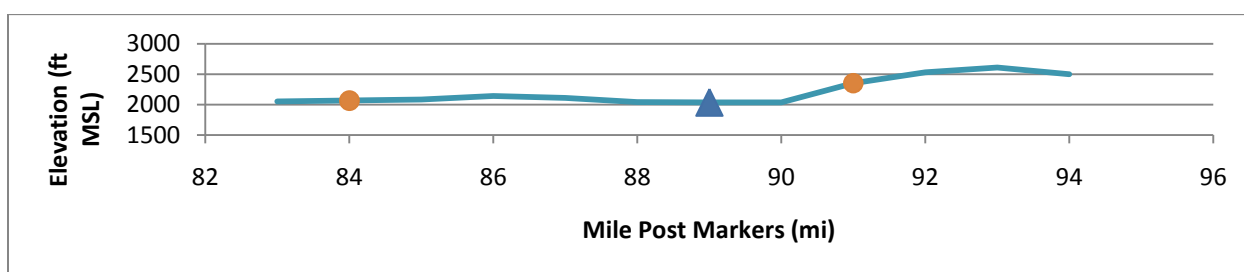


Figure 1: Horizontal profile of surface elevations at the Missouri River crossing. Note that the vertical axis is exaggerated compared to the horizontal axis. Solid circles show locations of pipeline valves. The solid triangle shows the location of the river crossing.

Worst Case Release Volume Calculation for the Yellowstone River

The crossing on the Yellowstone River is at MP 196.5 which is at an elevation of 2,125 feet. The closest upstream valve is at MP 194.5 at an elevation of 2,230 feet. The nearest major high point on the upstream side is at MP 183 at an elevation of 2,910 feet. The closest valve on the downstream side is at MP 200 at an elevation of 2,506 which is also the high point on the downstream side of the crossing. Figure 2 shows the elevation profile for the crossing at the Yellowstone River.

The first scenario for drain-down volume is if all valves work properly. The drain-down volume is 80 percent of the volume between the valves (the cross-sectional area of the pipe (7.07 ft^2) times the pipe length between the valves (5.5. miles)) which equals $1.64 \times 10^5 \text{ ft}^3$ (29,252 Bbl, 1.23 million gallons).

Another scenario considers the volume if the valve at MP 194.5 does not work. In this case, the drain-down volume is the volume of the pipe between the two high elevations which are at MP 183 and MP 200 (17 miles). In this scenario the drain-down volume is $5.07 \times 10^5 \text{ ft}^3$ (90,416 Bbl, 3.80 million gallons). Assuming failure of the valve at mile-post 194.5 is a reasonable assumption for conditions of the worst-case spill volume. The total worst-case volume is then

the drain-down volume of 90,416 Bbl plus the pumping rate volume of 75,000 Bbl totaling 165,416 Bbl (6.95 million gallons).

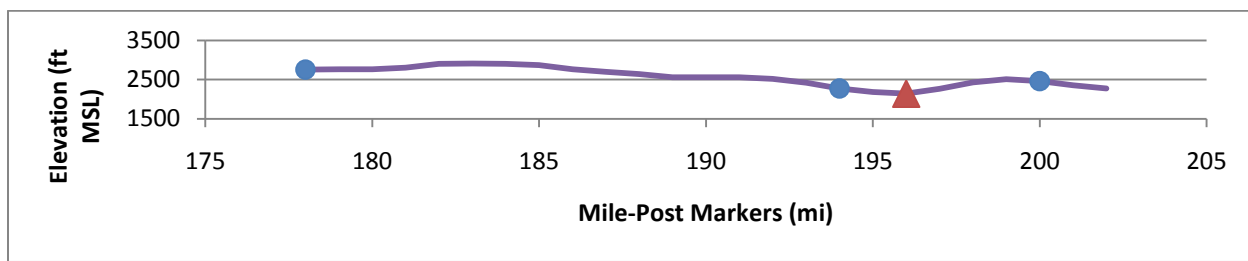


Figure 2: Horizontal profile of surface elevations at the Yellowstone River crossing. Note that the vertical axis is exaggerated compared to the horizontal axis. Solid circles show locations of pipeline valves. The solid triangle shows the location of the river crossing.

Worst-Case Release Volume Calculation for the Platte River, NE

The Keystone XL Pipeline is proposed to cross the Platte River in Nebraska at MP 756.5. There is an upstream valve at MP 747.6 and a downstream valve at MP 765. Figure 3 shows the elevation profile for the crossing at the Platte River. A reasonable worst-case spill scenario is to consider the valve at MP 765 (i.e., closest to the river) to fail. The drain-down volume would then be the pipeline volume between the high point at MP 760 and the valve at MP 747.6. The resulting drain-down volume would be $3.70 \times 10^5 \text{ ft}^3$ (65,950 Bbl, 2.77 million gallons). Adding the pumping rate volume, the worst-case spill at the Platte River crossing would be 140,950 Bbl (5.92 million gallons).

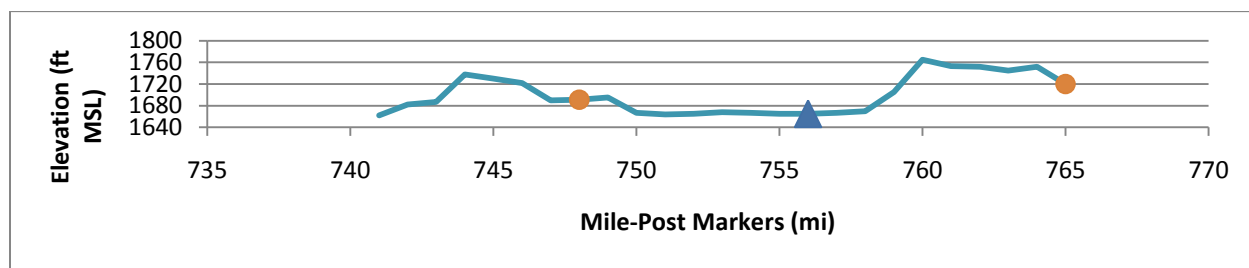


Figure 3: Horizontal profile of surface elevations at the Platte River crossing. Note that the vertical axis is exaggerated compared to the horizontal axis. Solid circles show locations of pipeline valves. The solid triangle shows the location of the river crossing.

Table 3: Worst-Case Spill Volume Estimates.

| Location | Estimate from this analysis | | |
|-------------------|-----------------------------|-------------------------|---------------------|
| | Pumping Rate Volume (Bbl) | Drain Down Volume (Bbl) | Total Release (Bbl) |
| Groundwater | 189,000 ^(a) | NA | 189,000 |
| Missouri River | 75,000 ^(b) | 47,867 ^(c) | 122,867 |
| Yellowstone River | 75,000 ^(b) | 90,416 ^(c) | 165,416 |
| Platte River | 75,000 ^(b) | 65,950 ^(c) | 140,950 |

(a) 900,000 Bbl/d (Keystone XL design pumping rate) * 1.5 percent leak * shut-down time of 14 days

(b) 900,000 Bbl/d (Keystone XL design pumping rate) * shut-down time of 2 hours

(c) Expected volume to drain from ruptured pipeline after pumps and valves closed

Comparison to TransCanada methods

TransCanada calculated the total Worst-Case Release Volume in a way that appears to be flawed. The worst-case volume was calculated from (ERP, 2009):

$$WCV = ALV + PRV$$

Where:

WCV = worst-case volume (Bbl)

ALV = adjusted line volume (Bbl)

PRV = pumping rate volume (Bbl) i.e., pumping rate (Bbl/min) * time to shut-down (min)

The adjusted line volume was calculated from:

$$ALV = (ILFV - PRV) * 0.60$$

Where:

ILFV = initial line fill volume (Bbl) i.e., the volume of the pipe between the leak and the nearest valve on both sides of the leak.

0.60 = drain-down factor where 60percent of the oil in the pipe will drain after shut-down.

For the Hardisty Pump Station/Regina Pump Station (Keystone pipeline) calculation, the ILFV was stated as 63,346 Bbl. The pumping rate was 662,400 Bbl/day, and the time to shut down was 19 minutes (10 minutes of evaluation of whether a leak had occurred and 9 minutes to shut down the system). This resulted in a PRV of 8,740 Bbl, and an ALV of 32,763 Bbl. The ALV plus the PRV resulted in a total release of 41,503 Bbl.

TransCanada does not explain how the initial line fill volume is calculated. They simply provide a value (ERP, 2009). For the Hardisty Pump Station/Regina Pump Station calculation, they state the value to be 63,346 Bbl. There is no way to verify this value. Whatever method was used, the value should be the pipeline volume between the leak and the high points of elevation on both sides of the leak. TransCanada then, in what appears to be a flawed process, subtracts the pumping rate volume from the initial line fill volume. It is not clear why this

subtraction was done. Apparently, TransCanada considered that since the PRV would be pumped out of the pipeline during the leak discovery and shutdown time, that volume of oil would not be still in the pipeline during draining. However, even though the PRV would be removed from the pipeline during shutdown time, an equal amount would be pumped into the draining section. Therefore, the DDV should be calculated as simply the volume of the draining pipeline modified by the fraction of oil trapped in local low points. That is, the PRV should not have been subtracted from the ILFV. The result of subtracting the PRV from the ILFV was then multiplied by 0.60 to account for 40 percent of the oil in the pipe being caught in locally low spots in the pipeline and failing to drain out. Certainly some of the oil in the pipe will fail to drain, especially in locally low spots; however, considering siphon effects, it is very likely that nearly all of the oil will drain even through the locally low spots. Therefore, the 60 percent drain factor is likely to be a significant underestimate of the fraction of oil that will drain. For this worst case spill analysis, a drainage factor of 80 percent is a more reasonable assumption.

Table 4 shows the PRV, DDV, and total worst-case release estimates for the Hardisty Pumping Station on the original Keystone pipeline using methods recommended in this analysis and methods used by TransCanada (ERP, 2009). Note that the PRV values using the method of this paper are much larger than those using TransCanada's method because the assumed shut-down time is much shorter in TransCanada's method (19 minutes compared to 2 hours). The drain-down volumes used for both methods are the reported drain-down volumes from TransCanada's method because sufficient detail was not available in the TransCanada report (ERP, 2009) to allow a comparison of methods.

Table 4: Worst-Case spill volume estimate using the method recommended in this analysis and the method used by TransCanada for the Keystone Pipeline.

| | Estimate from this Paper | | | TransCanada Estimate ^(a) | | |
|--------------------------|--------------------------|-----------------------|---------------------|-------------------------------------|-----------------------|---------------------|
| | PRV (Bbl) | DDV (Bbl) | Total Release (Bbl) | PRV (Bbl) | DDV (Bbl) | Total Release (Bbl) |
| Hardisty Pumping Station | 55,200 ^(b) | 32,764 ^(c) | 87,964 | 8,740 ^(d) | 32,764 ^(c) | 41,504 |

(a) ERP, 2009

(b) Pumping rate volume = 662,400 Bbl/d (Hardisty) * shut-down time of 2 hours

(c) Drain-down volume reported by TransCanada (ERP, 2009)

(d) Pumping rate = 662,400 Bbl/d * shut-down time of 19 min

Impacts from Worst-Case Spill

Impacts to the Air

The primary impacts to the air will be from benzene, hydrogen sulfide, and light molecular weight constituents of the DilBit. The DilBit will be pumped at high temperatures (up

to 158°F) and pressures (up to 1440 psi) causing these compounds to volatilize into the air at the site of the spill. The Occupational Health and Safety Agency (OSHA) acceptable concentration of benzene in the air for a workplace is 3.25 mg/m³ (NIOSH, 1990) for short-term (8-hour) exposures. Since benzene is denser than air, it could accumulate in low-lying areas that are protected from the wind. Under these conditions, the benzene concentration could be above acceptable levels for inhalation. The basements of buildings located above groundwater plumes could also trap benzene gases that exceed safe levels. This could have serious consequences for the occupants of such a building, who may not be aware that a plume of benzene lies beneath the building.

Hydrogen sulfide is another toxic gas that could cause dangerous conditions at the site. The OSHA acceptable concentration for a workplace is 14 mg/m³ for an 8-hour exposure and 21 mg/m³ for even a momentary exposure (NIOSH, 1990). The concentrations of hydrogen sulfide in the air are expected to be above acceptable levels in areas near a spill site (Enbridge, 2010) and will likely be a serious health threat to emergency workers, remediation workers, and possibly to local residents.

In addition to toxicity effects, benzene, hydrogen sulfide, and the light molecular weight fractions of the oil could create explosive conditions as they volatilize from the spilled oil. Again, this risk will be greatest in areas that are protected from the wind and where concentrations could reach the explosive limits.

Impacts to Terrestrial Resources

The proposed pipeline will cross numerous types of terrestrial habitats (e.g., upland prairies, lowland prairies, woodlands, northern high plains, etc.) as it passes from Canada to Texas. Each of these habitats is unique in terms of its physical conditions (e.g., soils, climates), biological communities, and human communities. Because the physical, biological, and human conditions are so varied in these habitats, the potential impacts from a spill will be different for each type of habitat and location. Therefore, it is not possible to thoroughly assess the potential impacts to terrestrial habitats in this paper.

In general, a primary negative impact caused by a crude oil spill on land will be burial and smothering of plants and ground-dwelling animals. The spilled DilBit will form a very dense and thick layer over the ground that will kill essentially any organisms that are contacted. This effect will be localized to the immediate area of the spill, and most animals will be able to avoid contact with the oil. However, some animals may inadvertently contact the oil (e.g., birds landing in the oil) and be harmed or killed. In addition, the spill will release toxic constituents such as benzene, hydrogen sulfide, light molecular weight oil fractions, and polycyclic aromatic hydrocarbons (PAHs), all of which will have toxic effects on local wildlife. A significant concern arises when the pipeline crosses habitats of the numerous threatened or endangered species

that are found along the pipeline route. Finally, the spill could affect human communities via exposures to the toxic constituents.

Impacts to Surface Water Resources

The primary constituents of concern in surface water are: benzene, PAHs, hydrogen sulfide, and bulk crude oil. The amounts of these constituents in the surface water are affected by several factors including: the concentration of the constituent in the crude oil, the solubility of the constituent, and the turbulence and velocity of the water. Constituents of special concern are benzene and certain PAHs because they are carcinogenic.

Benzene makes up 0.1 to 1.0 percent of DilBit crude oil (Shell Canada, 2008), and it is relatively soluble in water. The amount of benzene that will be dissolved in the water can be estimated from the octanol-water partition coefficient (a measure of how much of a contaminant will dissolve into the water) which is 131.8 for benzene (LaGrega et al., 2001). Using the octanol-water relationship, and assuming that the benzene concentration in the DilBit is 1 per cent ($\sim 1 \times 10^4$ mg/L), results in a benzene water concentration immediately at the oil/water interface of 75 mg/L (1×10^4 mg/L \div 131.8). This benzene concentration is 15,000 times the MCL for benzene of 0.005 mg/L. Since the temperature of the DilBit will be up to 158°F, the actual water concentration at the spill will likely be somewhat higher than this calculation, which is based on an octanol-water partition coefficient for ambient temperatures. The benzene concentration will decrease with distance from the oil/water interface. TransCanada's Risk Assessment calculated that the average (mixed) benzene concentration in surface water for a 10,000 Bbl spill in a 10,000 ft³/sec stream would be 2.2 mg/L (ENTRIX, 2010); however, this calculated concentration assumes that all of the benzene would be released into the water within one hour (likely over-estimates resulting concentrations) and that the benzene is immediately mixed across the entire stream (under-estimates resulting concentrations). Note that 2.2 mg/L is 440 times the MCL for benzene. In most cases, the benzene will form a plume that travels downstream from the spill site. The concentration in the plume will gradually decrease as it moves farther from the spill site.

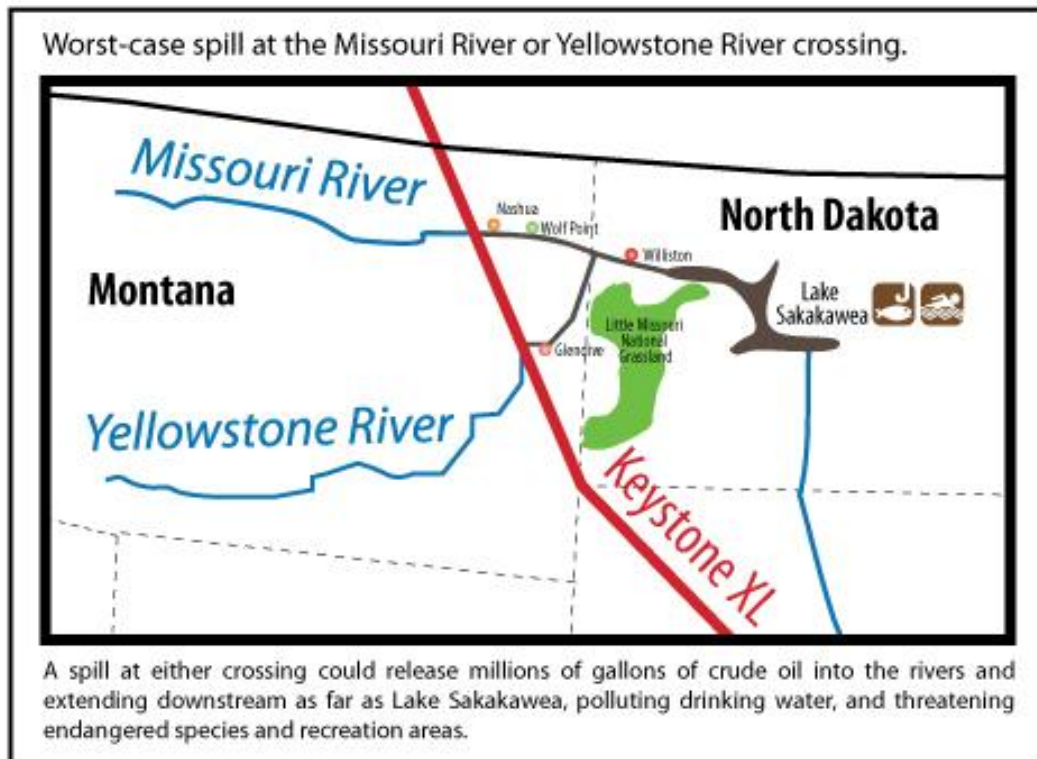
Besides human health risks from contaminated drinking water supplies, benzene also poses risks to aquatic species. The EPA Region III screening water concentration for benzene designed to be protective of aquatic biota is 0.370 mg/L (EPA, 2011b). The predicted benzene concentration at the oil/water interface is 75 mg/L which is 200 times higher than the screening concentration. Therefore, negative ecological impacts due to toxicity are expected, at least in localized areas where benzene is actively dissolving from the oil.

If a spill of 150,000 Bbl (i.e., in the range of predicted worst-case spill volumes) were to occur in a stream with a flow of 10,000 ft³/sec and a velocity of 3 ft/sec (e.g., the Missouri River below Fort Peck dam has a flow of 9,225 cfs, and the Yellowstone River at Miles City, MT has a flow of 11,180 cfs (USGS, 2009)), the mass and resulting plume of the benzene in the water

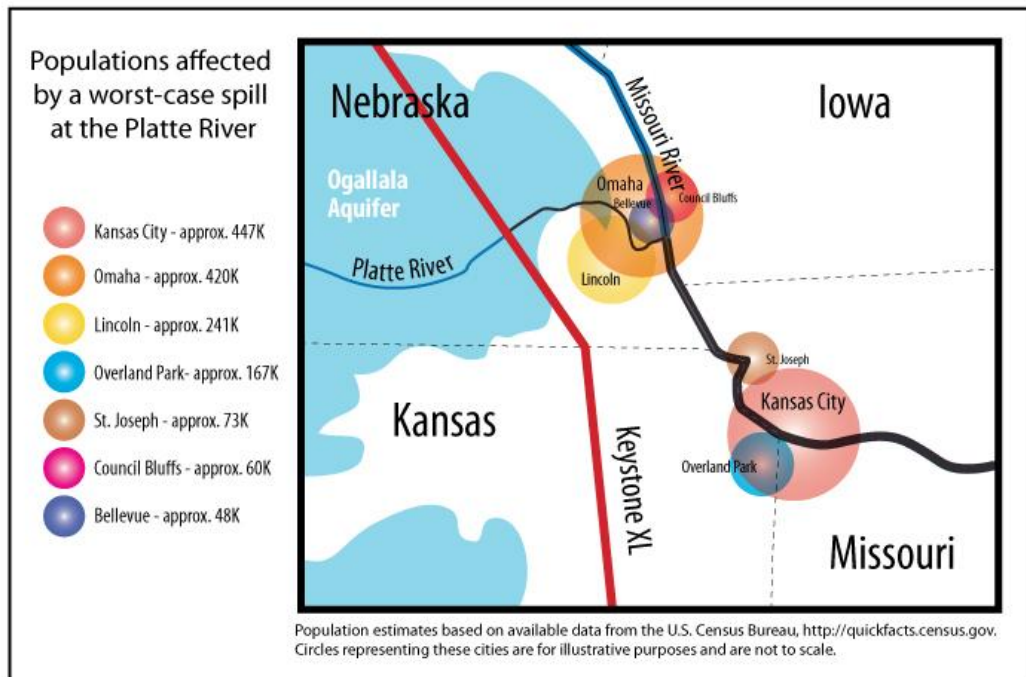
could be characterized as follows. Assuming that benzene makes up 1.0 percent of the DilBit, 150,000 Bbl of DilBit would contain approximately 2.3×10^5 Kg of benzene ($150,000 \text{ Bbl} * 42 \text{ gal/Bbl} * 3.788 \text{ L/gal} * 1 \text{ Kg/L} * 0.01$). If 80 percent of the benzene is lost via volatilization and product removal during and immediately after the spill, 4.77×10^4 Kg of benzene would remain in the stream. This benzene would dissolve through time into the water from the DilBit mixture. To be released into the water, the benzene in the mass of crude would have to diffuse to the oil/water interface. Since the composition of DilBit is variable and since the thickness of the crude mass is case-specific (i.e., depends on turbulence, temperature, etc.), it is not possible to predict precisely the rate at which the benzene will diffuse to the oil/water interface; however, a reasonable assumption would be that 5 percent of the benzene would reach the oil/water interface per day. If this assumption is too high, these calculations will over estimate the water concentrations but underestimate the duration of the negative impacts, and if it is too small, the opposite will be true. Assuming 5 percent of the benzene is released into the water per day, over 2.3 million grams of benzene will be released to the water per day. This will result in a water concentration of 0.09 mg/L ($2.3 \times 10^6 \text{ g/d} * \text{sec}/10,000 \text{ ft}^3 * 1\text{d}/86,400 \text{ sec} * 1,000 \text{ mg/g} * 35.3 \text{ ft}^3/\text{m}^3 * 0.001 \text{ m}^3/\text{L}$) once the contaminant plume completely mixes across the entire width of the stream (several miles downstream of the spill). This concentration exceeds the MCL of 0.005 mg/L by 18.8 times. As the benzene plume migrates downstream, the concentration will decrease because of processes such as degradation and volatilization. Reported half-lives of benzene in surface water range from 1 to 6 days (USEPA, 1986). Assuming a half-life of 3 days, a stream velocity of 3 ft/sec, and a tributary contribution of 20 cfs/mi (the measured value for the Missouri River downstream of the proposed crossing (USGS, 2009)), the plume would reach over 450 miles before its concentration would drop to the MCL and be safe for public water intakes. The plume length was modeled using a series of 10-mile long river reaches with first-order decay ($k = -0.231 \text{ d}^{-1}$) and increased flow of 200 cfs/10 mi reach.

Contaminants from a release at the Missouri or Yellowstone River crossing would enter Lake Sakakawea in North Dakota where they would adversely affect drinking water intakes, aquatic wildlife, and recreation. Contaminants from a spill at the Platte River crossing would travel downstream unabated into the Missouri River for several hundred miles affecting drinking water intakes for hundreds of thousands of people (e.g., Lincoln, NE; Omaha, NE; Nebraska City, NE; St. Joseph, MO; Kansas City, MO) as well as aquatic habitats and recreational activities. In addition, other constituents from the spill would pose serious risks to humans and to aquatic species in the river.

Map 1:



Map 2:



Of course other assumptions (e.g., shorter half-life) would give somewhat different results. For example, assuming that benzene makes up only 0.3 percent of DilBit and that 10 percent of the benzene is released per day, the calculated plume length would be reduced to around 200 miles. However, since the case-specific details are not known at this point, the precise impacts cannot be calculated; however, it has been clearly shown that if a worst-case spill occurs in a major stream, the impacts would be serious, far-reaching, and long-lasting, and claims to the contrary should be challenged.

The concentrations of PAHs (e.g., benz(a)pyrene) are not specified in the Material Safety Data Sheet(MSDS) for DilBit (Shell Canada, 2008). Also, the risk assessment done for the pipeline (ENSR, 2006) discusses the presence of PAHs, but doesn't detail specific concentrations. Therefore, this analysis will assume that PAHs make up 2 percent of DilBit, and that benz(a)pyrene (BaP) makes up one-tenth of the PAHs or 0.2 percent of the DilBit. This is likely an underestimate. PAHs are not as soluble or as mobile in surface water as is benzene. Much of the released PAH mass will sorb to sediments and remain closer to the location of the spill. However, they will be transported downstream with suspended solids and sediments, and the PAH fraction that does dissolve will form a plume and also be transported downstream. Since they are less soluble and mobile than benzene, PAHs pose less of a threat to municipal water intakes. Using the octanol-water coefficient for benz(a)pyrene (BaP) of 1.1×10^6 (LaGrega et al., 2001), the BaP concentration at the oil/water interface would be 0.0018 mg/L (1.8 µg/L). This concentration exceeds the MCL for BaP of 0.0002 mg/L by a factor of about ten; however, this concentration would be quickly reduced as the plume mixes in the stream. Therefore, based on the assumption that PAHs make up 2percent of the DilBit, drinking water is probably not significantly threatened from release of PAHs.

However, PAHs are toxic to aquatic organisms. The EPA Region III water quality criteria for benz(a)pyrene to protect aquatic species is 0.015 µg/L (EPA, 2011b). In addition, there are several other PAHs with water quality values to protect aquatic species (e.g., benzo(a)anthracene (0.018 µg/L), fluoranthene (0.04 µg/L), and naphthalene (1.1 µg/L)) that are likely to have concentrations that exceed water quality criteria in a major spill. Therefore, the estimated concentration of PAHs is approximately 100 times the allowable level for protection of aquatic life.

Hydrogen sulfide is very volatile, and much of it will likely volatilize to the air during a major spill. However, some of the hydrogen sulfide will dissolve into the surface water and cause toxic effects to the aquatic biota. The EPA Region III screening water concentration protective of aquatic species is 2.0 µg/L. Since the hydrogen sulfide will quickly volatilize, it is expected that these toxic effects will be limited to areas near the spill.

Bitumen, which makes up most of the DilBit, is more dense than water, so it will sink to the bottom and smother any aquatic plants or sediment-dwelling organisms. These effects will be limited to the immediate area of the spill and are expected to pose a significant risk

primarily if the stream is the habitat to threatened or endangered species. Since the Missouri, Yellowstone, and Platte Rivers all provide habitat to threatened and endangered species, including the pallid sturgeon, interior least tern, and piping plover, these impacts should be considered potentially significant.

Table 5: Benzene Plume Development for Spill of 150,000 Bbl into a 10,000 cfs Stream.

| | Estimate From This Analysis |
|--|-----------------------------|
| Spill Volume | 150,000 Bbl |
| Stream Discharge | 10,000 cfs |
| Fully Mixed Concentration ^(a) | 0.09 mg/L |
| Ratio of Concentration to MCL ^(b) | 18.8 |
| Length of Plume > MCL ^(c) | 450 miles |
| Duration of Release to Water ^(d) | 20 days |

(a) mg/sec benzene release to stream ÷ L/sec of flow (10,000 cfs = 283,286 L/sec)

(b) fully mixed concentration ÷ 0.005 mg/L

(c) assumes half-life of 3 d; velocity of 3 ft/sec;

(d) assumes 5percent of benzene is released from DilBit mass per day

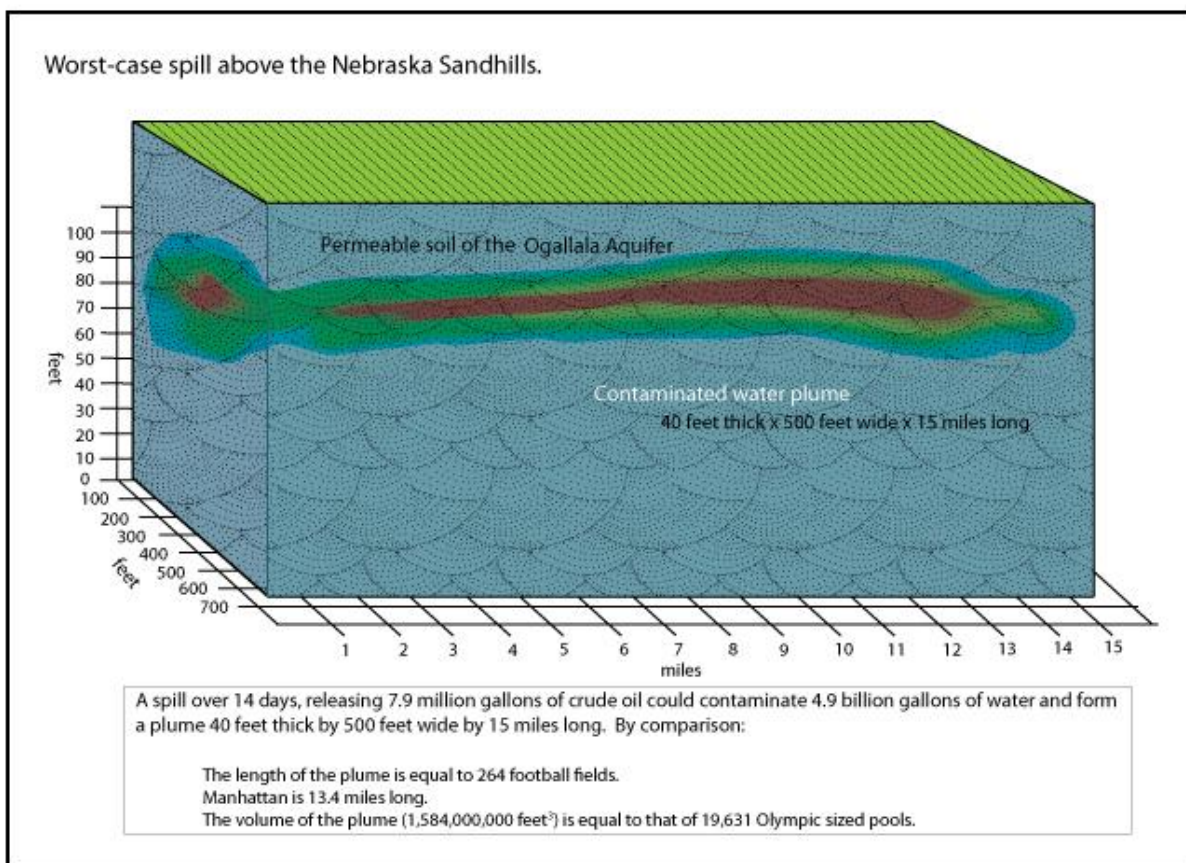
Impacts to Groundwater Resources

The primary constituent of concern for a spill into groundwater is benzene. Since DilBit is very viscous, the bulk crude oil will not likely migrate through the soil to groundwater in large quantities. However, if a small, underground leak remains undetected for an extended period of time, a large amount of benzene will be released with the DilBit. The released benzene could then be transported to groundwater via infiltrating rainwater. According to a TransCanada publication “Frequency-Volume Study of Keystone Pipeline” (DNV, 2006), a leak of 1.5 percent of total flow could remain undetected for 90 days. For this analysis, the discovery and shut-down time is assumed to be 14 days which corresponds to the time between pipeline inspections. At the design flow rate of 900,000 Bbl/d, a 1.5 percent leak would release 189,000 Bbl (7.9 million gallons) of DilBit in 14 days. Since DilBit is 0.1 to 1.0 percent benzene, this would result in a release of up to 79,380 gallons of benzene.

A spill of the magnitude of 189,000 Bbl of DilBit would occupy approximately 2.65×10^6 cubic feet of subsurface sands with a porosity of 0.4 ($189,000 \text{ Bbl} * 5.61 \text{ ft}^3/\text{Bbl} \div 0.4$). Assuming that the DilBit mass occupies a somewhat cylindrical volume and that the aquifer is 20 feet below the pipeline, the DilBit would spread to an area approximately 335 feet in diameter (335 feet diameter X 30 feet high). A reasonable worst-case 100-year, 24-hour storm would deposit 6 inches of rainwater on the site. In the Sandhills of Nebraska, nearly all of this water would infiltrate. Six inches of water infiltrating onto a contaminated area of $8.8 \times 10^4 \text{ ft}^2$ (335 feet diameter) results in 4.4×10^4 cubic feet of water ($8.8 \times 10^4 \text{ ft}^2 * 0.5 \text{ ft}$ infiltrating water) contacting the DilBit. Using the octanol-water partition coefficient of 131.8 (LaGrega et al., 2001), the benzene concentration in the infiltrating water would be approximately 75 mg/L.

The 4.4×10^4 cubic feet of water at a concentration of 75 mg/L equates to 9.35×10^7 milligrams of benzene. Thus, this storm would transport 9.35×10^7 milligrams of benzene to the groundwater. Once in the groundwater, the benzene plume would migrate down-gradient, potentially to down-gradient water supplies or basements where it could pose a cancer risk to residents. The 9.35×10^7 milligrams of benzene in the groundwater, if evenly distributed (not likely) could pollute 1.9×10^{10} Liters (4.9×10^9 gallons) of groundwater at the MCL, enough water to form a plume 40 feet thick by 500 feet wide by more than 15 miles long (assuming porosity of 0.4) at the MCL. These plume dimensions are given for illustrative purposes only. The actual dimensions of a groundwater plume cannot be determined with the available information. Of course, the benzene would not be evenly distributed; however, the plume would still be many miles long. In addition, future storms would transport additional benzene to the groundwater increasing the size of the plume.

Figure 4:



The worst-case site for such a spill is in the Sandhills region of Nebraska. The Sandhills are ancient sand dunes that have been stabilized by grasses. Because of their very permeable

geology, nearly 100 percent of the annual rainfall infiltrates to a very shallow aquifer, often less than 20 feet below the surface. This aquifer is the well-known Ogallala Aquifer that is one of the most productive and important aquifers in the world.

Table 6: Benzene Plume from a 189,000 Bbl Spill to Groundwater.

| | |
|---|-------------------------------|
| Volume of released DilBit (Bbl) | 189,000 |
| Volume of benzene in spill (gal) | 79,380 |
| Mass of benzene dissolved in groundwater (mg) | 9.35×10^7 |
| Volume of contaminated water > MCL (gal) | 4.9×10^9 |
| Equivalent plume dimensions | 40 feet X 500 feet X 15 miles |

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Excerpts and thoughts by Dr. John Stansbury re. human health effects from KXL:

a. TransCanada's Risk Assessment calculated that the average (mixed) benzene concentration in surface water for a 10,000 Bbl spill in a 10,000 ft³/sec stream would be 2.2 mg/L (ENTRIX, 2010); however, this calculated concentration assumes that all of the benzene would be released into the water within one hour (likely over-estimates resulting concentrations) and that the benzene is immediately mixed across the entire stream (under-estimates resulting concentrations). Note that 2.2 mg/L is 440 times the MCL for benzene. Beyond admitting that the concentration will be unacceptable, and therefore, pose a human health risk, there is no further analysis. There should have been a human health risk assessment that would have estimated the increased risk of cancer, but there isn't any such assessment. They simply state that the concentration will be unacceptable and leave it at that.

b. Stansbury (not TransCanada) estimates benzo(a)pyrene (BaP) concentration at the oil/water interface of a major spill into a stream would be 1.8 µg/L. The EPA Region III water quality criteria for benz(a)pyrene to protect aquatic species is 0.015 µg/L (EPA, 2011b). In addition, there are several other PAHs with water quality values to protect aquatic species (e.g., benzo(a)anthracene (0.018 µg/L), fluoranthene (0.04 µg/L), and naphthalene (1.1 µg/L)) that are likely to have concentrations that exceed water quality criteria in a major spill. Therefore, the estimated concentration of PAHs is approximately 100 times the allowable level for protection of aquatic life. Note that the reason Stansbury's estimate is used here is that TransCanada failed to assess even the potential concentrations of PAHs let alone assess the potential health and environmental risks posed by the release of these chemicals.

c. According to a TransCanada publication "Frequency-Volume Study of Keystone Pipeline" (DNV, 2006), a leak of 1.5 percent of total flow could remain undetected for 90 days. For this analysis, the discovery and shut-down time is assumed to be 14 days which corresponds to the time between pipeline inspections. At the design flow rate of 900,000 Bbl/d, a 1.5 percent leak would release 189,000 Bbl (7.9 million gallons) of DilBit in 14 days. Since DilBit is 0.1 to 1.0 percent benzene, this would result in a release of up to 79,380 gallons of benzene into the groundwater. If the leak does go undetected for 90 days as the TransCanada document reports, a groundwater user could be exposed to unacceptable concentrations of benzene for a significant period of time. There should have been a human health risk assessment that would have estimated the increased risk of cancer, but there isn't any such assessment. They simply indicate that there could be a significant, undetected release of benzene which could be consumed by human receptors and leave it at that. Note, be careful using my "estimate" of a groundwater plume dimensions. As it states in my report, this is not a prediction of a plume size, it is only the dimensions that a plume could have for the predicted amount of released benzene – the actual plume size would depend on a lot of site-specific conditions.

Exhibit Cindy 5- <https://youtu.be/9Dw7a7YSnH0> Dr Stansbury Interview

This is a video located at - <https://youtu.be/9Dw7a7YSnH0>

**BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA**

| | | |
|-----------------------------------|---|---|
| IN THE MATTER OF THE PETITION OF |) | |
| TRANSCANADA KEYSTONE PIPELINE, |) | Docket 14-001 |
| LP FOR ORDER ACCEPTING |) | |
| CERTIFICATION OF PERMIT ISSUED IN |) | TESTIMONY OF DR. ARDEN D. |
| DOCKET HP09-001 TO CONSTRUCT THE |) | DAVIS, Ph.D., P.E., ON BEHALF OF |
| KEYSTONE XL PIPELINE |) | DAKOTA RURAL ACTION |
| |) | |

My name is Arden D. Davis, Ph.D., P.E. My address is 1014 Milwaukee Street, Rapid City, South Dakota 57701.

This testimony is submitted regarding Findings of Fact 12(2)-(3), 20, 22, 33-34, 36, 37, 40-41, 43-53, 64, 77, 79, 82, 86, 94-95, 98-99, 101-104, 110, 113, and Amended Conditions: 22, 34-35, 37 of the Amended Final Decision and Order in HP 09-001.

Professional Qualifications and Background

I have been involved in the fields of ground water and environmental contamination since 1978. I hold a B.A. degree in Geology from the University of Minnesota, and M.S. and Ph.D. degrees in Geological Engineering from South Dakota School of Mines and Technology. I am a registered professional engineer in South Dakota (no. 4663). Since 1985, I have taught courses in ground water, ground-water contamination, geological engineering, and environmental pollution at South Dakota School of Mines and Technology. I have also presented expert witness testimony in numerous cases, and have assisted the State of South Dakota in ground-water contamination problems, including the Williams Pipe Line / Hayward Elementary School site in Sioux Falls.

Potential Impact of Keystone XL Pipeline on Water Resources in South Dakota

A crude-oil or diluted bitumen leak could have devastating effects on ground-water supplies, surface water, and environmental resources in South Dakota. The proposed Keystone XL Pipeline would cross the recharge areas of several shallow aquifers in the western part of the State, including the Ogallala aquifer and Sand Hills type material, especially in Tripp County. Other shallow aquifers that would be crossed by the proposed pipeline route are terrace gravel aquifers, eolian (wind-blown) aquifer materials, alluvial aquifers, and the Fox Hills aquifer.

The proposed pipeline also would have major stream crossings at water courses such as the Little Missouri River, the Grand River and its tributaries, the Moreau River, the Cheyenne River upstream from Oahe Reservoir, the Bad River, and the White River. These drainages have associated alluvial aquifers beneath and adjacent to the rivers, and dissolved hydrocarbon contaminants could be transported downgradient in surface water, in ground water within the aquifers, or both.

The proposed route is shown on Figure 1 (from U.S. Dept. of State, 2014) and would cross the western part of South Dakota in a northwest-to-southeast trend. The South Dakota state geologic map is shown on Figure 2, with the proposed route superimposed.

In Harding County, in the extreme northwestern part of South Dakota, the route would cross the Little Missouri River (Figure 3) and the Grand River (Figure 4). The Hell Creek Formation (shown as K_h on Figure 3 and Figure 4) contains bentonitic shale and is exposed in the river valleys at these crossings. The Little Missouri River flows northward into North Dakota, where it eventually joins the Missouri River. The Grand River flows generally eastward and joins the Missouri River in north-central South Dakota.

In Harding County the proposed route would cross permeable wind-blown deposits, shown as Q_e on Figure 4. These wind-blown deposits of silt and sand recharge from rainfall and snowmelt, and they are capable of supplying water to shallow wells in the area. The proposed route also would cross the Fox Hills aquifer (shown as K_{fh} on Figure 4) in Harding County. This sandstone aquifer is one of the most important ground-water reservoirs in northwestern South Dakota and supplies drinking water to public supplies for the City of Buffalo as well as a standby well for the City of Lemmon.

In Butte County the proposed route would cross the North Fork of the Moreau River (Figure 4), and in Perkins County the route would cross the Moreau River (Figure 4), which flows eastward and joins the Missouri River in north-central South Dakota.

In Meade County the proposed route would cross Cherry Creek and Red Owl Creek, as well as a large expanse of the exposed recharge area of the Fox Hills Formation (see Figure 5). As mentioned above, the Fox Hills aquifer is a major aquifer in northwestern South Dakota.

Near the border of Meade, Haakon, and Pennington counties, the proposed route would cross the Cheyenne River (Figure 6). This part of the Cheyenne River watershed is downstream from the Belle Fourche River, which drains the northern Black Hills, and the main branch of the Cheyenne, which drains the southern and eastern Black Hills. At this site, the Cheyenne River has gathered the surface-water drainage from the entire Black Hills. From here downstream, the Cheyenne River flows into the Oahe Reservoir on the Missouri River. The Pierre Shale (shown as K_p), which contains bentonite, is exposed along steep sides of the Cheyenne River valley and is prone to slope failures in western South Dakota. The proposed route also would cross the Bad River near Midland in Haakon County (Figure 7), where Pierre Shale also is exposed along the valley sides.

South of the Cheyenne River in Haakon County, the proposed route would cross permeable Quaternary terrace gravels (shown as Q_t on Figure 6) and wind-blown deposits (Q_e on Figure 6). The terrace gravels are stream-bed deposits of former flood plains. Both the terrace gravels and wind-blown deposits are permeable and are recharged by precipitation. In places they are capable of supplying water to wells, springs, and seeps, as well as providing soil moisture for trees and other vegetation.

In Jones and Lyman counties, the proposed pipeline route would cross permeable wind-blown deposits (shown as Q_e on Figure 8) and also would cross Quaternary terrace deposits north of the White River (shown as Q_t on Figure 8). The terrace deposits in this area have a shallow water table and are recharged by rainfall and snowmelt, which provide water for springs and seeps at the heads of streams that drain southward toward the White River. The shallow water table also supports small lakes, ponds, and wetlands in the area.

The proposed pipeline route would cross the White River at the border of Lyman and Tripp counties (Figure 8). The Pierre Shale is exposed in the White River valley at this location and is a concern because of potential slope failures.

In Tripp County, near the southeastern end of the proposed pipeline in South Dakota, the route would cross the Ogallala aquifer (shown as T_o on Figure 9). It also would cross wind-blown Sand Hills type material (shown as Q_e) above the Ogallala aquifer. According to Martin et al. (2004) the wind-blown material shown as Q_e on the South Dakota state geologic map includes the Sand Hills Formation. The hydrologic situation is similar to the Sand Hills of Nebraska, which form a permeable recharge zone above the Ogallala aquifer and therefore deserve consideration for special protection as a high-consequence area. As noted by Stansbury (2011), areas with shallow ground water that are overlain by permeable soils, such as Sand Hills type material, pose risks of special concern because leaks could go undetected for long periods of time

Contaminants and Potential Problems

The proposed Keystone XL pipeline would transport crude oil and diluted bitumen. As noted by Stansbury (2011), diluted bitumen is more corrosive than conventional crude oil transported in existing pipelines. Crude oil and diluted bitumen contain hydrocarbons, including benzene, toluene, ethylbenzene, and xylene. Benzene is of particular note because its maximum contaminant level (MCL) in drinking water is 5 parts per billion. Benzene is known to produce leukemia in humans. It has been identified as a human carcinogen by the Occupational Safety and Health Administration and the National Toxicology Program.

Benzene is soluble in water and can be transported downgradient toward receptors such as public water-supply wells, private wells, and springs or seeps. In certain cases, benzene can be transported more than 500 or 1000 feet downgradient in aquifers,

according to records of agencies such as the South Dakota Geological Survey, the South Dakota Department of Environment and Natural Resources, and the South Dakota Petroleum Release Compensation Fund. For example, a benzene contaminant plume from a leaking tank at the Williams Pipe Line / Hayward Elementary School site in Sioux Falls, South Dakota, was documented to have traveled about 800 feet downgradient from the tank (Iles et al., 1988). Because of benzene's solubility and its allowable limit of only 5 parts per billion in drinking water, a pipeline leak could contaminate a large volume of surface water or ground water in shallow aquifers of western South Dakota.

Leaks from pipelines have occurred in the past in South Dakota and have threatened ground-water supplies. These include a pipeline spill from Williams Pipe Line Company near water-supply wells for the City of Sioux Falls, and a large spill north of the City of Sioux Falls on glacial till near the Big Sioux aquifer. Reports of these are available in the files of the South Dakota Department of Environment and Natural Resources. A spill of more than 840,000 gallons in 2010 at Marshall, Michigan, caused extensive environmental damage and polluted the Kalamazoo River. The rupture and subsequent investigation resulted in new recommendations for pipeline safety from the National Transportation Safety Board. Two recent pipeline ruptures along the Yellowstone River in Montana were particularly serious and caused serious environmental problems. One, in 2011 near Laurel, Montana, resulted in the discharge of about 63,000 gallons of crude oil. The second, in 2015, released about 30,000 gallons of crude oil and contaminated the public drinking water supply of the City of Glendive, Montana.

A major concern involves the stability of steep slopes where the Pierre Shale or other bentonite-bearing shales are exposed, particularly along the breaks of major rivers, including the Cheyenne River, the White River, the Bad River, the Little Missouri River, the Grand River, and the Moreau River. Expansive clays such as bentonite are a particular concern because they can absorb large amounts of water during wet periods, leading to instability and potential failure. Slope failures are common along these river valleys, and could cause ruptures and serious leaks from the proposed pipeline. Additional safeguards for pipeline integrity should be undertaken in such locations. Leaks in these areas potentially could result in surface-water contamination downstream toward the Missouri River and its reservoirs

A report for TransCanada by DNV Consulting (Appendix A: Frequency-Volume Study of Keystone Pipeline), dated May 1, 2006, indicates on page 19, Table 5-2, that a leak rate of less than 1.5% could go undetected for 90 days for below-ground pipe. Page 20, Figure 5-1, of the same report indicates a leak detection and verification time of 138 min (2.3 hours) for a leak rate of 1.5%. The leak rate for this detection time is approximately 200 barrels per hour (BPH). This potentially could result in a leak of about 19,000 gallons (2.3 hr x 200 barrels/hr x 42 gallons/barrel). It appears, therefore, that larger volumes of oil could leak over a longer time (e.g., 90 days), if the leak rate is less than 1.5%. A leak of 19,000 gallons or greater could contaminate a large volume of ground-water supplies because of the solubility of crude oil components such as benzene and other volatile hydrocarbons.

The Final Supplemental Environmental Impact Statement for the Keystone XL Project (U.S. Department of State, 2014) stated that spill volumes from larger-diameter pipelines tend to be larger than those from smaller-diameter pipelines. It also stated that the primary releases causes, aside from failure of components such as valves, are outside forces and corrosion. In addition, the spill size and impact, for medium to large spills, are more sensitive to response time than for small spills. In other cases, smaller leaks might not be detected (U.S. Department of State, 2014).

The executive summary of the Final Environmental Impact Statement (U.S. Department of State, 2011) stated, “Although the leak detection system would be in place, some leaks might not be detected by the system. For example, a pinhole leak could be undetected for days or a few weeks if the release volume rate were small and in a remote area.” The executive summary also stated, “In spite of the safety measures included in the design, construction, and operation of the proposed Project, spills are likely to occur during operation over the lifetime of the proposed Project. Crude oil could be released from the pipeline, pump stations, or valve stations.” In addition, the executive summary mentioned 14 spills since 2010 from the existing Keystone pipeline system, including a spill of 21,000 gallons in North Dakota.

Stansbury (2011) stated concerns about questionable assumptions and calculations by TransCanada of expected frequency of spills from the proposed Keystone XL Pipeline. He noted that the pipeline would operate at higher temperatures and pressures than existing pipelines, and that the crude oil that would be transported in the Keystone XL Pipeline will be more corrosive than conventional crude oil. These factors would tend to increase spill frequency. Stansbury (2011) also stated that worst-case spill volumes from the proposed Keystone XL Pipeline are likely to be significantly larger than those estimated by TransCanada.

The Final Supplemental Environmental Impact Statement (U.S. Department of State, 2014) noted, “For all spills, especially those that reached water resources, the response time between initiation of the spill event and arrival of the response contractors would influence the potential magnitude of impacts to environmental resources.” If a pipeline leak goes undetected and a spill of crude oil reaches a major water course such as the Cheyenne River, it could potentially be transported many miles downstream during high-velocity flows at certain times of the year. For example, the Cheyenne River can have a velocity of 7½ to 8 feet per second at times of high discharges (Dawdy, 1961). A river velocity of 8 feet per second is equivalent to about 5½ miles per hour. If a leak is undetected and a spill reaches the river under these conditions, it could potentially be transported about 60 miles downstream in 12 hours. If a leak cannot be controlled or is undetected for 24 hours, it could be transported about 120 miles downstream. This raises concerns about emergency response and mobilization in such a situation. For example, the straight-line distance is about 40 miles from the proposed pipeline route’s crossing of the Cheyenne River to the Oahe Reservoir. This is in a remote, sparsely populated area. Assuming a channel sinuosity of about 2 to 2.5 for this reach of the Cheyenne River, the river’s actual distance would be about 80 to 100 miles from this crossing to the Missouri River’s reservoir. Thus, if a release occurred at this crossing and it could not be

controlled or went undetected for 12 to 24 hours, petroleum contaminants could reach the Missouri River, potentially affecting water supplies and surface-water users, and causing environmental damage.

Summary

The Keystone XL Pipeline, as currently proposed, would cross shallow aquifers including the Ogallala aquifer, Sand Hills type aquifer material, terrace gravel aquifers, wind-blown aquifer materials, alluvial aquifers along rivers, and the Fox Hills aquifer. Spills in these aquifers could pose serious health risks to ground-water users. The proposed route also would have river crossings at water courses that include the Cheyenne River upstream from Oahe Reservoir, the White River, and the Bad River, and other streams. The sides of these river valleys are vulnerable to large slope failures, especially where bentonite-containing shales are exposed, which potentially could cause pipeline rupture. At these river crossings and downstream, the proposed pipeline poses serious risks and could have devastating effects on surface water and associated environmental resources, potentially affecting water supplies and surface-water users.

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I hereby affirm under penalty of perjury that the above testimony is true and correct.

Arden D. Davis
ARDEN D. DAVIS

April 2, 2015
(date)

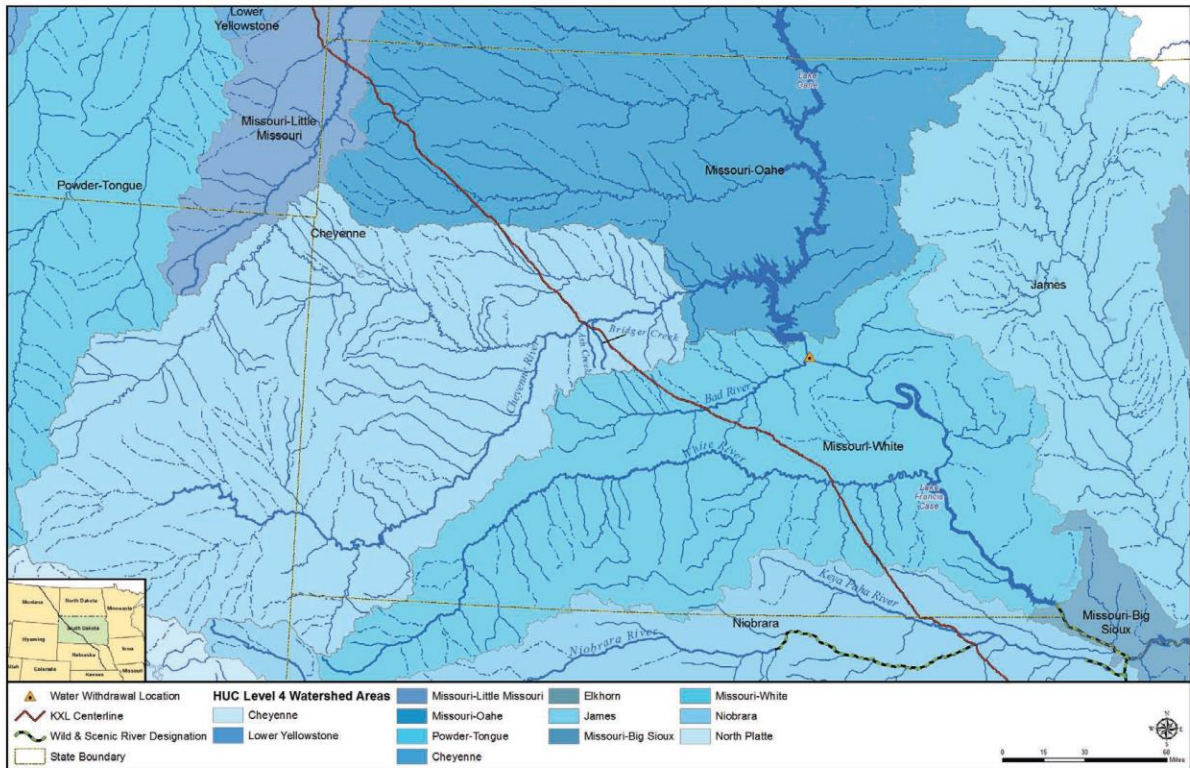


Figure 1. Water crossings of the proposed Keystone XL Pipeline in western South Dakota (from U.S. Dept. of State, 2014, p. 3.3-39).

South Dakota Geological Survey

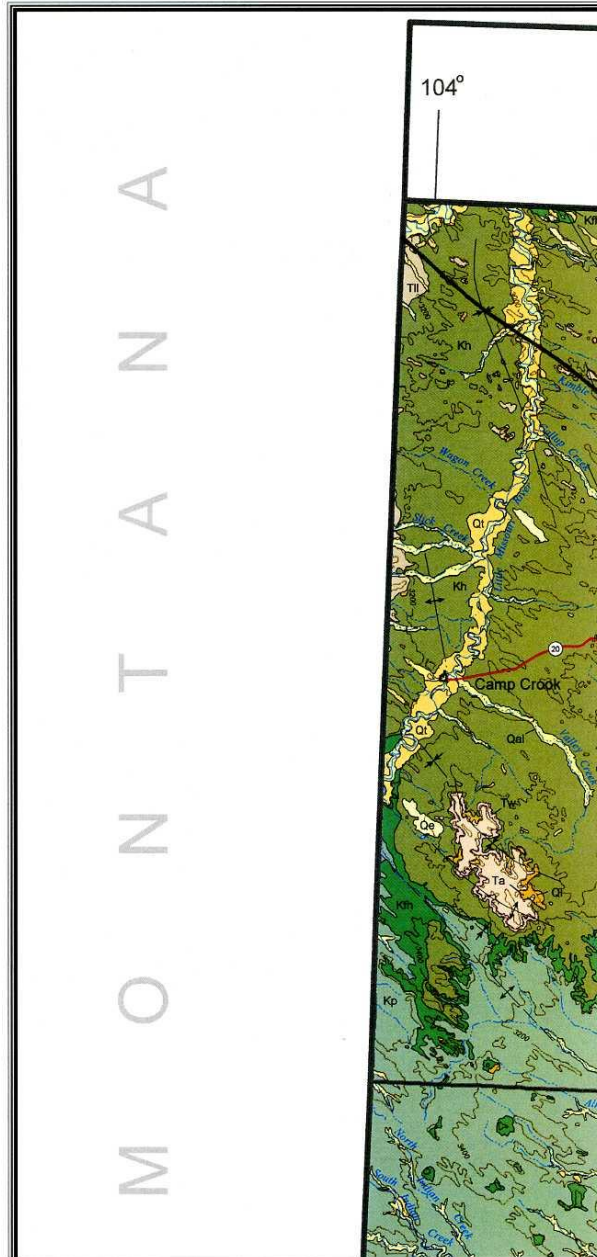


Figure 3. Part of the South Dakota geologic map (from Martin et al., 2004) in the northwestern part of Harding County, with proposed Keystone XL route superimposed.

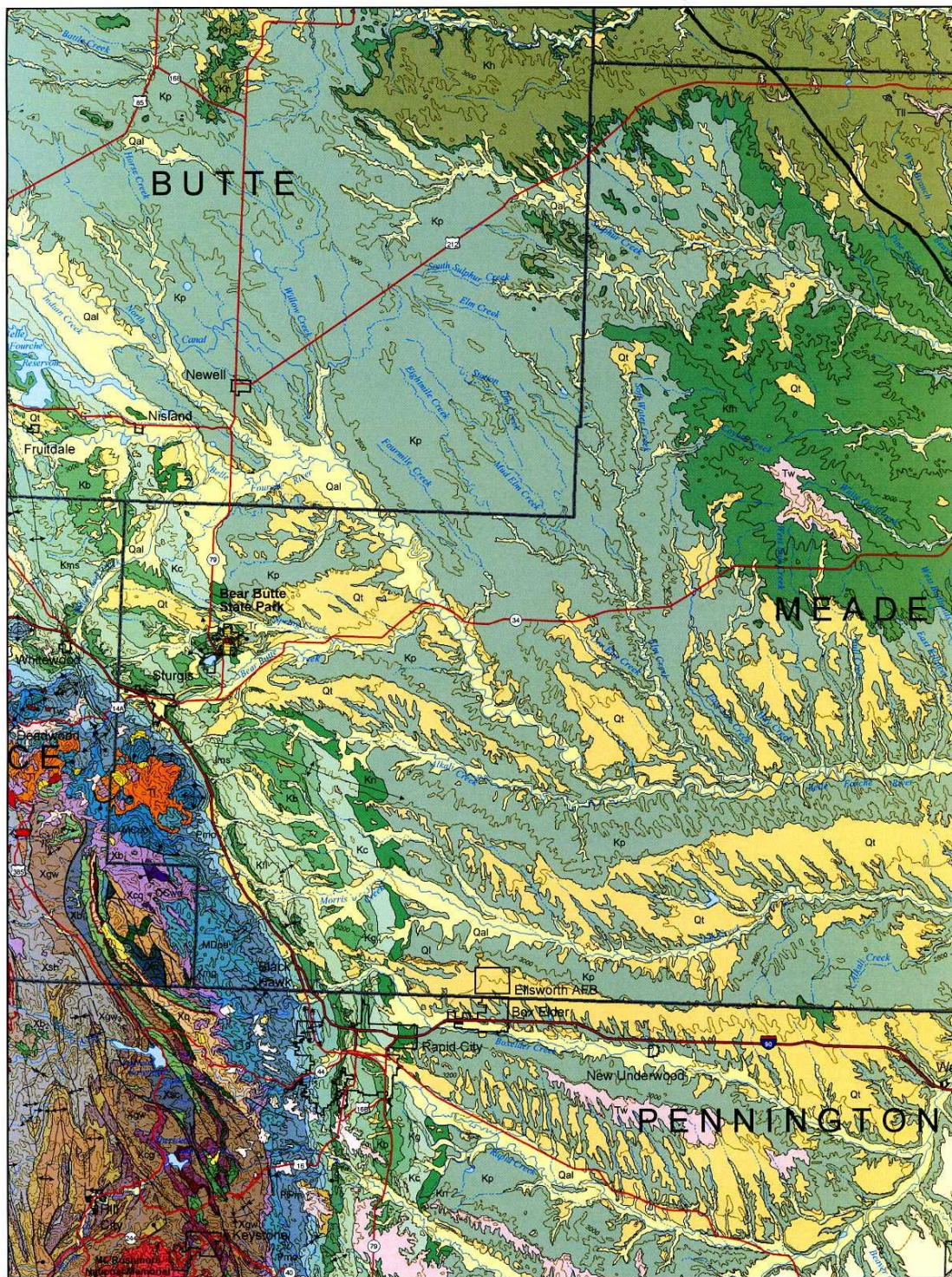


Figure 5. Part of the South Dakota geologic map (from Martin et al., 2004) in Perkins and Meade counties, with proposed Keystone XL route superimposed. The area shown as K_{fh} is mapped as the Fox Hills Formation.

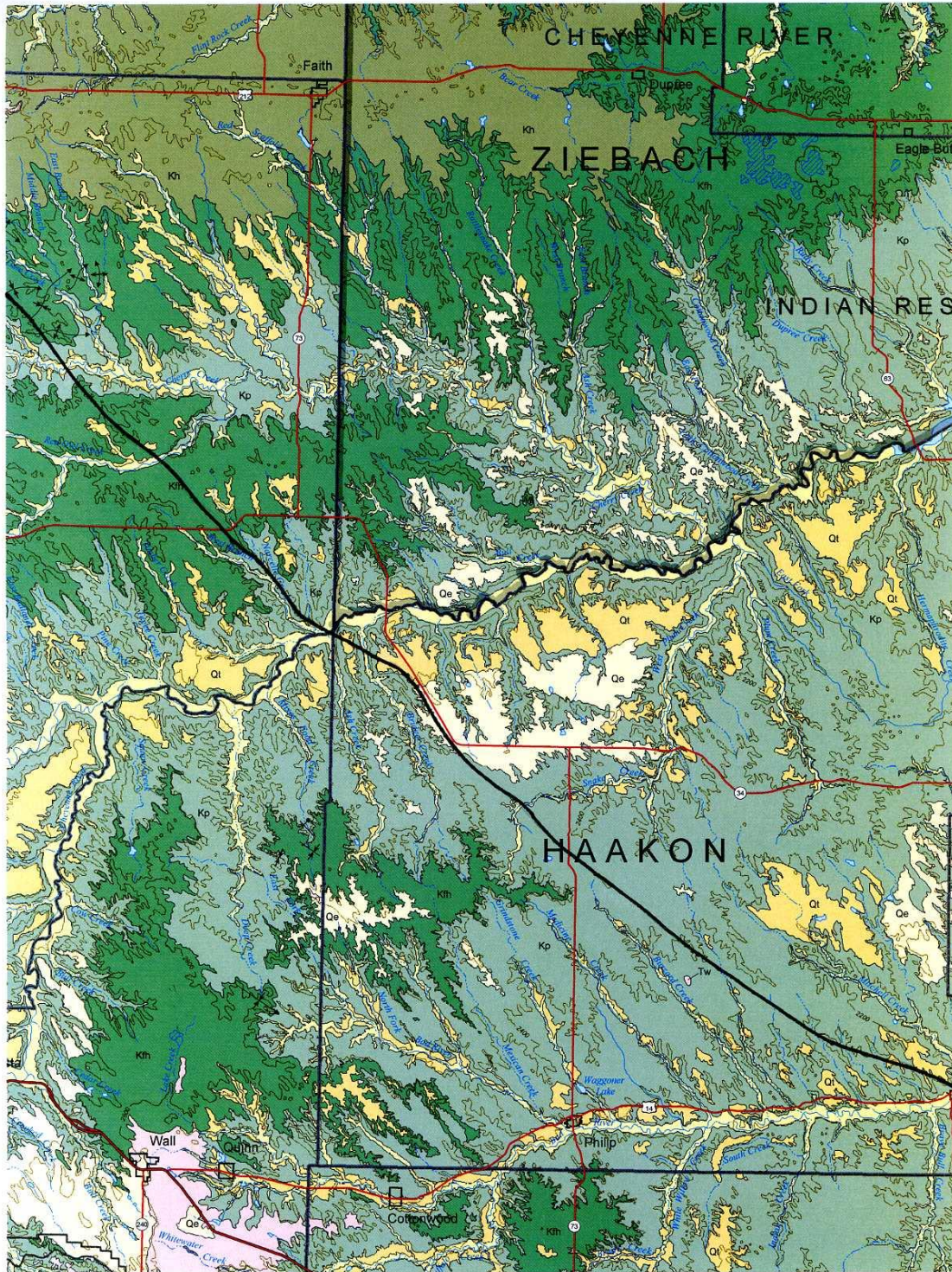


Figure 6. Part of the South Dakota geologic map (from Martin et al., 2004) in Meade and Haakon counties, with proposed Keystone XL route superimposed. The route would cross the Cheyenne River near the border of Meade and Haakon counties. The area mapped as Q_t refers to terrace deposits of streams in former flood plains.

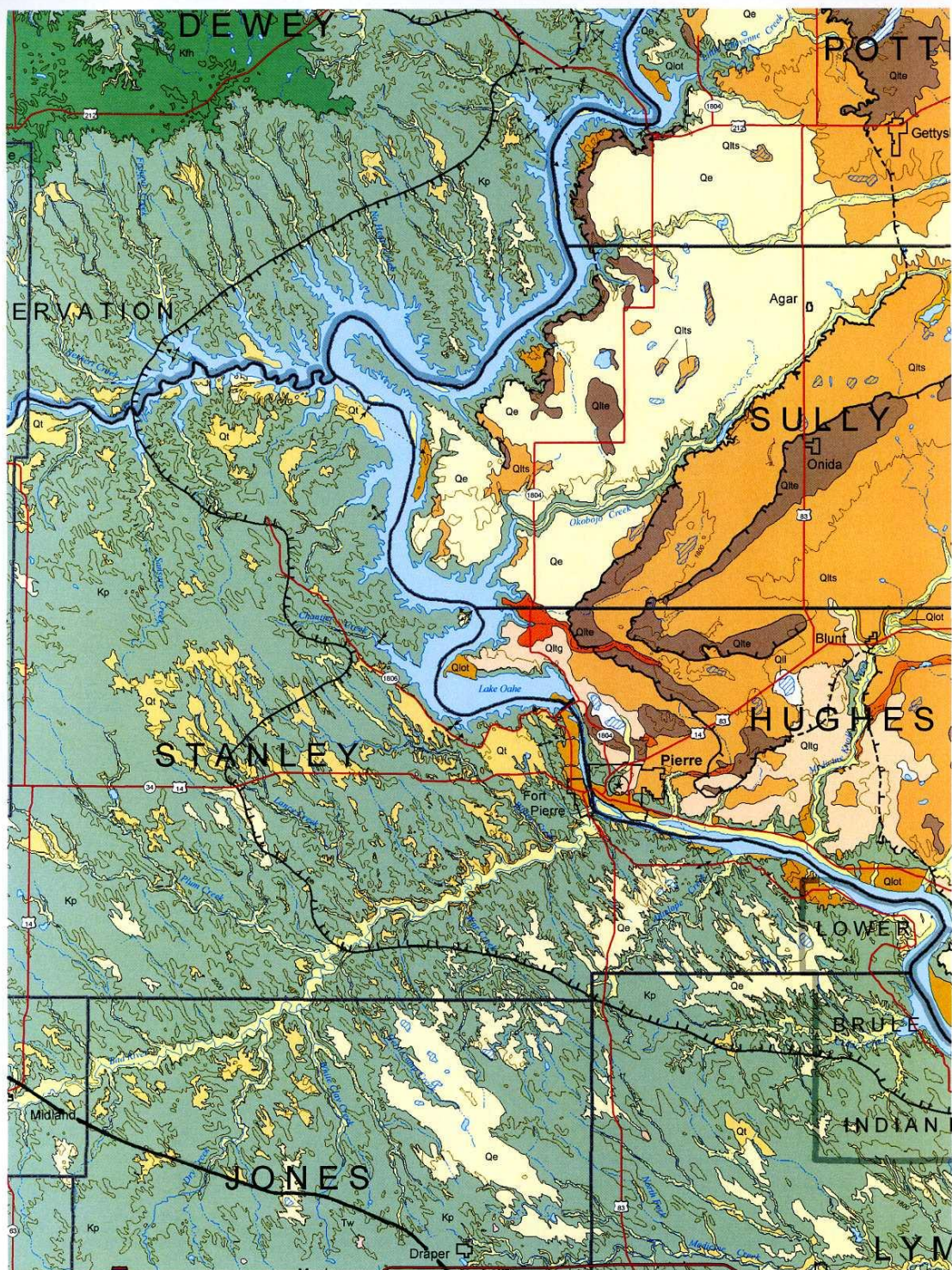


Figure 7. Part of the South Dakota geologic map (from Martin et al., 2004) in Haakon and Jones counties, with proposed Keystone XL route superimposed.

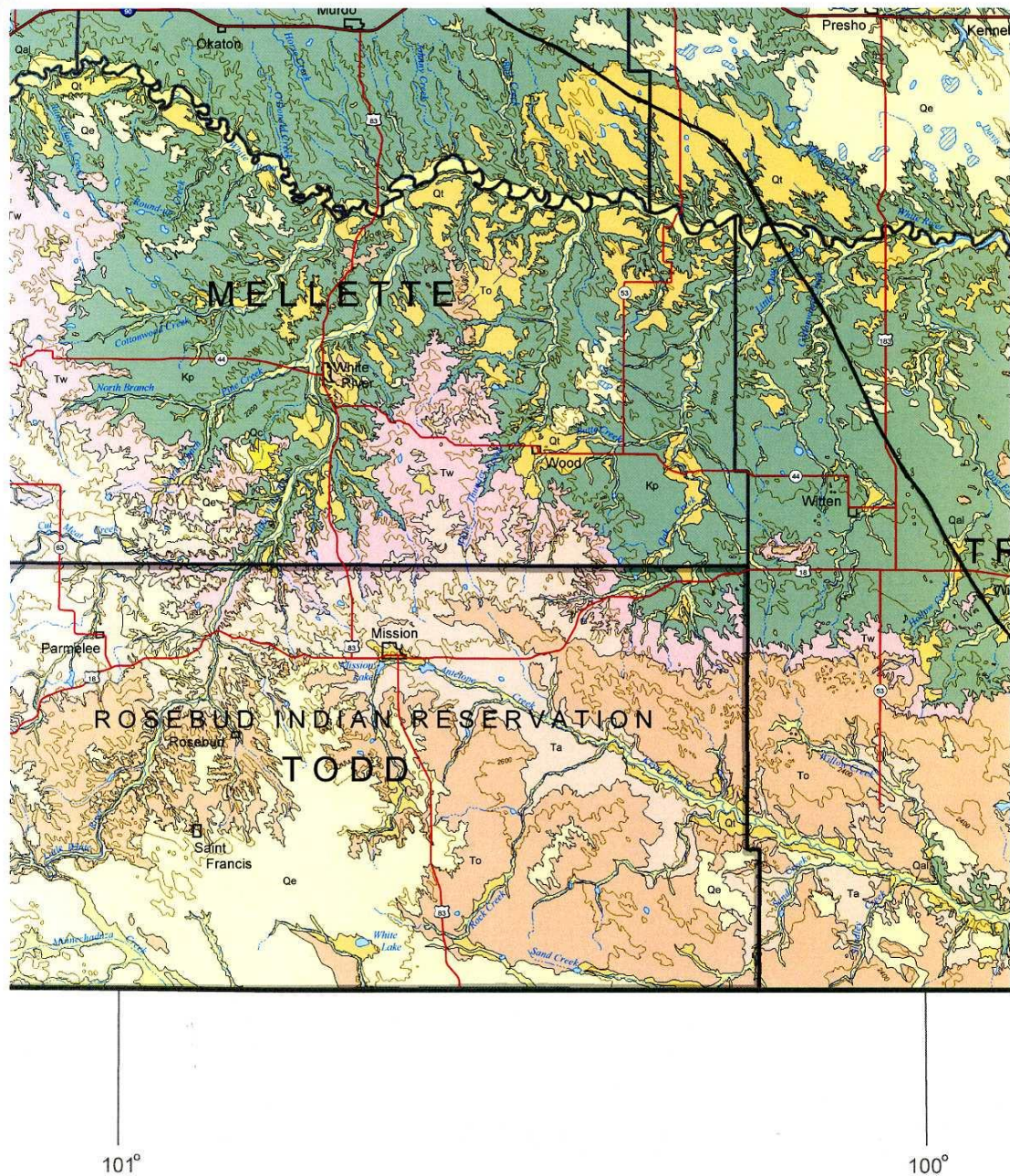
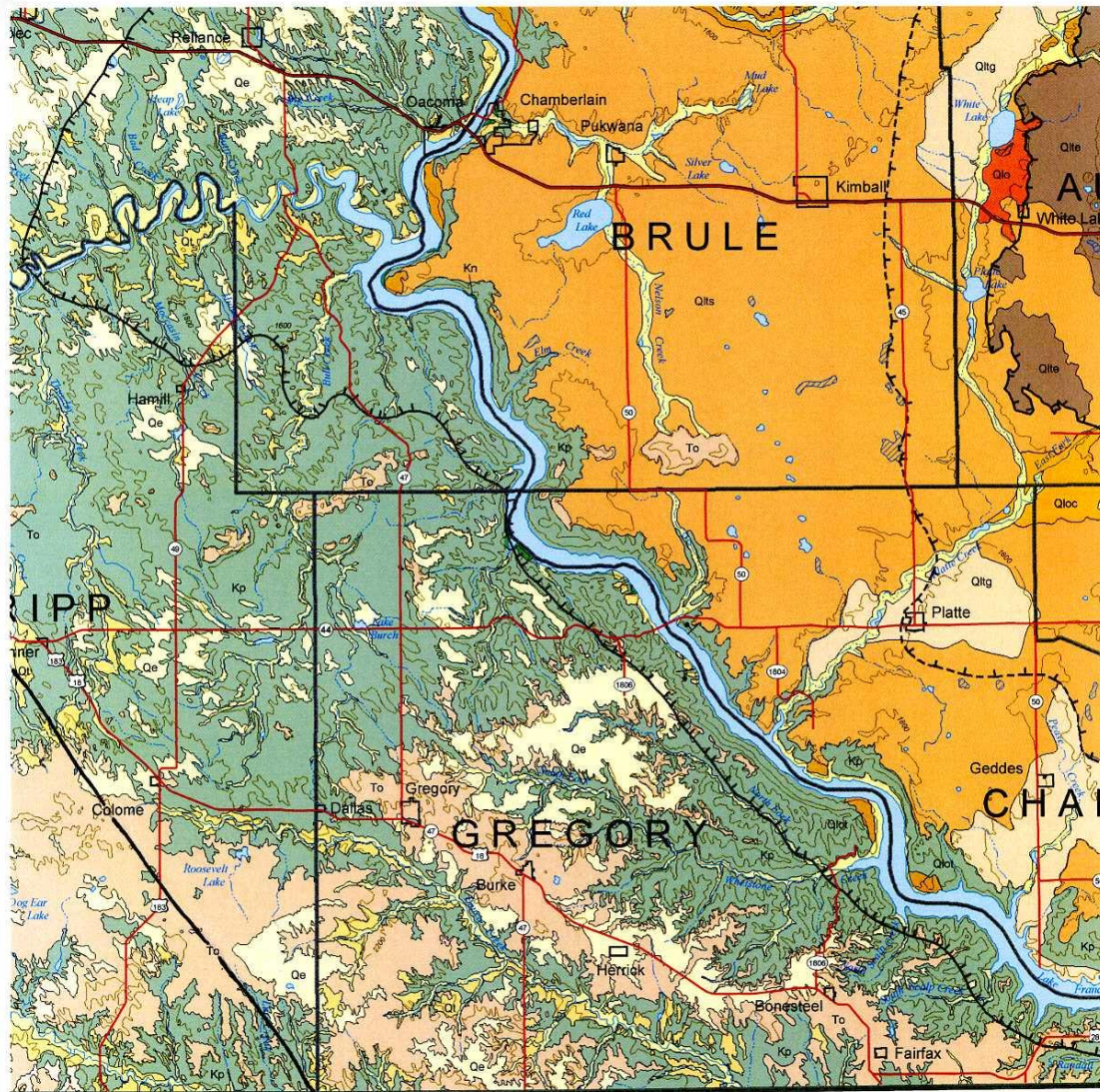


Figure 8. Part of the South Dakota geologic map (from Martin et al., 2004) in Jones, Lyman, and Tripp counties, with proposed Keystone XL route superimposed. The area mapped as Q_t shows terrace deposits of streams in former flood plains.



99°

Figure 9. Part of the South Dakota geologic map (from Martin et al., 2004) in Tripp County, with proposed Keystone XL route superimposed. The area mapped as T_o shows the Ogallala aquifer. The areas mapped as Q_e show eolian (wind-blown) deposits, including Sand Hills type material.

BEFORE THE
PUBLIC UTILITIES COMMISSION
STATE OF SOUTH DAKOTA

KEYSTONE XL PROJECT
DOCKET HP09-001

PREFILED TESTIMONY OF MICHAEL K. MADDEN
ON BEHALF OF THE COMMISSION STAFF
SEPTEMBER 2009

BEFORE THE PUBLIC UTILITIES COMMISSION STATE OF SOUTH DAKOTA

PREFILED TESTIMONY OF MICHAEL K. MADDEN

Q: Please state your name and business address.

A: Michael K. Madden, 63 Langdon Road, Buffalo, Wyoming 82834.

Q: Describe your educational background.

A: I received my Bachelor of Science Degree in 1965 from South Dakota State University with a major in Economics and a minor in Mathematics. I received my Doctorate with a major in Economics and minor in Statistics from Iowa State University in 1970.

Q: What is your employment history?

A: I served as Assistant Professor of Economics at the University of Wyoming from 1968 to 1972, Associate Professor of Economics at South Dakota State University from 1972 to 1975 and Associate Professor, Professor and Assistant Dean at the University of South Dakota from 1975 to 1999. From 1999 until 2003, I served as Dean of Graduate Studies at National American University in Rapid City. During all of this time, I also devoted significant time to private consulting activities.

Q: By whom are you now employed?

A: Since retiring from the academic field, I am now self-employed as a business and economic consultant. During the last three years, I have served as a Wyoming State Representative of Johnson and Sheridan Counties.

Q: What work experience have you had that is relevant to your research on this project?

A: I have conducted economic impact and feasibility studies for nearly three decades in South Dakota. Industries in which I have performed these analyses include electric power, mining, agriculture, health, banking and tourism.

Q. On whose behalf was this testimony prepared?

A. This testimony was prepared on behalf of the Staff of the South Dakota Public Utilities Commission (Staff).

Q: What is the purpose of your testimony?

A: My purpose in providing this testimony is to report my findings regarding various socioeconomic impacts that can be expected in connection with the construction and operation of the proposed Keystone XL hydrocarbon pipeline. The study I am preparing in providing a basis for this testimony will be entitled "Assessment of Socioeconomic Impacts Associated with Keystone XL."

Q: Which socioeconomic areas are you studying?

A: The retail sectors that are similar to those impacted by the travel industry, such as eating and drinking establishments, lodging and general retail trade. Other business sectors that are examined include health, agriculture and housing. Social services, such as emergency ambulance services, police and fire protection and transportation are also being examined.

Q: What methodology are you employing?

A: A primary basis of the analysis involves an examination of changes in socioeconomic factors that has occurred and is presently occurring during the construction cycle of the first Keystone Pipeline in eastern South Dakota. In economic sectors for which data is available, I am examining changes in business volume from secondary sources. This information is being supplemented by field interviews with representatives of key community business organizations and providers of social services. Since the same company is involved with both projects at nearly the same span of time, it is expected that reliable results for Keystone XL will be obtained. In addition, much useful information will be synthesized from the Wyoming Industrial Siting Council and the Wyoming Pipeline Authority. Both of these organizations have had detailed experience with dozens of pipeline projects in the state of Wyoming.

Q: Is the study complete?

A: No, the study could not be finalized until the specific communities which were impacted most from the first Keystone pipeline could be determined and until the bulk of these community impacts had transpired. I will, therefore, substantiate the findings relayed below prior to the hearing through the submission of the aforementioned report.

However, some preliminary findings have emerged.

Q: Summarize the findings that have been determined to this point.

A: The source and direction of impacts within the industries studied are summarized below.

| Industry | Source of Economic Impacts | Direction of Impact | Net Impact |
|--------------------|-----------------------------------|---------------------|-------------------|
| Leisure Travel | Revenue | Positive | Positive |
| | Labor Costs | None Significant | |
| | Displacement of Traditional Users | Somewhat Negative | |
| Health | Revenue | Positive | Positive |
| | Labor Costs | None Significant | |
| | Displacement of Traditional Users | None | |
| Law Enforcement | Volume | Somewhat Positive | Moderate Negative |
| | Labor Costs | None | |
| Emergency Services | Volume | None | None Significant |
| | Labor Costs | None | |
| Fire Services | Volume | None | None Significant |
| | Labor Costs | None | |
| Agriculture | Revenue | None | None Significant |
| | Labor Costs | None Significant | |
| Retail | Revenue | Positive | Positive |

| | | | |
|---------|-----------------------------------|----------|----------|
| | Labor Costs | Negative | |
| | Displacement of Traditional Users | None | |
| Housing | Revenue | Positive | Positive |
| | Displacement/Rent Increases | Minor | |

Most sectors are impacted by changes in gross revenues. Agriculture does not appear to have been impacted, but adjoining landowners may have benefited slightly by access fees.

Labor expense for farmers has not noticeably increased due to increased competition from pipeline businesses. Labor costs are not expected to rise in the Keystone XL project because of increased unit labor competition of the moderate amount of local labor demanded and because of the short-term character of the positions that will be available. On balance, most sectors are projected to experience an economic benefit because increases in revenues will exceed increased labor expenses.

Displacement of traditional leisure travelers in Western South Dakota by construction workers demanding the same goods and services is likely to be limited to the summer season. Any potential impacts are likely to be mitigated because of the intent on the part of the company to utilize temporary worker camps in two or three communities in close proximity to the project. Murdo, the community with potentially the largest tourism impact, will have specifically been addressed by the company by providing workers for the area a temporary worker camp near Winner. Any impacts to that community will occur in 2011 and is therefore expected to be minor.

Moderately increased revenue is expected to be the primary economic impact accruing to the health industry in connection with the project.

The retail sector is projected to experience moderate growth in revenue. Retail businesses providing goods that are directly bought by construction workers will experience the largest growth. Other businesses will see revenues grow through indirect spending. Providers of fuel and other supplies directly required by the project itself will experience increased revenues, with moderate increases in labor requirements. An increased demand for labor created by the construction of the pipeline will induce higher local wages. Generally, sectors providing goods and services directly to the project will experience the highest growth in demand for labor, but will probably not significantly increase wage rates due to the short-term nature of the growth in business volume.

Because of its unique nature, the need for housing has the potential to generate negative community impacts in towns such as Buffalo, Belle Fourche, Philip, Murdo and Winner. Any substantial increase in temporary housing demand may produce increased competition seen by local tenants as competition from temporary construction workers, earning higher than average wages, takes place. This, in turn, may produce undesirable economic consequences in the long run if displaced tenants choose to leave the area permanently.

The project plan however, provides a mitigation of these impacts by the operation of large construction camps in the vicinity of Union Center and Winner. It is important that these worker camps be a part of the company commitment to help ease the load on local housing stocks.

Q: How else can the possible negative remaining impact on the housing market be mitigated?

A: If adequate sized worker camps providing board and room to temporary workers are provided, there is probably nothing else that needs to be done. Any remaining capacity

shortcomings to the worker camps can be supplemented by:

- Bus transportation could be provided for workers from larger and more distant communities such as Rapid City, Pierre or Chamberlain to the job site. This policy would mitigate the otherwise added cost of transportation to and from work for those living in more distant communities.
- Agreements could be negotiated with area motels guaranteeing a minimum quantity and price of lodging rooms throughout the region. These agreements could be negotiated with consideration given to geographic dispersion and to available capacity throughout annual cycles.

Q: Aside from your study to substantiate your conclusions, does this conclude your testimony?

A: Yes



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Yellowstone: Rupture Probe Is Stalled, But Pipeline Restart Plan Moving Forward

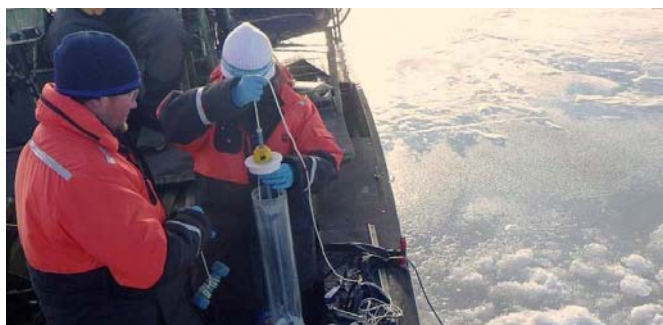
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The spill has renewed concerns about the safety of oil pipelines that cross rivers and other bodies of water in more than 18,000 places nationwide.

BY ELIZABETH DOUGLASS, INSIDECLIMATE NEWS

FEB 20, 2015



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Workers collect water samples in the Yellowstone River, where Bridger Pipeline LLC's Poplar Pipeline cracked under the riverbed and leaked up to 40,000 gallons into the water. Credit: EPA

The investigation into last month's oil pipeline spill in the Yellowstone River will be stalled until at least next fall because the most critical piece of evidence—the failed segment of pipe—can't be safely retrieved from the river until after snow-melt flooding is over, according to the pipeline's owner.

The 193-mile Poplar Pipeline, meanwhile, could be repaired and re-opened as soon as March 31, according to Bill Salvin, spokesman for [Bridger Pipeline LLC](#), which owns the ruptured oil line.

The company is preparing to install a replacement pipe segment that would cross the Yellowstone deeper below the riverbed, though it wasn't immediately clear what the depth would be. The Poplar was eight feet under the river in late 2011, but at the time of the spill, river forces had eroded away all of that cover in places.

The [Poplar breach has renewed concerns about the safety of oil pipelines that cross rivers and other bodies of water](#) in more than 18,000 places nationwide. Many of them are buried just a few feet below the water—and it's increasingly clear that pipelines should be installed much deeper.



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Under a Jan. 23 corrective action order from federal regulators, Bridger must subject the replacement pipe to hydrostatic pressure testing and carry out a restart plan that has been approved by the Pipeline and Hazardous Materials Safety Administration. When the Poplar resumes carrying crude oil across Montana, it must operate at reduced pressure.

The order also gave Bridger 45 days to complete a battery of tests and failure analysis on the broken pipe. With the river still covered in ice, Bridger will seek an extension of that requirement until conditions allow for safe removal of the pipe, said Salvin, the Bridger spokesman. He said the pipe will likely to stay in the river until after the Yellowstone's seasonal flooding, which can last into August.

Last week, [Montana's Department of Environmental Quality](#) formally notified Bridger that the spill violated state water quality standards, that the company must reimburse the state for its emergency response efforts, and that it must conduct extensive testing and complete corrective actions to remediate damage from the spill once the ice melts. The DEQ's Feb. 12 letter also noted that it "will be seeking to negotiate with Bridger to enter into a settlement to address final compliance and penalties."

Salvin said the company expected the DEQ notice. "Nothing in there was a surprise to us," he said.

When the Poplar broke in eastern Montana on Jan. 17, about 30,000 gallons of crude oil spilled into the Yellowstone and contaminated the drinking water for residents of nearby



Ice Hinders Cleanup of Yellowstone Oil Pipeline Spill

BY ZAHRA HIRJI

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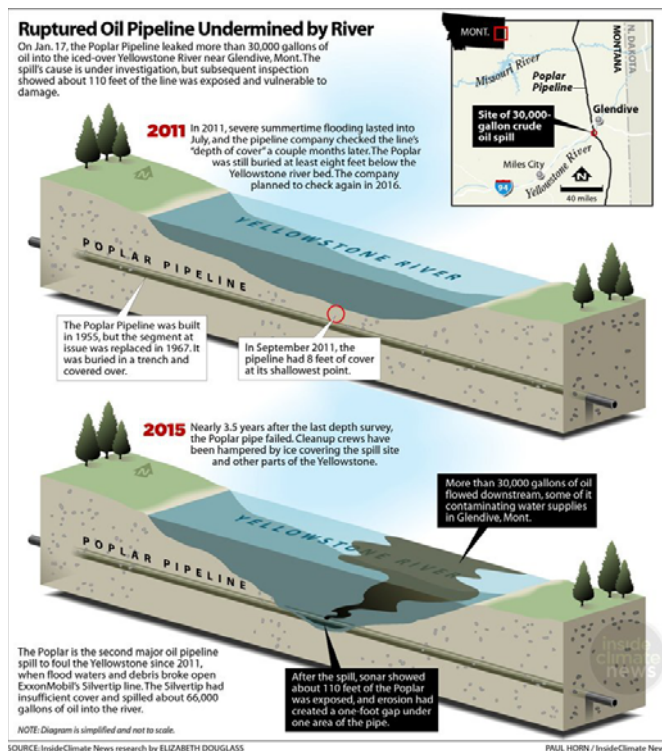
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Glendive. Oil recovery was hampered by a thick layer of ice at the rupture site and for several miles downstream.

Subsequent sonar testing showed that about 110 feet of the pipeline were completely exposed along the bottom of the river. In one area, river scour had whisked away a foot of earth underneath the pipe, leaving it unsupported and especially vulnerable to damage for 22 feet.

The company said the Poplar was still buried at least eight feet under the river bottom in September 2011, when it was last checked. Bridger planned to check the depth of cover again in September 2016. While the rupture's cause will not be known until testing is completed, it's likely that the pipeline's exposure was a factor.



This case and several other recent spills—including ExxonMobil's 2011 pipeline

spill into the Yellowstone—have involved pipelines that were uncovered after floods and natural forces scoured away the earth that was covering them.

To address that concern, PHMSA also required Bridger to replace the Poplar pipeline crossings at the Yellowstone and Poplar rivers using "horizontal directional drilling."

That technique involves drilling a tube-like opening for the pipeline tens of feet below the bottom of the riverbed. Bridger will construct a 6,000-foot pipe segment on land, and then place it under the Yellowstone river through the drilled opening.

TransCanada, the company behind the controversial Keystone XL pipeline, plans to use horizontal directional drilling where the pipeline would cross the Yellowstone and in some other places. The pipeline would carry Canadian tar sands and would cross nearly 2,000 rivers, streams and reservoirs in Montana, South Dakota and Nebraska, according to one estimate.

The Poplar segment that leaked was installed by digging a trench in the riverbed, laying the pipe and then covering it with earth. It's a method that's been used extensively in the industry, but many now consider trenched pipeline crossings to be more susceptible to river scour and other hazards.

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BEFORE THE PUBLIC UTILITIES COMMISSION
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| PIPELINE, LP FOR A PERMIT UNDER | : | TRANSCANADA KEYSTONE |
| THE SOUTH DAKOTA ENERGY | | PIPELINE, LP'S OBJECTIONS TO |
| CONVERSION AND TRANSMISSION | : | CINDY MYERS' FIRST |
| FACILITIES ACT TO CONSTRUCT THE | | INTERROGATORIES AND |
| KEYSTONE XL PROJECT | : | REQUEST FOR PRODUCTION OF |
| | | DOCUMENTS |
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TransCanada Keystone Pipeline, LP ("Keystone") makes the following objections to interrogatories pursuant to SDCL § 15-6-33 and objections to request for production of documents pursuant to SDCL § 15-6-34(a). Keystone will further respond, as indicated throughout the objections, on or before February 6, 2015. These objections are made within the scope of SDCL § 15-6-26(e) and shall not be deemed continuing nor be supplemented except as required by that rule.

GENERAL OBJECTION

Keystone objects to the instructions and definitions contained in Cindy Myers' First Set of Interrogatories and Requests for Production of Documents to the extent that they are inconsistent with the provisions of SDCL Ch. 15-6. *See* ARSD 20:10:01:01.02.

Keystone's answers are based on the requirements of SDCL §§ 15-6-26, 15-6-33, 15-6-34, and 15-6-36.

INTERROGATORIES AND REQUEST FOR PRODUCTION OF DOCUMENTS

1. Please identify the person or persons providing each answer to an Interrogatory or portion thereof, giving the full name, address of present residence, date of birth, business address and occupation.

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

2. Prior to answering these interrogatories, have you made due and diligent search of all books, records, and papers of the Applicant with the view of eliciting all information available in this action?

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

2(a). Describe how TransCanada will comply with these Acts as they apply to the project in relation to rivers, ground water and water system crossings in South Dakota.

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

2(b). Provide research entailing migration of benzene in watersheds, rivers and ground water.

ANSWER: Any responsive, non-privileged documents will be provided on or before February 6, 2015.

8(a). Explain what changes have been made in the Emergency Response Plan and Integrity Management Plan since 2010.

OBJECTION: To the extent that this request seeks production of the Emergency Response Plan, the request seeks information that is beyond the scope of the PUC's jurisdiction and Keystone's burden under SDCL § 49-41B-27. This request also seeks information addressing an issue that is governed by federal law and is within the province of PHMSA. The PUC's jurisdiction over pipeline safety is preempted by federal law. *See* 49 C.F.R. Part 194; 49 U.S.C. § 60104(c). This request further seeks information that is confidential and proprietary. Public disclosure of the emergency response plan and the integrity management plan could commercially disadvantage Keystone. In addition, Keystone is not required to submit its Emergency Response Plan to PHMSA until sometime close to when the Keystone Pipeline is placed into operation. Keystone's Emergency Response Plan is addressed in The Final Supplemental Environmental Impact Statement at <http://keystonepipeline-xl.state.gov/documents/organization/221189.pdf>.

8(b). Provide the Emergency Response Plan.

OBJECTION: The request seeks information that is beyond the scope of the PUC's jurisdiction and Keystone's burden under SDCL § 49-41B-27. This request also seeks information addressing an issue that is governed by federal law and is within the province of PHMSA. The PUC's jurisdiction over pipeline safety is preempted by federal law. *See* 49 C.F.R. Part 194; 49 U.S.C. § 60104(c). This request further seeks information that is confidential and proprietary. Public disclosure of the emergency response plan could commercially disadvantage Keystone. In addition, Keystone is not required to submit its Emergency Response Plan to PHMSA until sometime close to when the Keystone Pipeline is placed into operation. Keystone's Emergency Response Plan is addressed in The Final Supplemental Environmental Impact Statement at <http://keystonepipeline-xl.state.gov/documents/organization/221189.pdf>.

8(c). Provide the Integrity Management Plan.

OBJECTION: The request seeks information that is beyond the scope of the PUC's jurisdiction and Keystone's burden under SDCL § 49-41B-27. This request also seeks information addressing an issue that is governed by federal law and is within the province of PHMSA. The PUC's jurisdiction over pipeline safety is preempted by federal law. *See* 49 C.F.R. Part 194; 49 U.S.C. § 60104(c). This request further seeks information that is confidential and proprietary. Public disclosure of the integrity management plan could commercially disadvantage Keystone. In addition, Keystone is

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not required to submit its Integrity Management Plan to PHMSA until sometime close to when the Keystone Pipeline is placed into operation.

18(a). Where will fuel storage facilities be located within 200 feet of private wells and 400 feet of municipal wells?

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

18(b). How will minimizing and exercising vigilance be enforced?

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

21(a). Define "frac-out."

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

21(b). What are concerns and safety issues related to a "frac-out."

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

21(c). Provide "frac-out plan."

ANSWER: Any responsive, non-privileged documents will be provided on or before February 6, 2015.

34(a). Describe what progress has been made in the evaluation and performance assessment activities regarding high consequence areas since 2010.

OBJECTION: To the extent that this request seeks a list of High Consequence Areas, the identity and location of High Consequence Areas is confidential by statute and Keystone is required by PHMSA to keep this information confidential. To the extent that this request seeks production of the Emergency Response Plan, the request seeks information that is beyond the scope of the PUC's jurisdiction and Keystone's burden under SDCL § 49-41B-27. This request also seeks information addressing an issue that is governed by federal law and is within the province of PHMSA. The PUC's jurisdiction over pipeline safety is preempted by federal law. *See* 49 C.F.R. Part 194; 49 U.S.C. § 60104(c). This request further seeks information that is confidential and proprietary. Public disclosure of the emergency response plan could commercially disadvantage Keystone. In addition, Keystone is not required to submit its Emergency Response Plan to PHMSA until sometime close to when Keystone Pipeline is placed into operation. Keystone's Emergency Response Plan is addressed in The Final Supplemental Environmental Impact Statement at <http://keystonepipeline-xl.state.gov/documents/organization/221189.pdf>. Without waiving the objection, Keystone will provide a response to the rest of the request on or before February 6, 2015.

34(b). Define "high consequence area."

OBJECTION: To the extent that this request seeks a list of High Consequence Areas, the identity and location of High Consequence Areas is confidential by statute and Keystone is required by PHMSA to keep this information confidential. Without waiving the objection, Keystone will provide a response to the rest of the request on or before February 6, 2015.

34(c). Provide a completed list of high consequence areas.

OBJECTION: The identity and location of High Consequence Areas is confidential by statute and Keystone is required by PHMSA to keep this information confidential.

34(d). Explain how project inhabitants and local communities will be informed and educated about high consequence areas.

OBJECTION: To the extent that this request seeks a list of High Consequence Areas, the identity and location of High Consequence Areas is confidential by statute and Keystone is required by PHMSA to keep this information confidential. Without waiving the objection, Keystone will provide a response to the rest of the request on or before February 6, 2015.

34(c). Provide a copy of the Emergency Response Plan. (Requested above with #8.)

OBJECTION: The request seeks information that is beyond the scope of the PUC's jurisdiction and Keystone's burden under SDCL § 49-41B-27. This request also seeks information addressing an issue that is governed by federal law and is within the province of PHMSA. The PUC's jurisdiction over pipeline safety is preempted by federal law. *See* 49 C.F.R. Part 194; 49 U.S.C. § 60104(c). This request further seeks information that is confidential and proprietary. Public disclosure of the emergency response plan could commercially disadvantage Keystone. In addition, Keystone is not required to submit its Emergency Response Plan to PHMSA until sometime close to when the Keystone Pipeline is placed into operation. Keystone's Emergency Response Plan is addressed in The Final Supplemental Environmental Impact Statement at <http://keystonepipeline-xl.state.gov/documents/organization/221189.pdf>.

34(f). Provide Integrity Management Plan. (Requested above with #8.)

OBJECTION: The request seeks information that is beyond the scope of the PUC's jurisdiction and Keystone's burden under SDCL § 49-41B-27. This request also seeks information addressing an issue that is governed by federal law and is within the province of PHMSA. The PUC's jurisdiction over pipeline safety is preempted by federal law. *See* 49 C.F.R. Part 194; 49 U.S.C. § 60104(c). This request further seeks information that is confidential and proprietary. Public disclosure of the integrity management plan could commercially disadvantage Keystone. In addition, Keystone is

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not required to submit its Integrity Management Plan to PHMSA until sometime close to when the Keystone Pipeline is placed into operation.

35(a). Provide the Integrity Management and Emergency Response Plans. (Requested above.)

OBJECTION: The request seeks information that is beyond the scope of the PUC's jurisdiction and Keystone's burden under SDCL § 49-41B-27. This request also seeks information addressing an issue that is governed by federal law and is within the province of PHMSA. The PUC's jurisdiction over pipeline safety is preempted by federal law. *See* 49 C.F.R. Part 194; 49 U.S.C. § 60104(c). This request further seeks information that is confidential and proprietary. Public disclosure of the emergency response plan and the integrity management plan could commercially disadvantage Keystone. In addition, Keystone is not required to submit these documents to PHMSA until sometime close to when the Keystone Pipeline is placed into operation. Keystone's Emergency Response Plan is addressed in The Final Supplemental Environmental Impact Statement at <http://keystonepipeline-xl.state.gov/documents/organization/221189.pdf>.

35(b). Define "Unusually Sensitive Areas."

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

35(c). Define "Hydrologically Sensitive Areas."

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ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

35(d). Explain how unusually sensitive areas and hydrologically sensitive areas are addressed differently compared to other areas.

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

35(e). Confirm that you are not fully aware of all vulnerable and beneficially useful aquifers and your intent is to only become aware of them during construction and route evaluation not yet completed.

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

35(f). Define "unconfined aquifers."

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

35(g). List known unconfined aquifers to be crossed by the project.

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

35(h). Explain the concern of routing through unconfined aquifers.

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

35(i). Describe how it could be possible to route through an unknown, unconfined aquifer during construction.

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

35(j). Provide documentation of further route evaluation since 2010, including assessments for aquifers and hydrologically sensitive areas.

OBJECTION AND RESPONSE: This request is vague, overlybroad, and unduly burdensome. Without waiving the objection, any responsive, non-privileged documents showing changes in the route or addressing aquifers and hydrologically sensitive areas will be provided on or before February 6, 2015.

35(k). Explain how you will deem an aquifer vulnerable and beneficially useful?

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

35(l). This condition states: "...in some reaches of the Project in southern Tripp County, the High Plains Aquifer is present at or very near ground surface and is overlain by highly permeable sands permitting the uninhibited infiltration of contaminants."

Sandy soil and ground water at or above the surface means a pipe with expected pinhole

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leaks will be immersed in ground water. This is the exact type of situation of soil/ground water which caused the route change in Nebraska. If this was reason to change the route in Nebraska, explain why it is still acceptable in South Dakota.

OBJECTION AND RESPONSE: This request is argumentative and assumes facts not in evidence. Without waiving the objection, Keystone will answer this interrogatory on or before February 6, 2015.

35(m). Explain TransCanada's follow-up with suggestion by DENR staff, given in testimony, to reroute the KXL pipeline around the city of Colome's source water area.

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

36(a). Identify all emergency medical response planning contained within the emergency response plan.

OBJECTION: This request seeks information that is beyond the scope of the PUC's jurisdiction and Keystone's burden under SDCL § 49-41B-27. This request also seeks information addressing an issue that is governed by federal law and is within the exclusive province of PHMSA. The PUC's jurisdiction over the emergency response plan is preempted by federal law, which has exclusive jurisdiction over issues of pipeline safety. *See* 49 C.F.R. Part 194; 49 U.S.C. § 60104(c). This request further seeks information that is confidential and proprietary. *See* Amended Final Order, HP 09-001,

Condition ¶ 36. Public disclosure of the emergency response plan would commercially disadvantage Keystone. In addition, Keystone is not required to submit its Emergency Response Plan to PHMSA until sometime close to when the Keystone Pipeline is placed into operation. Keystone's Emergency Response Plan is addressed in The Final Supplemental Environmental Impact Statement at

<http://keystonepipeline-xl.state.gov/documents/organization/221189.pdf>.

36(b). What actions have been taken by TransCanada to ensure the medical communities in South Dakota are prepared and educated to treat people exposed to spills and water contamination from spills?

OBJECTION AND RESPONSE: To the extent that this request seeks production of the Emergency Response Plan, this request seeks information that is beyond the scope of the PUC's jurisdiction and Keystone's burden under SDCL § 49-41B-27. This request also seeks information addressing an issue that is governed by federal law and is within the exclusive province of PHMSA. The PUC's jurisdiction over the emergency response plan is preempted by federal law, which has exclusive jurisdiction over issues of pipeline safety. *See* 49 C.F.R. Part 194; 49 U.S.C. § 60104(c). This request further seeks information that is confidential and proprietary. *See* Amended Final Order, HP 09-001, Condition ¶ 36. Public disclosure of the emergency response plan would commercially disadvantage Keystone. In addition, Keystone is not required to submit its Emergency

Response Plan to PHMSA until sometime close to when the Keystone Pipeline is placed into operation. Keystone's Emergency Response Plan is addressed in The Final Supplemental Environmental Impact Statement at

<http://keystonepipeline-xl.state.gov/documents/organization/221189.pdf>. Without

waiving the objection, Keystone will provide a response on or before February 6, 2015.

36(c). How will inhabitants and communities near the project area be notified of spills?

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

40(a). Provide documentation supporting your assertion that polyethylene water piping is permeable to BTEX.

ANSWER: Any responsive, non-privileged documents will be provided on or before February 6, 2015.

40(b). Explain health concerns related to BTEX.

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

40(c). Provide an MSDS of all products to be transported in KXL, including the diluents.

ANSWER: Any responsive, non-privileged documents will be provided on or before February 6, 2015.

40(d). Provide list of ground water quality standards, specifically listing chemicals involved in tar sands oil product and diluents.

OBJECTION: Keystone does not determine ground water quality standards. They are established by the South Dakota Department of Environment and Natural Resources.

40(e). Describe how the decision was made to designate concern of BTEX only within 500 feet of the Project.

OBJECTION: This request seeks information that is not within Keystone's custody or control. This decision was made by the PUC as part of Amended Permit Condition 40.

40(f). Confirm this safety measure will only be implemented at the request of a landowner or public water supply system.

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

40(g). Explain why this measure is optional instead of mandatory.

OBJECTION: This request seeks information that is not within Keystone's custody or control. This decision was made by the PUC as part of Amended Permit Condition 40.

40(h). TransCanada has agreed to do this: “At least forty-five days prior to commencing construction, Keystone shall publish a notice in each newspaper of general circulation in each county through which the Project will be constructed advising landowners and public water supply systems of this condition.” What percent of inhabitants do you expect to reach by issuing a warning in this manner?

OBJECTION AND RESPONSE: This request is speculative and argumentative. A notice is not a “warning.” Without waiving the objection, Keystone expects that notice in newspapers of general circulation would reach a substantial portion of the inhabitants.

46(a). Provide written plan as to how you will find and provide a permanent water supply for various locations along route if a well should become contaminated, including specific alternate sources.

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

46(b). Define “quantity” as it is used in this condition.

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

46(c). Provide cost estimates for providing water to the city of Colome, domestic wells or an entire ranching operation should water supplies become contaminated.

ANSWER: Any responsive, non-privileged documents will be provided on or before February 6, 2015.

46(d). Explain how providing a permanent water supply will be ensured into perpetuity.

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

46(e). Explain how people and cattle using private wells and public wells can be assured their water is free of contamination from undetected leakage, particularly in Tripp County.

OBJECTION: This request seeks information that is not within Keystone's custody or control.

46(f). Describe what experience South Dakota has had cleaning up tar sands oil product spills into rivers and ground water.

OBJECTION: This request seeks information that is not within Keystone's custody or control.

46(g). Describe any experience the State of South Dakota or any other state has had in "sparging" ground water in order to cleanse tar sands oil product from aquifers.

OBJECTION: This request seeks information that is not within Keystone's custody or control.

46(h). Describe types of spills which may be difficult or impossible to remediate.

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

46(i). Identify responsible parties who will conduct water analysis to assure toxins from undetected leaks have not migrated into water resources, including frequency of testing and who will assume cost of testing.

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

46(j). Describe potential scenarios in which medical costs related to contamination will be reimbursed.

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

46(k). Provide a detailed listing of potential toxins which could contaminate wells.

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

46(l). Provide documentation detailing adverse health effects caused from exposure to these toxins, including the various routes of entry into the human body.

ANSWER: Any responsive, non-privileged documents will be provided on or before February 6, 2015.

18(a). Regarding an advisory warning issued in September, 2014 by the federal Pipeline

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and Hazardous Materials Safety Administration, what are TransCanada's plans to ensure pipeline safety due to the fact different types of product will be transported in KXL?

OBJECTION AND RESPONSE: This request seeks information related to pipeline safety, which is within the exclusive jurisdiction of PHMSA. Without waiving the objection, Keystone will answer this interrogatory on or before February 6, 2015.

18(b). PHMSA cautioned pipeline operators across the country about "the potential significant impact flow reversals, product changes and conversion to service may have on the integrity (safety) of a pipeline." The advisory adds: "Flow reversals, product changes, and conversions to service may impact various aspects of a pipeline's operation, maintenance, monitoring, integrity management, and emergency response. Pressure gradients, velocity, and the location, magnitude, and frequency of pressure surges and cycles may change. Operators may also consider increasing the throughput capacity of the pipeline. Increasing throughput may also impact the pressure profile and pressure transients. ... Leak detection and monitoring systems may be affected."

OBJECTION: This request is not a question and cannot be answered. It also relates to an issue that is within the exclusive jurisdiction of PHMSA and is therefore not relevant or likely to lead to the discovery of admissible evidence.

18(c). Current regulations state: "Operators must review their integrity (safety) management program. ... Operators must notify PHMSA if these changes will

substantially affect their integrity management program, its implementation, or modifies the schedule for carrying out the program elements.”

OBJECTION: This request is not a question and cannot be answered. It also relates to an issue that is within the exclusive jurisdiction of PHMSA and is therefore not relevant or likely to lead to the discovery of admissible evidence.

18(d). KXL is intended to transport two very different products, the much less dense and highly volatile Bakken oil product and the heavy diluted bitumen from Alberta. How will the two very different products affect KXL's operation, maintenance, monitoring, integrity management, and emergency response? How will the two very different products affect pressure gradients, velocity, and the location, magnitude, and frequency of pressure surges and cycles?

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

33(a). Provide updated maps.

OBJECTION: This request is vague, overlybroad, unduly burdensome, and seeks information that is not relevant or likely to lead to the discovery of admissible evidence. Without waiving the objection, Keystone will provide maps showing changes to the route on or before February 6, 2015.

41(a). Provide map detailing all water bodies to be crossed in S.D., to include locations KXL would cross the Missouri and Yellowstone Rivers upstream from S.D.

OBJECTION: Keystone has previously filed with the PUC maps showing the route through South Dakota, which also show where the pipeline crosses rivers and other water bodies. Waterbody crossing permitting is within the control of the United States Army Corps of Engineers, and is beyond Keystone's control.

41(b). Provide map clearly depicting all waterways crossed by route which are tributaries into the Missouri River.

OBJECTION: Keystone has previously filed with the PUC maps showing the route through South Dakota, which also show where the pipeline crosses rivers and other water bodies.

41(c). Identify distances from KXL waterway crossings to point of confluence with the Missouri River.

OBJECTION: This request seeks information that is beyond Keystone's custody and control and not maintained within the ordinary course of business.

41(d). Provide map(s) demonstrating all public water utility intakes on the Missouri River system.

OBJECTION AND RESPONSE: This request is overlybroad, unduly burdensome, and seeks information that is not within Keystone's custody or control.

Without waiving the objection, Keystone will provide information related to defined well head protection areas and source water intakes within the area of its risk assessment to the extent that they are not confidential.

41(e). By what date will permitting of water body crossings be completed?

OBJECTION: Permitting of water body crossings is within the control of the United States Army Corps of Engineers, and is beyond Keystone's control.

41(f). Provide a copy of the CMR Plan. Ex TC-1, 5.4.1, pp. 45-46.

OBJECTION: A current copy of the CMR Plan is attached to Keystone's certification petition and is on file with the PUC.

41(g). Provide research which describes migration of spillage in these waterways.

OBJECTION: This request is vague, overlybroad, and unduly burdensome.

41(h). Please explain and describe water protection areas located downstream of major river crossings on the proposed route.

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

41(i). Explain risks of HDD, including possibility of contaminants being released into waterways during this process.

ANSWER: Keystone will answer this interrogatory on or before February 6, 2015.

50(a). Provide a map depicting the High Consequence Areas.

OBJECTION: This request seeks the identity and location of High Consequence Areas, which is confidential by statute, and Keystone is required by PHMSA to keep this information confidential.

50(b). Explain why the total length of pipe affecting HCA decreased from 34.3 miles to 19.9 miles.

OBJECTION: To the extent that this request seeks the identity and location of High Consequence Areas, that information is confidential by statute and Keystone is required by PHMSA to keep this information confidential. Keystone will provide a response to the rest of the request on or before February 6, 2015.

50(c). Explain how the statistic which states a spill could affect a HCA no more than once in 250 years.

OBJECTION: To the extent that this request seeks the identity and location of High Consequence Areas, that information is confidential by statute and Keystone is required by PHMSA to keep this information confidential. Keystone will provide a response to the rest of the request on or before February 6, 2015.

107(a). Provide the analysis by Dr. Michael Madden which professes the Project would not (ii) substantially impair the health, safety, or welfare of the inhabitants in the project area.

OBJECTION: Dr. Madden was PUC Staff's witness in Docket 09-001, and his direct testimony is a matter of public record.

107(b). Explain how the 2010 permit, which relies on the federal environmental impact statement prepared by the Department of State, addresses specific concerns of South Dakota, including the health, safety and welfare of South Dakota citizens.

OBJECTION: This request is vague, unclear, argumentative, and seeks information that is not relevant or likely to lead to the discovery of admissible evidence. The PUC addressed the health, safety, and welfare of South Dakota residents in the Amended Final Decision and Order in Docket 09-001. In addition, South Dakota residents had notice and opportunity to participate in the lengthy NEPA process conducted by the Department of State.

107(c). Explain your interpretation of "substantially" as it is used in state law SDCL 49-41 B-22 which states the applicant for a facility construction permit has the burden of proof to establish that:

(3) "The facility will not substantially impair the health, safety or welfare of the inhabitants."

OBJECTION: This request seeks a legal opinion or conclusion and is therefore beyond the scope of discovery and not likely to lead to the discovery of

admissible evidence under SDCL § 15-6-26(b). It was an issue for the PUC to determine in Docket HP 09-001.

107(d). State with 100% certainty that this project will have no impact on the health, safety or welfare of the people of South Dakota.

OBJECTION: This request is argumentative and seeks information that is not relevant or likely to lead to the discovery of admissible evidence. The PUC addressed the health, safety, and welfare of South Dakota residents in the Amended Final Decision and Order in Docket 09-001. Keystone has not asserted that the project would have “no impact” on the health, safety, or welfare of the people of South Dakota.

107(e). Describe how areas of dense populations versus areas of sparse populations affect project decision.

OBJECTION AND RESPONSE: This request is vague and unclear. Without waiving the objection, to the extent feasible and consistent with other routing criteria, areas of dense population are avoided during project routing.

Dated this 23rd day of January, 2015.

WOODS, FULLER, SHULTZ & SMITH P.C.

By /s/ James E. Moore

William Taylor

James E. Moore

Post Office Box 5027

300 South Phillips Avenue, Suite 300

Sioux Falls, SD 57117-5027

Phone: (605) 336-3890

Fax: (605) 339-3357

Email: Bill.Taylor@woodsfuller.com

James.Moore@woodsfuller.com

Attorneys for Applicant TransCanada

CERTIFICATE OF SERVICE

I hereby certify that on the 23rd day of January, 2015, I sent by e-mail transmission, a true and correct copy of Keystone's Objections to Cindy Myers' First Interrogatories and Request for Production of Documents, to the following:

Cindy Myers, R.N.

PO Box 104

Stuart, NE 68780

csmyers77@hotmail.com

/s/ James E. Moore

One of the attorneys for TransCanada

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

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| IN THE MATTER OF THE APPLICATION | : | HP 14-001 |
| BY TRANSCANADA KEYSTONE | | |
| PIPELINE, LP FOR A PERMIT UNDER | : | TRANSCANADA KEYSTONE |
| THE SOUTH DAKOTA ENERGY | : | PIPELINE, LP'S RESPONSES TO |
| CONVERSION AND TRANSMISSION | : | CINDY MYERS' FIRST |
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| KEYSTONE XL PROJECT | : | REQUEST FOR PRODUCTION OF |
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Applicant TransCanada makes the following responses to interrogatories pursuant to SDCL § 15-6-33, and responses to requests for production of documents pursuant to SDCL § 15-6-34(a). These responses are made within the scope of SDCL 15-6-26(e) and shall not be deemed continuing nor be supplemented except as required by that rule. Applicant objects to definitions and directions in answering the discovery requests to the extent that such definitions and directions deviate from the South Dakota Rules of Civil Procedure.

GENERAL OBJECTION

Keystone objects to the instructions and definitions contained in Cindy Myers' First Set of Interrogatories and Requests for Production of Documents to the extent that they are inconsistent with the provisions of SDCL Ch. 15-6. *See* ARSD 20:10:01:01.02. {01815033.1}

Keystone's answers are based on the requirements of SDCL §§ 15-6-26, 15-6-33, 15-6-34, and 15-6-36.

INTERROGATORIES AND REQUEST FOR PRODUCTION OF DOCUMENTS

1. Please identify the person or persons providing each answer to an Interrogatory or portion thereof, giving the full name, address of present residence, date of birth, business address and occupation.

ANSWER: Given the extremely broad scope volume of more than 800 discovery requests received by Keystone in this docket, a range of personnel were involved in answering the interrogatories. Keystone will designate the following witnesses with overall responsibility for the responsive information as related to the Conditions and proposed changes to the Findings of Fact, which are identified in Appendix C to Keystone's Certification Petition: Corey Goulet, President, Keystone Projects, 450 1st Street S.W., Calgary, AB Canada T2P 5H1; Steve Marr, Manager, Keystone Pipelines & KXL, TransCanada Corporation, Bank of America Center, 700 Louisiana, Suite 700, Houston, TX 77002; Meera Kothari, P. Eng., 450 1st Street, S.W., Calgary, AB Canada T2P 5H1; David Diakow, Vice President, Commercial, Liquids Pipeline, 450 1st Street S.W., Calgary, AB Canada T2P 5H1; Jon Schmidt, Vice President, Environmental & Regulatory, exp Energy Services, Inc., 1300 Metropolitan Boulevard, Suite 200,

Tallahassee, FL 32308; Heidi Tillquist, Senior Associate, Stantec Consulting Ltd., 2950 E. Harmony Rd., Suite 290, Fort Collins, CO 80528.

2. Prior to answering these interrogatories, have you made due and diligent search of all books, records, and papers of the Applicant with the view of eliciting all information available in this action?

ANSWER: Yes, to the extent reasonably practicable in attempting to respond to over 800 discovery requests within the time allowed.

2(a). Describe how TransCanada will comply with these Acts as they apply to the project in relation to rivers, ground water and water system crossings in South Dakota.

ANSWER: Keystone will comply with Clean Water Act 404 by permitting the crossing of all jurisdictional waterbodies in South Dakota under the US Army Corps of Engineers Nationwide General Permit (NWP) 12. As part of the permitting process of the Project route in South Dakota, Keystone will submit a NOI to the US Army Corps of Engineers, South Dakota Regulatory Office and will consult as required with the South Dakota Regulatory Office.

No waterbody crossing in South Dakota requires permitting under the Section 10 Rivers and Harbor Act.

2(b). Provide research entailing migration of benzene in watersheds, rivers and ground water.

ANSWER: The fate and transport of benzene and other crude oil constituents is discussed in numerous studies and articles, including those in the Department of State SFEIS Appendix P, 2009 Keystone XL Risk Assessment, such as:

Freeze, R. A. and J. A. Cherry. 1979. Groundwater. Prentice Hall, Inc. Englewood Cliffs, New Jersey. 604 pp.

Minnesota Pollution Control Agency. 2005. Assessment of Natural Attenuation at Petroleum Release Sites. Guidance Document c-prp4-03, Petroleum Remediation Program, Minnesota Pollution Control Agency. April 2005. 11 pp.

Neff, J. M. 1979. Polycyclic aromatic hydrocarbons in the aquatic environment. Applied Science publ. Ltd., London. 262 pp.

Newell, C. J. and J. A. Connor. 1998. Characteristics of Dissolved Petroleum Hydrocarbon Plumes: Results from Four Studies. American Petroleum Institute Soil / Groundwater Technical Task Force. December 1998.

Spence, L. R., K. T. O'Reilly, R. I. Maagaw, and W. G. Rixey. 2001. Chapter 6 – Predicting the fate and transport of hydrocarbons in soil and groundwater. in: risk-based decision-making or assessing petroleum impacts at exploration and production sites. Edited by S. McMillen, R. Magaw, R. Carovillano, Petroleum Environmental Research Forum and US Department of Energy.

United States Geological Service (USGS). 1998. Groundwater Contamination by Crude Oil near Bemidji, Minnesota. US Geological Survey Fact Sheet 084-98, September 1998.

Additional references on this subject from the FSEIS include:

American Petroleum Institute (API). 1992. Review of Natural Resource Damage Assessments in Freshwater Environments: Effects of Oil Release into Freshwater Habitats. API Publ. No. 4514.

API. 1997. Petroleum in the Freshwater Environment: An annotated Bibliography 1946-1993. API Publ. No. 4640.

Grimaz, S., S. Allen, J. Steward, and G. Dolcetti. 2007. Predictive evaluation of the extent of the surface spreading for the case of accidental spillage of oil on ground. Selected Paper IcheaP8, AIDIC Conference series, Vol. 8, 2007, pp. 151-160.

Hult, M.F. 1984. Groundwater Contamination by Crude Oil at the Bemidji, Minnesota, Research Site: U.S. Geological Survey Toxic Waste—Ground-Water Contamination Study. Papers presented at the Toxic-Waste Technical Meeting, Tucson, Arizona, March 20-22. USGS Water Investigations Report 84-4188.

Weaver, J.W., R.J. Charbeneau, J.D. Tauxe, B.K. Lien, and J.B. Provost. 1994. The hydrocarbon spill screening model (HSSM) Volume 1: User's guide. USEPA/600/R-94/039a. U.S. Environmental Protection Agency, Office of Research and Development, Robert S. Kerr, Environmental Research Laboratory, Ada, OK.

8(a). Explain what changes have been made in the Emergency Response Plan and Integrity Management Plan since 2010.

OBJECTION: To the extent that this request seeks production of the Emergency Response Plan, the request seeks information that is beyond the scope of the PUC's jurisdiction and Keystone's burden under SDCL § 49-41B-27. This request also seeks information addressing an issue that is governed by federal law and is within the province of PHMSA. The PUC's jurisdiction over pipeline safety is preempted by federal law. *See* 49 C.F.R. Part 194; 49 U.S.C. § 60104(c). This request further seeks information that is confidential and proprietary. Public disclosure of the emergency response plan and the integrity management plan could commercially disadvantage Keystone. In addition, Keystone is not required to submit its Emergency Response Plan

to PHMSA until sometime close to when the Keystone Pipeline is placed into operation.

Keystone's Emergency Response Plan is addressed in The Final Supplemental Environmental Impact Statement at

<http://keystonepipeline-xl.state.gov/documents/organization/221189.pdf>.

8(b). Provide the Emergency Response Plan.

OBJECTION: The request seeks information that is beyond the scope of the PUC's jurisdiction and Keystone's burden under SDCL § 49-41B-27. This request also seeks information addressing an issue that is governed by federal law and is within the province of PHMSA. The PUC's jurisdiction over pipeline safety is preempted by federal law. *See* 49 C.F.R. Part 194; 49 U.S.C. § 60104(c). This request further seeks information that is confidential and proprietary. Public disclosure of the emergency response plan could commercially disadvantage Keystone. In addition, Keystone is not required to submit its Emergency Response Plan to PHMSA until sometime close to when the Keystone Pipeline is placed into operation. Keystone's Emergency Response Plan is addressed in The Final Supplemental Environmental Impact Statement at <http://keystonepipeline-xl.state.gov/documents/organization/221189.pdf>.

8(c). Provide the Integrity Management Plan.

OBJECTION: The request seeks information that is beyond the scope of the PUC's jurisdiction and Keystone's burden under SDCL § 49-41B-27. This request also

seeks information addressing an issue that is governed by federal law and is within the province of PHMSA. The PUC's jurisdiction over pipeline safety is preempted by federal law. *See* 49 C.F.R. Part 194; 49 U.S.C. § 60104(c). This request further seeks information that is confidential and proprietary. Public disclosure of the integrity management plan could commercially disadvantage Keystone. In addition, Keystone is not required to submit its Integrity Management Plan to PHMSA until sometime close to when the Keystone Pipeline is placed into operation.

18(a). Where will fuel storage facilities be located within 200 feet of private wells and 400 feet of municipal wells?

ANSWER: The locations of the fuel storage facilities have not been determined at this point in the planning process. The fuel storage facility locations will be determined at the time of construction. Refer to Section 2.1.5.3, Fuel Transfer Stations of the DOS FSEIS (2014). Wells will be identified prior to the fuel storage facility final locations and will adhere to HP 09-001, Condition 18.

18(b). How will minimizing and exercising vigilance be enforced?

ANSWER: Keystone will minimize and exercise vigilance by providing adequate training and supervision of its contractors with respect to this provision.

21(a). Define "frac-out."

ANSWER: "Frac-out" is addressed in the FSEIS in Section 4.3.3.2 at page 4.3-21, which provides:

In some instances, pressurized fluids and drilling lubricants used in the HDD process have the potential to escape the active HDD bore, migrate through the sills, and come to the surface at or near the crossing construction site, an event commonly known as a frac-out. Measures identified in a required HDD contingency plan would be implemented, including monitoring of the directional drill bore, monitoring downstream for evidence of drilling fluids, and mitigation measures to address a frac-out should one occur.

21(b). What are concerns and safety issues related to a "frac-out."

ANSWER: This question is addressed at page 4.8-20 of the FSEIS:

The HDD method avoids direct disturbance to the river, channel bed, or banks. While the HDD method poses a small risk of frac-out (i.e., release of bentonite-based drilling fluids), potential releases would be contained by best management practices that would be described within the HDD Contingency Plans required for drilled crossings. Most leaks of HDD fluids occur near the entry, exit locations for the drill, and are quickly contained and cleaned up. Frac-outs that may release drilling fluids into aquatic environments are difficult to contain primarily because bentonite readily disperses in flowing water and quickly settles in standing water. Should this type of release occur, bentonite is non-toxic but in sufficient concentration may physically inhibit respiration of adult fish and eggs.

It is also addressed at pages 4.7-11 to -12 of Section 4.7.3.2 of the FSEIS:

The HDD method for crossing waterbodies would be used to minimize disturbance to aquatic habitat, stream banks, and recreational or commercial fisheries. Impacts could occur if there is an unintended release of drilling fluids (i.e., a frac out) during the HDD operation. A frac out could release bentonitic drilling mud into the aquatic environment. The released drilling mud would readily disperse in flowing water or eventually settle in standing

water. Although bentonite is non-toxic, suspended bentonite may produce short-term impacts to the respiration of fish and aquatic invertebrates due to fouled gills. Longer-term effects could result if larval fish are covered and suffocate due to fouled gills and/or lack of oxygen. If the frac out occurred during a spawning period, egg masses of fish could be covered, thus inhibiting the flow of dissolved oxygen to the egg masses. Benthic invertebrates and the larval stages of pelagic organisms could also be covered and suffocate.

To minimize the potential for these impacts to occur, a contingency plan would be implemented to address an HDD frac out. This plan would include preventive and response measures to control the inadvertent release of drilling fluids. The contingency plan would also include instructions for downstream monitoring for any signs of drilling fluid during drilling operations, and would describe the response plan and impact reduction measures in the event a release of drilling fluids occurred. Drill cuttings and drilling mud would be disposed of according to applicable regulations; disposal/management options may include spreading over the construction ROW in an upland location or hauling to an approved off-site, licensed landfill or other approved sites.

21(c). Provide "frac-out plan."

ANSWER: Keystone currently has no contractors retained to undertake construction. When Keystone employs a pipeline contractor, that contractor will develop the plan. See Section 7.4.5 and Appendix G.

34(a). Describe what progress has been made in the evaluation and performance assessment activities regarding high consequence areas since 2010.

OBJECTION: To the extent that this request seeks a list of High Consequence Areas, the identity and location of High Consequence Areas is confidential

and Keystone is required by PHMSA to keep this information confidential. To the extent that this request seeks production of the Emergency Response Plan, the request seeks information that is beyond the scope of the PUC's jurisdiction and Keystone's burden under SDCL § 49-41B-27. This request also seeks information addressing an issue that is governed by federal law and is within the province of PHMSA. The PUC's jurisdiction over pipeline safety is preempted by federal law. *See* 49 C.F.R. Part 194; 49 U.S.C. § 60104(c). This request further seeks information that is confidential and proprietary. Public disclosure of the emergency response plan could commercially disadvantage Keystone. In addition, Keystone is not required to submit its Emergency Response Plan to PHMSA until sometime close to when Keystone Pipeline is placed into operation. Keystone's Emergency Response Plan is addressed in The Final Supplemental Environmental Impact Statement at <http://keystonepipeline-xl.state.gov/documents/organization/221189.pdf>.

34(b). Define "high consequence area."

OBJECTION: To the extent that this request seeks a list of High Consequence Areas, the identity and location of High Consequence Areas is confidential and Keystone is required by PHMSA to keep this information confidential. Without waiving the objection, the definition of high consequence area can be found in Department of State SFEIS chapter 3 Section 3.13.4.1 and Code of Federal Regulation 49

CFR 195.450.

34(c). Provide a completed list of high consequence areas.

OBJECTION: The identity and location of High Consequence Areas is confidential and Keystone is required by PHMSA to keep this information confidential.

34(d). Explain how project inhabitants and local communities will be informed and educated about high consequence areas.

ANSWER: TransCanada Public Awareness Program is designed to increase awareness of pipeline safety to protect the public, environment and TransCanada facilities. The PA Program reaches out to affected public, excavators/contractors, emergency officials and local public to ensure they are engaged and education about living and working safely near TransCanada facilities. This includes awareness of areas that have been defined as high consequence areas.

34(c). Provide a copy of the Emergency Response Plan. (Requested above with #8.)

OBJECTION: To the extent that this request seeks production of the Emergency Response Plan, the request seeks information that is beyond the scope of the PUC's jurisdiction and Keystone's burden under SDCL § 49-41B-27. This request also seeks information addressing an issue that is governed by federal law and is within the province of the U.S. Department of Transportation, Pipeline and Hazardous Materials

Safety Administration (PHMSA). The PUC's jurisdiction over the emergency response plan is preempted by federal law. *See* 49 C.F.R. Part 194; 49 U.S.C. § 60104(c). This request further seeks information that is confidential and proprietary. Public disclosure of the emergency response plan could commercially disadvantage Keystone.

34(f). Provide Integrity Management Plan. (Requested above with #8.)

OBJECTION: The request seeks information that is beyond the scope of the PUC's jurisdiction and Keystone's burden under SDCL § 49-41B-27. This request also seeks information addressing an issue that is governed by federal law and is within the province of PHMSA. The PUC's jurisdiction over pipeline safety is preempted by federal law. *See* 49 C.F.R. Part 194; 49 U.S.C. § 60104(c). This request further seeks information that is confidential and proprietary. Public disclosure of the integrity management plan could commercially disadvantage Keystone. In addition, Keystone is not required to submit its Integrity Management Plan to PHMSA until sometime close to when the Keystone Pipeline is placed into operation.

19. Explain what has been discussed with the SD Geological Survey, the Dept. of Game Fish and Parks, local landowners and govt. officials.

ANSWER: Keystone referenced publicly available data/reports from the SD Geological Survey. Discussion between Keystone and the South Dakota Dept. of Game, Fish, and Parks focused on the identification of the potential biological resources that may

be impacted by the Project route in South Dakota and the potential mitigation measures that could be implemented to minimize impacts.

The following is a summary of Keystone consultation history with SD Game, Fish, and Parks as documented in the USFWS issued May 2013 Biological Opinion (Appendix H of the of the Department of State FSEIS (2014))

- June 10, 2008: Keystone met with staff from USFWS and South Dakota Department of Game, Fish, and Parks (SDGFP), at the SDGFP office in Pierre, South Dakota, to discuss issues pertaining to wildlife, special status species, and sensitive habitat that could potentially occur in the Project area. The goal of the meeting was to gather input on agency recommendations based on the information sent to them in April 2008 for species occurrence, habitat assessments, and future field surveys. Keystone incorporated comments from the meeting into survey protocols and BMPs for future agency verification.

- January/February 2009: Keystone initiated section 7 consultation with the USFWS. Keystone continued discussions with BLM, and state wildlife agency offices for South Dakota that included state-specific special status species survey protocols and BMPs for the species identified as potentially occurring during the 2008 meetings. A summary of the findings from the 2008 biological field surveys was included in the discussions.

- January 27, 2009: Keystone met with staff from the USFWS and SDGFP at the SDGFP office in Pierre, South Dakota, to discuss issues pertaining to special status species surveys. The goals of the meeting were to verify Keystone's survey approach, BMPs, discuss required field surveys, and review the information that was sent to the USFWS in the January/February 2009, informal consultation package. The USFWS and SDGFP provided additional recommendations to Keystone's sensitive species mitigation approach to be updated prior to final agency concurrence.

- October 23, 2012: A meeting was held between the USFWS, Department, SDGFP, BLM, and Keystone regarding the greater sage-grouse and a compensatory mitigation plan for the species in South Dakota. Discussions included a management plan and avoidance, minimization, and mitigation strategies.

35(a). Provide the Integrity Management and Emergency Response Plans. (Requested above.)

OBJECTION: The request seeks information that is beyond the scope of the PUC's jurisdiction and Keystone's burden under SDCL § 49-41B-27. This request also seeks information addressing an issue that is governed by federal law and is within the province of PHMSA. The PUC's jurisdiction over pipeline safety is preempted by federal law. *See* 49 C.F.R. Part 194; 49 U.S.C. § 60104(c). This request further seeks information that is confidential and proprietary. Public disclosure of the emergency

response plan and the integrity management plan could commercially disadvantage Keystone. In addition, Keystone is not required to submit these documents to PHMSA until sometime close to when the Keystone Pipeline is placed into operation. Keystone's Emergency Response Plan is addressed in The Final Supplemental Environmental Impact Statement at <http://keystonepipeline-xl.state.gov/documents/organization/221189.pdf>.

35(b). Define "Unusually Sensitive Areas."

ANSWER: Unusually Sensitive Areas are defined by U.S. federal pipeline safety regulations (49 CFR 195.6) as:

As used in this part, a USA means a drinking water or ecological resource area that is unusually sensitive to environmental damage from a hazardous liquid pipeline release.

(a) An USA drinking water resource is:

- (1) The water intake for a Community Water System (CWS) or a Non-transient Non-community Water System (NTNCWS) that obtains its water supply primarily from a surface water source and does not have an adequate alternative drinking water source;
- (2) The Source Water Protection Area (SWPA) for a CWS or a NTNCWS that obtains its water supply from a Class I or Class IIA aquifer and does not have an adequate alternative drinking water

source. Where a state has not yet identified the SWPA, the Wellhead Protection Area (WHPA) will be used until the state has identified the SWPA; or

(3) The sole source aquifer recharge area where the sole source aquifer is a karst aquifer in nature.

(b) An USA ecological resource is:

(1) An area containing a critically imperiled species or ecological community;

(2) A multi-species assemblage area;

(3) A migratory waterbird concentration area;

(4) An area containing an imperiled species, threatened or endangered species, depleted marine mammal species, or an imperiled ecological community where the species or community is aquatic, aquatic dependent, or terrestrial with a limited range; or

(5) An area containing an imperiled species, threatened or endangered species, depleted marine mammal species, or imperiled ecological community where the species or community occurrence is considered to be one of the most viable, highest quality, or in the best condition, as identified by an element occurrence ranking (EORANK) of A (excellent quality) or B (good quality)."

35(c). Define "Hydrologically Sensitive Areas."

ANSWER: Hydrological sensitive areas were defined by the South Dakota Public Utilities Commission Amended Final Order as "the High Plains Aquifer area in southern Tripp County," as well as "other similarly vulnerable and beneficially useful surficial aquifers that Keystone is aware of."

35(d). Explain how unusually sensitive areas and hydrologically sensitive areas are addressed differently compared to other areas.

ANSWER: Unusually sensitive areas are High Consequence Areas (HCAs), as defined by 49 CFR 195.6. Keystone has elected to treat "hydrologically sensitive areas," as defined in the South Dakota Public Utilities Commission Order Condition 35, as operator-defined HCAs. By designating these segments as operator-defined HCAs, these locations are treated by Keystone as if they were PHMSA-identified HCAs. Portions of the pipeline that could potentially affect HCAs are subject to high levels of inspection and repair criteria, as mandated by 49 CFR 195.

35(e). Confirm that you are not fully aware of all vulnerable and beneficially useful aquifers and your intent is to only become aware of them during construction and route evaluation not yet completed.

ANSWER: Keystone does not confirm these statements. Keystone has consulted with groundwater staff with South Dakota's Department of Natural Resources (SD

DENR) and rural water districts regarding Keystone's route relative to aquifers in South Dakota. Keystone also used data available on the SDDENR website <http://denr.sd.gov/data.aspx> and published literature regarding the geology and hydrology of the along and near the pipeline ROW to assist in identifying vulnerable aquifers in South Dakota. Geological references and hydrogeological references are listed in Chapters 3 and 4 in the Department of State Supplemental FEIS. Some pertinent additional references are:

- Gutentag (1984): USGS Prof. Paper 1400-B
- Downey (1986): USGS Prof. Paper 1402-E
- Thamke et al (2014): USGS Scientific Inv. Report SIR 2014-5047.
- In addition, lithologic logs available from the SD DENR at

<http://denr.sd.gov/des/wr/dblog.search.aspx> and <http://denr.sd.gov/data.aspx> provide aquifer thickness data.

35(f). Define "unconfined aquifers."

ANSWER: From Applied Hydrogeology (1994) "*Unconfined Aquifer: Aquifer close to the surface with materials of high permeability extending from the land surface to the base of the aquifer. Water table aquifer.*"

Source: Fetter, C.W. (1994.) Applied Hydrogeology. Prentice Hall. 680 pp.

35(g). List known unconfined aquifers to be crossed by the project.

ANSWER: Department of State Table 3.3-2 (SFEIS) presents a list of unconfined aquifers in South Dakota crossed by the Keystone XL Pipeline Project. Along the route in South Dakota, the High Plains Aquifer (Ogallala Formation) in Tripp County is often unconfined. Other areas with unconfined aquifers include alluvial aquifers associated with streams, and occasional unconfined stretches in the Hell Creek, Fox Hills, and Pierre Shale aquifers. However, along the majority of the route, aquifers crossed by the Keystone XL pipeline are confined.

35(h). Explain the concern of routing through unconfined aquifers.

ANSWER: In South Dakota, unconfined aquifers are found mainly associated with streams (alluvial aquifers) and in portions of the High Plains Aquifer (Ogallala Formation) in Tripp County (FSEIS). Table 3.3-2 (FSEIS) presents the unconfined aquifers in South Dakota. The Keystone XL pipeline in South Dakota was routed to reduce impacts to a number of valuable resources, including but not limited to, unconfined aquifers.

35(i). Describe how it could be possible to route through an unknown, unconfined aquifer during construction.

ANSWER: Keystone has attempted to identify vulnerable aquifers through consultation with State agencies and rural water districts, as well as data provided South Dakota Department of Environment and Natural Resources (SD DENR)

(<http://denr.sd.gov/data.aspx>), and published literature. The location of unconfined aquifers is documented in the literature on the hydrogeology of South Dakota and the SD DENR website provides well logs for wells near the pipeline ROW, so that unconfined conditions can be identified.

It is possible that, during construction and through discussion with landowners crossed by the Project, Keystone may identify shallow wells located in unconfined aquifers. Many water-bearing units in South Dakota may be unmapped due to their small size and type of geological formation that has limited use due to low water productivity and generally lower water quality. If present, these wells are often associated with agricultural uses (e.g., livestock stock tanks).

35(j). Provide documentation of further route evaluation since 2010, including assessments for aquifers and hydrologically sensitive areas.

OBJECTION AND RESPONSE: This request is vague, overlybroad, and unduly burdensome. Without waiving the objection, since 2010, Keystone has continued to identify groundwater resources through agency consultation use of the South Dakota Department of Environment and Natural Resources (SD DENR) website (<http://denr.sd.gov/data.aspx>) and the following publications. Geological references and hydrogeological references are listed in chapters 3 and 4 in the FSEIS. Some pertinent additional references are:

- Gutentag (1984): USGS Prof. Paper 1400-B
- Downey (1986): USGS Prof. Paper 1402-E
- Thamke et al (2014): USGS Scientific Inv. Report SIR 2014-5047.

In addition, lithologic logs available from the SD DENR at <http://denr.sd.gov/des/wr/dblog.search.aspx> and <http://denr.sd.gov/data.aspx> provide aquifer thickness data. Since 2010, the Keystone XL pipeline route was evaluated using these data sources to identify hydrologically sensitive areas.

35(k). Explain how you will deem an aquifer vulnerable and beneficially useful?

ANSWER: Keystone relies on two primary sources to identify vulnerable and beneficially useful aquifers: Pipeline and Hazardous Materials Safety Administration (PHMSA)-identified unusually sensitive areas for drinking water, as defined in 49 CFR 195.6, and Source Water Protection Areas for groundwater as identified by the South Dakota Department of Environment and Natural Resources (SD DENR). Both PHMSA and the SD DENR have provided these data confidentially to Keystone.

35(l). This condition states: "...in some reaches of the Project in southern Tripp County, the High Plains Aquifer is present at or very near ground surface and is overlain by highly permeable sands permitting the uninhibited infiltration of contaminants."

Sandy soil and ground water at or above the surface means a pipe with expected pinhole leaks will be immersed in ground water. This is the exact type of situation of soil/ground

water which caused the route change in Nebraska. If this was reason to change the route in Nebraska, explain why it is still acceptable in South Dakota.

OBJECTION AND RESPONSE: This request is argumentative and assumes facts not in evidence. Without waiving the objection, "*Pipeline routing is optimized to reduce impacts and risks to the environment, population, and to reduce integrity concerns.*"

Routing decisions in each state were made in consultation with the various local state and federal agencies. Reroutes in Nebraska were determined based on public and agency input during the NEPA process. Routes approved in South Dakota were based on consultation with South Dakota local agencies. All routing decisions took into account the screening options outlined in the FSEIS Section 2.2.2.2 Major Pipeline Route Alternatives and Section 2.2.5.1 Screening of Major Route Alternatives. The first round of screening included the following criteria:

- "Meeting the proposed Project's purpose and need, including the extent to which additional infrastructure (pipeline) is necessary to access Bakken crude oil;
- Consistency with the proposed border crossing and therefore the approved routing in Canada;
- Availability;
- Reliability;

- Length within the United States;
- Total length of the pipeline, including both the United States and Canada;
- Estimated number of aboveground facilities;
- Length co-located within an existing corridor;
- Acres of land directly affected during construction; and
- Acres of land directly affected permanently.” (FSEIS Section 2.2.2.2 pg 2-2-2).

The second round of screening included the following criteria:

- “Total length of the pipeline, including both the United States and Canada;
- Use of the Canadian-approved Keystone XL pipeline ROW outside of the United States;
- Approximate acres affected by construction of the proposed Project (based on a typical 110-foot construction ROW)
- Federal lands crossed (miles);
- Principal aquifers crossed (miles);
- American Indian lands crossed (miles);
- Total wetlands crossed (miles);
- USFWS critical habitat for threatened and endangered species crossed (miles);

- Known cultural resource sites (listed on National Register of Historic Places) within 500 feet of proposed pipeline;
- Number of waterbodies crossed; and
- Soils designated as highly erodible by wind crossed (miles).” FSEIS Section 2.2.5.1 pg 2.2-59)

Rerouting away from the environmentally sensitive Nebraska Department of Environmental Quality (NDEQ)-identified Sand Hills Region was based on input from the NDEQ and the public.

South Dakota Public Utilities Commission's (SD PUC) Amended Order identified the southern portion of Tripp County as having a “hydrologically sensitive area” for groundwater resources due to the sandy soils and presence of unconfined portions of the High Plains Aquifer. As discussed previously, Keystone will treat “hydrologically sensitive areas”, as defined in the SD PUC Order Condition 35, as operator-defined high consequence areas (HCAs). By designating these segments as operator-defined HCAs, these locations are treated by Keystone as if they were Pipeline and Hazardous Materials Safety Administration (PHMSA)-identified HCAs. Portions of the Keystone XL pipeline that could potentially affect HCAs are subject to high levels of inspection and repair criteria, as mandated by 49 CFR 195.

Where soils are fragile (i.e., sandy soils that exhibit conditions similar to the Nebraska Department of Environmental Quality-identified Sand Hills Region that are highly susceptible to erosion by wind), special considerations and measures also would be undertaken in proposed Project areas to protect environmentally sensitive resources.

“Approximately 76 percent (11,664 acres) of the overall proposed Project would affect soils characterized as highly erodible by either wind or water (see Figure 4.2.1-1). Erosion control measures would be implemented wherever soil is exposed, steep slopes are present, or erosion potential is high. To enforce use of these methods, an environmental inspector (EI) would be assigned to each construction spread. In addition, specific procedures have been developed to address concerns related to potential erosion to the fragile soils in the southern South Dakota and northern Nebraska region; the proposed Project right-of-way (ROW) through these fragile soils would be monitored for several years to ensure that reclamation and revegetation efforts are successful (see Section 4.2.3.2, Operation Impacts).” (FSEIS Section 4.2 Soils, pg 4.2-2)

“Fragile Soils in Southern South Dakota and Northern Nebraska

In southern South Dakota and northern Nebraska, the proposed Project

route would enter an area with fragile soils (i.e., landscapes where the soil exhibits conditions similar to the NDEQ-identified Sand Hills Region and the soils are very susceptible to wind erosion; see Soils Environmental Setting Sections 3.2.2.2, South Dakota, 3.2.2.3, Nebraska, and Figure 3.2.2-2, Highly Wind Erodible Soils). To address concerns related to potential erosion in the region, specific construction, reclamation, and post-construction procedures have been developed, as described in Section 4.15 of the CMRP, Fragile Soil Clean Up and Reclamation/Revegetation, (see Appendix G). This document provides site-specific reclamation plans that itemize construction, erosion control, and revegetation procedures for these fragile areas. Additionally, Keystone would implement micro-routing adjustments where practicable and appropriate to minimize steep topography with fragile soils.

To reduce potential impacts related to severe wind and water erosion, the following provides a summary of proposed Project best management practices (BMPs) that would be implemented during construction, reclamation, and post-construction. These BMPs are included in the CMRP for fragile soil areas. Additional procedures are also described in Sandy Prairie Construction/Reclamation Unit Plan (see Appendix R,

Construction/Reclamation Plans):

- Keystone would educate construction personnel regarding the necessity to strictly adhere to the proposed Project BMPs designed to minimize impacts to fragile soil landscape areas.
- Minor route re-alignments would be incorporated through these fragile areas to avoid particularly erosion-prone locations, such as ridgetops and existing blowouts as much as practicable.
- Keystone would avoid highly saturated areas, such as wetlands, to the maximum extent possible.
- Construction soil handling procedures would strive to reduce the width of disturbance to the native prairie landscape by adopting Trench-line or Blade-width stripping procedures where practicable.
- Topsoil conservation would be conducted on all areas where excavation occurs.
- Topsoil piles would be protected from erosion through matting, mulching, watering, or tackifying as deemed practicable.
- Traffic management limitations would be employed on specific areas possessing high erosion potential or sensitive habitat.
- Native seed mixes would be developed with input from the local

NRCS offices and through collaboration with regional experts. All seed would be certified noxious weed-free and would be calculated on a pure live seed basis.

- Straw or native prairie hay may be used as mulch, applied to the ROW, and crimped into the soil to prevent wind erosion. All mulch would be documented as noxious weed-free.
- Land imprinting may be employed to create impressions in the soil, thereby reducing erosion, improving moisture retention, and creating micro-sites for seed germination. (Land imprinting adds a waffle-like texture to the soil, forming indentations that capture and absorb rainwater that otherwise runs off untreated land.)
- Sediment logs (barriers in the form of logs used to control soil erosion) or straw wattles would be used in place of slope breakers (short terraces) that are constructed of soil. Using sediment logs would result in less soil disturbance to the ROW.
- Photodegradable matting would be applied on steep slopes or areas prone to extreme wind exposure such as north- or west-facing slopes and ridge tops. Biodegradable pins would be used in place of metal staples to hold the matting in place.

- Keystone would work with landowners to evaluate fencing the ROW from livestock, or alternatively, provide compensation to rest a pasture until vegetation can become established.
- Management concerns such as livestock access to water or movement within a pasture would be addressed as necessary by Keystone working with the landowner.
- As part of post-construction monitoring and repair, Keystone would monitor reclamation on the ROW for several years and would repair erosion and reseed poorly revegetated areas as deemed necessary by Keystone. During monitoring, landowners would be informed of these efforts and intended actions going forward.
- A noxious weed management plan would be established based on consultation with state and county experts.

Fragile Soils in Southern South Dakota and in Northern Nebraska

To address concerns related to potential erosion in the fragile soil areas in southern South Dakota and northern Nebraska, specific construction, reclamation, and post-construction procedures have been developed as described in the Fragile Soils section within the CMRP (see Appendix G).

This document provides a site-specific reclamation plan that itemizes

construction, erosion control, and revegetation procedures for these fragile areas. Additional procedures are also described in Sandy Prairie Construction/Reclamation Unit Plan (see Appendix R, Construction/Reclamation Plans and Documentation). The proposed Project ROW through this region would be monitored for several years to ensure that reclamation and revegetation efforts are successful. Any proposed Project areas where reclamation and revegetation efforts are initially unsuccessful would be re-evaluated and restored.

Proposed Project areas that have been revegetated would be attractive as cattle forage. Due to potentially warmer soils in the immediate vicinity of the proposed pipeline, early forage may be concentrated along the ROW over time (Dave Wedin, personal communication, June 29, 2011).

Additionally, animal trackways (i.e., a route of frequent travel by animals) can serve as incipient blowout areas. Keystone has agreed to inform landowners of this concern. Fencing of the ROW may be completed if required; however, fencing could be a serious impediment to landowner access. As described previously, Keystone would work with landowners to evaluate fencing the ROW from livestock, or alternatively, provide compensation to rest a pasture until vegetation can become established.

Also as previously indicated, Keystone would monitor reclamation on the ROW for several years and repair erosion and reseed poorly revegetated areas as necessary.

Additionally, based on input received from the NRCS, Keystone would be required to employ a method of assessment of soil productivity such as yield comparison between ROW and non-ROW areas in areas where susceptible soils have been identified with the NRCS." (FSEIS, Section 4.2 Soils).

35(m). Explain TransCanada's follow-up with suggestion by DENR staff, given in testimony, to reroute the KXL pipeline around the city of Colome's source water area.

ANSWER: Routing is an iterative process where refinements to the route are continuously made as new, substantive data are obtained. In this case, Keystone had obtained HCA data from the Pipeline and Hazardous Materials Safety Administration (PHMSA) and consulted with the South Dakota Department of Environment and Natural Resources' (SD DENR) ground water Staff. During the consultation process, Keystone received Source Water Protection Area (SWPA) data. These data sets were integrated into the routing process and, upon identification of the route through the Colome SWPA, Keystone rerouted out of the area. Keystone consulted with the SD DENR's groundwater Staff and informed them of the issue with the initially proposed route and a proposed route refinement to avoid the SWPA. SD DENR staff confirmed that the reroute was acceptable.

36(a). Identify all emergency medical response planning contained within the emergency response plan.

OBJECTION: This request seeks information that is beyond the scope of the PUC's jurisdiction and Keystone's burden under SDCL § 49-41B-27. This request also seeks information addressing an issue that is governed by federal law and is within the exclusive province of PHMSA. The PUC's jurisdiction over the emergency response plan is preempted by federal law, which has exclusive jurisdiction over issues of pipeline safety. *See* 49 C.F.R. Part 194; 49 U.S.C. § 60104(c). This request further seeks information that is confidential and proprietary. *See* Amended Final Order, HP 09-001, Condition ¶ 36. Public disclosure of the emergency response plan would commercially disadvantage Keystone. In addition, Keystone is not required to submit its Emergency Response Plan to PHMSA until sometime close to when the Keystone Pipeline is placed into operation. Keystone's Emergency Response Plan is addressed in The Final Supplemental Environmental Impact Statement at

<http://keystonepipeline-xl.state.gov/documents/organization/221189.pdf>.

36(b). What actions have been taken by TransCanada to ensure the medical communities in South Dakota are prepared and educated to treat people exposed to spills and water contamination from spills?

OBJECTION AND RESPONSE: To the extent that this request seeks production of the Emergency Response Plan, this request seeks information that is beyond the scope of the PUC's jurisdiction and Keystone's burden under SDCL § 49-41B-27. This request also seeks information addressing an issue that is governed by federal law and is within the exclusive province of PHMSA. The PUC's jurisdiction over the emergency response plan is preempted by federal law, which has exclusive jurisdiction over issues of pipeline safety. *See* 49 C.F.R. Part 194; 49 U.S.C. § 60104(c). This request further seeks information that is confidential and proprietary. *See* Amended Final Order, HP 09-001, Condition ¶ 36. Public disclosure of the emergency response plan would commercially disadvantage Keystone. In addition, Keystone is not required to submit its Emergency Response Plan to PHMSA until sometime close to when the Keystone Pipeline is placed into operation. Keystone's Emergency Response Plan is addressed in The Final Supplemental Environmental Impact Statement at <http://keystonepipeline-xl.state.gov/documents/organization/221189.pdf>. Without waiving the objection, TransCanada has provided educational information to possible affected public elected officials, excavators, and first responders. This educational material comes in the form of a pamphlet and is titled Oil Pipeline for Emergency Responders. It is marked as Keystone 1523-1538.

36(c). How will inhabitants and communities near the project area be notified of spills?

ANSWER: Keystone's response teams will use the National Incident Management System (NIMS) Incident Command System (ICS) to manage emergency response activities. First response to an incident will be provided by a Keystone local response team. Keystone's Regional Emergency Operations Center (EOC) will respond, to the degree necessary, to incidents exceeding local capability. Duties of the local responders are described in the TransCanada-Keystone Emergency Response Plan (see FSEIS, Appendix I) which will be adapted for use on Keystone XL.

Response teams will be led by an Incident Commander, and will include persons accountable for external notifications including a Public Information Officer (including media communications), and a Liaison Officer (including agency communications).

External notifications are those made to entities outside of the Company including Federal, State and local regulatory agencies, as well as railroad and utility companies.

These notifications include both verbal and written requirements. Landowners and appropriate public agencies will be notified in the case of potential groundwater contamination.

40(a). Provide documentation supporting your assertion that polyethylene water piping is permeable to BTEX.

ANSWER: Permeation of polyvinyl chloride (PVC) and polyethylene (PE) pipes by any hydrocarbon is extremely rare (Gaunt et al. 2006). Permeation incidents were

reported at a frequency of one per 14,000 miles of mains and one per 1,000,000 miles of PE/PVC service connections (Gaunt et al. 2006).

A number of studies have been conducted on the topic of hydrocarbon permeation through PVC and PE water piping, including:

Gaunt, James A. et. al. 2006. "Performance of Plastic Pipes and Pipe Gaskets In Hydrocarbon Contamination: Field Experience and Laboratory Studies". Department of Civil, Construction, and Environmental Engineering Iowa State University, Ames, IA. American Waterworks Association.

Berens, A.R. 1985. "Prediction of organic chemical permeation through PVC pipe". JAWWA 77 (11), 57-64 (1985).

40(b). Explain health concerns related to BTEX.

ANSWER: BTEX consists of benzene, toluene, ethylbenzene, and xylenes.

Benzene can result in health impacts from short term (i.e., acute) exposure or long-term (i.e., chronic) exposure. Acute effects can include drowsiness, dizziness, rapid heart rate, headaches, and unconsciousness. At extremely high concentrations, acute toxicity can result in mortality. Benzene levels at these concentrations would not be anticipated from a release from the Keystone XL Pipeline Project. Potential chronic health effects of benzene exposure include anemia and excessive bleeding. Long-term exposure to high concentrations of benzene in the air can lead to cancer (ATSDR 2007a, EPA 2015). Due

to emergency response cleanup, sampling, and monitoring, remedial actions, and the high volatility of benzene, benzene concentrations would largely dissipate within the first 24 hours, minimizing the potential for chronic effects in humans.

Toluene exposure may cause fatigue, confusion, and weakness (ATSDR 2001, EPA 2015). At extremely high levels, toluene may cause mortality. Toluene levels at this concentration would not be expected to occur due to a release along the Keystone XL Pipeline Project.

Ethylbenzene exposure may cause eye and throat irritation or dizziness (ATSDR 2010, EPA 2015). Chronic exposure to low levels of ethylbenzene (weeks to years) may cause damage to the inner ear or kidneys. Ethylbenzene has been identified as a possible human carcinogen.

High levels of xylene exposure, either acute or chronic, can cause headaches, lack of muscle coordination, confusion, and eye, skin, throat, and nose irritation. Extremely high levels can cause unconsciousness and mortality (ATSDR 2007b, EPA 2015). Xylene levels at this concentration would not be expected to occur due to a release along the Project. Studies by the International Agency for Research on Cancer and the EPA have not been able to rule xylene out as a carcinogen.

More detailed information is available through the Agency for Toxic Substances & Disease Registry (ATSDR; <http://www.atsdr.cdc.gov/>) and the US Environmental

Protection Agency (USEPA; <http://water.epa.gov/drink/contaminants/>).

Agency for Toxic Substances and Disease Registry. 2014. ATSDR Toxic Substances Portal. Available from: <http://www.atsdr.cdc.gov/>

Agency for Toxic Substances & Disease Registry (ATSDR). 2010. ToxFAQs for Ethylbenzene. Accessed January 20, 2015.

<http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=382&tid=66>.

Agency for Toxic Substances & Disease Registry (ATSDR). 2001. ToxFAQs for Toluene. Accessed January 20, 2015.

<http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=160&tid=29>.

Agency for Toxic Substances & Disease Registry (ATSDR). 2007a. ToxFAQs for Benzene. Accessed January 20, 2015.

<http://www.atsdr.cdc.gov/toxfaqs/TF.asp?id=38&tid=14>.

Agency for Toxic Substances & Disease Registry (ATSDR). 2007b. ToxFAQs for Xylene. Accessed January 20, 2015.

<http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=295&tid=53>.

US Environmental Protection Agency (EPA). 2015. Drinking Water Contaminants. Accessed January 20, 2015. <http://water.epa.gov/drink/contaminants/>.

Environmental Protection Agency. 2014. National Primary Drinking Water Regulations. Available from: <http://water.epa.gov/drink/contaminants/>

40(c). Provide an MSDS of all products to be transported in KXL, including the diluents.

ANSWER: Representative Material Safety Data Sheets are provided in Appendix Q of the FSEIS.

40(d). Provide list of ground water quality standards, specifically listing chemicals involved in tar sands oil product and diluents.

OBJECTION: Keystone does not determine ground water quality standards. They are established by the South Dakota Department of Environment and Natural Resources.

40(e). Describe how the decision was made to designate concern of BTEX only within 500 feet of the Project.

ANSWER: This decision was made by the PUC as part of Amended Permit Condition 40.

40(f). Confirm this safety measure will only be implemented at the request of a landowner or public water supply system.

ANSWER: Yes.

40(g). Explain why this measure is optional instead of mandatory.

ANSWER: This decision was made by the PUC as part of Amended Permit Condition 40.

40(h). TransCanada has agreed to do this: "At least forty-five days prior to commencing construction, Keystone shall publish a notice in each newspaper of general circulation in each county through which the Project will be constructed advising landowners and public water supply systems of this condition." What percent of inhabitants do you expect to reach by issuing a warning in this manner?

OBJECTION AND RESPONSE: This request is speculative and argumentative. A notice is not a "warning." Without waiving the objection, Keystone expects that notice in newspapers of general circulation would reach a substantial portion of the inhabitants.

46(a). Provide written plan as to how you will find and provide a permanent water supply for various locations along route if a well should become contaminated, including specific alternate sources.

ANSWER: In the unlikely event of a leak, petroleum hydrocarbons generally do not move more than 300 feet through the subsurface and substantive movement takes months to years offering ample time for emergency response and containment. Therefore, impacts to private and public wells are not anticipated. Further, Keystone will comply with the South Dakota Public Utilities Commission order (Condition of Permit #46): "In the event that a person's well is contaminated as a result of construction or pipeline operation, Keystone shall pay all costs associated with finding and providing a permanent

water supply that is at least of similar quality and quantity; and any other related damages, including but not limited to any consequences, medical or otherwise, related to water contamination.”

46(b). Define “quantity” as it is used in this condition.

ANSWER: Keystone interprets “quantity” to have its ordinary meaning.

46(c). Provide cost estimates for providing water to the city of Colome, domestic wells or an entire ranching operation should water supplies become contaminated.

ANSWER: Please refer to DOS SFEIS Appendix Z Mitigation Measures page 108 item 7. Keystone has committed, in the event that a spill contaminates potable water supplies, be responsible for cleanup and restoration. Keystone would be responsible for providing an appropriate alternative potable water supply of comparable volume and quality to those impacted or provide compensation, if this option is agreed upon by the affected parties and Keystone. For groundwater used for industrial or irrigation purposes, Keystone may provide either an alternate supply of water or appropriate compensation for those facilities impacted, as may be agreed upon among the affected parties and Keystone. If the permit were approved, Keystone would memorialize that agreement through an appropriate written agreement with the Environmental Protection Agency.

46(d). Explain how providing a permanent water supply will be ensured into perpetuity.

ANSWER: See answer to interrogatory no. 46(a).

46(e). Explain how people and cattle using private wells and public wells can be assured their water is free of contamination from undetected leakage, particularly in Tripp County.

ANSWER: Given the leak detection methodologies that are part of the project, undetected well contamination is unlikely.

46(f). Describe what experience South Dakota has had cleaning up tar sands oil product spills into rivers and ground water.

OBJECTION: This request seeks information that is not within Keystone's custody or control.

46(g). Describe any experience the State of South Dakota or any other state has had in "sparging" ground water in order to cleanse tar sands oil product from aquifers.

OBJECTION: This request seeks information that is not within Keystone's custody or control.

46(h). Describe types of spills which may be difficult or impossible to remediate.

ANSWER: Crude oil spills can be remediated. Initial contaminant and cleanup is important to limit the area affected and to remove as much product as quickly as possible. Any residual oil can be remediated through a variety of remediation technologies as well as through natural attenuation.

As discussed in Section 2.1 of the FSEIS, Keystone has reviewed the National Transportation Safety Board 2012 Marshall, Michigan Accident Report, including the conditions that led to operational failures on the pipeline that resulted in the spill.

Keystone has stated they would include lessons learned from this spill, including the following:

- “Get big quick: timeliness of a tactical response to an oil spill into water is imperative. While Keystone has stated that it already uses this philosophy, the Kalamazoo spill reinforced this need to respond with as many resources as possible as quickly as possible. To that end, Keystone would strategically store equipment and employ personnel and contractors along the length of the pipeline to ensure a maximum 6-hour response time.
- Pre-qualify a large contractor network: Contractors would be used to supplement any response Keystone would make to an oil spill. By ensuring a large pool of trained/skilled contractors along the length of the pipeline have been pre-qualified and contracted with Keystone, the response time would be minimized and resources (equipment and personnel) available are maximized.
- Emergency response planning details need to include source

containment: source containment plans including strategies and tactics would be included in the overarching ERP.

- Equipment resources required for sunken and submerged oil:
Keystone would further identify equipment resources required to respond to sunken and submerged oil and ensure personnel are appropriately trained on the equipment. A primary strategy for oil spill response would still be to contain and recover as much oil as possible as quickly as possible to prevent oil from weathering and therefore potentially becoming submerged and sinking. In addition, Keystone already owns and practices the use of containment devices that would prevent downstream migration of submerged and sunken oil such as dams. This type of equipment would be further identified and procured for the proposed Project.”

Section 2.1 of the FSEIS also covers remediation of potential crude oil spills and construction related spills.

“Corrective remedial actions would be dictated by federal, state, and local regulations and enforced by the PHMSA Office of Pipeline Safety as well as appropriate state and/or local agencies. Required remedial actions may be large or small, dependent upon a number of factors including state

mandated remedial cleanup levels, potential effects to sensitive receptors, the volume and extent of the contamination, whether or not there is a violation of water quality standards, and the magnitude of adverse impacts caused by remedial activities. A large remediation action could include one or more of a number of approaches (such as excavation of soil, pumping and treating ground water, or natural attenuation). However, the selection of a remedial measure would be in coordination and agreement with the appropriate regulatory agency.

If, during construction, tanks or contamination are found, they would be managed according to federal, state, and/or local regulations. Further, Keystone would make individuals available who are trained in identifying and disposing of hazardous materials during construction.

If there is an accidental release from the proposed Project, Keystone would implement the remedial measures necessary to meet the federal, state, and local standards that are designed to help ensure protection of human health and environmental quality. Additional information on remediation is presented in Section 4.13 of the FSEIS, Potential Releases.”

46(i). Identify responsible parties who will conduct water analysis to assure toxins from

undetected leaks have not migrated into water resources, including frequency of testing and who will assume cost of testing.

ANSWER: If a release were to occur, Keystone would implement its Emergency Response Plan (ERP). This ERP is responsive to the size of spill and resources potentially affected. In the event surface waters were impacted, Keystone would implement its ERP and notify appropriate federal and state agencies. If the release is significant, an Incident Command Team will develop a sampling plan, determined in consultation with the appropriate state and federal agencies that identifies the appropriate sampling, frequency, and responsible payee.

46(j). Describe potential scenarios in which medical costs related to contamination will be reimbursed.

ANSWER: If it is determined that medical costs are incurred and result of contamination caused by Keystone, Keystone will reimburse such costs.

46(k). Provide a detailed listing of potential toxins which could contaminate wells.

ANSWER: The South Dakota Department of Environment and Natural Resources (SD DENR) identifies a number of compounds that can potentially contaminate wells (refer to the following list [SD DENR 2009]). Many of these chemicals are not constituents of petroleum hydrocarbons but are associated with farming, industrial activities, and urban runoff.

- 1,1,1-Trichlorethane
- 1,1,2-Trichlorethane
- 1,1-Dichloroethylene
- 1,2 Dibromo-3-chloropropane (DBCP)
- 1,2,4-Trichlorobenzene
- 1,2-Dichloroethane
- 1,2-Dichloropropane
- 2,4,5-TP (Silvex)
- 2,4-d, 3-Hydroxycarbofuran
- Alachlor (Lasso)
- Aldicarb
- Aldicarb sulfone
- Aldicarb sulfoxide
- Aldrin
- Antimony (total)
- Arsenic (total)
- Atrazine
- Barium (total)
- Benzene
- Benzo[a]pyrene
- Beryllium (total)
- Butachlor
- Cadmium (total)
- Carbaryl
- Carbofuran
- Carbon tetrachloride
- Chlordane
- Chromium (total)
- cis-1,2-Dichloroethylene
- Dalapon
- Di(2-Ethylhexyl) adipate
- Di(2-ethylhexyl) phthalate
- Dicamba
- Dichloromethane (methylene chloride)
- Dieldrin
- Dinoseb
- Diquat
- Endothall
- Endrin
- Ethylbenzene
- Ethylene dibromide (EDB)
- Glyphosate
- Heptachlor
- Heptachlor epoxide
- Hexachlorobenzene (HCB)
- Hexachlorocyclopenta-diene
- Lindane
- m-Xylene
- Mercury (total inorganic)
- Methomyl
- cis-1,2-Dichloroethylene
- Dalapon
- Di(2-Ethylhexyl) adipate
- Di(2-ethylhexyl) phthalate
- Dicamba
- Dichloromethane (methylene chloride)
- Methoxychlor
- Metolachlor
- Metribuzin
- Monochlorobenzene (Chlorobenzene)
- Nitrate
- Nitrite
- o-Dichlorobenzene
- o-Xylene
- Oxamyl (Vydate)
- p-Dichlorobenzene
- p-Xylene
- Pentachlorophenol
- Picloram
- Propachlor
- Selenium (total)
- Simazine
- Styrene
- Tetrachloroethylene
- Thallium (total)
- Toluene
- Total polychlorinated biphenyls (PCBs)
- Toxaphene
- trans-1,2-Dichloroethylene
- Trichloroethylene
- Vinyl chloride

South Dakota Department of Environment and Natural Resources (SD DENR). 2009.

Tripp County Water User District Drinking Water Quality Report. Available from:

<http://www.ewg.org/tap-water/whatsinyourwater2/SD/tripp-county-water-user-district/4600520>.

46(l). Provide documentation detailing adverse health effects caused from exposure to these toxins, including the various routes of entry into the human body.

ANSWER: As stated in the previous response (#54), many of these compounds identified in the previous response are not constituents of crude oil.

The U.S. Environmental Protection Agency has a detailed listing of potential drinking water contaminants. This includes the toxins addressed above and their potential health effects on humans due to ingestion of contaminated drinking water. This information is available at <http://water.epa.gov/drink/contaminants/>.

Additionally, the Agency for Toxic Substances and Disease Registry (ATSDR) website includes detailed reports on potential health effects of these toxins as well as potential routes of entry into the human body. This information is available at <http://www.atsdr.cdc.gov/>.

Agency for Toxic Substances and Disease Registry. 2014. ATSDR Toxic

Substances Portal. Available from: <http://www.atsdr.cdc.gov/>

Environmental Protection Agency. 2014. National Primary Drinking Water

Regulations. Available from: <http://water.epa.gov/drink/contaminants/>.

18(a). Regarding an advisory warning issued in September, 2014 by the federal Pipeline

and Hazardous Materials Safety Administration, what are TransCanada's plans to ensure pipeline safety due to the fact different types of product will be transported in KXL?

OBJECTION AND RESPONSE: This request seeks information related to pipeline safety, which is within the exclusive jurisdiction of PHMSA. Without waiving the objection, PHMSA Advisory 2014-0040 is not applicable to Keystone. This advisory is related to flow reversal, product change (e.g., crude oil to refined product) and/or conversion to service (e.g., convert from natural gas to crude oil) and throughput capacity change.

18(b). PHMSA cautioned pipeline operators across the country about "the potential significant impact flow reversals, product changes and conversion to service may have on the integrity (safety) of a pipeline." The advisory adds: "Flow reversals, product changes, and conversions to service may impact various aspects of a pipeline's operation, maintenance, monitoring, integrity management, and emergency response. Pressure gradients, velocity, and the location, magnitude, and frequency of pressure surges and cycles may change. Operators may also consider increasing the throughput capacity of the pipeline. Increasing throughput may also impact the pressure profile and pressure transients. ... Leak detection and monitoring systems may be affected."

OBJECTION AND ANSWER: This request is not a question and cannot be answered. It also relates to an issue that is within the exclusive jurisdiction of PHMSA

and is therefore not relevant or likely to lead to the discovery of admissible evidence.

Without waiving the objection, PHMSA Advisory 2014-0040 is not applicable to Keystone. This advisory is related to flow reversal, product change (e.g., crude oil to refined product) and/or conversion to service (e.g., convert from natural gas to crude oil) and throughput capacity change.

18(c). Current regulations state: "Operators must review their integrity (safety) management program. ... Operators must notify PHMSA if these changes will substantially affect their integrity management program, its implementation, or modifies the schedule for carrying out the program elements."

OBJECTION: This request is not a question and cannot be answered. It also relates to an issue that is within the exclusive jurisdiction of PHMSA and is therefore not relevant or likely to lead to the discovery of admissible evidence.

18(d). KXL is intended to transport two very different products, the much less dense and highly volatile Bakken oil product and the heavy diluted bitumen from Alberta. How will the two very different products affect KXL's operation, maintenance, monitoring, integrity management, and emergency response? How will the two very different products affect pressure gradients, velocity, and the location, magnitude, and frequency of pressure surges and cycles?

ANSWER: Please refer to Department of State FSEIS Chapter 3 Section 3.13.3.

The Keystone pipeline is designed to transport a range of crude oils. The hydraulic analysis considers various inputs such velocity, surge and cyclic loading. The operation, maintenance, monitoring, integrity management, and emergency response plans consider the range of products transported.

33(a). Provide updated maps.

OBJECTION AND ANSWER: This request is vague, overlybroad, unduly burdensome, and seeks information that is not relevant or likely to lead to the discovery of admissible evidence. Without waiving the objection, please refer to the attached route variation maps marked as Keystone 0470-0583.

41(a). Provide map detailing all water bodies to be crossed in S.D., to include locations KXL would cross the Missouri and Yellowstone Rivers upstream from S.D.

OBJECTION: Keystone has previously filed with the PUC maps showing the route through South Dakota, which also show where the pipeline crosses rivers and other water bodies. Waterbody crossing permitting is within the control of the United States Army Corps of Engineers, and is beyond Keystone's control.

41(b). Provide map clearly depicting all waterways crossed by route which are tributaries into the Missouri River.

OBJECTION: Keystone has previously filed with the PUC maps showing the route through South Dakota, which also show where the pipeline crosses rivers and other water bodies.

41(c). Identify distances from KXL waterway crossings to point of confluence with the Missouri River.

OBJECTION: Keystone withdraws its previous objection. For the perennial stream crossings where the downstream portions of the stream are located within the boundaries of South Dakota and have a point of confluence with the Missouri River, the distance from the KXL pipeline crossing of each waterway to the Missouri River are in Table 1 below.

Table 1. Downstream Distance to the Missouri River

| Stream Name | Periodicity | Miles downstream to Missouri River |
|-------------------------|--------------------|---|
| Cottonwood Creek | Perennial | 87.2 |
| Bad River | Perennial | 93.4 |
| South Fork Grand River | Perennial | 290.4 |
| Clarks Fork Creek | Perennial | 285.7 |
| South Fork Moreau River | Perennial | 290.4 |
| Pine Creek | Perennial | 222.7 |
| Dry Creek | Perennial | 86.5 |

41(d). Provide map(s) demonstrating all public water utility intakes on the Missouri River system.

OBJECTION: This request is overlybroad, unduly burdensome, and seeks information that is not within Keystone's custody or control. In addition, the location of the information is related to HCA's and deemed confidential by PHMSA.

41(e). By what date will permitting of water body crossings be completed?

OBJECTION: Permitting of water body crossings is within the control of the United States Army Corps of Engineers, and is beyond Keystone's control.

41(f). Provide a copy of the CMR Plan. Ex TC-1, 5.4.1, pp. 45-46.

ANSWER: A current copy of the CMR Plan is attached to Keystone's certification petition and is on file with the PUC.

41(g). Provide research which describes migration of spillage in these waterways.

OBJECTION: This request is vague, overlybroad, and unduly burdensome.

41(h). Please explain and describe water protection areas located downstream of major river crossings on the proposed route.

OBJECTION: This request is overlybroad, unduly burdensome, and seeks information that is not within Keystone's custody or control. In addition, the location of the information is related to HCA's and deemed confidential by PHMSA.

41(i). Explain risks of HDD, including possibility of contaminants being released into waterways during this process.

ANSWER: This issue is addressed in the FSEIS at pages 4.3-21, 4.8-20, and 4.7-11, 12.

50(a). Provide a map depicting the High Consequence Areas.

OBJECTION: This request seeks the identity and location of High Consequence Areas, which is confidential by statute, and Keystone is required by PHMSA to keep this information confidential.

50(b). Explain why the total length of pipe affecting HCA decreased from 34.3 miles to 19.9 miles.

OBJECTION AND ANSWER: To the extent that this request seeks the identity and location of High Consequence Areas, that information is confidential by statute and Keystone is required by PHMSA to keep this information confidential. Without waiving the objection, during the detailed engineering design phase of the Project, the route was adjusted. In doing so, the route deviated away from DOT designated HCA areas there by reducing total HCA miles crossed by the Project. Please refer to the attached route variation list and maps.

50(c). Explain how the statistic which states a spill could affect a HCA no more than once in 250 years.

OBJECTION AND ANSWER: To the extent that this request seeks the identity and location of High Consequence Areas, that information is confidential by statute and

Keystone is required by PHMSA to keep this information confidential. Without waiving the objection, page 4-21 of the 2009 KXL Risk Assessment shows that a spill affecting HCA in any state crossed by the Project has an occurrence interval of 53 years. This is calculated based on historical incident data from Pipeline and Hazardous Materials Safety Administration, as discussed in Section 3.0. This is calculated by taking the inverse of the incident frequency (measured as incidents per mile per year) multiplied by the miles of high consequence areas crossed (141.2 miles). The result is an estimate, in years, of the time between spills. This is similar to the concept of flood recurrence intervals (e.g., 100-year floods).

107(a). Provide the analysis by Dr. Michael Madden which professes the Project would not (ii) substantially impair the health, safety, or welfare of the inhabitants in the project area.

OBJECTION: Dr. Madden was PUC Staff's witness in Docket 09-001, and his direct testimony is a matter of public record.

107(b). Explain how the 2010 permit, which relies on the federal environmental impact statement prepared by the Department of State, addresses specific concerns of South Dakota, including the health, safety and welfare of South Dakota citizens.

OBJECTION: This request is vague, unclear, argumentative, and seeks information that is not relevant or likely to lead to the discovery of admissible evidence.

The PUC addressed the health, safety, and welfare of South Dakota residents in the Amended Final Decision and Order in Docket 09-001. In addition, South Dakota residents had notice and opportunity to participate in the lengthy NEPA process conducted by the Department of State.

107(c). Explain your interpretation of "substantially" as it is used in state law SDCL 49-41 B-22 which states the applicant for a facility construction permit has the burden of proof to establish that:

(3) "The facility will not substantially impair the health, safety or welfare of the inhabitants."

OBJECTION: This request seeks a legal opinion or conclusion and is therefore beyond the scope of discovery and not likely to lead to the discovery of admissible evidence under SDCL § 15-6-26(b). It was an issue for the PUC to determine in Docket HP 09-001.

107(d). State with 100% certainty that this project will have no impact on the health, safety or welfare of the people of South Dakota.

OBJECTION: This request is argumentative and seeks information that is not relevant or likely to lead to the discovery of admissible evidence. The PUC addressed the health, safety, and welfare of South Dakota residents in the Amended Final Decision and Order in Docket 09-001. Keystone has not asserted that the project would

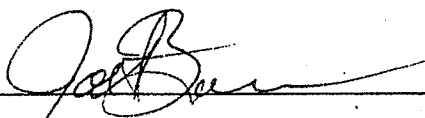
have "no impact" on the health, safety, or welfare of the people of South Dakota.

107(e). Describe how areas of dense populations versus areas of sparse populations affect project decision.

OBJECTION AND RESPONSE: This request is vague and unclear. Without waiving the objection, to the extent feasible and consistent with other routing criteria, areas of dense population are avoided during project routing.

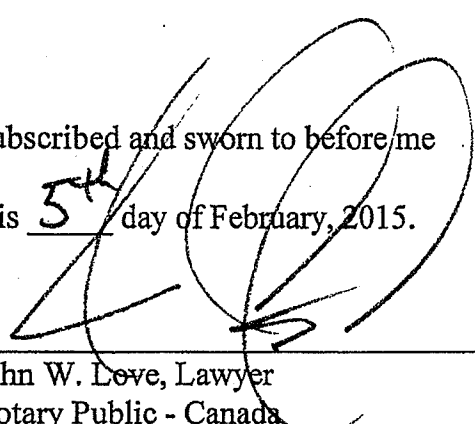
Dated this 5th day of February, 2015.

TRANSCANADA KEYSTONE PIPELINE, LP
by its agent, TC Oil Pipeline Operations, Inc.

By 

Its Director, Authorized Signatory

Subscribed and sworn to before me
this 5th day of February, 2015.



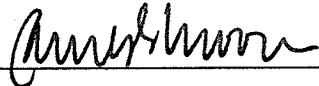
John W. Love, Lawyer
Notary Public - Canada

OBJECTIONS

The objections stated to Cindy Myers' Interrogatories and Request for Production of Documents were made by James E. Moore, one of the attorneys for Applicant TransCanada herein, for the reasons and upon the grounds stated therein.

Dated this 6th day of February, 2015.

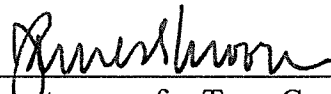
WOODS, FULLER, SHULTZ & SMITH P.C.

By 
William Taylor
James E. Moore
Post Office Box 5027
300 South Phillips Avenue, Suite 300
Sioux Falls, SD 57117-5027
Phone: (605) 336-3890
Fax: (605) 339-3357
Email: Bill.Taylor@woodsfuller.com
James.Moore@woodsfuller.com
Attorneys for Applicant TransCanada

CERTIFICATE OF SERVICE

I hereby certify that on the 6th day of February, 2015, I sent by e-mail transmission,
a true and correct copy of Keystone's Responses to Cindy Myers' First Interrogatories
and Request for Production of Documents, to the following:

Cindy Myers, R.N.
PO Box 104
Stuart, NE 68780
csmyers77@hotmail.com



One of the attorneys for TransCanada

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

0-0

| | | |
|----------------------------------|---|-----------------------------|
| IN THE MATTER OF THE APPLICATION | : | HP 14-001 |
| BY TRANSCANADA KEYSTONE | | |
| PIPELINE, LP FOR A PERMIT UNDER | : | TRANSCANADA KEYSTONE |
| THE SOUTH DAKOTA ENERGY | : | PIPELINE, LP'S SUPPLEMENTAL |
| CONVERSION AND TRANSMISSION | : | RESPONSES TO CINDY MYERS' |
| FACILITIES ACT TO CONSTRUCT THE | : | FIRST INTERROGATORIES AND |
| KEYSTONE XL PROJECT | : | REQUEST FOR PRODUCTION OF |
| | | DOCUMENTS |
| | : | |

0-0

Applicant TransCanada makes the following supplemental responses to interrogatories pursuant to SDCL § 15-6-33, and responses to requests for production of documents pursuant to SDCL § 15-6-34(a). These supplemental responses are made within the scope of SDCL 15-6-26(e) and shall not be deemed continuing nor be supplemented except as required by that rule. Applicant objects to definitions and directions in answering the discovery requests to the extent that such definitions and directions deviate from the South Dakota Rules of Civil Procedure.

GENERAL OBJECTION

Keystone objects to the instructions and definitions contained in Cindy Myers' First Set of Interrogatories and Requests for Production of Documents to the extent that they are inconsistent with the provisions of SDCL Ch. 15-6. *See* ARSD 20:10:01:01.02.

{01855195.1}

Keystone's answers are based on the requirements of SDCL §§ 15-6-26, 15-6-33, 15-6-34, and 15-6-36.

INTERROGATORIES AND REQUEST FOR PRODUCTION OF DOCUMENTS

1. Please identify the person or persons providing each answer to an Interrogatory or portion thereof, giving the full name, address of present residence, date of birth, business address and occupation.

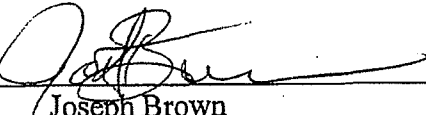
ANSWER: Given the extremely broad scope volume of more than 800 discovery requests received by Keystone in this docket, a range of personnel were involved in answering the interrogatories. Keystone will designate the following witnesses with overall responsibility for the responsive information as related to the Conditions and proposed changes to the Findings of Fact, which are identified in Appendix C to Keystone's Certification Petition: Corey Goulet, President, Keystone Projects, 450 1st Street S.W., Calgary, AB Canada T2P 5H1; Steve Marr, Manager, Keystone Pipelines & KXL, TransCanada Corporation, Bank of America Center, 700 Louisiana, Suite 700, Houston, TX 77002; Meera Kothari, P. Eng., 450 1st Street, S.W., Calgary, AB Canada T2P 5H1; David Diakow, Vice President, Commercial, Liquids Pipeline, 450 1st Street S.W., Calgary, AB Canada T2P 5H1; Jon Schmidt, Vice President, Environmental & Regulatory, exp Energy Services, Inc., 1300 Metropolitan Boulevard, Suite 200,

Tallahassee, FL 32308; Heidi Tillquist, Senior Associate, Stantec Consulting Ltd., 2950 E. Harmony Rd., Suite 290, Fort Collins, CO 80528.

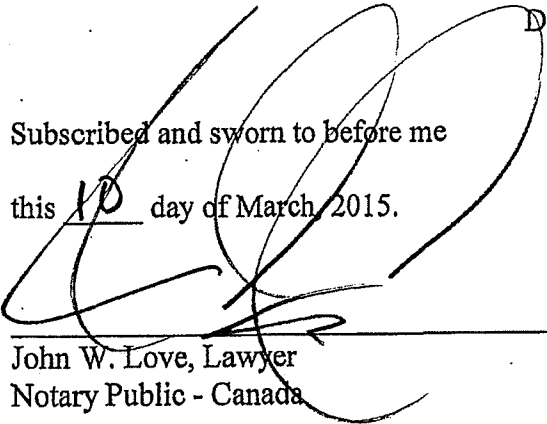
In addition to the witnesses previously identified, Keystone may offer rebuttal testimony from Danielle Dracy regarding emergency response; Lou Thompson regarding tribal engagement; Steve Klekar regarding tax issues; and Doug Robertson regarding SCADA and leak detection. Resumes for these possible rebuttal witnesses are marked as Keystone 1930-1934.

Dated this 10 day of March, 2015.

TRANSCANADA KEYSTONE PIPELINE, LP
by its agent, TC Oil Pipeline Operations, Inc.

By 
Joseph Brown
Director, Authorized Signatory

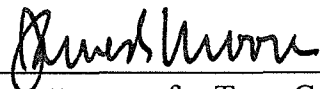
Subscribed and sworn to before me
this 10 day of March, 2015.


John W. Love, Lawyer
Notary Public - Canada

CERTIFICATE OF SERVICE

I hereby certify that on the 10th day of March, 2015, I sent by e-mail transmission, a true and correct copy of Keystone's Supplemental Responses to Cindy Myers' First Interrogatories and Request for Production of Documents, to the following:

Cindy Myers, R.N.
PO Box 104
Stuart, NE 68780
csmyers77@hotmail.com



One of the attorneys for TransCanada

Climate

‘It Will Never Be The Same’: North Dakota’s 840,000-Gallon Oil Spill One Year Later

by Emily Atkin  Oct 21, 2014 3:02 pm



CREDIT: AP Photo/Kevin Cederstrom

In this Oct. 11, 2013 file photo, cleanup continues at the site of an oil pipeline leak and spill north of Tioga, N.D.

One year ago, when more than 20,000 barrels (840,000 gallons) of crude oil spilled from a pipeline and soaked a wheat field in Tioga, North Dakota, the public almost never knew about it. After the spill was discovered by a lone farmer, it was not reported for nearly two weeks, and only after reporters from the The Associated Press asked about it specifically.

Now, a year later, environmentalists say North Dakota's oil spill reporting process has improved, but that more needs to be done to prevent those types of spills from happening in the first place. In North Dakota's Bakken shale, more than 1.2 million barrels of oil are produced every day, and spills from wells and pipelines happen frequently.

"The real lesson from this spill is that haste makes waste," Wayde Schaffer, a conservation organizer for the Sierra Club's North Dakota chapter, told ThinkProgress on Tuesday. "With the Bakken oil boom the development is outpacing the safeguards for the environment and people's health that need to be in place. I don't see that lesson being taken to heart."

The real lesson from this spill is that haste makes waste. ... I don't see that lesson being taken to heart.

By all accounts, the year-old 20,000-barrel spill — one of the largest onshore spills in U.S. history — happened by chance. Tesoro Corp., the company who owns the pipeline, told the AP that the spill was caused by a lightning strike.

The freak nature of the accident is apparently why no one knew about it until wheat farmer Steve Jensen discovered it during a harvest. To this day, the farmland is still sopped with oil, and Tesoro is still working to clean it up. "It's a big cleanup and it's become part of our life," Jensen told the AP on Monday. "The ground is still saturated with oil. And they're out there seven days a week, 24 hours a day."

Tesoro has said it is committed to cleaning up the spill and "making things right." But the fact that the company didn't know what had happened, and that such a large release of oil into the environment took so long to be discovered and reported, sparked outrage at the time of the incident. The AP conducted an investigation after the spill, and found that nearly 300 oil spills and 750 "oil field incidents" had occurred in North Dakota since January 2012 — none of which were reported to the public.

Since then, Schaffer says things have improved. Before the spill, he said, state agencies would routinely be alerted when a spill occurred, but they didn't always let the public know. Now, the Health Department puts out press releases about significant oil spills — an improvement, Schaffer said, but not the greatest achievement.

"It's sort of a passive way of getting it out there," he said. "I mean, you still have to look for it. It'd be better if they would alert the public right away, but at least the information is available now."

Oil is messy. It does contaminate the soil, and it takes a long time to clean up. And it will never be the same.

North Carolina Oil and Gas Division spokesperson Ashley Ritter confirmed to ThinkProgress that the Health Department had started putting out press releases about significant oil spills since the Tesoro incident, and that her agency had begun putting out press releases about spills that happen on oil and gas well sites. The state Oil and Gas Division does not have jurisdiction over large pipelines like Tesoro's, but does regulate smaller diameter gathering pipelines and well sites. The agency also only has jurisdiction over spills that happen on well sites themselves — if any oil reaches outside that site, the spill falls into the jurisdiction of the Health Department.

Tesoro's pipeline is regulated by the federal Pipeline and Hazardous Materials Safety Administration (PHMSA). But even the director of that agency has admitted that it faces extreme difficulty in enforcing their regulations. PHMSA head Jeffrey Wiese said last year that the agency has "very few tools to work with" in enforcing safety rules, and that the regulatory process surrounding pipelines is "kind of dying."

Companies in North Dakota are required to report all their spills to whatever agency has jurisdiction over them. Those state agencies are required to put those reports into public record, but they are not required to put out press releases on their websites about every incident. "We use our best judgment," Ritter said. "If there is a situation where we think the public needs to know about it, we let the first responders know, and the first responders will get the information out to the immediate public. But if it's a 5-barrel spill on-site, then we're not going to put out a press release."

The public notification process is only one part of the story brought to light by the Tesoro spill. Since the spill, there have still been a number of contamination incidents in the state, and Schaffer says more needs to be done to stop them. Just this month, a North Dakota pipeline owned by Oasis Petroleum spilled 42,000 gallons of salty wastewater into a creek, and 300 barrels of oil and water were spilled at a well site owned by XTO Energy.

Oil companies are making a lot of money in North Dakota, and they should be spending money to put these safeguards in place so we don't have people's health and safety at risk.

"It's one thing to report these spills but it's another thing to prevent them, and there hasn't been much movement in that direction," Schaffer said. "Oil is messy. It does contaminate the soil, and it takes a long time to clean up. And it will never be the same."

Schaffer said there has been somewhere in the neighborhood to 1,500 to 1,600 incidents of contamination by oil, gas, and wastewater from pipelines and well sites in 2013 — most of which were small, and none of which were as big as the Tesoro incident. But what that proves to him is that pipeline infrastructure needs to be

updated, more pipeline inspectors need to be on the ground, and new technologies need to be implemented to monitor both the condition of the pipelines and whether an accident has occurred.

“We don’t have those things in place, and we should,” he said. “Oil companies are making a lot of money in North Dakota, and they should be spending money to put these safeguards in place so we don’t have people’s health and safety at risk.”

For its part, Tesoro has said it could be \$20 million and another year before the farm in Tioga is fully cleaned up and ready to be planted on again. But Jensen told the AP that the company is cooperating — excavating the contaminated soil, heating it until the oil is gone, and then replacing it. He told the AP he is optimistic that one day he’ll be able to farm the land again.

That’s at least some progress, but it’s not the most important thing to take from the spill, Schaffer said.

“The one year anniversary is certainly nothing to celebrate,” he said. “It’s really only a good opportunity to remind people that these spills are taking place every day, and we need to take care of this problem.”

TAGS

- North Dakota
- Oil Spill
- Tesoro

Exhibit Cindy 13 - <http://www.deq.mt.gov/statesuperfund/silvertipoilspill/default.mcpx>. This link is not available on the internet.



New price tag for Kalamazoo River oil spill cleanup: Enbridge says \$1.21 billion

Garret Ellison | gellison@mlive.com By Garret Ellison | gellison@mlive.com

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on November 05, 2014 at 1:45 PM, updated November 05, 2014 at 1:48 PM

MARSHALL, MI — The largest inland oil spill in U.S. history has cost Canadian energy giant Enbridge \$1.21 billion to clean up — a substantially higher figure than previously estimated.

In a securities filing this week, Enbridge Energy Partners reported the total cleanup cost of the 2010 Kalamazoo River oil spill to be \$85.9 million higher than figures released last year.

According to the Securities and Exchange Commission filing, the \$1.21 billion figure included \$551.6 million spent on response personnel and equipment, \$227 million on environmental consultants and \$429.4 million on professional, regulatory, and other costs.

The company estimates it has \$219 million in spill costs yet-to-be-paid.

The new numbers follow substantial cleanup activities and restoration of the Kalamazoo River, which was fouled by 843,000 gallons of diluted bitumen, or dilbit, a viscous type of heavy crude oil from the tar sands region of Canada.

The spill occurred when a six-foot break in Enbridge's Line 6B, which runs from Griffith, Ind., to Sarnia, Ontario, sent oil into the river's Tallmadge Creek tributary near Marshall on July 25, 2010.

Portions of the river were dredged and riverbank was restored with native plantings along the entire 35-mile stretch of waterway in Calhoun and Kalamazoo counties. Dredging near Ceresco and Morrow Lake is being completed.

On Oct. 9, the Michigan Department of Natural Resources reported that all sections of the river had reopened for public use.

The U.S. Dept. of Transportation fined Enbridge \$3.7 million dollars after the spill. The U.S. Environmental Protection Agency is expected to levy additional fines for violations of the Clean Water Act. In the filing, Enbridge estimates those to be around \$40 million.

022427

The Michigan Department of Environmental Quality is taking over responsibility for monitoring and remediation of remaining submerged oil from the EPA.

On Oct. 21, U.S. District Judge Gordon Quist approved an undisclosed settlement between Enbridge and developers who planned to convert 420 acres of undeveloped land in Marshall into a \$14 million community vineyard.

In a Nov. 3 earnings call, Enbridge president Mark Maki said the company increased its insurance liability coverage to \$700 million following the 2010 spill.

"If you go back over our history, the Marshall incident was without question really a confluence of a number of very, very difficult and bad events in terms of what it cost ultimately," Maki said. "So we just don't see a lot of value in ensuring for another Marshall.."

*Garret Ellison covers business, government and breaking news for MLive/The Grand Rapids Press. Email him at **gellison@mlive.com** or follow on **Twitter & Instagram***

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The Keystone XL pipeline is dead

Greg Awtry Publisher | Posted: Tuesday, November 18, 2014 12:00 am

America is waking up to the fact the Keystone XL pipeline is dead. This poorly conceived idea had a life of its own early on, but once Nebraska correctly diagnosed the problems, the pipeline has been on life support powered only by expensive lobbyists and posturing politicians ever since.

The only place it still shows signs of life is in Washington, where it has been relegated to nothing more than a meaningless poker chip, to be wagered back and forth by both political parties until it finally goes the way of Alaska's "Bridge to Nowhere." Congress seems more concerned with making money for China (who has invested over \$30 billion into the tar sands) than it does protecting America.

"But, wait," you say. "Congress passed a bill just last week authorizing the KXL, and the Senate will vote this week." You are correct. But President Obama will veto the bill anyway, and since approval still depends on a presidential permit, the only thing the House and Senate are doing is what they do best, political posturing while bloviating nothing but ignorance on this issue.

"But wait." You say. "America needs that oil." In light of the great expansion of American oil in the past six years, the KXL has become a non-issue. There is actually a glut of oil that is forcing prices so low it is nearing the point where the Canadian tar sands cannot be mined profitably.

Listen folks, there was only one reason the KXL was needed anyway. There was so much oil in the upper Midwest that refineries were discounting the Canadian tar sands because they had too much oil to refine. The only way tar sand oil could be profitable was if they could get it to a port refinery where it could be turned into usable fuel and exported at much higher world prices.

Oh, the KXL might have gone through had TransCanada not been so greedy and had followed their existing Keystone I route. But no, they decided it would be cheaper to build if they drew a straight line between Alberta and Steele City, Nebraska saving \$2 billion in capital costs. Heck with the farmers and ranchers who are trying to protect their land and water as TransCanada would take control of their land using eminent domain. And, heck with the Nebraska Sandhills and America's most valuable natural resource, the Ogallala Aquifer.

022429

TransCanada should have listened to Governor Dave Heineman and Senator Mike Johanns when they said not to run the pipe through the Sandhills and the center of the Ogallala Aquifer. Oh sure, TransCanada moved their route about 20 miles to the east up in the Sandhills, but in doing so the new route actually crossed more miles of the aquifer than before. Nebraskans saw right through this scheme while the politicians took TransCanada's bait, hook, line and sinker.

So now, America owes a big "THANK YOU!" to Nebraska, who doggedly exposed the truth about this project, the truth this pipeline was never about a pipeline to America, but a pipeline through America.

Nebraskans correctly pointed out that the contents of this pipe is not crude oil in the sense we know it, but a highly toxic concoction of thick gooey tarsands diluted with lighter weight petroleum products like Naphtha, a known carcinogen capable of causing birth defects and reproductive harm.

Nebraskans came together and said there is no way we will allow 33 million gallons (per day) of this poison to travel under extremely high pressure just a half inch (thickness of the pipe) from our soil and water.

Nebraskans correctly pointed out that Congress' own House Ways and Means Committee didn't even consider these tarsands to be oil, which gives the owners and or refiners a tax exemption by not requiring them to pay 8 cents per barrel into the Oil Spill Liability Trust Fund like American oil has to pay, saving hundreds of millions of dollars for owners of the tarsands.

Nebraskans weighed in on the outrageous claims of hundreds of thousands of jobs and said, "Phooey!" Even the study done by Nebraska's own Department of Environmental Quality stated there would be only 15 permanent jobs created in Nebraska.

So, Nebraska "Pipeline Fighters", as they have come to be known, thank you! Thank you for stopping this ill-conceived project. Thank you for protecting Nebraska's land, water and rights. Thank you for standing in adversity while those who chose to listen only to pro-pipe lobbying groups splattered us with misconceptions.

So this KXL thing is over and done with.

Oh, Congress will continue to play with it like a worn out toy for a couple more years, but soon, the people we elected to represent us will become as smart as us! They will see there are no more political points to be made by making over-exaggerated claims about job numbers and by using some term made up solely to promote the KXL, "North American Energy Independence".

Congress, move on. You have a country called America to run!

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022432



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022433

DENVER AND THE WEST

Dead babies near oil drilling sites raise questions for researchers

By Nancy Lofholm

The Denver Post (mailto:nlofholm@denverpost.com?subject=The Denver Post:)

POSTED: 10/26/2014 12:01:00 AM MDT | UPDATED: ABOUT A YEAR AGO

224 COMMENTS (HTTP://WWW.DENVERPOST.COM/NEWS/CI_26800380/DEAD-BABIES-NEAR-OIL-DRILLING-SITES-RAISE-QUESTIONS#DISQUS_THREAD)



DPTV: I-70 open, test scores, infant death rate, and Mike Dunafon

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(<http://dptv.denverpost.com/2014/10/27/i-70-open-test-scores-infant-death-rate-and-mike-dunafon/>)

VERNAL, Utah — The smartphone-sized grave marker is nearly hidden in the grass at Rock Point Cemetery. The name printed on plastic-coated paper — Beau Murphy — has been worn away. Only the span of his life remains.

"June 18, 2013 - June 18, 2013"

For some reason, one that is not known and may never be, Beau and a dozen other infants died in this oil-booming basin last year. Was this spike a fluke? Bad luck? Or were these babies victims of air pollution fed by the nearly 12,000 oil and gas wells in one of the most energy-rich areas in the country?

Some scientists whose research focuses on the effect of certain drilling-related chemicals on fetal development believe there could be a link.

But just raising that possibility raises the ire of many who live in and around Vernal. Drilling has been an economic driver and part of the fabric of life here since the 1940s. And if all that energy development means the Uintah Basin has a particularly nasty problem with pollution, so be it, many residents say. Don't blame drilling for baby deaths that obituaries indicate were six times higher than the national average last year.

"People like to blame stuff on that all the time, but I don't feel like it has anything to do with oil and gas. I just feel like it's a trial I was given," said Heather Jensen, whose two infant sons are buried near Beau. One died in late 2011 and another early in 2013.

Questions about drilling's possible effect on infants and the unborn aren't confined to this northeast corner of Utah. Late in 2013, an unusually high number of fetal anomalies in Glenwood Springs, 175 miles away in Colorado, were reported to state

Continue to article...

(http://www.denverpost.com/breakingnews/ci_29590373/appeals-court-hear-oral-arguments-deflategate-case?source=JPopUp)



([/portlet/article/html/imageDisplay.jsp?contentItemRelationshipId=6339329](http://portlet/article/html/imageDisplay.jsp?contentItemRelationshipId=6339329))

Donna Young, a midwife, became worried about air pollution from the oil and gas industry causing child deaths after attending a memorial at a Vernal cemetery and seeing a row of graves for babies. (RJ Sangosti, The Denver Post)

NEXT ARTICLE IN NEWS (NEWS)



Appeals court to hear oral arguments in 'Deflategate' case

(<http://www.denverpost.com/breakingnews/ci-court-hear-oral-arguments-deflategate-case?source=JPopUp>)

022434



authorities. A study found no connection with drilling.

(http://www.denverpost.com/news/ci_25684818/state-finds-no-link-drilling-garfield-county-fetal)

Concerns have been raised in other areas of heavy drilling, but no clusters have been documented. No dots have been connected. But there are some in the scientific and medical communities working to try to make a connection.

"I suspect it is real — that there is a relationship," said Susan Nagel, Ph.D, a University of Missouri School of Medicine researcher who is focusing her studies on fracking-fluid chemicals that affect hormones.

Scads of medical studies (http://uphe.org/166-70-198-2.plesko2.xmission.com/?page_id=186) have concluded that air pollution can harm embryos. Drilling is a documented contributor to that pollution. It is a given that some of the harmful chemicals released in drilling, like benzene, toluene and xylenes, can cross the placental barrier and cause heart, brain and spinal defects.



(portlet/article/html/imageDisplay.jsp?contentItemRelationshipId=6339330)

Oil and gas trucks roll through Vernal, Utah, which is home to some 11,200 oil and gas wells, this month. (RJ Sangosti, The Denver Post)

"Suffice it to say that air pollution from drilling is a part of it," Dr. Brian Moench said of the Vernal-area deaths.

Moench, a Salt Lake City-based anesthesiologist and president of Utah Physicians for a Healthy Environment (<http://uphe.org/>), admits that establishing a scientifically solid link between dead babies and drilling pads is complicated.

Air pollution is often a stew of chemicals and particles from multiple sources. In Vernal, diesel pickups and fracking rigs roll down Main Street spewing fumes.

Oil field-support businesses, with their tanks of fluids and fuels, string out for miles. A coal-fired power plant sends a plume of smoke high in the air.

A recent National Oceanic and Atmospheric administration study (http://www.noaa.gov/stories2014/20141001_utahwinterozonestudy.html) showed dangerously high levels of ozone in the Uintah Basin around Vernal. Last winter, ozone levels spiked well beyond the safe level set by the Environmental Protection Agency — worse than the highest ozone days in Los Angeles. The study blamed the oil and gas industry.

"Decades of scientific research show that impaired air quality impacts human health, including fetal and infant health and survival," said Seth Lyman, an air-quality researcher with Utah State University in Vernal. "However, many other factors also impact infant survival, and it is extremely unlikely that poor air quality in Vernal is the primary cause of an infant mortality epidemic."

There was another factor last year: An explosion occurred east of Vernal on March 1, 2013, at a business that handles and cleans fracking equipment. The blast blew debris over a half-mile area. No one knows what it might have blown into the air. No measurements were taken.

Uintah County Commissioner Mike McKee said that wasn't a concern, just as drilling rigs aren't. He cited a county study done several years ago to determine if there was a spike in asthma cases in Vernal, as some residents feared. The study found there was not.

"People complaining about our air are from out of the area, from what I am seeing," McKee said.

One of the most vocal is Moench.

Moench took it seriously this year when Vernal midwife Donna Young told him that she had researched obituaries and was alarmed by the high numbers of dead babies.

Young and Moench were able to convince the TriCounty Health Department (<http://www.tricountyhealth.com/>) in Vernal to work with the state on a study to determine if Young's trend figures are correct.

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Moench said that people who aren't looking at the possibility of a connection "have blinders on."

Nagel is in Moench's corner.

In two phases of research, she has gathered samples in Colorado's Garfield County and is currently exposing pregnant mice to fracking fluids in her lab. She will be looking for effects on the offspring.

Nagel said it is too early to have results, but she won't be surprised if there are effects from hormone-harming chemicals called "endocrine-disrupters."

"Mechanistically, from what we know about [endocrine-disrupting chemicals](http://en.wikipedia.org/wiki/Endocrine_disruptor), (http://en.wikipedia.org/wiki/Endocrine_disruptor) it is highly plausible," she said about linking the chemicals to fetal problems.

Part of the reluctance of residents around Vernal to ascribe any ill effects to energy-field pollution could be tied to the average \$3,963 average monthly nonfarm wage in Uintah County — the highest in Utah.

Young said she benefits from that and has no bias against the industry in spite of receiving threats and suffering vandalism after she started talking about the infant deaths. Many of the fathers of the babies she delivers work in the oil fields.

"I just really, really want to find out what is going on," said Young, who now insists that all her pregnant patients use air and water filters.

It was midwives who also raised concerns and triggered the study in Garfield County this year. They had noticed a higher-than-normal number of anomalies in fetuses during ultrasounds and reported that to the Colorado Department of Public Health and Environment.

The study found no common denominator in 22 cases and determined the midwives may have erred in their use of ultrasounds and in record-keeping.

The [Utah Department of Health \(http://health.utah.gov/\)](http://health.utah.gov/) is now working on a study.

Epidemiologists initially are using birth and death certificates to determine if there truly was a spike in infant deaths, as Young's numbers show.

Her numbers show an upward four-year trend in infant deaths: One in every 95.5 burials in Uintah County in 2010 was a baby, according to Young. In 2011 it was one in every 53. In 2012, one in every 39.7. And in 2013 the number jumped to one in every 15.

State epidemiologist Sam LeFevre said his study will crunch numbers and not delve into causes for deaths unless the numbers show a potential problem.

Besides oil-and-gas-stoked pollution, there could be many other causes.

Uintah County is 24th of 27 Utah counties in [health rankings](http://www.countyhealthrankings.org/sites/default/files/state/downloads/CHR2014_UT_v2.pdf) (http://www.countyhealthrankings.org/sites/default/files/state/downloads/CHR2014_UT_v2.pdf).

Twice as many residents here smoke than in the rest of Utah. More residents, in an area rife with new fast-food chains, are overweight. More residents admit to drinking heavily. There are more teen mothers and more mothers on average who don't get good prenatal care.

Dr. Karl Breitenbach, a physician who has done deliveries and prenatal and newborn care in Vernal for 27 years, was the only Vernal physician who responded to requests for comment. He said he has reviewed data through 2012 and hasn't seen any increase in baby deaths.

"I am unwilling to speculate until I see some proof that there actually is an increased rate of infant morbidity or mortality," he said in an e-mail.

A mother bringing her arm-waving 9-month-old into a Vernal pediatrician's office for a well-child visit recently said she has no concerns about pollution and hadn't heard about the infant deaths.

"I have no worries," Jeni Taylor said.

While the state studies in Utah and Colorado address numbers, general research on fracking fluids and developing babies is expected to go farther.

Nagel said she is trying to establish a laboratory link that future researchers can then use as they study health effects in drilling areas.

Liza McKenzie, a research associate at the Colorado School of Public Health who has studied health effects of fracking fluids in Colorado, said she plans to do more research on the subject of fetuses and infants exposed to the chemicals.

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Her earlier research showed (<http://ehp.niehs.nih.gov/1306722/>) babies born to mothers living within 10 miles of wells are at greater risk of congenital heart defects and neural tube defects. But some other researchers and the oil and gas industry have [criticized her research](http://inewsnetwork.org/media-partners/state-questions-study-linking-fracking-to-birth-defects/) (<http://inewsnetwork.org/media-partners/state-questions-study-linking-fracking-to-birth-defects/>) methods and findings.

Results from the state study in Vernal are expected early next year.

For now, infant deaths have dropped back to average. Residents are reluctant to talk about the infant-death issue. Many are focusing on a future that is filled with expanded fossil-fuel prospects. Nearly 85 percent of Vernal residents indicated in a recent survey that they welcome oil shale development.

Commercial removal of oil from shale rock is expected to get underway next year. More than 25,000 new oil and gas wells are proposed in the basin. The first tar sands project in the United States is underway in Vernal's corner of Utah.

In Vernal, all that is translating into mushrooming amenities.

Finishing touches are being put on a sprawling new mall.

An energy-funded conference center with swooping modernistic glass walls is taking shape not far from an eye-popping community center.

A new library is a daytime magnet for mothers and kids.

And there are new babies to celebrate. Ben and Caren Moon, who previously lost a pre-term baby, just gave birth to a healthy new baby. They are feeling blessed even as they still grieve their earlier loss.

"Oil-field drilling has been here forever," Ben Moon said. "I don't believe it all had anything to do with that."

Nancy Lofholm: 970-256-1957, nlofholm@denverpost.com or twitter.com/nlofholm

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022439

Madden Report Misses Distress Among Keystone Pipeline Neighbors

Posted: Monday, November 2, 2009 at 8:07 am

By: Cory Allen Heidelberger

[Comment](#) | [Trackback](#) 

Report Also Finds Going Rate for Land Rights:

\$40,000 per Mile

The South Dakota Public Utility Commission [begins its hearing today](#) on the Keystone XL pipeline permit. A public input session tomorrow (Tuesday) evening at 6 p.m. will be part of a week-long process in Room 414 of the State Capitol Building in Pierre.

The state appears ready to propagate the illusion that another strip of sovereign Canadian territory across South Dakota is hunky-dory. *SD Tar Sands Pipelines* [highlights a report submitted](#) to the Keystone XL docket by economist Michael Madden on behalf of the state. Dr. Madden assesses the socioeconomic impacts of the Keystone I pipeline TransCanada is currently completing in eastern South Dakota. Somewhat maddeningly, Dr. Madden finds that among farmers he interviewed near the pipeline route he didn't get to have the project on their land, "it was sensed that there was feeling of lack of good fortune on their part." He finds "no major worry road rehabilitation would not be performed by the company" [p. 13].

Dr. Madden evidently [avoided speaking to Mike and Sue Sibson](#)—"pipeline shoved up my..." doesn't strike me as an expression of "good fortune." Dr. Madden also apparently didn't catch the KDLT story (now deleted—evidently KDLT can't afford the server space to [archive a few kilobytes of text](#) each week) about TransCanada tearing up roads and [dragging its feet on repairs](#) in Beadle County. (For more on road concerns, see the Beadle County [Commission minutes from July 30](#).)

But let's back up. Where did that "lack of good fortune" comment come from? Dr. Madden appears to have discovered how much money it took to keep landowners quiet and perhaps make other neighbors wish they could have cashed in on black gold and perpetual environmental disruption. While landowners were [bound to secrecy by confidentiality agreements](#) with TransCanada, Dr. Madden appears to have wheedled from at least a few of his interviewees some numbers.

Although exact numbers were not easily acquired from those interviewed, it appears that in the area where these interviews were conducted a typical access easement involved a payment of approximately \$40,000 per mile of land. In addition ample mitigation has been arranged for loss of crop or grassland production for the interruption in production caused by construction activity and post-construction restoration. No one interviewed indicated that the amounts involved were unfair. In talking to other farm operators who lived near the project, but had no land on the corridor, it was sensed that there was feeling of lack of good fortune on their part [[Madden report to PUC](#), p. 13].

\$40,000 per mile. Given a 150-foot construction easement, that's \$2,200 per acre. Compare that to [\\$1,863–\\$2,634 ag land values](#), depending on the neighborhood.

But here's the real kicker: \$40K per mile, across about 220 miles through eastern South Dakota. Total TransCanada would be shelling out to our landowners by Dr. Madden's estimate: \$8.8 million... the [current price](#) of the amount of oil that will shoot through the Keystone pipeline every four and a half hours.

Looks to me like TransCanada bought its way across our state with payments hardly bigger than rounding error on their final balance sheet.

Why am I not feeling good fortune?

...comments welcome at the PUC (Room 414, State Capitol, Tuesday, Nov. 3, 6 p.m.) and at the [Madville Times](#)!

http://billingsgazette.com/news/state-and-regional/montana/breach-in-pipeline-found-cancer-causing-agent-detected-in-water/article_c39e74b3-08ec-5fce-8d18-4085c5c03ed2.html

Breach in pipeline found; cancer-causing agent detected in water

Billings Gazette and Associated Press Jan 20, 2015



MATTHEW BROWN/Associated Press

Residents line up to receive drinking water from a distribution center Tuesday in Glendive. A cancer-causing component detected in the Glendive drinking water supply, just downstream from a crude oil spill that entered the Yellowstone

GLENDIVE — Eastern Montana residents rushed to stock up on bottled water Tuesday after authorities detected a cancer-causing component of oil in public water supplies downstream of a Yellowstone River pipeline spill.

022441

Elevated levels of benzene were found in water samples from a treatment plant that serves about 6,000 people in the agricultural community of Glendive, near North Dakota.

Scientists from the federal Centers for Disease Control and Prevention said the benzene levels were above those recommended for long-term consumption, but did not pose a short-term health hazard. Residents were warned not to drink or cook with water from their taps.

Some criticized the timing of Monday's advisory, which came more than two days after 50,000 gallons of oil spilled from the 12-inch Poplar pipeline owned by Wyoming-based Bridger Pipeline Co. The spill occurred about 5 miles upstream from the city.

Adding to the frustrations was uncertainty over how long the water warning would last. Also, company and government officials have struggled to come up with an effective way to recover the crude, most of which appears to be trapped beneath the ice-covered Yellowstone River.

A mechanical inspection of the damaged line Tuesday revealed the breach occurred directly beneath the river, about 50 feet from the south shore, Bridger Pipeline spokesman Bill Salvin said.

The cause remained undetermined.

By Tuesday, oil sheens were reported as far away as Williston, North Dakota, below the Yellowstone's confluence with the Missouri River, officials said.

"It's scary," said 79-year-old Mickey Martini of Glendive. "I don't know how they're going to take care of this."

Martini said she first noticed a smell similar to diesel fuel coming from her tap water Monday night. Officials previously didn't know whether the spill happened beneath the iced-over river or somewhere on the riverbank.

Martini said she was unable to take her daily medicines for a thyroid condition and high cholesterol until she picked up water from a public distribution center later in the day.

Representatives from the state and the U.S. Environmental Protection Agency earlier said preliminary monitoring of the city's water showed no cause for concern. The water treatment plant operated until Sunday afternoon, more than 24 hours after pipeline operator Bridger Pipeline discovered the spill, officials said.

Additional tests were conducted early Monday after residents began complaining of the petroleum- or diesel-like smell from their tap water. That's when the high benzene levels were found.

Benzene in the range of 10 to 15 parts per billion was detected from the city's water, said Paul Peronard with the EPA. Anything above 5 parts per billion is considered a long-term risk, he said.

Peronard acknowledged problems in how officials addressed the city's water supply, including not having the right testing equipment on hand right away to pick up contamination. But Peronard and others involved in the spill response said officials acted based on the best information available.

"Emergencies don't work in a streamlined fashion," said Bob Habeck with the Montana Department of Environmental Quality. "It's a process of discovery and response."

Several residents interviewed by The Associated Press said they first heard about the water problems through friends and social media sites, not the official advisory.

"They could have been more on top of it," Whitney Schipman said as she picked up several cases of bottled water for her extended family from a water distribution center. "As soon as there was a spill, they should have told everybody."

Officials took initial steps Tuesday to decontaminate the water system. Glendive Mayor Jerry Jimison said it was unknown when the water treatment plant would be back in operation.

Until that happens, Salvin said the company will provide 10,000 gallons of drinking water a day to Glendive.

The company established a hotline for people with questions about the water supply and to report any wildlife injured by the spill: (888) 959-8351.

Another pipeline spill along the Yellowstone River in Montana released 63,000 gallons of oil in July 2011. An Exxon Mobil Corp. pipeline broke during flooding, and oil washed up along an 85-mile stretch of riverbank.

Exxon Mobil faces state and federal fines of up to \$3.4 million from the spill. The company has said it spent \$135 million on the cleanup and other work.

The Poplar pipeline involved in Saturday's spill runs from Canada to Baker, Montana, picking up crude along the way from Montana and North Dakota's Bakken oil-producing region.

The pipeline receives oil at four points in Montana: Poplar Station in Roosevelt County, Fisher and Richey stations in Richland County, and at Glendive in Dawson County. The section of pipeline that crosses the Yellowstone River was last inspected in 2012, in response to the Exxon accident, according to company officials.

At that time, the line was at least 8 feet below the riverbed where it crosses the Yellowstone.

No cost estimate for the Glendive spill was yet available.

The Associated Press contributed to this report.

2011 Yellowstone River oil spill near Laurel

022444

- On July 2, 2011, ExxonMobil's 12-inch Silvertip pipeline was ruptured by high river flow.
- The spill released an estimated 63,000 gallons of crude oil into the river.
- The oil fouled farmland and riverbank for more than 70 miles downstream.
- Scores of workers from around the country descended on Billings for several months to clean up the spill using pumps and absorbent pads.
- The cleanup and environmental penalties cost ExxonMobil more than \$135 million and triggered several lawsuits by landowners along the river.
- Federal regulators said ExxonMobil was slow to respond to the pipeline break. The damage could have been significantly reduced if pipeline controllers had shut safety valves in the system more quickly.
- ExxonMobil officials contested \$1.7 million in civil penalties proposed by federal regulators.
- Last December, the state's Department of Environmental Quality said inspection teams had verified that the river cleanup was complete. The agency said it had reviewed and analyzed results from about 1,325 soil and sediment samples.

Drinking water press release

On January 17th at 3:00 pm, Bridger Pipeline, LLC notified local authorities of a potential release from a pipeline that crosses the Yellowstone River approximately 5 miles upstream from Glendive. Shortly thereafter MDEQ notified municipal water utilities of the potential of crude oil passing by their water intakes. DEQ further advised the water utilities to monitor their intakes for potential impact. Thus far no abnormalities have been reported by the water plant in Glendive. It is unlikely the crude oil would impact Glendive's water intake because the intake is 14 feet below the water surface, and the oil will tend to float on the water surface. This is especially true of the light crude transported by Bridger Pipeline. However, on Sunday, January 18th, Dawson County began receiving some complaints of odor in drinking water from people who use the municipal water supply. Because of this, the incident unified command has decided to take a collection of samples from the municipal drinking water supply and will provide teams to monitor taps along Glendive's water distribution system. This will be done starting on Monday, January 19th. At this point in time, the incident command has no reason to think there has been an adverse impact to the Glendive water system. However, if you feel uncomfortable, use bottled water, although that is not a recommendation at this time. For more information, contact the City of Glendive Public Works Department at 377-3318 ext. 16.

Brine, oil spill in North Dakota county



Pipeline breach spills oil into Yellowstone River

MORE INFORMATION

2011 Yellowstone oil spill cost ExxonMobil \$135 million

Hanser's makes quick work of hazardous spills

Study says there's more to do as oil trains pose new risks

DEQ seeking information from public on Yellowstone River oil spill cleanup

Unusual alliance on oil spill cleanup

022446



+13

Oil spill in Yellowstone River
Jan 19, 2015

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Gallery: Yellowstone River oil spill (2011)

Chris Cioffi

Chris Cioffi covers city news for The Billings Gazette in Montana.

Tom Lutey

Politics and agriculture reporter for The Billings Gazette.

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Yellowstone oil spills fuel arguments over Keystone line

By [MATTHEW BROWN](#) Jan. 29, 2015 11:17 PM EST

BILLINGS, Mont. (AP) — Oil pipeline accidents have become increasingly frequent in the U.S. as Congress presses the Obama administration to approve the Keystone XL pipeline — a project that would pass near the spot where 30,000 gallons of crude spilled into Montana's Yellowstone River earlier this month.

The Montana pipeline breach temporarily fouled a city's water supply and emerged as the latest in a string of spills to highlight ongoing problems with maintenance of the nation's 61,000 miles of crude oil pipelines.

An Associated Press review of government records shows accident numbers growing steadily since 2009, reversing a decade-long decline.

After the U.S. Senate voted 62-36 Thursday to approve Keystone, Democratic Sen. Maria Cantwell of Washington state cited the increase in spills in calling for President Barack Obama veto the measure.

Yet in the politically charged debate over Keystone, its detractors aren't the only ones seizing on the Yellowstone spill. So are lawmakers who support the project.

North Dakota Democrat Sen. Heidi Heitkamp said building it was preferable to using older pipelines such as the one in the Yellowstone spill, which was installed in 1967.

"To the extent that we have problems with spills, it's with aging infrastructure," Heitkamp said. "Keystone is going to be state-of-the-art."

U.S. Department of Transportation records show at least 73 pipeline-related accidents in 2014 — an 87 percent increase over 2009. Because of a lag in reporting by companies, the 2014 figure still could rise.

The tally includes accidents in which someone was killed or hospitalized, five or more barrels of oil were released, a fire or explosion occurred, or costs from the accident topped \$50,000.

The increase came as surging domestic oil production boosted crude shipments by pipeline by about 20 percent, to 8.3 billion barrels annually, between 2009 and 2013, the most recent year available.

Meanwhile, pipes that were put in the ground decades ago are wearing out, said Rebecca Craven, program director for the advocacy group Pipeline Safety Trust.

Almost half the pipeline-related accidents since 2009 involved lines or equipment installed more than 40 years ago, according to records on more than 250 accidents that were reviewed by The AP and included age information.

Pipeline industry representatives say the increase in accidents is less straightforward than the federal data suggest.

An industry examination of crude oil and other hazardous-liquid accidents in 2013 showed that in two-thirds of cases, the spill did not leave the responsible company's property, said John Stoodly, vice president of the Association of Oil Pipe Lines. Most of the accidents involved fewer than five barrels, or 210 gallons.

The recent Montana spill was the second in less than four years on the Yellowstone, a largely untamed river that flows from Yellowstone National Park and across the breadth of Montana before feeding into the Missouri River in North Dakota.

The accident happened after a 120-foot section of Bridger Pipeline LLC's Poplar Pipeline became exposed beneath the river, increasing its vulnerability to underwater debris.

The 12-inch steel line had been at least 8 feet beneath the river as recently as 2011, when a survey was performed in response to an earlier Exxon Mobil pipeline break beneath the Yellowstone.

For Keystone, project sponsor TransCanada plans to drill the 36-inch pipeline dozens of feet beneath major rivers to protect it from floodwaters or other outside forces.

Keystone's critics say no pipeline is entirely safe.

"You know what they say about pipelines? There's only two kinds: The ones that are leaking, and the ones that are going to leak," said Dena Hoff, a farmer and rancher whose property fronts the Yellowstone at the site of the Poplar Pipeline spill.

Keystone would move up to 830,000 barrels of oil a day. A break in the line could dwarf the recent Montana accident, on a line with a capacity of just 42,000 barrels daily.

TransCanada says Keystone would be buried deeply enough — at least 25 feet beneath the Yellowstone — to avoid even a 500-year flood event, Keystone spokesman Shawn Howard said. Precautions at 13 other major water crossings would be similar.

Yet even with the latest technologies, protecting pipelines beneath rivers presents challenges.

In 2011, days after flooding across the Northern Plains broke the Exxon pipe, U.S. Geological Survey researchers found "scour holes" as deep as 53 feet along the Missouri River.

While engineers have equations they can use to forecast locations where floodwaters may eat away at a river bottom, the USGS' Brenda Densmore said the dynamic nature of rivers can make them unpredictable.

"It's nature," Densmore said. "Is it going to follow the equation? I don't know for sure."

Follow Matthew Brown on Twitter: <https://twitter.com/matthewbrownap>

Yellowstone Oil Spill Missing from Keystone XL Coverage On CNN, Fox

MSNBC, Other Outlets Put Spill In Context Of Keystone's Environmental Risks

[Blog](#) >>> January 26, 2015 5:48 PM EST >>> DENISE ROBBINS

CNN and Fox News repeatedly reported on the Keystone XL pipeline without connecting it to a major oil spill near the pipeline's proposed route. By contrast, MSNBC and others in the media have reported on the spill, which occurred in the Yellowstone River in Montana, in the context of concerns about Keystone XL's environmental risks.

Yellowstone Spill Threatened Health Of Residents Near Keystone XL's Proposed Path

Oil Pipeline Leaked 50,000 Gallons Of Crude Into Yellowstone River. On January 17, an oil pipeline owned by Bridger Pipeline Co. spilled 1,200 barrels of crude oil -- or about 50,000 gallons -- into the Yellowstone River, prompting the governor to declare a state of emergency. Reuters reported:

A small but heavily subscribed pipeline that transports 42,000 barrels a day of crude oil from North Dakota's Bakken region is expected to remain closed on Tuesday after a weekend breach that spilled 1,200 barrels of crude into the Yellowstone River near Glendive, Montana.

[...]

Montana Governor Steve Bullock declared a state of emergency in the state's eastern Dawson and Richland counties on Monday while towns and cities downstream, including Williston, North Dakota, are monitoring their water systems in case of contamination.

However the water supply of Glendive, the town of 5,000 about 10 miles (16 km) downstream of the spill, has already been tested and found to have elevated levels of hydrocarbons. Water intakes in the river for the city have been closed, according to the EPA. The company, EPA and other agencies are trying to get other drinking water supplies for Glendive, the EPA's Mylott said. [Reuters, [1/20/15](#)]

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Spill Has Released Cancer-Causing Agent Into Region's Water. Days after the spill, officials detected benzene -- a cancer-causing agent -- in the water supply of Glendive. From CBSNews.com:

Some residents of an eastern Montana farm community are criticizing officials for taking more than two days to notify them that their drinking water is contaminated with a cancer-causing chemical.

Elevated levels of benzene were found in water samples taken from a treatment plant that serves about 6,000 people in the agricultural community of Glendive near the North Dakota border. The contamination followed a 50,000 gallon oil spill that found its way from a break in a 12-inch pipeline into the Yellowstone River. [CBSNews.com, [1/20/15](#)]

Keystone XL Would Be Built Close To The Site Of Yellowstone Spill. On January 21, *The New York Times* reported that Keystone XL "would pass about 25 miles north of Glendive," a town located downstream of the Yellowstone spill. [*The New York Times*, [1/21/15](#)]

A Spill From Keystone XL Could Be Much Worse Than The Yellowstone Spill. As Think Progress reported, the proposed Keystone XL pipeline is much wider than the Bridger pipeline and would pump much more oil on a daily basis:

The proposed -- and controversial -- northern leg of the Keystone XL pipeline would be three times the diameter of the breached Bridger pipeline, and pump more than 34 million gallons of oil per day through the Dakotas down into Nebraska and into the southern leg in Oklahoma and Texas. Many landowners and local residents are concerned about what a potential spill would mean for critical watersheds and aquifers -- not to mention what subsequent increased tar sands oil production means for Canadian watersheds. [ThinkProgress, [1/19/15](#)]

CNN And Fox News Ignored Yellowstone Spill In Their Keystone XL Coverage

CNN And Fox Barely Mentioned Yellowstone Spill -- And Didn't Tie It To Keystone XL. CNN and Fox News each provided only a single brief mention of the Yellowstone oil spill, according to a review of *Media Matters'* internal video archives, and neither mention was in the context of reporting on Keystone XL. CNN made a 20-second mention of the spill in a headline rundown on the January 21 edition of *Early Start*, while Fox News provided an equally brief mention of the spill on the January 21 edition of *Fox & Friends First*.

Other Media Outlets Did Link Yellowstone Spill to Environmental Concerns About Keystone XL

MSNBC's Schultz Cited Yellowstone Spill As Reminder That "The President Is Right To Veto" Keystone XL. On the January 21 edition of *The Ed Show*, host Ed Schultz noted that Keystone XL would be a much bigger pipeline than the Bridger pipeline, and pointed to the Yellowstone spill as the latest reminder that "oil pipelines are risky":

SCHULTZ: No matter how you cut it, oil pipelines are risky just like cars crash, planes crash, trains have derailments -- pipelines leak. It's a dangerous game, case and point. Let's check out Yellowstone River in Montana that's unfolding right now.

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MADDOW: Senator, does it give you pause when we have pipeline accidents like the one that we had over the weekend in the Yellowstone River in Montana? That's very close to the Keystone route. That's not a pipeline that was seen as very high risk. In Glendive, Montana tonight, they're drinking bottled water and nobody knows how much of the beautiful Yellowstone River has been destroyed by an oil spill there on a very small pipeline. Are you worried at all that we're essentially selling the safety of this country, putting some very important aquifers at risk, essentially to help Canadian companies get their stuff to the world market at no real benefit to Americas?

MANCHIN: We respectfully disagree on the real benefits to America. Any time we have more security and we have more independence from foreign oil, we're going to be more secure and it might not take us to places such as Afghanistan and Iraq and Syria and all the other places, which I don't believe we should be. So, I've been very clear about that. [MSNBC Special Coverage: State of the Union Address, 1/21/15]

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Environmental groups, however, said the pipeline rupture was an omen.

"Every barrel of oil that spills into the Yellowstone River is another reason to reject Keystone XL," said Jamie Henn, spokesman for 350.org, an environmental group opposed to Keystone, which is being built to transport crude oil from Canada to refineries in the United States.

"Pipelines are inherently unsafe," Mr. Henn said. "If they're not spilling oil into rivers, they're still spilling carbon into the atmosphere." [*The New York Times*, 1/21/15]

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While President Barack Obama has vowed to veto Keystone, the enthusiasm of its boosters has left many who live in its path worried that

it will still be built, possibly at the expense of vital infrastructure upkeep and without sound contingency plans for spills. The scene in Glendive offered them no comfort.

"This is bad," said Irene Moffett, 79, who ranches and farms on a vast bench of grass above the Yellowstone River in Glendive. "But it's nothing compared to what they want to put in." [Al Jazeera America, [1/21/15](#)]

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- The January 22 edition of *The Real Story with Gretchen Carlson* featured Sen. John Cornyn's (R-TX) comments that the president's supporters "won't allow [him] to do the rational, realistic, practical thing, which would be to approve this pipeline." Correspondent Mike Emanuel also reported: "Bottom line, supporters here on Capitol Hill are trying to keep the pressure on the president to finally back the project." [Fox News, *The Real Story with Gretchen Carlson*, [1/22/15](#)]
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Pipeline rupture under Yellowstone River

Ralph
Maughan

Second rupture under Yellowstone River in four years makes Keystone look more ominous-

There has been a massive rupture of the Poplar oil pipeline under the Yellowstone River near Glendive, Montana. This is about a hundred miles upstream from the North Dakota border and the Yellowstone's confluence with the Missouri River.

The pipeline lay buried eight feet under the river bed when checked last in 2011. After 2011, river scouring perhaps, brought pipeline in contact with the flow of the mighty Yellowstone, and it broke, sending 40,000 gallons into the largely frozen over river. Federal law requires pipelines be buried at least four feet under a river, but here it appears the eight feet of gravel and whatever over the pipe disappeared in the last four years.

The Yellowstone is the longest undammed river in the lower 48, and it is a haven for big river fish. Riparian forests and badlands of clay along the river add much scenery and wildlife to the scene.

A very similar pipeline break happened in 2011 when an Exxon Mobil pipeline broke under the Yellowstone upstream near Billings, Montana. Exxon ended up paying a fine of over a million dollars. That spill was perhaps slightly larger than the present one.

The Poplar pipeline, which carries fracked oil from the big Bakkan shale play, is only a third the diameter of the proposed Keystone XL pipeline. The Keystone would also cross the Yellowstone in the same general area. The Keystone would be filled with the much more toxic and hard to clean up "dilbit." Dilbit contains "oil," actually diluted bitumen from the Alberta tar sand mines, and a dilutant. The dilutant consists of various hydrocarbon liquids. The exact composition is a trade secret. The dilution is needed to make the bitumen flow because it otherwise has the viscosity of asphalt.

It isn't really known why this pipeline broke under the Yellowstone because most breaks happen when a river is high and potentially damaging objects are rolling down the stream. An environmental consultant told the *Missoulian* newspaper, " 'It doesn't happen that often, to be very honest about it,' said Carl Oskins, an environmental consultant from Taos, New Mexico, who specializes in oil recovery from frozen-over, fast-moving water. 'I'm not sure why Bridger (Popular's owner) has a leak at all.' "

Unlike real crude oil, bitumen sinks to the bottom and the dilutant consists of some toxic, carcinogenic liquids such as benzene. Submerged bitumen is much harder to clean up than regular crude oil. It can be supremely expensive. In 2010, the Kalamazoo River in Michigan was subjected to more than a million gallons of spilled dilbit. Now five years later it is still not all cleaned up and billions of dollars have been spent trying to clean the river.

[About the Kalamazoo River oil pipeline spill.](#)

The Yellowstone is the Missouri's major tributary. Of course, the Missouri is the major tributary of the Mississippi.



Drinking Water Contaminants – Standards and Regulations

The Environmental Protection Agency (EPA) identifies contaminants to regulate in drinking water. The Agency sets regulatory limits for the amounts of certain contaminants in water provided by public water systems. These contaminant standards are required by the Safe Drinking Water Act (SDWA). EPA protects public health by implementing the SDWA provisions while working with states, tribes, and many other partners.

Regulated Drinking Water Contaminants



National Primary Drinking Water Regulations (NPDWRs) - table of contaminants
Secondary drinking water standards
Drinking water requirements for states and public water systems

Developing and Reviewing Contaminant Regulations



Regulation development process
Regulations under development or review
Six-year review of drinking water standards

Evaluating Drinking Water Contaminants



Contaminant Candidate List (CCL) and regulatory determination
Unregulated Contaminant Monitoring (UCM) program

Monitoring Drinking Water Contaminants



Analytical methods
Laboratory certification
National Contaminant Occurrence Database

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Private Well Information

Last updated on January 6, 2016

Yellowstone Oil Spill Missing from Keystone XL Coverage On CNN, Fox

MSNBC, Other Outlets Put Spill In Context Of Keystone's Environmental Risks

[Blog](#) >>> January 26, 2015 5:48 PM EST >>> DENISE ROBBINS

CNN and Fox News repeatedly reported on the Keystone XL pipeline without connecting it to a major oil spill near the pipeline's proposed route. By contrast, MSNBC and others in the media have reported on the spill, which occurred in the Yellowstone River in Montana, in the context of concerns about Keystone XL's environmental risks.

Yellowstone Spill Threatened Health Of Residents Near Keystone XL's Proposed Path

Oil Pipeline Leaked 50,000 Gallons Of Crude Into Yellowstone River. On January 17, an oil pipeline owned by Bridger Pipeline Co. spilled 1,200 barrels of crude oil -- or about 50,000 gallons -- into the Yellowstone River, prompting the governor to declare a state of emergency. Reuters reported:

A small but heavily subscribed pipeline that transports 42,000 barrels a day of crude oil from North Dakota's Bakken region is expected to remain closed on Tuesday after a weekend breach that spilled 1,200 barrels of crude into the Yellowstone River near Glendive, Montana.

[...]

Montana Governor Steve Bullock declared a state of emergency in the state's eastern Dawson and Richland counties on Monday while towns and cities downstream, including Williston, North Dakota, are monitoring their water systems in case of contamination.

However the water supply of Glendive, the town of 5,000 about 10 miles (16 km) downstream of the spill, has already been tested and found to have elevated levels of hydrocarbons. Water intakes in the river for the city have been closed, according to the EPA. The company, EPA and other agencies are trying to get other drinking water supplies for Glendive, the EPA's Mylott said. [Reuters, [1/20/15](#)]

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Spill Has Released Cancer-Causing Agent Into Region's Water. Days after the spill, officials detected benzene -- a cancer-causing agent -- in the water supply of Glendive. From CBSNews.com:

Some residents of an eastern Montana farm community are criticizing officials for taking more than two days to notify them that their drinking water is contaminated with a cancer-causing chemical.

Elevated levels of benzene were found in water samples taken from a treatment plant that serves about 6,000 people in the agricultural community of Glendive near the North Dakota border. The contamination followed a 50,000 gallon oil spill that found its way from a break in a 12-inch pipeline into the Yellowstone River. [CBSNews.com, [1/20/15](#)]

Keystone XL Would Be Built Close To The Site Of Yellowstone Spill. On January 21, *The New York Times* reported that Keystone XL "would pass about 25 miles north of Glendive," a town located downstream of the Yellowstone spill. [*The New York Times*, [1/21/15](#)]

A Spill From Keystone XL Could Be Much Worse Than The Yellowstone Spill. As Think Progress reported, the proposed Keystone XL pipeline is much wider than the Bridger pipeline and would pump much more oil on a daily basis:

The proposed -- and controversial -- northern leg of the Keystone XL pipeline would be three times the diameter of the breached Bridger pipeline, and pump more than 34 million gallons of oil per day through the Dakotas down into Nebraska and into the southern leg in Oklahoma and Texas. Many landowners and local residents are concerned about what a potential spill would mean for critical watersheds and aquifers -- not to mention what subsequent increased tar sands oil production means for Canadian watersheds. [ThinkProgress, [1/19/15](#)]

CNN And Fox News Ignored Yellowstone Spill In Their Keystone XL Coverage

CNN And Fox Barely Mentioned Yellowstone Spill -- And Didn't Tie It To Keystone XL. CNN and Fox News each provided only a single brief mention of the Yellowstone oil spill, according to a review of *Media Matters'* internal video archives, and neither mention was in the context of reporting on Keystone XL. CNN made a 20-second mention of the spill in a headline rundown on the January 21 edition of *Early Start*, while Fox News provided an equally brief mention of the spill on the January 21 edition of *Fox & Friends First*.

Other Media Outlets Did Link Yellowstone Spill to Environmental Concerns About Keystone XL

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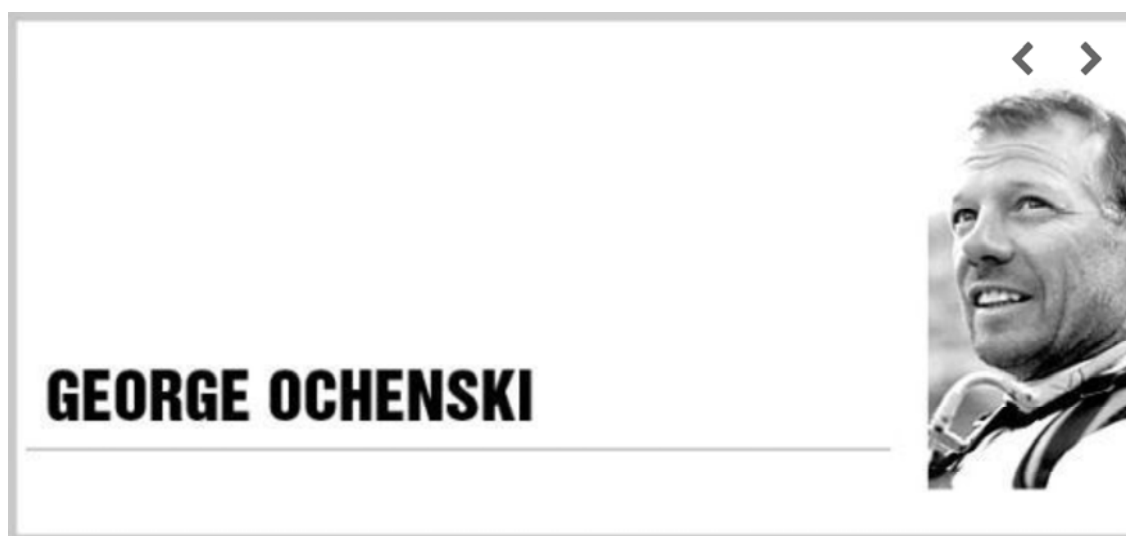
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http://missoulain.com/news/opinion/columnists/oil-and-water-don-t-mix/article_3c09934b-435e-5a43-a41b-e14646fc2d12.html

Oil and water don't mix

GEORGE OCHENSKI Jan 26, 2015



It's been a tough couple weeks for the environment in the Bakken area of eastern Montana and western North Dakota. For the second time in four years, an oil pipeline beneath the Yellowstone River has broken and leaked a combined 116,000 gallons of oil into the longest undammed river in the Lower 48 states. Meanwhile, just over the border in North Dakota, they're dealing with a spill of 3 million gallons of salty, toxic fracking brine leaked from yet another pipeline.

More and more, it's looking like the nation and our state leaders have decided that eastern Montana, a spectacularly beautiful landscape in its own right, is doomed to be an environmental sacrifice area, ceding its precious surface and groundwater resources to a short-lived oil and gas boom that dooms it to long-term environmental destruction.

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It doesn't take a long memory to recall the disastrous 2011 ExxonMobil pipeline leak that dumped an estimated 69,000 gallons of crude oil into the Yellowstone River near Laurel. It happened while former Gov. Brian Schweitzer was busy pumping up open-ended energy development including coal, oil and natural gas. Suddenly, Schweitzer had to face the grim realities that there is no free ride to energy development and that significant pollution, whether permitted or by accident, is a constant companion to the short-term economic benefits such development might bring.

Being Brian Schweitzer, the governor jumped on ExxonMobil with both feet, loudly declaring they'd pay for cleaning up every drop of oil and making the Yellowstone, its banks and riparian areas, whole again. Of course that didn't happen since it's pretty dang tough to find every drop of oil when it's coating piles of drift logs in the middle of a major river and seeped into the lush riparian vegetation and adjacent wetlands, where it was left once run-off subsided. But it made for good political theater, of which Schweitzer was an accomplished performer.

Schweitzer followed up the clean-up act with a declaration that Monana's pipelines would be inspected so there would be no repeat of the oil and water disaster in the future. But again, that was a mere four years ago and it seems the great pipeline inspection promise was yet more political theater, otherwise perhaps they'd have done something proactively about the Poplar pipeline that burst under the Yellowstone River last week about nine miles above the town of Glendive, spilling an estimated 50,000 gallons of Canadian and U.S. crude oil into the river.

In a whole new twist to the ongoing leaking pipeline disasters, this one happened under the ice of the Yellowstone, preventing much of anything in the way of effective containment, cleanup or remediation. Even worse, officials are now concerned that oil sticking to the bottom of the river ice will be released when warming weather causes breakup this spring.

But the contamination is already significant, since it unexpectedly found its way into the municipal water supply of Glendive, bringing carcinogenic benzene and other toxic petroleum byproducts into homes and businesses, dishwashers, washing machines, hot water heaters, and plumbing causing as yet unknown damages.

And while Governor Steve Bullock sought to downplay the disaster by assuring Montanans that most of the oil was within six miles of the break, oil sheens have been spotted as far downstream as Williston, N.D., which is about 60 miles away and beyond the confluence of the Yellowstone and Missouri rivers.

By week's end, officials were declaring Glendive's municipal water "safe," but as noted by Glendive resident Roseann Koepke in an Associated Press article: "I ran it for about 10 minutes and had to open up the door for five minutes to get the smell out. My God did I end up getting a headache." Clean water, as everyone knows, doesn't cause headaches.

Given that rivers always work their way slowly downward due to continuous erosion of the riverbeds – and that ice scouring can have devastating effects – it seems a no-brainer that putting petroleum pipelines under rivers is a dumb idea and that, sooner or later, the river is going to make its way down to and rupture the pipe.

Yet Montana's leading politicians continue their support for the Keystone XL pipeline, which will cross hundreds of rivers, wetlands and watercourses over its 1,179-mile length. Given the ongoing environmental destruction, it's time for our political leaders to reconsider turning eastern Montana into a petroleum sacrifice zone — and drop their endless cheerleading for yet another sure-to-leak petroleum pipeline.

George Ochenski's column appears each Monday on the Missoulain's Opinion page.

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THE SPOKESMAN-REVIEW

SATURDAY, JAN. 24, 2015

New spill into Yellowstone River prompts pipeline upgrade order



Glendive water is flushed from fire hydrants and tested by the EPA and the Center for Toxicology and Environmental Health Wednesday in Montana. (Associated Press)

By Matthew Brown

Associated Press

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BILLINGS – Federal regulators on Friday ordered a pipeline company to make major upgrades to a line that spilled almost 40,000 gallons of oil into Montana's Yellowstone River and fouled a local water supply.

The order comes after Bridger Pipeline of Casper, Wyoming, announced plans to bury its line deeper beneath

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the Yellowstone to protect against future accidents.

The Department of Transportation order would make that improvement mandatory and require identical action where the line runs beneath the Poplar River in northeast Montana.

The cause of the Jan. 17 spill remains under investigation. It prompted a five-day shutdown of drinking water services for 6,000 people in the city of Glendive after oil got into a treatment plant.

Cleanup crews so far have made minimal progress recovering oil from the ice-covered river. The Yellowstone is a popular recreation destination and home to fish including the endangered pallid sturgeon.

Warmer weather Friday added a new complication, softening the ice and making it even more dangerous to be on. That forced workers to dismantle equipment set up 60 miles downstream from the spill, where they had hoped to catch oil passing through a huge gash carved into the ice, said Jeni Garcin with the Montana Department of Environmental Quality.

“We’re not able to get anything substantial, but we’re mopping it up where we find it,” she said.

The Poplar Pipeline will stay shut down from Glendive to near the Canada border until the damaged section is replaced and the requirements of the federal order are met, said Bill Salvin, spokesman for Bridger Pipeline.

“We’re not in a race to get back to business,” Salvin said. “The most important thing is getting the water (for Glendive) back online, then cleaning up (the river) as much as possible.”

The 193-mile pipeline delivers crude from the Bakken oil patch of North Dakota and Montana to a terminal in Baker, Montana, about 55 miles south of Glendive. It was built in the 1950s and has a capacity of 42,000 barrels of oil a day.

The southern section of the line remains operational.

When the pipeline was first installed, workers dredged the Yellowstone and laid the pipe across the bottom.

A 2011 survey determined the line was buried at least 8 feet beneath the riverbed, according to the Transportation Department. Bridger Pipeline had earlier said the survey was done in 2012, but Salvin said that was an error.

PUBLISHED: JAN. 24, 2015, MIDNIGHT

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Montana city gets OK to drink water after oil spill in river

By [MATTHEW BROWN](#) Jan. 23, 2015 1:12 AM EST

BILLINGS, Mont. (AP) — Thousands of people in an eastern Montana city were told Thursday they can resume using tap water after tests showed no further signs of contamination from a weekend oil spill into a nearby river.

The 6,000 residents of Glendive had relied on bottled water since Monday after elevated levels of cancer-causing benzene were found in the public water supply. The chemical came from 40,000 gallons of oil that spilled on Saturday from a pipeline breach beneath the Yellowstone River, about six miles upstream of the city.

Paul Peronard with the U.S. Environmental Protection Agency said residents should open their taps and run the water to flush out any residual contamination.

"If it doesn't smell anymore you have cleaned it out, you're good," Peronard said. "Citizens can start drinking it."

Filters added to the city treatment plant should protect against further contamination to the water supply.

Yet even as Glendive appeared to have overcome the initial public health threat from the spill, officials struggled over how to clean up the crude released by the pipeline break. Most of that oil is believed trapped beneath ice on the river.

The river's environmental damage could take months to gauge. The section of river downstream from the spill is home to fish, including the endangered pallid sturgeon, and is used for irrigation, boating and other recreation.

The U.S. Fish and Wildlife Service recorded no wildlife covered by oil during initial flyovers of the spill area on Wednesday, though spokesman Ryan Moehring said the agency was still very early in its surveying.

Most river activity takes place after the ice breaks up in the spring. So the longer the cleanup drags on, Glendive Mayor Jerry Jimison said, the more the spill's effects will be felt.

"That could be a worry down the road," Jimison said.

Resident Roseann Koepke, 65, said she'd been using bottled water to bathe, brush her teeth, drink and cook.

Koepke ran the taps in her trailer home Thursday after her landlord told her the contamination had been cleared. But she turned off the water after the strong smell of oil gave her a headache.

"I ran it for about ten minutes and had to open up the door for five minutes to get the smell out," she said. "My God, did I end up getting a headache."

Koepke said she would try again.

Also Thursday, government regulators and representatives of the Poplar Pipeline owner — Casper, Wyoming-based Bridger Pipeline — were trying to set up sites downstream where some oil might be recovered by cutting holes into the ice.

"We've got 22,000 feet of boom available for deployment," said Bridger spokesman Bill Salvin. "Unfortunately, there's just not a lot of place to deploy boom" to capture the oil.

Oil sheens have been reported as far away as Williston, North Dakota, below the Yellowstone's confluence with the Missouri River, officials said.

The farthest downstream that free-floating oil has been seen was at an intake dam about 28 miles from the spill site, officials said.

The accident was the second large oil spill into Montana's Yellowstone River in less than four years, raising questions about oversight of the nation's aging pipeline network.

The Poplar Pipeline was constructed in the 1950s. The breached section beneath the Yellowstone was replaced at least four decades ago, in the late 1960s or early 1970s, according to the company.

Montana Democratic Sen. Jon Tester wants more frequent inspections by regulators and says that older pipelines should face stricter safety standards.



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Ice Hinders Cleanup of Yellowstone Oil Pipeline Spill

Yellowstone River becomes a mystifying mix of oil, ice and water; pipeline company trucks in 10,000 gallons of water a day for town of 6,000.

By Zahra Hirji, InsideClimate News

Jan 21, 2015



Oil spill response workers carry out ice slotting operations on the Yellowstone River, where Bridger Pipeline LLC's Poplar Pipeline cracked under the riverbed and leaked up to 50,000 gallons into the water. Credit: Environmental Protection Agency

This article has been updated on Jan. 22 at 4:00 PM to reflect more recent estimates on the maximum amount of oil that could have spilled in the Yellowstone River.

In eastern Montana, an oil spill under the Yellowstone River over the weekend has tainted the water supply of Glendive, a nearby town of about 6,000 people. The river's thick ice cover, which is two feet in places, is complicating the cleanup efforts.

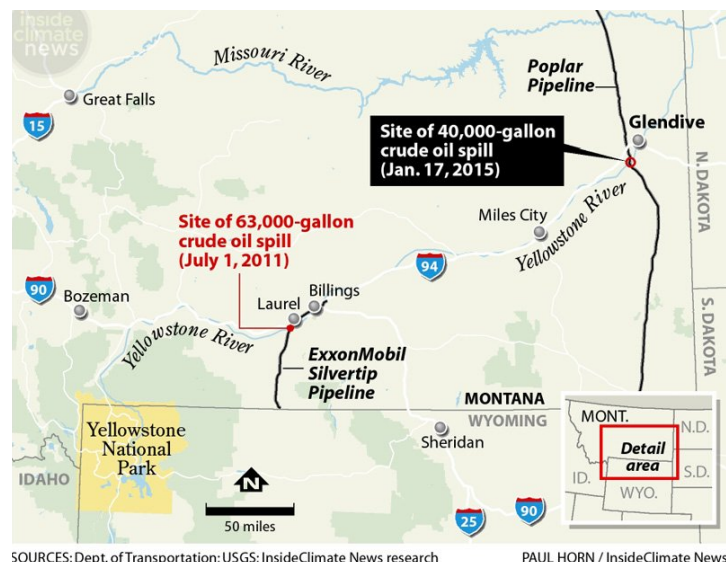
"My gosh, I know what diesel smells like...and we had a definite diesel smell in our drinking water," said [Glendive City Councilman Gerry Reichert](#) [1]. "We sort of have a mess."

022478

Around 10 a.m. on Saturday, Jan. 17, a stretch of the [Bridger Pipeline LLC](#) [2]'s [Poplar Pipeline](#) [3] that crosses the Yellowstone River cracked, for reasons still unknown. Company workers in Wyoming detected a drop in pressure and shut off the pipeline by 11 a.m. During that time, between 300 to 954 barrels (or 12,000 to 40,000 gallons) of oil were released.

Four days after the spill, the Poplar Pipeline, which transports crude oil across Montana, is still shut down. The section of the 50-year old pipeline measures 12 inches in diameter and is a half-inch thick.

According to Bill Salvin, a public relations specialist hired by the pipeline company, the size and the type of the rupture is unknown and it's in a stretch of pipe directly underneath the riverbed. That means most of the oil likely leaked into the water. A 2011 leak from Exxon's Silvertip Pipeline spilled 63,000 gallons of crude oil in the same river—very little of it was recovered.



[Click to enlarge](#)

Bridger hired [SWAT Consulting Inc.](#) [4] to help with the cleanup efforts and provide special equipment to combat spills in cold and icy conditions. Federal, state and local agencies are also involved in the response; they include the [Environmental Protection Agency](#) [5], the [Montana Department of Environmental Quality](#) [6] and [Dawson County Disaster & Emergency Services](#) [7].

The spill site is approximately seven miles upstream from Glendive. Where the river passes through town, it's frozen over. Councilman Reichert, who can see the river from his house, told InsideClimate News that no oil is visible.

But around 50 miles downstream, near the city of Sidney, there's open water, and an oily sheen has been detected. Sidney doesn't draw drinking water from the river.

While state and local officials won't say how long they expect the cleanup to last, [Glendive Mayor Jerry Jimison](#) [8] predicts it will be a while.

Jimison said the river's ice can linger until as late as mid-March. Until all the ice is gone, he said, "I don't think [the response team] is going to have much success in cleaning up."

Richard Mylott, an Environmental Protection Agency spokesman, told InsideClimate News in an email: "The challenges posed by ice in the river will make collection and recovery more difficult."

Early this week, Montana Gov. Steve Bullock declared a state of emergency in Glendive's county of Dawson and the neighboring county of Richland.

Ice Makes the Going Slow and Unsure

In an oil spill, the goal is to clean it all up, said Dee Bradley, vice president of [DOWCAR Environmental Management, Inc.](#), [9] an oil spill response consulting company not involved in this incident.

But that rarely happens, she said, and "when ice is involved, it makes [the cleanup] slower and more difficult."

That's partially because the cleanup situation is riskier for workers in icy conditions. Before oil recovery can begin, the strength of the ice needs to be determined. The thicker and cleaner, or whiter, the ice is, the stronger it is—and the safer it is to walk and work on, said Bradley, who has 23 years of experience of handling such spills. Thinner and dirtier ice is more prone to breaking.

Once the ice is established as safe to move around on, it's possible to start a process called "ice slotting." That involves carving out narrow channels in the ice and scooping up, or skimming, the oil that's floating near the water's surface.

"Crews have begun ice slotting operations in the river between the spill site and Glendive, Montana. Reconnaissance crews are working to identify and access pockets of trapped oil beneath the river in the same segment," according to a Tuesday night [report by EPA's on-site coordinator](#) [10], Paul Peronard.

But this hasn't always been easy, Peronard explains, because "the ice is not structurally sound enough in many locations to conduct response efforts."

To prevent oil from spreading too far, floating barriers to block oil flow called "booms" are set up near the spill's outer edges. But if currents are too strong or there's debris in the water, the boom can get pushed around and even pulled under the ice.

In Montana, a boom was set up 40 miles downstream from Glendive in a patch of open water near the town of Crane. But even there, issues have arisen. According to EPA's Peronard, "further ice formation is creating flows of smaller chunks of ice and bergs that are hampering the ability to boom the river to prevent further migration."

Benzene Shows Up in Town's Water

About 8 a.m. on Sunday, Jan. 18, Mayor Jimison was heading out to church when he received a phone call alerting him of an oil spill nearby. At the time, he was told that the spill from a pipeline break posed no danger to the town or its drinking supply. A test of the city's water supply that morning revealed no contamination.

But later in the day, the mayor received several calls to his home from citizens concerned about strange odors in the drinking water. New tests from Monday morning detected benzene, a known carcinogen found in oil products, in the town's water treatment plant supply. The city's water is now being treated to remove contaminants.

Councilman Reichert finds the presence of benzene disconcerting. The federal Centers for Disease Control says the observed level of benzene [isn't bad in the short term](#) [11], but according to the EPA's website, [there's no safe level of benzene](#) [12] exposure in drinking water, he said.

Residents are instructed [not to drink or cook with city water](#) [11] and instead use the 10,000 gallons water trucked in daily by the company responsible for the spill. The mayor said Bridger has "really stepped up to the plate" in terms of handling the spill response and the city's needs.

But he is wary of how long it will be before the water supply is deemed safe enough to drink.

For now, Councilman Reichert joked, "I've been drinking beer...and I know how to cook with beer."

On a more serious note, he added: "Will this be an ongoing problem? Will it just clear up? I don't know."

InsideClimate News reporter Elizabeth Douglass contributed to this story.

Published Under:

[Water and Oceans](#) [13]

[Water/Drought](#) [14]

[Oil spills/Pipelines](#) [15]

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Links

[1] http://www.cityofglendive.us/government/city_council/meet_the_council/index.php

[2] <http://truecompanies.truecos.com/Bridger/>

[3] http://truecompanies.truecos.com/Bridger/maps/POPLAR_System8.5.pdf

[4] <http://swat-ab.ca/contact.php>

[5] <http://www.epa.gov/>

[6] <http://www.deq.mt.gov/default.mcpX>

[7] http://www.dawsoncountymontana.com/departments/disaster_and_emergency_services/index.php

[8] http://www.cityofglendive.us/government/mayor_s_welcome/index.php

[9] <http://www.dowcarenenvironmental.com/>

[10] http://epaosr.org/site/sitrep_profile.aspx?site_id=9708

[11] <http://www.deq.mt.gov/yellowstonespill2015.mcpX>

[12] <http://water.epa.gov/drink/contaminants/index.cfm#List>

[13] <http://insideclimatenews.org/topics/water-and-oceans>

[14] <http://insideclimatenews.org/topics/waterdrought>

[15] <http://insideclimatenews.org/topics/oil-spills/pipelines>

Subject: Re: Review quotes for accuracy please

> To: csmyers77@hotmail.com

> From: Vann.Bradley@epamail.epa.gov

> Date: Fri, 10 Jun 2011 15:51:45 -0500

>

> •Brad Vann, Environmental Scientist, EPA, Region 7

> "Its a lot easier to put chemicals in the ground than to take them out
> of the ground or groundwater"

> •"I would also be concerned if I had a drinking water well down-gradient
> from any petroleum or chemical source, and would want to know
> specifically what safety protocols are being employed to ensure that a
> release has not occurred, or if it did, it would not impact my water
> supply (i.e., leak preventers, inspection frequency, routine testing,
> installation of sentinel wells, leak response protocols, etc.)."

> "Petroleum is a mixture of many of organic compounds"

> •Benzene:

> Is a known human carcinogenic.

> •Benzene is a degradation chemical from crude oil. In pure form it is
> not soluble with water but solubility can occur with mixtures of other
> chemicals and at dilute concentrations. These dilute concentrations do
> mix with the water sufficiently to exceed safe drinking water limits.

> •"The safe drinking water limit (Maximum Contaminant Level or MCL) for
> Benzene in drinking water is 5 parts per billion"

> •Because this is such a minute amount, "you can't smell, taste or see it
> (below odor and taste threshold). It requires laboratory analysis to
> detect at these concentrations. Therefore, it would be possible to
> drink dilute Benzene above the MCL and not know.

>

> Bradley Vann - RPM

> US EPA Region VII (SUPR/IANE)

> 901 N. 5th Street

> Kansas City, KS 66101

> phone: (913) 551-7611

> fax: (913) 551- 9611

> vann.bradley@epa.gov

>

>

>

>

> From: Cindy Myers <csmyers77@hotmail.com>

>

> To: Bradley Vann/R7/USEPA/US@EPA

>

> Date: 06/10/2011 02:56 PM

>

> Subject: Review quotes for accuracy please

>

>

>

>

>

- >
- > •Brian Vann, EPA, Region 7
- > "Lot easier to put in the ground than to take out of the ground"
- > •"I would be concerned also if I had a well down-gradient from a
- > chemical source"
- > •Benzene:
- > Known carcinogenic
- > •A degree of benzene from crude oil is soluble in water, mix with the
- > water.
- > •"Allowable limit in drinking water is 5 parts per billion"
- > •Because this is such a minute amount, "you can't smell, taste or see
- > it." Analysis required to detect. Would be possible that you would
- > drink and not know.

Safety in the Community

Safety is a core value at TransCanada. We make safety — for ourselves, each other, our contractors and for members of our communities — an integral part of the way we work.

TransCanada's operations extend across North America with established offices in various communities. Each region is fully staffed with qualified employees trained in pipeline safety and emergency response to ensure the safe and efficient operation of the facilities in the area.

We view the communities we operate in as emergency response partners. We will work collaboratively with emergency responders, extending invitations to participate in exercises and training.

In the event of an emergency, we work with emergency response officials in a Unified Command to ensure everyone is familiar with local operations and is ready to respond in the event of an incident. TransCanada does not expect volunteer or dedicated local emergency services to have the equipment or specific experience needed to respond to a leak or rupture with the exception of protecting the public by conducting evacuations if necessary and keeping them out of the impacted area.



KEYSTONE 1533

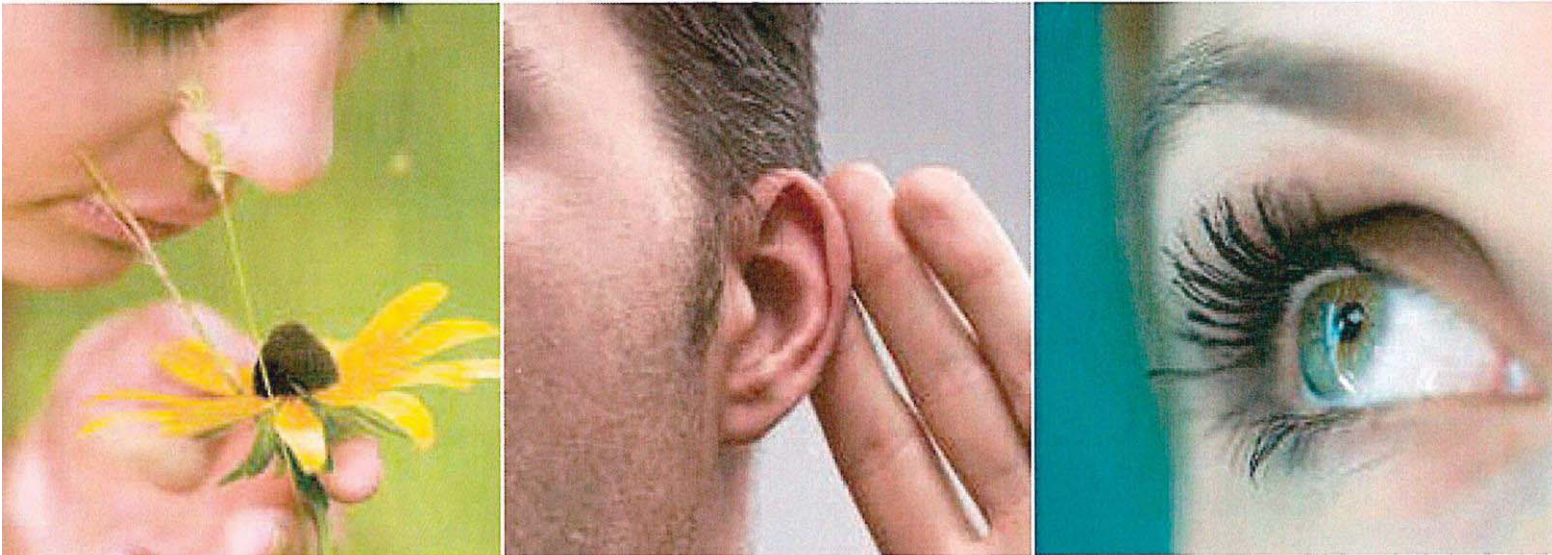
Actions for Emergency Services

Do

- Protect yourselves and the public.
- Contain and extinguish any secondary fires if safe to do so.
- Refer to 128 in the 2012 ERG for guidance on initial response including potential evacuation distances.
- Provide traffic and crowd control.
- Secure the site and establish a safe zone to ensure public safety. Keep a safe distance away. ● Evacuate unnecessary personnel.
- Monitor for I-EL, H S and benzene if possible.
- Eliminate all ignition sources if safe to do so. ● Provide first aid as needed.
- Allow TransCanada employees clear and quick access to the emergency site.

Do Not

- Attempt to operate any valves.
- Go near the spill until a hazard assessment has been conducted by TransCanada.
- Attempt to contain the oil or try to identify the oil.



Leak Detection

Although a pipeline leak is rare, it is important to know how to recognize the signs. Use your senses of smelling, seeing and hearing to detect a potential pipeline leak.

What you may smell

- Many petroleum products have a distinct smell. Crude oil can possess a rotten egg, gasoline, tar or "skunk-like" odor.

What you may hear

- A hissing or roaring sound.

What you may see

- Amber to black liquid.
- Rainbow sheen or black liquid on top of water.
- Discolored vegetation on or near a pipeline in an area that is usually green.
- Stained or melted snow/ice over pipeline areas.

KEYSTONE 1534



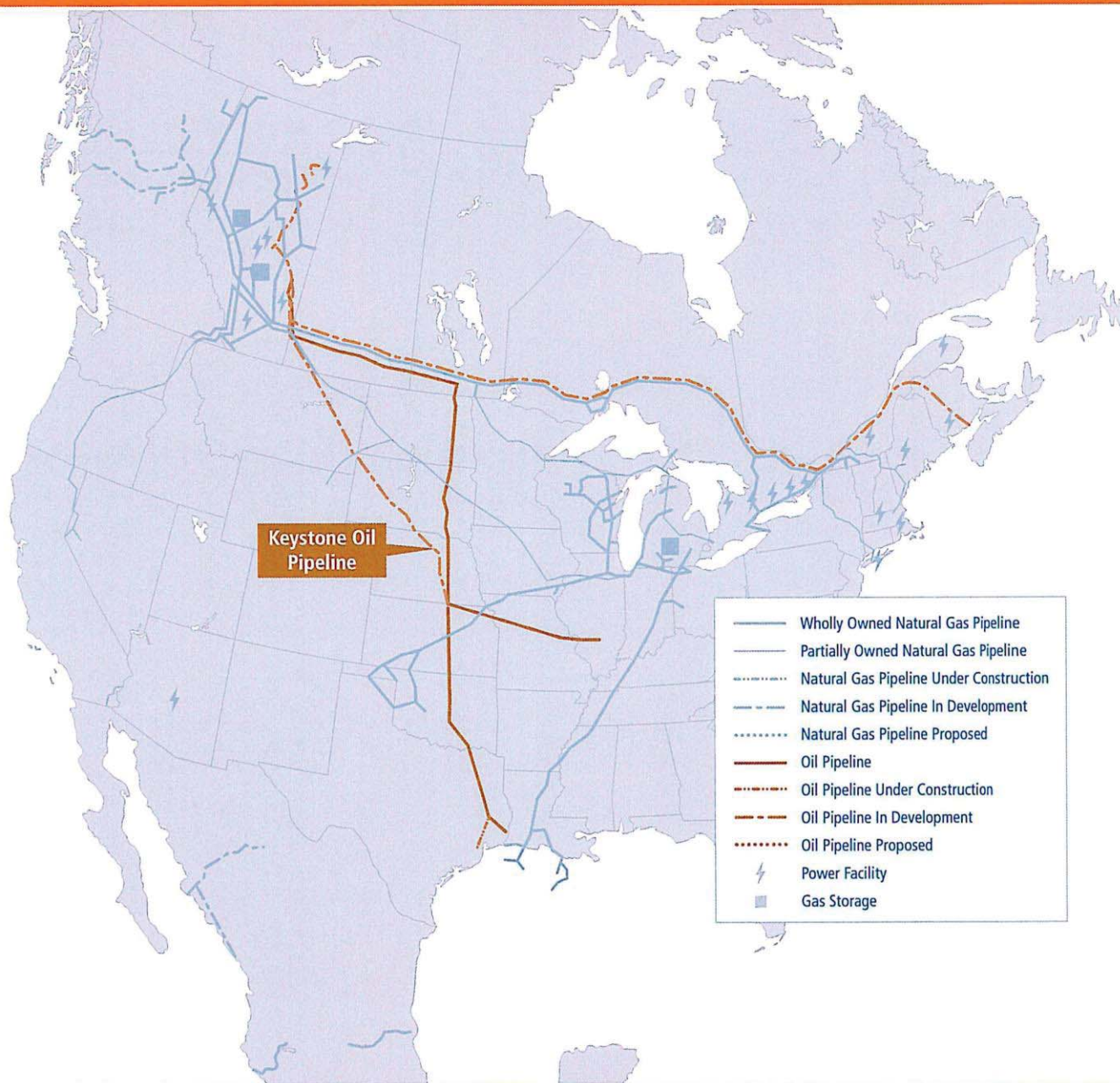
If You Suspect a Leak

If you witness any of the typical signs listed, or any other unusual sights, sounds or smells near a pipeline location, it is important that you follow these steps:

1. Leave the area immediately.
2. Move to a safe location, call '911'.
3. Call TransCanada's emergency number: 1.800.447.8066. This number can be found on all pipeline marker signs and facility gates.
4. Warn others to stay away.

KEYSTONE 1535

North American Assets



KEYSTONE 1536

Important Contact Information

Call Before You Dig - It's Free

United States.....811

| | | | | |
|--|--|--|--|--|
| | | | | |
|--|--|--|--|--|

Emergencies 1.800.447.8066

General Inquiries..... 1.866.717.7473
For Crossing or Encroachment Agreements..... us_crossings@transcanada.com

Actions for Emergency Services

Do

- Protect yourselves and the public.
- Contain and extinguish any secondary fires if safe to do so.
- Refer to 128 in the 2012 ERG for guidance on initial response including potential evacuation distances.
- Provide traffic and crowd control.
- Secure the site and establish a safe zone to ensure public safety. Keep a safe distance away.
- Evacuate unnecessary personnel.

- Monitor for I-EL, H2S and benzene if possible.
- Eliminate all ignition sources if safe to do so.
- Provide first aid as needed.
- Allow TransCanada employees clear and quick access to the emergency site.

Do Not

- Attempt to operate any valves.
- Go near the spill until a hazard assessment has been conducted by TransCanada.
- Attempt to contain the oil or try to identify the oil.

TransCanada Emergency Number:

1-8001447-8066

10towwhat'sbelow.
Call beforeyou dig.

TransCanada
In business to deliver

KEYSTONE 1538

BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF SOUTH DAKOTA

| | | |
|--|----------|-------------------------------|
| IN THE MATTER OF THE APPLICATION BY |) | ORDER GRANTING IN PART |
| TRANSCANADA KEYSTONE PIPELINE, LP |) | MOTION TO RECONSIDER |
| FOR A PERMIT UNDER THE SOUTH DAKOTA |) | AND AMENDING CERTAIN |
| ENERGY CONVERSION AND TRANSMISSION |) | CONDITIONS IN FINAL |
| FACILITIES ACT TO CONSTRUCT THE |) | DECISION AND ORDER |
| KEYSTONE XL PROJECT |) | |

HP09-001

On March 12, 2010, the South Dakota Public Utilities Commission ("Commission") issued its Final Decision and Order; Notice of Entry in this proceeding ("Decision")¹. The permit to construct approved in the Decision was granted subject to fifty Permit Conditions ("Conditions") appended as Exhibit A to the Decision. On April 14, 2010, TransCanada Keystone Pipeline, LP ("Keystone" or "Applicant") filed Applicant's Motion for Limited Reconsideration of Certain Permit Conditions ("Motion"). On April 19, 2010, intervenors David Niemi ("Niemi") and Paul Seamans ("Seamans") filed responses to the Motion. On April 19, 2010, Peter Larson ("Larson") filed two comments responsive to the Motion. On April 27, 2010, Keystone filed Applicant's Reply Brief In Support of Motion for Limited Reconsideration responding to the responses and comments filed by Niemi, Seamans and Larson. On April 28, 2010, the Commission's Staff ("Staff") filed a response to the Motion. On April 29, 2010, intervenor Dakota Rural Action ("DRA") filed the Answer of Dakota Rural Action in Opposition to Applicant's Motion for Limited Reconsideration of Certain Permit Conditions ("Answer").

The Commission has jurisdiction over this matter pursuant to SDCL Chapter 49-41B, specifically SDCL 49-41B-24, and ARSD 20:10:01:29 through 20:10:01:30.02.

At its regularly scheduled meeting on May 4, 2010, the Commission considered the Motion and the responses and comments filed by the parties and Larson. Applicant, Staff, intervenor John H. Harter, DRA and Larson appeared and participated in the hearing on the Motion. After an extensive discussion among the Commission and participants, the Commission made the following rulings on the specific requests in the Motion and voted to grant the Motion in part and deny in part and amend certain of the Conditions as set forth herein with respect to each action taken.

Condition 16(j) – Chairman Johnson moved to amend the last sentence of Condition 16(j) to read as follows: "Keystone shall notify landowners prior to any discharge of saline water on their lands or of any spills of hazardous materials on their lands of one pint or more or of any lesser volume which is required by any federal, state, or local law or regulation or product license or label to be reported to a state or federal agency, manufacturer, or manufacturer's representative." The Commission voted unanimously in favor of the motion.

Condition 20(a) - Chairman Johnson moved to amend Condition 20(a) by substituting for the current language Staff's proposed language on page 2 of its response to the Motion, with the second sentence modified as proposed by DRA on page 11 of its Answer to read as follows: "Keystone shall use floating sediment curtains to maintain sediments within the construction right of

¹The transcript of the May 4, 2010 hearing on the Motion and all other filings and documents in the record are available on the Commission's web page for Docket HP09-001 at: <http://puc.sd.gov/dockets/hydrocarbonpipeline/2009/hp09-001.aspx>

way in open water bodies with no or low flow when the depth of non-flowing water exceeds the height of straw bales or silt fence installation. In such situations the floating sediment curtains shall be installed as a substitute for straw bales or silt fence along the edge or edges of each side of the construction right-of-way that is under water at a depth greater than the top of a straw bale or silt fence as portrayed in Keystone's construction Detail #11 included in the CMR Plan." The Commission voted unanimously in favor of the motion.

Condition 22(a) – Chairman Johnson moved to amend Condition 22(a) as requested by Keystone by adding the following language to the end of the subparagraph: "unless a different width is approved or required by the United States Army Corps of Engineers." The Commission voted unanimously in favor of the motion.

Condition 22(c) – Chairman Johnson moved to amend Condition 22(c) as requested by Keystone to correct an editing error in the original by deleting "greater than" and substituting "up to." The Commission voted unanimously in favor of the motion.

Condition 22(e) – Chairman Johnson moved to amend Condition 22(e) as requested by Keystone to clarify that the 15-foot buffer need only be maintained where practicable for streams other than non-flowing streams. The Commission voted unanimously in favor of the motion.

Condition 41 – Commissioner Kolbeck moved to amend Condition 41 as requested by Keystone to clarify that the measures to be followed for buffering and protection of wildlife, including greater prairie chicken and greater sage and sharp-tailed grouse, will be those specified by the U.S. Fish and Wildlife Service ("USFWS") and the South Dakota Department of Game, Fish and Parks ("SDGFP"). The Commission voted unanimously in favor of the motion.

Condition 43 – Commissioner Hanson moved to approve the amendments requested by Keystone dealing with cultural resource discovery but with the re-inclusion of notice to the landowner of a discovery as provided in the original language. The Commission voted unanimously in favor of the motion.

Condition 44 – Chairman Johnson moved to not allow the striking of economic value or significance from the Conditions, particularly Condition 44. The Commission voted unanimously in favor of the motion.

Condition 44(c) – Commissioner Hanson moved to adopt the Applicant's suggestion of substituting "BLM permitted paleontologists" for "monitors" Condition 44(c). The Commission voted unanimously in favor of the motion.

Condition 44(d) – Chairman Johnson moved to adopt the Applicant's change to paragraph Condition 44(d) to allow only BLM permitted paleontologists the ability to trigger the chain of events listed in Condition 44(d). Prior to action on the motion, Chairman Johnson made a substitute motion that that instead of wording proposed by the Applicant, that Condition 44, and in particular the provisions of Condition 44(d) dealing with responsibility for the costs of a reroute or excavation to avoid or mitigate damage to a paleontological discovery, be revised to make it clear that the same legal framework that BLM operates under and the Applicant has to operate under on BLM lands would apply between the landowner and the Applicant, as applicable (e.g. curation costs would not be paid by Keystone in situations where possession of the recovered fossil(s) was turned over to the landowner). The Commission voted unanimously in favor of the motion.

Condition 44 – Commissioner Kolbeck moved to adopt DRA's change to have the Applicant take appropriate steps within its control to maintain the confidentiality of the location of sensitive and valuable resources. The Commission voted unanimously in favor of the motion.

Condition 44 – Chairman Johnson moved to adopt the Applicant's remaining changes to Condition 44 that had not been addressed in prior motions. The Commission voted unanimously in favor of the motion.

Condition 45 – Chairman Johnson moved to deny the request of the Applicant to change Condition 45 of the Conditions by deleting or loss of value to a paleontological resource. The Commission voted unanimously in favor of the motion.

General – Chairman Johnson moved to allow Mr. John Smith, Commission Counsel, the ability to bring issues regarding these changes before the Commission for further clarification. The Commission voted unanimously in favor of the motion.

It is therefore

ORDERED, that certain of the Conditions to the Permit set forth in Exhibit A of the Decision, as denoted by Condition and subparagraph number, shall be amended to read as follows, with the changes indicated by overstrikes and underlines:

16. j) Keystone shall monitor and take appropriate mitigative actions as necessary to address salinity issues when dewatering the trench, and field conductivity and/or other appropriate constituent analyses shall be performed prior to disposal of trench water in areas where salinity may be expected. Keystone shall notify landowners prior to any discharge of saline water on their lands or of any spills of hazardous materials on their lands of one pint or more or of any lesser volume which is required by any federal, state, or local law or regulation or product license or label to be reported to a state or federal agency, manufacturer, or manufacturer's representative.
20. a) Keystone shall use floating sediment curtains to maintain sediments within the construction right of way in lieu of straw bales in open water bodies with no or low flow when the depth of non-flowing water exceeds the height of straw bales or silt fence installation. In such situations the floating sediment curtains shall be installed as a substitute for straw bales or silt fence along the edge or edges of each side of the construction right-of-way that is under water at a depth greater than the top of a straw bale or silt fence as portrayed in Keystone's construction Detail #11 included in the CMR Plan.
22. a) Unless a wetland is actively cultivated or rotated cropland or unless site specific conditions require utilization of Keystone's proposed 85 foot width and the landowner has agreed to such greater width, the width of the construction right-of-way shall be limited to 75 feet in non-cultivated wetlands unless a different width is approved or required by the United States Army Corps of Engineers.
 - c) Water body crossing spoil, including upland spoil from crossings of streams greater than up to 30 feet in width, shall be stored in the construction right of way at least 10 feet from the water's edge or in additional extra work areas and only on a temporary basis.

e) Wetland and water body boundaries and buffers shall be marked and maintained until ground disturbing activities are complete. Keystone shall maintain 15-foot buffers where practicable, which for stream crossings shall be maintained except during the period of trenching, pipe laying and backfilling the crossing point. Buffers shall not be required in the case of non-flowing streams.

41. Keystone shall follow all protection and mitigation efforts as identified by the US Fish and Wildlife Service ("USFWS") and SDGFP. Keystone shall identify all greater prairie chicken and greater sage and sharp-tailed grouse leks within the buffer distances from the construction right of way set forth for the species in Application, Section 5.5.2.4, Table 10 the FEIS and Biological Assessment (BA) prepared by DOS and USFWS. In accordance with ~~its commitments in Application, Section 5.5.2 and Exhibit TC 44, ¶¶ 25 and 26~~ the FEIS and BA, Keystone shall avoid or restrict construction activities as specified by USFWS and SDGFP within such buffer zones between March 1 and June 15 and for other species as specified by USFWS and SDGFP.

43. In accordance with Application, Section 6.4, Keystone shall follow the "Unanticipated Discoveries Plan," as reviewed by the State Historical Preservation Office ("SHPO") and approved by the ~~Department of State DOS~~ and provide it to the Commission upon request. Ex TC-1.6.4, pp. 94-96; Ex S-3. If during construction, Keystone or its agents discover what may be an archaeological resource, cultural resource, historical resource or gravesite, Keystone or its contractors or agents shall immediately cease work at that portion of the site and notify the DOS, the affected landowner(s) and the ~~State Historical Preservation Office SHPO.~~ If the DOS and SHPO determines that a ~~protectable~~ significant resource is present, Keystone shall develop a plan that is ~~acceptable to the SHPO~~ approved by the DOS and commenting/signatory parties to the Programmatic Agreement to salvage, avoid or protect the archaeological resource. If such a plan will require a materially different route than that approved by the Commission, Keystone shall obtain Commission and landowner approval for the new route before proceeding with any further construction. Keystone shall be responsible for any costs that the landowner is legally obligated to incur as a consequence of the disturbance of a protected cultural resource as a result of Keystone's construction or maintenance activities.

44. Keystone shall implement and comply with the following procedures regarding paleontological resources:

a) Prior to commencing construction, Keystone shall conduct a literature review and records search, and consult with the BLM and Museum of Geology at the S.D. School of Mines and Geology Technology ("SDSMT") to identify known fossil sites along the pipeline route and areas where the probability is high of encounter during construction of fossils identify locations of surface exposures of scientific or economic significance paleontologically sensitive rock formations using the BLM's Potential Fossil Yield Classification system. Any area where trenching will occur into the Hell Creek Formation shall be considered a high probability area.

b) Keystone shall at its expense conduct a pre-construction field survey of each area identified by such review and consultation as a known site or high probability area within the construction ROW. Following BLM guidelines as modified by the provisions of Condition 44, including the use of BLM permitted paleontologists, areas with exposures of high sensitivity (PFYC Class 4) and very high sensitivity (PFYC Class 5) rock formations shall be subject to a 100% pedestrian field survey, while areas with exposures of moderately sensitive rock formations (PFYC Class 3) shall be spot-checked for occurrences of scientifically or economically significant surface fossils and evidence of subsurface fossils. Scientifically or economically significant surface fossils shall be avoided by the Project or mitigated by

collecting them if avoidance is not feasible. Following BLM guidelines for the assessment and mitigation of paleontological resources, scientifically significant paleontological resources are defined as rare vertebrate fossils that are identifiable to taxon and element, and common vertebrate fossils that are identifiable to taxon and element and that have scientific research value; and scientifically noteworthy occurrences of invertebrate, plant and trace fossils. Fossil localities are defined as the geographic and stratigraphic locations at which fossils are found.

c) Following the completion of field surveys, Keystone shall prepare and file with the Commission a paleontological resource mitigation plan. The mitigation plan shall specify monitoring locations, and include a trained on-site BLM permitted monitor in high probability areas and proper employee and contractor training to identify any paleontological resources discovered during construction and the procedures to be followed following such discovery. In all areas where the trench will be located in the Hell Creek Formation, Keystone shall, if requested by the landowner, utilize a trained on-site paleontological monitor, which may be the environmental monitor if trained in paleontological resource identification. Paleontological monitoring will take place in areas within the construction ROW that are underlain by rock formations with high sensitivity (PFYC Class 4) and very high sensitivity (PFYC Class 5), and in areas underlain by rock formations with moderate sensitivity (PFYC Class 3) where significant fossils were identified during field surveys.

d) If during construction, Keystone or its agents discover what may be a paleontological resource of economic significance, or of scientific or economic significance, as defined in subparagraph (b) above, Keystone or its contractors or agents shall immediately cease work at that portion of the site and, if on private land, notify the affected landowner(s). Upon such a discovery, Keystone's paleontological monitor will evaluate whether the discovery is of economic significance, or of scientific significance as defined in subparagraph (b) above, or if an economically or scientifically significant paleontological resource is discovered on state or federal land, Keystone will notify the Museum of Geology at the SD School of Mines and Technology SDSMT and if on federal land, Keystone will notify the BLM or other federal agency. In no case shall Keystone shall, upon discovery, turn over any fossils in its possession to the owner of the land from which excavated or, if on state or federal land, the Museum of Geology and shall not return any excavated fossils to the trench. If a qualified and BLM-permitted paleontologist, in consultation with the landowner, BLM, or Museum of Geology SDSMT determines that a valuable economically or scientifically significant paleontological resource is present, Keystone shall develop a plan that is reasonably acceptable to the landowner(s), BLM, or Museum of Geology SDSMT, as applicable, to accommodate the landowner's or Museum of Geology's salvage or avoidance of the paleontological resource at their expense or to avoid and protect or mitigate damage to the resource. The responsibility for conducting such measures and paying the costs associated with such measures, whether on private, state or federal land, shall be borne by Keystone to the same extent that such responsibility and costs would be required to borne by Keystone on BLM managed lands pursuant to BLM regulations and guidelines, including the BLM Guidelines for Assessment and Mitigation of Potential Impacts to Paleontological Resources, except to the extent factually inappropriate to the situation in the case of private land (e.g. museum curation costs would not be paid by Keystone in situations where possession of the recovered fossil(s) was turned over to the landowner as opposed to curation for the public). If such a plan will require a materially different route than that approved by the Commission, Keystone shall obtain Commission approval for the new route before proceeding with any further construction. Keystone shall, upon discovery and salvage of paleontological resources either during pre-construction surveys or construction and

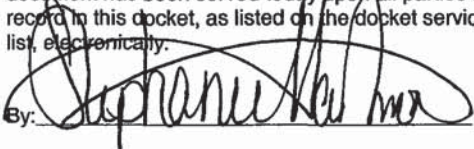
monitoring on private land, return any fossils in its possession to the landowner of record of the land on which the fossil is found. If on state land, the fossils and all associated data and documentation will be transferred to the SDSM; if on federal land, to the BLM.

e) To the extent that Keystone or its contractors or agents have control over access to such information, Keystone shall, and shall require its contractors and agents to, treat the locations of sensitive and valuable resources as confidential and limit public access to this information.

and it is further

ORDERED, that the Permit Conditions of the Final Decision and Order; Notice of Entry shall be so amended as to incorporate the amendments approved in this Order and an Amended Final Decision and Order shall be issued in non-redlined form with the Notice of Entry amended to conform to the issuance date.

Dated at Pierre, South Dakota, this 29th of June, 2010.

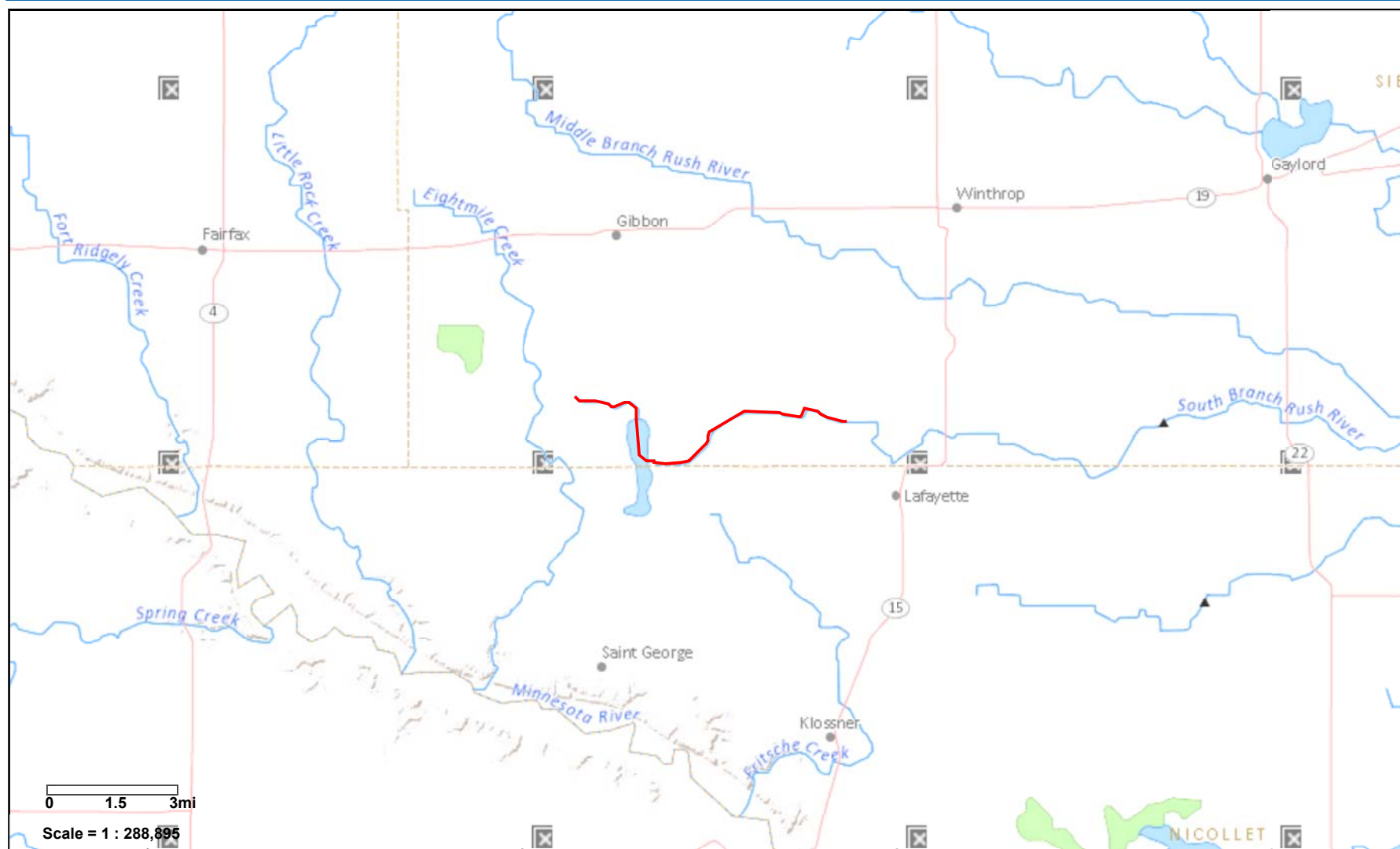
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| <p align="center">CERTIFICATE OF SERVICE</p> <p>The undersigned hereby certifies that this document has been served today upon all parties of record in this docket, as listed on the docket service list, electronically.</p> <p>By: </p> <p>Date: <u>06/29/10</u></p> <p align="center">(OFFICIAL SEAL)</p> |
|--|

BY ORDER OF THE COMMISSION:


DUSTIN M. JOHNSON, Chairman


STEVE KOLBECK, Commissioner


GARY HANSON, Commissioner



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022499

First Nations' cancer linked to oil sands' toxins in wild food: study

Deeply frustrated by provincial denials of health concerns, two First Nations commissioned their own study using out-of-province university researchers to examine oil sands pollutants in their foods.



[Mychaylo Prystupa](#)

Jul 7th, 2014

photo of Syncrude and Suncor oil sands bitumen processing facilities near Fort McMurray, Alberta by Andrew S. Wright

Two northern Alberta First Nations downstream of massive oil sands smoke plumes and tailing ponds released a human health study Monday, implicating the growth of the industry to many serious Aboriginal health concerns, including cancer.

The worry? Oil sands pollution is contaminating their wild food.

“I don’t know what it is that they’re hiding. What’s causing these cancers? Why is it so hard that they cannot take it out of their production, so it’s not hurting anyone or killing anyone?” asked Chief Steve Courterille of the Mikisew Cree First Nation at an Edmonton press conference.

The new scientific study states the region's "country food" contains elevated levels of toxic metals and carcinogens, that members of the Mikisew Cree and Athabasca Chipewyan First Nations traditionally eat.

But recent fears that oil sands pollution is contaminating the food, has led fewer people to eat it. The research was partly funded by Health Canada and reviewed by federal scientists.



Moose meat being prepared near Fort Chip Chipewyan - Youtube video

The wild foods include: moose, ratroot, duck, wild mint, spruce gum, pickerel, caribou, and Labrador tea. Fish are no longer eaten from the Athabasca River, due to government health warnings.

The study reveals these foods contained elevated levels of heavy metals and carcinogens, and that nearly a quarter of the Aboriginal participants -- 23 out of 94 -- had cancer, among other ailments.

Government not trusted

The push for the study was motivated by a deep distrust of provincial and federal health officials, who they say have "failed" to comprehensively study the issue, said the leaders.

"One thing most striking... is that both province and federal governments refuse to do anything about [the high rates of cancer]. Even though the pressure is escalating," said ACFN Chief Allan Adam.

"We are being brainwashed by the Conservative government that everything is ok. It's not," he added.

Conservative Health Minister Rona Ambrose's press secretary was reached in Ottawa to comment on the study, but a statement was not provided.

The Canadian Association of Petroleum Producers said:

"A recent Alberta study (March 2014) confirms the results of earlier studies (e.g. Royal Society of Canada) that indicate no linkage between oil sands development and health concerns in Fort Chipewyan."

"It is the responsibility of the responsible health officials to provide the definitive interpretation of health studies and to assess whether further studies are required. And we fully support recommendations made by the responsible health authorities in this regard," wrote Geraldine Anderson in an e-mail.

Questions about cancer in the oil sands have been swirling for months, since Alberta doctor John O'Connor raised concerns in Washington, D.C. in February with U.S. Senators about studies linking the oil sands' pollution to elevated cancer levels.



Dr. John O'Connor - photo by Andrew S. Wright - May 2014

First Nations' cancer linked to oil sands' toxins in wild food: study

Deeply frustrated by provincial denials of health concerns, two First Nations commissioned their own study using out-of-province university researchers to examine oil sands pollutants in their foods.



[Mychaylo Prystupa](#)

Jul 7th, 2014

(Page 2 of 2)

O'Connor's remarks sparked an international reaction, and were followed shortly in March by comments from [Alberta's Chief Medical officer](#), who said his data review of cancer records showed that the "overall number of cancers is not significantly higher than expected" in the Fort Chipewyan area versus the rest of Alberta.

The new First Nations study released Monday provides further details of cancer cases: four incidents of breast cancer, four of lung cancer, and two each of cervical, colon, gallbladder, kidney, prostate, and stomach cancer as well as leukemia, said the report.

Also worrying for community members were: neurological illnesses (e.g. sleeping disorders, migraines, and stress), respiratory illnesses (e.g. allergies, asthma) as well as circulatory (e.g. hypertension, coronary) and gastrointestinal (e.g. gallbladder, ulcers) illnesses.

Chemical soup

The [study](#) also found:

"Arsenic levels were high enough in muskrat and moose muscle; duck, moose, and muskrat livers; and moose and duck kidneys that they were of concern for young children."

“Cadmium levels were again elevated in moose kidney and liver samples but also those of beaver and ducks, although muskrat samples were again low. Mercury levels were also high for duck muscle, kidneys, and livers as well as moose and muskrat kidneys, specially for children.” “Total levels of PAHs and levels of carcinogenic and alkylated PAHs were very high relative to other studies on food conducted around the world,” said the report.

The report stated that exposure rates to these contaminants “were generally not of health concern” because of the low amounts of traditional foods that are now consumed as community members transition towards store-bought foods.

A feature-length documentary “One River Many Relations” will be released in October, to communicate issues about health impacts from the oil sands.

Excerpts have already been released:

Alberta universities 'too biased' - Chief Courteraille

The University of Manitoba and the University of Saskatchewan, in collaboration with the bands, conducted the research.

The choice to go with out-of-province researchers was deliberate.

“Dealing with the Alberta universities were in our view not credible, because of the close ties to the Alberta government...” said Chief Steve Courteraille.

Dr. John O'Connor, who frequently attends to cancer patients in the Fort Chipewyan area said Monday:

"This (study) is just another piece of information which is on top of all other previous scientific reports that have come out," O'Connor said.

"God knows what difference this report will make. But if someone doesn't act, and come to their senses...we've always said comprehensive studies are needed."

Still, Athabasca Chipewyan First Nation's leader admitted, his nation shares the responsibility for allowing the industrial free for all, that's led to so many changes to the environment in northern Alberta.

“We recognize we were partly to blame for granting the approvals of projects. What we are asking is a slow down of further development, in regards to what is going on in our region, and start cleaning up the mess, and putting down on paper in regards to what you're putting in the Athabasca River,” said Chief Adam.

The oil sands industry employs 10 percent Aboriginal people, says the Alberta government. It also brings in \$3.5 billion in royalties per year to fund the province's social programs.

CAPP says the oils sands is projected to more than double by 2030, to 5.2 million barrels per day.

With files from Jenny Uechi



North view of Syncrude facilities near Fort McMurray, AB - Andrew S. Wright

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Breach in pipeline found; cancer-causing agent detected in water

Billings Gazette and Associated Press Jan 20, 2015



MATTHEW BROWN/Associated Press

Residents line up to receive drinking water from a distribution center Tuesday in Glendive. A cancer-causing component has been detected in the Glendive drinking water supply, just downstream from a crude oil spill that entered the Yellowstone River.

GLENDIVE — Eastern Montana residents rushed to stock up on bottled water Tuesday after authorities detected a cancer-causing component of oil in public water supplies downstream of a Yellowstone River pipeline spill.

022507

Elevated levels of benzene were found in water samples from a treatment plant that serves about 6,000 people in the agricultural community of Glendive, near North Dakota.

Scientists from the federal Centers for Disease Control and Prevention said the benzene levels were above those recommended for long-term consumption, but did not pose a short-term health hazard. Residents were warned not to drink or cook with water from their taps.

Some criticized the timing of Monday's advisory, which came more than two days after 50,000 gallons of oil spilled from the 12-inch Poplar pipeline owned by Wyoming-based Bridger Pipeline Co. The spill occurred about 5 miles upstream from the city.

Adding to the frustrations was uncertainty over how long the water warning would last. Also, company and government officials have struggled to come up with an effective way to recover the crude, most of which appears to be trapped beneath the ice-covered Yellowstone River.

A mechanical inspection of the damaged line Tuesday revealed the breach occurred directly beneath the river, about 50 feet from the south shore, Bridger Pipeline spokesman Bill Salvin said.

The cause remained undetermined.

By Tuesday, oil sheens were reported as far away as Williston, North Dakota, below the Yellowstone's confluence with the Missouri River, officials said.

"It's scary," said 79-year-old Mickey Martini of Glendive. "I don't know how they're going to take care of this."

Martini said she first noticed a smell similar to diesel fuel coming from her tap water Monday night. Officials previously didn't know whether the spill happened beneath the iced-over river or somewhere on the riverbank.

Martini said she was unable to take her daily medicines for a thyroid condition and high cholesterol until she picked up water from a public distribution center later in the day.

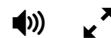
Representatives from the state and the U.S. Environmental Protection Agency earlier said preliminary monitoring of the city's water showed no cause for concern. The water treatment plant operated until Sunday afternoon, more than 24 hours after pipeline operator Bridger Pipeline discovered the spill, officials said.

Additional tests were conducted early Monday after residents began complaining of the petroleum- or diesel-like smell from their tap water. That's when the high benzene levels were found.

Benzene in the range of 10 to 15 parts per billion was detected from the city's water, said Paul Peronard with the EPA. Anything above 5 parts per billion is considered a long-term risk, he said.



Advertisement (1 of 1): 0:25



Peronard acknowledged problems in how officials addressed the city's water supply, including not having the right testing equipment on hand right away to pick up contamination. But Peronard and others involved in the spill response said officials acted based on the best information available.

"Emergencies don't work in a streamlined fashion," said Bob Habeck with the Montana Department of Environmental Quality. "It's a process of discovery and response."

Several residents interviewed by The Associated Press said they first heard about the water problems through friends and social media sites, not the official advisory.

"They could have been more on top of it," Whitney Schipman said as she picked up several cases of bottled water for her extended family from a water distribution center. "As soon as there was a spill, they should have told everybody."

Officials took initial steps Tuesday to decontaminate the water system. Glendive Mayor Jerry Jimison said it was unknown when the water treatment plant would be back in operation.

Until that happens, Salvin said the company will provide 10,000 gallons of drinking water a day to Glendive.

The company established a hotline for people with questions about the water supply and to report any wildlife injured by the spill: (888) 959-8351.

Another pipeline spill along the Yellowstone River in Montana released 63,000 gallons of oil in July 2011. An Exxon Mobil Corp. pipeline broke during flooding, and oil washed up along an 85-mile stretch of riverbank.

Exxon Mobil faces state and federal fines of up to \$3.4 million from the spill. The company has said it spent \$135 million on the cleanup and other work.

The Poplar pipeline involved in Saturday's spill runs from Canada to Baker, Montana, picking up crude along the way from Montana and North Dakota's Bakken oil-producing region.

The pipeline receives oil at four points in Montana: Poplar Station in Roosevelt County, Fisher and Richey stations in Richland County, and at Glendive in Dawson County. The section of pipeline that crosses the Yellowstone River was last inspected in 2012, in response to the Exxon accident, according to company officials.

At that time, the line was at least 8 feet below the riverbed where it crosses the Yellowstone.

No cost estimate for the Glendive spill was yet available.

The Associated Press contributed to this report.

2011 Yellowstone River oil spill near Laurel

- On July 2, 2011, ExxonMobil's 12-inch Silvertip pipeline was ruptured by high river flow.
- The spill released an estimated 63,000 gallons of crude oil into the river.
- The oil fouled farmland and riverbank for more than 70 miles downstream.
- Scores of workers from around the country descended on Billings for several months to clean up the spill using pumps and absorbent pads.
- The cleanup and environmental penalties cost ExxonMobil more than \$135 million and triggered several lawsuits by landowners along the river.
- Federal regulators said ExxonMobil was slow to respond to the pipeline break. The damage could have been significantly reduced if pipeline controllers had shut safety valves in the system more quickly.
- ExxonMobil officials contested \$1.7 million in civil penalties proposed by federal regulators.
- Last December, the state's Department of Environmental Quality said inspection teams had verified that the river cleanup was complete. The agency said it had reviewed and analyzed results from about 1,325 soil and sediment samples.

Drinking water press release

On January 17th at 3:00 pm, Bridger Pipeline, LLC notified local authorities of a potential release from a pipeline that crosses the Yellowstone River approximately 5 miles upstream from Glendive. Shortly thereafter MDEQ notified municipal water utilities of the potential of crude oil passing by their water intakes. DEQ further advised the water utilities to monitor their intakes for potential impact. Thus far no abnormalities have been reported by the water plant in Glendive. It is unlikely the crude oil would impact Glendive's water intake because the intake is 14 feet below the water surface, and the oil will tend to float on the water surface. This is especially true of the light crude transported by Bridger Pipeline. However, on Sunday, January 18th, Dawson County began receiving some complaints of odor in drinking water from people who use the municipal water supply. Because of this, the incident unified command has decided to take a collection of samples from the municipal drinking water supply and will provide teams to monitor taps along Glendive's water distribution system. This will be done starting on Monday, January 19th. At this point in time, the incident command has no reason to think there has been an adverse impact to the Glendive water system. However, if you feel uncomfortable, use bottled water, although that is not a recommendation at this time. For more information, contact the City of Glendive Public Works Department at 377-3318 ext. 16.

Brine, oil spill in North Dakota county



022512

Pipeline breach spills oil into Yellowstone River

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2011 Yellowstone oil spill cost ExxonMobil \$135 million


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Oil spill in Yellowstone River
Jan 19, 2015

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Gallery: Yellowstone River oil spill (2011)

022513


Chris Cioffi

Chris Cioffi covers city news for The Billings Gazette in Montana.

Tom Lutey

Politics and agriculture reporter for The Billings Gazette.

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oil spill

Yellowstone River: Sonar shows breached pipeline is exposed on riverbed

Associated Press Jan 25, 2015



LARRY MAYER, Billings Gazette

The sun sets over the Yellowstone River at Intake, one of the few areas with open water on the river below Glendive

GLENDIVE – Sonar indicates part of an underground pipeline that spilled almost 40,000 gallons of oil into Montana's Yellowstone River and fouled a local water supply is exposed on the riverbed.

022516

The pipeline is exposed for about 50 feet near where the breach occurred Jan. 17, according to a news release from public agencies involved with the response.

The pipeline had been buried at least 8 feet under the riverbed, and the depth was last confirmed in September 2011.

The cause of the spill remains under investigation. It prompted a five-day shutdown of drinking water services for 6,000 people in the city of Glendive after oil got into a treatment plant.

Prior accidents, including a 2011 Exxon Mobil pipeline spill on the Yellowstone near Billings, have demonstrated that pipelines beneath bodies of water can quickly become exposed by floodwaters or other natural forces.

Bridger Pipeline Co., which is based in Casper, Wyoming, says its pipeline will remain shut down from Glendive to near the Canada border until the river section is replaced. The company says the pipeline will be buried deeper beneath the river.

Federal rules require lines to be buried at least 4 feet beneath riverbeds.

The 193-mile Poplar Pipeline delivers crude from the Bakken oil patch of North Dakota and Montana to a terminal in Baker, about 55 miles south of Glendive. It was built in the 1950s and has a capacity of 42,000 barrels of oil a day.

The Yellowstone River is a popular recreation destination and home to fish, including the endangered pallid sturgeon.

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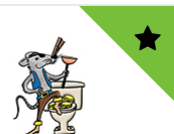
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Montana Oil Spill Renews Worries

Oil spill into Yellowstone River renews concerns about pipeline safety.



Crews work to contain an oil spill from Bridger Pipeline's broken pipeline near Glendive, Mont., in this aerial view showing both sides of the river on Monday.

Associated Press | Jan. 21, 2015, at 6:26 p.m.

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AP

By MATTHEW BROWN, Associated Press

BILLINGS, Mont. (AP) — A second large oil spill into Montana's Yellowstone River in less than four years is reviving questions about oversight of the nation's aging pipeline network.

Investigators and company officials on Wednesday were trying to determine the cause of the 40,000-gallon spill that contaminated downstream water supplies in the city of Glendive.

Sen. Jon Tester said Saturday's spill from the decades-old Poplar Pipeline was avoidable, but "we just didn't have the folks on the ground" to prevent it.

022520

The Montana Democrat told The Associated Press more frequent inspections by regulators are needed, and older pipelines should face stricter safety standards.

"We need to take a look at some of these pipelines that have been in the ground for half a century and say, 'Are they still doing a good job?'" Tester said.

The latest spill comes as Republicans and some Democrats, including Tester, want the Obama administration to approve TransCanada's Keystone XL pipeline from Canada to the Gulf.

Keystone would cross the Yellowstone roughly 20 miles upstream of the Poplar Pipeline spill.

In 2011, an ExxonMobil pipeline break spilled 63,000 gallons of oil during flooding on the Yellowstone near Billings. That break was blamed on scouring of the river bottom that exposed the company's Silvertip line to floodwaters.

Officials involved in the Poplar Pipeline spill have said it's too soon to say if that line also was exposed.

Poplar, owned by Wyoming-based Bridger Pipeline, was constructed in the 1950s. The section that was breached was replaced at least four decades ago, in the late 1960s or early 1970s, according to the company.

[**OPINION:** [Nebraska Ruling Gives Overdue Keystone XL Pipeline a Boost](#)]

Based on the number of miles of pipelines in the U.S. that carry oil, gasoline and other hazardous liquids, just over half were installed prior to 1970, according to the U.S. Department of Transportation.

The agency's Office of Pipeline Safety has roughly 150 inspectors overseeing 2.6 million miles of gas, oil and other pipelines.

That number could increase by another 100 inspectors under a \$27 million budget increase approved last year. That would still leave inspectors stretched thin given the mileage of pipelines.

Dena Hoff, a farmer and rancher whose land borders the site of the Poplar accident, said she's had a good working relationship with Bridger Pipeline, and she commended the company for taking responsibility for the spill.

But Hoff said the spill should spur second thoughts about Keystone and whether it's a good idea to have pipelines that cross under surface waters.

"It's the nature of the beast — pipelines leak, and pipelines break. We're never going to get around that," she said. "We have to decide if water is more valuable than oil."

Authorities continue work to clean up Glendive's public water supply after cancer-causing benzene was detected in water coming from the city's treatment plant. The plant draws directly from the Yellowstone.

Bridger Pipeline has committed to providing bottled water for Glendive's roughly 6,000 residents until the treatment plant is running again.

Workers late Tuesday recovered about 10,000 gallons of oil that was still in the Poplar line after it was shut down because of the breach.

[**READ:** [Clean Power Plan Makes 2015 a Big Year for the EPA](#)]

Bridger Pipeline Co. spokesman Bill Salvin said Wednesday only a "very small" amount of oil has been siphoned from the river itself.

Company officials and government regulators say most of the oil is thought to be within the first 6 miles of the spill site. That includes the stretch of the river through Glendive.

"What we're working on is identifying places where we can collect more oil," Salvin said. "The cleanup could extend for a while."

Oil sheens have been reported as far away as Williston, North Dakota, below the Yellowstone's confluence with the Missouri River, officials said.

The farthest downstream that free-floating oil has been seen was at an intake dam about 28 miles from the spill site, officials said.

Montana Department of Environmental Quality Director Tom Livers said he was concerned that when the ice breaks up in the spring, oil will spread farther downstream.

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oil spill

Yellowstone River: Sonar shows breached pipeline is exposed on riverbed

Associated Press Jan 25, 2015



LARRY MAYER, Billings Gazette

The sun sets over the Yellowstone River at Intake, one of the few areas with open water on the river below Glendive

GLENDIVE – Sonar indicates part of an underground pipeline that spilled almost 40,000 gallons of oil into Montana's Yellowstone River and fouled a local water supply is exposed on the riverbed.

The pipeline is exposed for about 50 feet near where the breach occurred Jan. 17, according to a news release from public agencies involved with the response.

022525

The pipeline had been buried at least 8 feet under the riverbed, and the depth was last confirmed in September 2011.

The cause of the spill remains under investigation. It prompted a five-day shutdown of drinking water services for 6,000 people in the city of Glendive after oil got into a treatment plant.

Prior accidents, including a 2011 Exxon Mobil pipeline spill on the Yellowstone near Billings, have demonstrated that pipelines beneath bodies of water can quickly become exposed by floodwaters or other natural forces.

Bridger Pipeline Co., which is based in Casper, Wyoming, says its pipeline will remain shut down from Glendive to near the Canada border until the river section is replaced. The company says the pipeline will be buried deeper beneath the river.


Federal rules require lines to be buried at least 4 feet beneath riverbeds.

The 193-mile Poplar Pipeline delivers crude from the Bakken oil patch of North Dakota and Montana to a terminal in Baker, about 55 miles south of Glendive. It was built in the 1950s and has a capacity of 42,000 barrels of oil a day.

The Yellowstone River is a popular recreation destination and home to fish, including the endangered pallid sturgeon.

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Acute Health Effects of the Enbridge Oil Spill

November 2010
(Minor revisions 12/20/2010)



Acute Health Effects of the Enbridge Oil Spill

November 2010
(Minor revisions December 20, 2010)

Martha Stanbury,¹ MSPH, Kim Hekman, MPH,¹ Eden Wells, MD, MPH,¹ Corinne Miller, DDS, PhD,¹ Susan Smolinske, PharmD,² James Rutherford, RS, MPA³

Address correspondence to:
Martha Stanbury, MSPH
Division of Environmental Health
Michigan Department of Community Health
PO Box 30195, Lansing, MI 48909
stanburym@michigan.gov
517-335-8364.

1. Michigan Department of Community Health, Lansing, MI
2. Poison Control Center, Children's Hospital of Michigan, Detroit, MI
3. Calhoun County Public Health Department, Battle Creek, MI

Acute health effects of the Enbridge Oil Spill

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Executive Summary

On Monday July 26, 2010, Enbridge Energy Partners, L.P., reported the burst of a 30-inch pipeline near Marshall, Michigan, in Calhoun County. In response to concerns about acute health effects from exposure to spilled oil in this major disaster, state and local public health in Michigan quickly set up a multi-faceted public health surveillance system that included health care provider reporting, community surveys, calls from the public to the Poison Control Center, and analysis of data submitted to the state's syndromic surveillance system. The surveillance system received 147 health care provider reports on 145 patients, identified 320 (58%) of 550 individuals with adverse health effects from four community surveys along the impacted waterways, identified one small worksite symptomatic employees, and tracked 41 calls that were placed to the poison center by the public. Headache, nausea, and respiratory symptoms were the predominant symptoms reported by exposed individuals in all reporting systems. These symptoms are consistent with the published literature regarding potential health effects associated with acute exposure to crude oil.

I. Background

On Monday July 26, 2010, Enbridge Energy Partners, L.P., reported the burst of a 30-inch pipeline near Marshall, Michigan, in Calhoun County. The spill started at least a day earlier based on 911 calls and other reports of strong odors starting July 25. Approximately 800,000 gallons of crude oil spilled into the Talmadge Creek, a waterway that feeds the Kalamazoo River. The contamination ultimately affected 25 miles of the creek and river. While the greatest impact was in Calhoun County, the spill also affected an area of Kalamazoo County encompassing five miles of the river downstream from the border of Calhoun County to a dam just upstream from the city of Kalamazoo (See map in the appendix). The U.S. Environmental Protection Agency (EPA), Calhoun County Public Health Department (CCPHD), Calhoun County Emergency Management, the Michigan Department of Community Health (MDCH) and many other agencies and organizations quickly became involved with public health and environmental response to this massive spill.

Beginning July 26, when the spill was reported to authorities, individuals near Talmadge Creek and the Kalamazoo River began complaining of strong, noxious odors and associated health symptoms in calls to CCPHD and the Michigan PCC. Subsequently, once it had been established, citizen concerns and complaints were routed to a phone hotline developed by Enbridge. Callers reported respiratory, gastrointestinal, and neurological symptoms, predominantly headache and nausea.

To adequately characterize the impact of the oil spill on the public's health, CCPHD, MDCH, and the Kalamazoo County Health and Community Services Department (KCHCS) developed and implemented a public health surveillance system to collect data on individuals with adverse health outcomes secondary to exposure to spilled oil and its vapors. The goal of this surveillance was to describe the magnitude and distribution of human health impacts due to exposure to the spilled oil, so that decision-makers could make informed decisions about actions needed to protect the public.

The surveillance system included four components: (1) active solicitation of health care provider reports, under legal authority of the Public Health Code, and (2) door-to-door health surveys in selected communities self-identified as particularly impacted by the spill, (3) monitoring daily counts of self-reported illnesses based on calls to the PCC, and (4) utilization of MDCH's syndromic surveillance system.

In order to protect personal confidential medical information, MDCH obtained a "Medical Research Designation".¹ This designation legally protected individual identifying information from disclosure by the participating public health authorities to other parties, including those situations in which the information

could be requested under the Michigan Freedom of Information Act or by subpoena.

This report describes the methods and results of the public health surveillance system established to measure and monitor health impacts from the Enbridge oil spill. Information about environmental sampling, clean-up efforts and other aspects of the spill response are available elsewhere.²

II. Methods and Results

A. Health care provider reporting

Methods

Initially, contacts were made at the two hospitals in the area, and they were asked to provide a daily count of the number of patients seen in the Emergency Department (ED) or admitted with oil exposure-related complaints. Then, on August 5, the CCPHD and the KCHHS sent out “blast faxes” to all health care providers in their respective counties requesting that clinicians and healthcare facilities formally report any patients seen due to illness or symptoms associated with oil spill exposure. Providers were advised that this reporting is required under the Michigan Public Health Code (R 325.71-75), and they were provided reporting information and forms.³ To gather data on patients who were seen at the local ED prior to establishment of this healthcare reporting system, medical records of patients identified as exposed to the oil or its vapors were abstracted by the MDCH medical epidemiologist.

The Michigan PCC was authorized as a legal agent of the state to receive the reports from health care providers for the purposes of this investigation. This allowed for 24/7 reporting, and allowed for PCC medical toxicologists to provide consultation to health care providers regarding oil spill-related patient diagnosis or treatment. Patient information collected included name, contact information and demographics, medical encounter date, clinical effects, laboratory test results, diagnosis, treatment, and contact information for the reporting provider.

Reported information was entered into Toxicall®, the electronic case management system used by the Michigan PCC. Each case was given a “medical outcome” classification based on information about reported clinical effects as follows: no effect (no symptoms due to exposure); minor effect (some minimally troublesome symptoms); moderate effect (more pronounced, prolonged symptoms); major effect (symptoms that are life-threatening or cause significant disability or disfigurement); death; not followed, judged as nontoxic exposure (clinical effects not expected); not followed, minimal clinical effects possible (no more than minor effect possible); unable to follow, judged as a potentially toxic exposure; unrelated effect, the exposure was probably not responsible for the effect(s); or, confirmed non-exposure.

Daily summary reports were provided by the PCC to MDCH, CCPHD, and KCHHS on numbers of reports and severity of illness (i.e. “medical outcome”). A spreadsheet of all case information was provided to MDCH for data analysis. Analysis was performed using SAS® version 9.2 (SAS Institute, Cary, NC).⁴

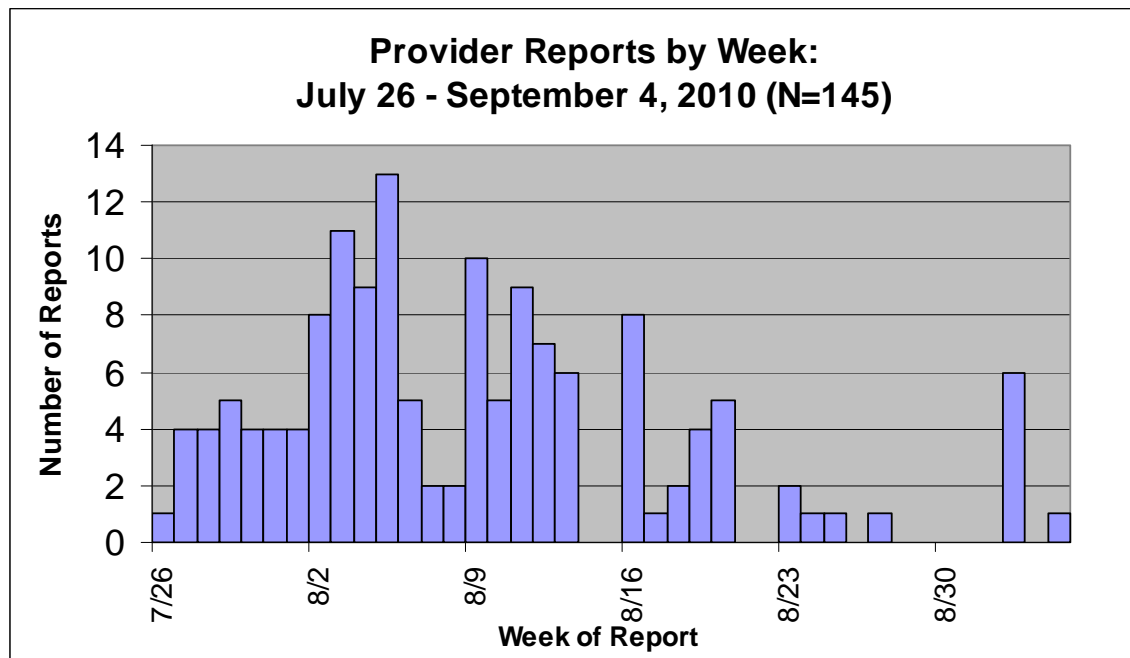
Results

Between July 26 and September 4, 2010, one hundred forty-seven health care visits for 145 individuals were reported by health care providers. (Two individuals were reported twice, by different providers, for separate visits.) One hundred seventeen (80.7%) of the 145 individuals lived and/or worked in areas near the affected waterways, 24 (16.5%) were oil-spill response workers, and four (2.7%) were transients/visitors.

The average age of these 145 individuals was 38. There were slightly more females (77/53.1%) than males (68/46.9%) reported. Adults age 18 to 64 predominated (100/69%), with the remainder being children under age 18 (36/24.8%), and a small number of adults over age 65 (9/6.2%).

The date of the reported visit to the health care provider is shown in **Figure 1**. (The two individuals reported twice are counted for date of their first visit.) The frequency of reported health care provider visits peaked in the second week after the spill, coinciding with the week providers were notified of the new reporting requirements. These visits included outpatient (N=77; 53%), hospital emergency department (N=64; 44%), hospital inpatient (N=1; 0.6%), and 3 (2%) where type of facility was unknown.

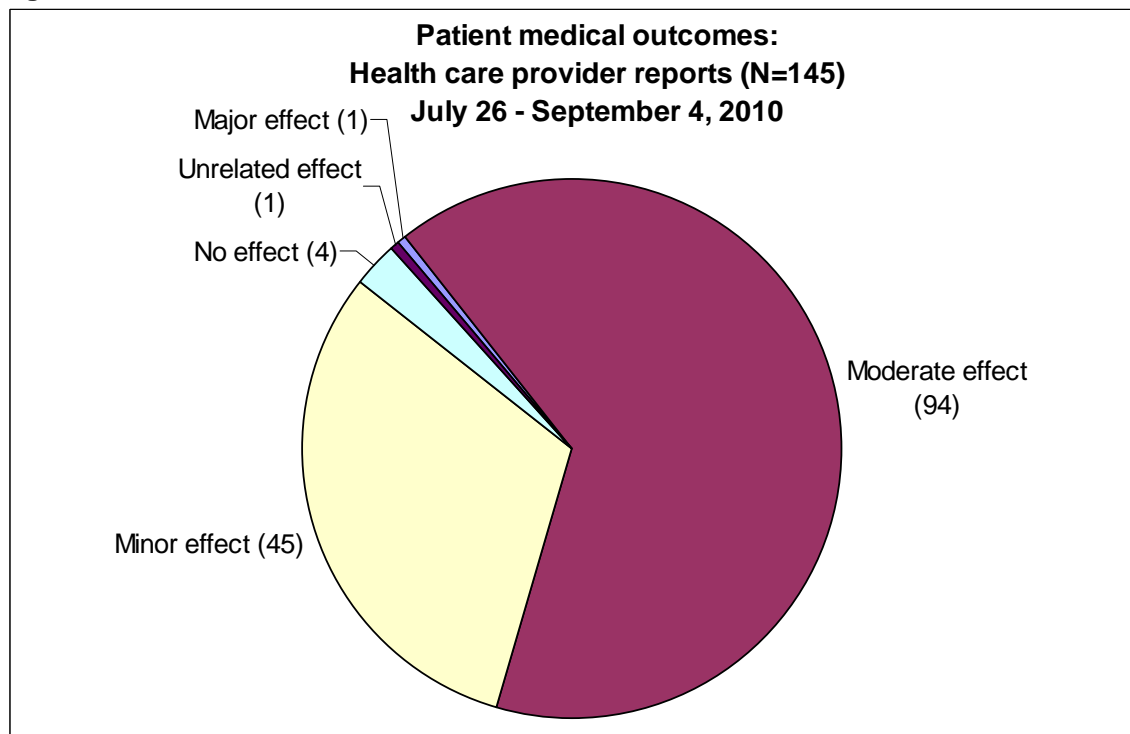
Figure 1



Approximately one-third (31%) of the medical outcomes of these individuals were classified as minor and two-thirds (64.8%) as moderate. There were no deaths.

(Figure 2) The one individual with medical outcome classified as “major” had significant exposure and had 8 reported clinical effects. Those with a medical outcome of “moderate” had on average 3.7 clinical effects whereas those classified as “minor” had 2.4 clinical effects.

Figure 2



Four (2.8%) of the reported individuals had no clinical effects. The remainder had from one to more than six clinical effects each (**Table 1**).

Table 1

| Number of Clinical Effects in Health Care Provider Visits | | |
|---|-------|-------|
| | Total | |
| | N | % |
| Number of Clinical Effects | | |
| 0 symptoms | 4 | 2.8% |
| 1 symptom | 21 | 14.5% |
| 2 symptoms | 38 | 26.2% |
| 3 symptoms | 26 | 17.9% |
| 4-5 symptoms | 37 | 25.5% |
| 6+ symptoms | 19 | 13.1% |

Neurological effects were reported most frequently (94/ 64.8%), with headache being the predominant of all neurological effects reported 83 (57.2%). Eighty-six individuals (59.3%) had at least one gastrointestinal clinical effect, with nausea predominating, and 68 (46.9%) had with at least one respiratory clinical effect with cough and choke predominating (**Table 2**).

Table 2

| Frequency of Clinical Effect Categories in Health Care Provider Visits | | |
|--|-------|------|
| | Total | |
| | N | % |
| Clinical Effect Category | | |
| Cardiovascular | 11 | 7.6 |
| Dermal | 9 | 6.2 |
| Gastrointestinal | 86 | 59.3 |
| <i>Nausea</i> | 57 | 39.3 |
| Neurological | 94 | 64.8 |
| <i>Headache</i> | 83 | 57.2 |
| Ocular | 23 | 15.9 |
| Renal | 1 | 0.7 |
| Respiratory | 68 | 46.9 |
| <i>Cough/Choke</i> | 47 | 32.4 |
| Other | 41 | 28.3 |

B. Community and Workplace Surveys

Methods: Four communities along the Talmadge Creek and Kalamazoo River and one small workplace were identified (from calls to the toll-free number and the CCPHD) as having multiple reports of adverse health effects and concerns about oil spill impacts.

A door-to-door health survey was conducted by MDCH and the CCPHD in each community. The community survey obtained information on whether the household had, or were planning to, relocate because of the spill; observations about the intensity and duration of the odor since July 25; and, for all members of the household, information about chronic/pre-existing health conditions that made them sensitive to fumes or odors. They were also asked about new or exacerbated health symptoms after the spill event. After the first survey, a question was added to assess whether those who had symptoms had seen a physician for their symptoms. For the most part, answers were provided by the person answering the door for all household members. Answers were provided in an open-ended format. Where no one was home, information was left at the door; in the second, third, and fourth communities, including a fact sheet from EPA on the oil spill and a cover letter that invited someone in the household to call a toll-free number at MDCH to answer the survey questions by telephone. In order to have an approximate measure of socio-economic status for each of these communities, a local realtor was asked to provide his estimate of the range of home prices that could be expected in each community.

The first health survey was conducted on August 6, 11 days after the spill was reported, in a neighborhood approximately 14 miles downstream from the spill origin and immediately adjacent to an area of wetland fed by the Kalamazoo River. Previously, on August 2, the CCPHD had visited the neighborhood to assess the need for temporary relocation of individuals concerned about the odors and their health, and to give information about how Enbridge would cover the costs of that relocation. However, information about health symptoms was not requested at that initial visit. Home prices in the neighborhood, which is referred to as “Neighborhood” in the tables, are estimated to range from \$500 to \$15,000.

The second community survey was conducted 16 days after the spill in a subdivision approximately two miles downstream. Home prices in the “Subdivision” are estimated to range from \$120,000 to \$325,000.

The third community, referred to as “Spill Site” in the tables, was surveyed in two parts, 22 and 24 days after the spill. This community included the homes surrounding the immediate area on the Creek where the pipeline burst. It was the only community where a voluntary evacuation notice had been issued, due to air sampling indicating elevated levels of benzene— a potential concern for long-term health. Each of these two surveys took place within 24 hours after the

evacuation notice was lifted for that area. A environmental contractor accompanied the survey team and offered air monitoring outside and inside homes to each of the interviewees, using a real-time monitoring instrument. Home values in this community are estimated to range from \$75,000 to \$350,000.

The fourth survey occurred 23 days after the spill in a small village of approximately 80 homes, situated directly on the river about five miles downstream from the spill's origin. Home values in the "Village" are estimated to range from \$10,000 to \$125,000.

For comparison purposes, a door-to-door survey was conducted 25 days after the spill in a community approximately fifteen miles stream upstream of the spill, in order to obtain information on the occurrence of health symptoms in the previous four weeks. The six neighborhoods surveyed in this community were on the Kalamazoo River; they were similar to the exposed communities in demographics and the range of home prices, encompassed homes valued from \$5,000 to \$225,000.

All 12 workers at the small workplace located a little less than one mile northeast of the confluence of Talmadge Creek and the Kalamazoo River were interviewed using the same open-ended format as the community surveys.

Results

Community Surveys

Table 3 shows the survey completion rates by community and in the Comparison community. Overall, 201 (59.6%) of the 337 homes visited provided information for a total of 550 household members in the exposed communities, and 51 (27.9%) of the 183 homes surveyed in the Comparison community provided information on 137 individuals. The average number of household members ranged from 2.5 to 3.1 in the exposed communities and was 2.7 in the Comparison community.

Table 3

| Survey Completion by Community | | | | | | |
|---|--------------|-------------|------------|---------|-------|------------|
| | Neighborhood | Subdivision | Spill Site | Village | Total | Comparison |
| Total Number of Homes Visited | 78 | 121 | 55 | 83 | 337 | 183 |
| Number of Homes that Completed Survey | 45 | 75 | 37 | 44 | 201 | 51 |
| Number of Homes that Refused Survey | 0 | 0 | 0 | 1 | 1 | 18 |
| Number of Homes with No One Home | 33 | 46 | 18 | 38 | 135 | 114 |
| Percentage of Homes Surveyed | 57.7% | 62.0% | 67.3% | 53.0% | 59.6% | 27.9% |
| Number of Individuals with Survey Information | 117 | 233 | 92 | 108 | 550 | 137 |
| Average Number of Individuals per Household | 2.6 | 3.1 | 2.5 | 2.5 | 2.7 | 2.7 |

In terms of race/ethnicity, all communities were almost entirely white. There were some differences between communities in other demographics. The community at

the spill site was on average older, had fewer children, and was over 50% male, in contrast to the other three exposed communities and the Comparison group. Smoking prevalence, which was asked in all surveys except at the Neighborhood, was notably different, with the two communities with more expensive homes reporting much lower smoking rates in adults (Spill site: 5.1%; Subdivision: 6.0%) than the other one (Village) at 20.7%. Smoking prevalence in the Comparison community was 19.8% (**Table 4**).

Table 4

| Demographics and Smoking Profile by Community | | | | | | |
|---|--------------|-------------|------------|---------|--------|------------|
| | Neighborhood | Subdivision | Spill Site | Village | Total | Comparison |
| Gender (%) | | | | | | |
| Male | 47.8% | 44.2% | 53.3% | 46.3% | 46.9% | 45.3% |
| Female | 52.2% | 55.8% | 46.7% | 53.7% | 53.1% | 54.7% |
| Average Age (yrs) | 32.1 | 35.8 | 48.9 | 41.9 | 38.4 | 39.1 |
| Age Distribution (%) | | | | | | |
| 0-7 yrs | 13.9% | 12.2% | 2.2% | 5.7% | 9.6% | 9.0% |
| 8-17 yrs | 15.6% | 21.8% | 13.0% | 16.2% | 17.9% | 14.3% |
| 18-30 yrs | 20.0% | 6.5% | 6.5% | 9.5% | 9.95% | 10.5% |
| 31-50 yrs | 28.7% | 31.3% | 16.3% | 29.5% | 27.85% | 34.6% |
| 51-65 yrs | 18.3% | 17.8% | 43.5% | 26.7% | 24.0% | 19.6% |
| 66+ yrs | 3.5% | 10.4% | 18.5% | 12.4% | 10.7% | 12.0% |
| Missing (n) | 2 | 3 | 0 | 3 | 8 | 4 |
| Smoker (age 18 and older) | not asked | 6.0% | 5.1% | 20.7% | | 19.8% |

The percent of residents that reported symptoms according to smoking status is shown in **Table 5**. A higher proportion of non-smokers reported no symptoms (39.6%) compared to smokers (25.0%). Similarly, a higher proportion of smoker reported 1 symptom and 4+ symptoms (39.3%, 10.7%), compared to non-smokers (26.8%, 5.4%). The proportion of residents that report 2-3 symptoms was very similar between smokers and non-smokers.

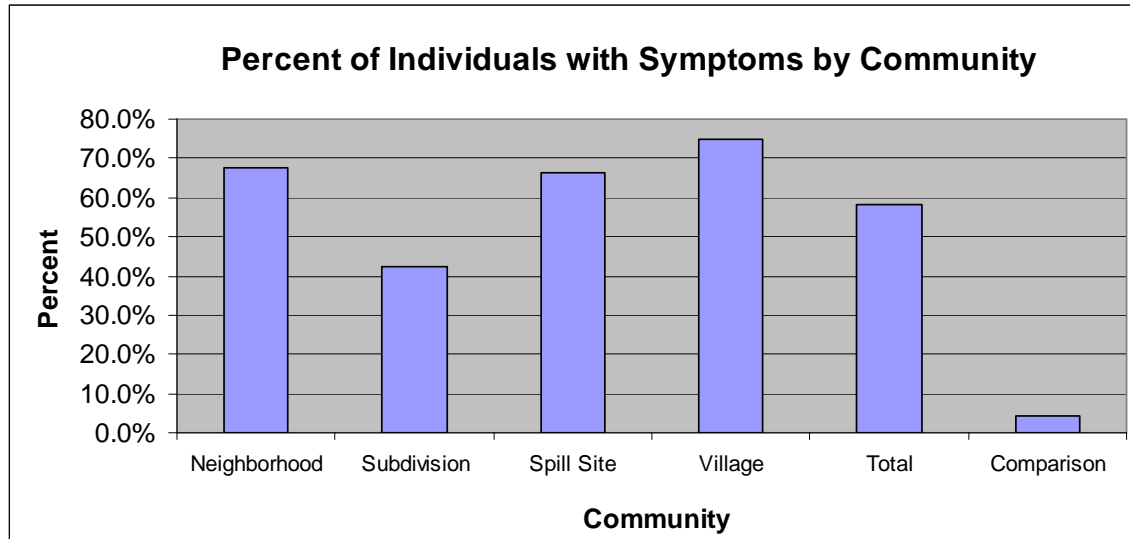
Table 5

| Symptoms by Smoking Status among Adults | | |
|---|--------|-------|
| | Smoker | |
| | Yes | No |
| Percent with Symptom | | |
| 0 symptoms | 25.0% | 39.6% |
| 1 symptom | 39.3% | 26.8% |
| 2-3 symptoms | 25.0% | 28.2% |
| 4+ symptoms | 10.7% | 5.4% |

Nearly all of the households in each of the four exposed communities reported noticing an odor since July 25, 2010 (Neighborhood: 100%, Subdivision: 97.3%, Spill Site: 97.2%, Village: 100%). In comparison, only a small minority of households in the Comparison community reported smelling an odor at any time after July 25 (15.7%).

Overall, 320 (58.2%) of the 550 individuals reported at least one new or exacerbated symptom after July 25 in contrast to 4.4% in the Comparison community. The frequency of symptoms varied by community. The Subdivision, which has homes more widely spread out from the river than any of the others, reported the lowest frequency (42.5%), and the Village had the highest (75.7%). By contrast, only 6 (4.4%) of the 131 individuals in the Comparison community reported any new or worsened symptoms in the timeframe following the spill (**Figure 3**).

Figure 3



Of the 320 individuals in the exposed communities who reported symptoms, 42.8% reported only one symptom, 44.7% reported 2-3 symptoms, and 12.5% reported 4 or more symptoms (**Table 6**). The proportion of exposed residents reporting symptoms was significantly greater than the proportion in the comparison community ($p < .0001$).

Table 6

| Frequency of Symptoms by Community | | | | | | | | | | | | |
|-------------------------------------|--------------|-------|-------------|-------|------------|-------|---------|-------|-------|-------|------------|-------|
| | Neighborhood | | Subdivision | | Spill Site | | Village | | Total | | Comparison | |
| | N | % | N | % | N | % | N | % | N | % | N | % |
| Number/percent without any Symptoms | 38 | 32.5% | 134 | 57.5% | 31 | 33.7% | 27 | 25.0% | 230 | 41.8% | 131 | 95.6% |
| Number/percent with any Symptom | 79 | 67.5% | 99 | 42.5% | 61 | 66.3% | 81 | 75.0% | 320 | 58.2% | 6 | 4.4% |
| 1 symptom | 27 | 34.2% | 49 | 49.5% | 27 | 44.3% | 34 | 42.0% | 137 | 42.8% | 5 | 83.3% |
| 2-3 symptoms | 37 | 46.8% | 44 | 44.4% | 28 | 45.9% | 34 | 42.0% | 143 | 44.7% | 1 | 16.7% |
| 4+ symptoms | 15 | 19.0% | 6 | 6.1% | 6 | 9.8% | 13 | 16.0% | 40 | 12.5% | 0 | 0.0% |

Headache was the most frequently reported symptom (34.5%) in all exposed communities, ranging from 25.3% in the Subdivision to 42.6% in the Village. This was followed by respiratory symptoms (e.g., breathing difficulty, cough) at 29.6% and gastrointestinal complaints (e.g., nausea and vomiting), 21.6% (**Table 7**). In the Comparison community, only 1 resident reported headache symptoms and

respiratory symptoms, respectively. None of the comparison residents reported gastrointestinal or skin/eyes symptoms. New onset or worsened anxiety was reported by 4.9% of all exposed residents. The Subdivision reported the least amount of anxiety (1.3%) and the Neighborhood reported the most (11.1%). There were no reports of anxiety among any of the residents in the Comparison community. Data on other symptoms were also included and compiled into an 'other' category, with 24.7% of residents in the exposed communities reporting other new or worsened symptoms and only 3.6% in the Comparison community.

Overall, 12.2% of exposed residents visited a doctor for new or worsened symptoms, and doctor visits ranged from 9.8% in the Spill Site to 14.8% in the Village. While only 6 individuals in the Comparison community reported new or worsened symptoms, 4 (66.7%) saw a health care provider for these symptoms.

Table 7

| Frequency of Types of Symptoms and Doctor Visits by Community | | | | | | | | | | |
|---|--------------|-------|-------------|-------|------------|-------|---------|-------|-------|-------|
| | Neighborhood | | Subdivision | | Spill Site | | Village | | Total | |
| | N | % | N | % | N | % | N | % | N | % |
| Symptoms | | | | | | | | | | |
| Headache | 48 | 41.0% | 59 | 25.3% | 37 | 40.2% | 46 | 42.6% | 190 | 34.5% |
| Respiratory (breathing diff., cough, sore throat/nose) | 34 | 29.1% | 53 | 22.7% | 23 | 25.0% | 53 | 49.1% | 163 | 29.6% |
| Gastrointestinal (nausea, vomiting, stomach ache) | 41 | 35.0% | 31 | 13.3% | 15 | 16.3% | 32 | 29.6% | 119 | 21.6% |
| Skin/Eyes | 10 | 8.5% | 11 | 4.7% | 11 | 12.0% | 23 | 21.3% | 55 | 10.0% |
| Anxiety | 13 | 11.1% | 3 | 1.3% | 7 | 7.6% | 4 | 3.7% | 27 | 4.9% |
| Other (dizziness, fatigue, chest pain, & other) | 51 | 43.6% | 20 | 8.6% | 25 | 27.2% | 40 | 37.0% | 136 | 24.7% |
| Individuals with One or more Symptoms | 79 | 67.5% | 99 | 42.5% | 61 | 66.3% | 81 | 75.0% | 320 | 58.2% |
| Individuals who Visited a Doctor for these Symptoms | 11 | 13.9% | 10 | 10.1% | 6 | 9.8% | 12 | 14.8% | 39 | 12.2% |
| | | | | | | | | | 4 | 66.7% |

The prevalence of reported chronic conditions/pregnancy potentially causing increased sensitivity to odors ranged from 23.6% in the Subdivision, to 26.1% (Spill site), 40.7% (Village), and 61% (Neighborhood), including four pregnancies. The prevalence of chronic conditions in the Comparison community was 40.7%. (It should be noted that some individuals reported chronic conditions that were not likely to increase sensitivity to odor, e.g., musculoskeletal disorders.) Individuals with chronic conditions reported proportionally more symptoms than individuals without chronic conditions (**Table 8**).

Table 8

| Frequency of Symptoms by Chronic Condition | | |
|--|-------------------|-------|
| | Chronic Condition | |
| | Yes | No |
| Number of Symptoms (%) | | |
| 0 symptoms | 30.9% | 47.1% |
| 1 symptom | 27.0% | 23.9% |
| 2-3 symptoms | 29.8% | 24.2% |
| 4+ symptoms | 12.3% | 4.8% |

Information was available on 501 of the 550 individuals in the four communities on relocation after the spill and 169 (33.7%) of the 501 relocated. These included 50 households where everyone left and 10 households where only some members left. Thus, relocation impacted 60 (29.9%) of the 201 households surveyed. Symptoms were more prevalent overall in the 169 individuals who

relocated (71.6%) than the 332 individuals who did not (50.9%). A greater percent of those with symptoms who relocated saw a physician (11.8%) than those who did not relocate (5.1%) (**Table 9**).

Table 9

| Symptoms by Relocation Status | | | | |
|---------------------------------------|--------------------------|-------|--------------------------------|-------|
| | Relocated (n=169) | | Didn't Relocate (n=332) | |
| Number/percent without Symptoms | 48 | 28.4% | 163 | 49.1% |
| Number/percent with any Symptom | 121 | 71.6% | 169 | 50.9% |
| 1 symptom | 44 | 26.0% | 77 | 23.2% |
| 2-3 symptoms | 58 | 34.3% | 72 | 21.7% |
| 4+ symptoms | 19 | 11.2% | 20 | 6.0% |
| Number/percent that Visited Doctor/ED | 20 | 11.8% | 17 | 5.1% |

Workplace survey

At the small worksite where the symptom survey was conducted, 100%* of the workers noted the odor. Eighty-three percent noted that the worst days for odor were early in the first week following the oil release (the week of July 26). The others did not identify the worst days.

- 92% said they still smelled the odor when they were interviewed, which was three weeks after the spill.
- 33% noted that they had pre-existing chronic health conditions that made them sensitive to fumes or odors.
- 92% noted a variety of new onset or worsened symptoms after the release, including: headache (92%), respiratory symptoms (33%); dizziness (50%); gastrointestinal symptoms (33%); fatigue (33%); eye, nose, throat irritation (75%); and anxiety (42%).
- 17% noted that they were planning to see a physician for these symptoms.

C. Calls to the PCC from the public

Methods

As noted above, within a few days of the spill, individuals began making calls to the PCC with concerns about the oil spill, using the nationwide poison control toll-free number. Although the PCC toll-free number and its services were not publicized to the public in Calhoun and Kalamazoo Counties during the spill event, these calls were consistent with the understanding among the general public that poison centers are available to answer questions about chemicals, poisonings, and toxic exposures. All calls were logged according to PCC standard operating procedures. They were coded so that they could be identified

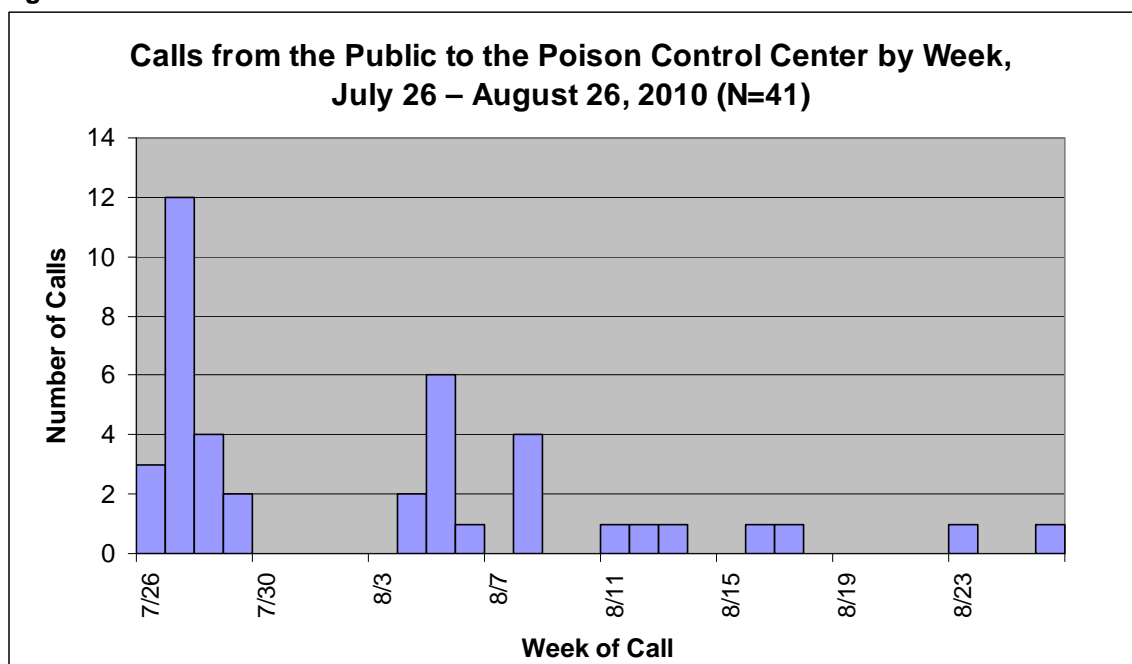
* Because of the small number of employees, numbers are not presented.

as related to the Enbridge spill event. Daily summaries of citizen calls were provided by the Michigan PCC to MDCH, in conjunction with the daily summaries of health care provider reports.

Results

Between July 26 and August 26, 41 calls were received by the PCC from individuals reporting health effects from exposure to the oil spill. No calls were received after August 26. **Figure 4** shows the number of calls by day of call. Over half (51%) of the calls (21 of 41) were received in the first week of the spill; July 27 was the day with the greatest number of calls (N= 12; 29%).

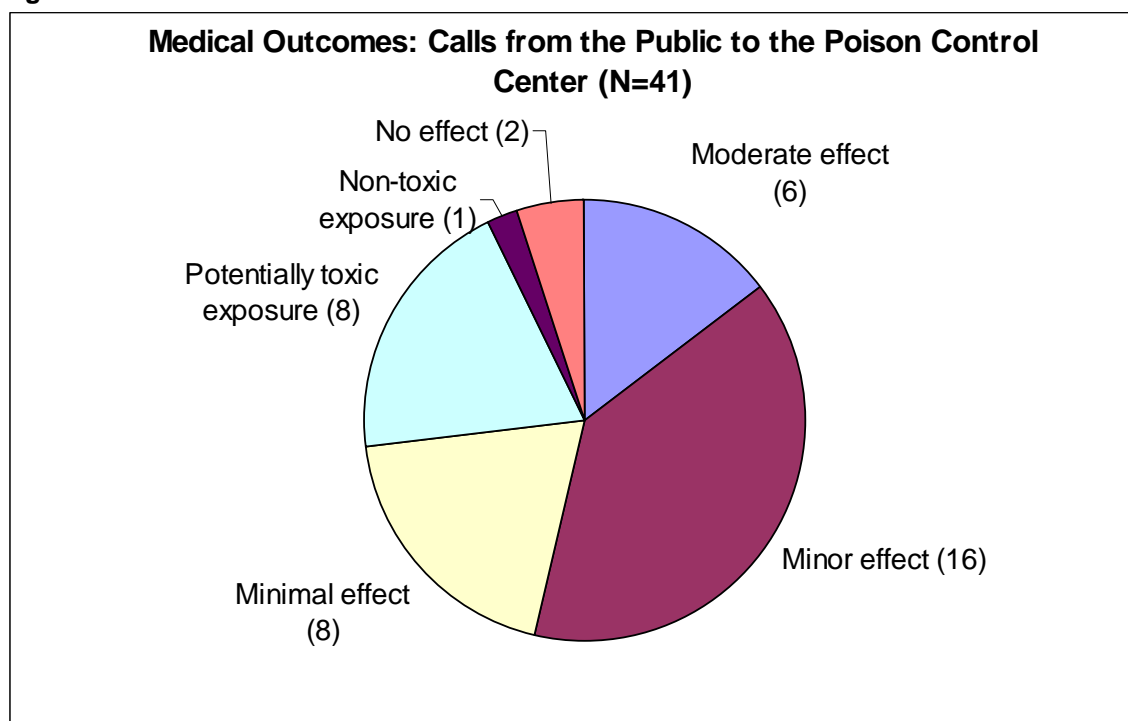
Figure 4



The ages of the individuals for whom a call was made ranged from 1 month to 60 years, with a mean of 26 years. Twenty-three (57.5%) of the 40 reports that documented gender were female.

The medical outcome classification assigned by the PCC for these calls included 39% with minor outcomes; 19.5% had possible minimal effects and 14.6% were classified with moderate effects (**Figure 5**). Nine (22%) individuals noted that they had seen a health care provider for their clinical effects, but no health care provider reports were received about these individuals.

Figure 5



D. Syndromic surveillance

Methods

The MDCH maintains a syndromic surveillance system designed to facilitate early and rapid detection and response to outbreaks that may be the result of bioterrorism, natural and/or emerging infectious disease, or other public health threats and emergencies. Real-time detection of significant increases in patients presenting with similar symptoms at designated Michigan hospital EDs is done through the use of statistical algorithms; these are applied to data obtained from hourly electronic searches through patient “chief complaints” in the electronic medical records. An “alert” is triggered when the proportion of visits for defined syndromes or geographic areas exceeds three standard deviations above predicted values, which are based on historical data. MDCH identified those potentially associated with oil exposure, which included rash, neurological, respiratory, and gastrointestinal syndromes. In addition, MDCH added an ad hoc query in order to detect chief complaints in the ED that contained “oil” and/or “spill”. A limitation of this method, however, is that not all hospitals in the impacted communities participate in the MDCH ED syndromic surveillance system.

MDCH also monitors over-the counter pharmaceutical sales from several hundred retail pharmacies throughout the state, using computer algorithms to detect statistically significant increases in daily sales of: anti-diarrheal and anti-fever medications, cough syrup and other respiratory medications; child

electrolytes; and thermometers; and related products. This system was continually monitored with attention to the communities within the area of the Enbridge oil spill.

Results

One “alert” was recorded in Kalamazoo County for rash several days after the spill. Otherwise there were no notable changes in the frequencies of syndromes of interest in the area compared to overall daily rolling averages and yearly comparisons.

There were no notable increases in sales of over-the-counter pharmaceutical products; numbers of sales remained within typical levels for the season.

III. Discussion

MDCH and the impacted local health departments quickly established a multi-component public health surveillance system to assess and measure the health impacts associated with exposure to crude oil, its vapors, and/or its odors resulting from the Enbridge pipeline spill in July 2010. The surveillance system received 147 health care provider reports on 145 patients; identified 320 (58%) of 550 individuals with adverse health effects from four community surveys along the impacted waterways, and tracked forty-one calls that were placed to the poison center by the public.

Headache, nausea, and respiratory symptoms were the predominant symptoms reported by exposed individuals in all reporting systems. These symptoms are consistent with the published literature and the Enbridge Material Safety Data Sheet regarding potential health effects associated with acute exposure to crude oil.^{5,6} A number of epidemiologic studies performed in the weeks or months following major oil spills have reported similar types of symptoms to those identified in our community surveys. Studies of acute health effects from an oil spill in Shetland, Scotland and Wales documented significant differences in similar sets of self-reported symptoms between exposed residents and control groups.^{7,8} The post-spill prevalence of headache in the exposed for these two studies was similar to our that in our community surveys (Shetland: 32%; Wales: 38%; Enbridge communities: 34.5%) but higher in their control groups than our Comparison group (Shetland: 8%; Wales: 14.1%; Enbridge: 0.7%). This pattern was similar for other symptoms. In a study of a spill near Karachi Pakistan, the frequency of one or more symptoms was markedly higher in both the exposed and the control groups (96% in exposed and 70% in controls) than in our populations.⁹ In a comprehensive review of all studies regarding the impact of oil exposure on human health, Aguilera et al. concluded that most studies “...provide evidence on the relationship between exposure and the appearance of acute physical, psychological, genotoxic and endocrine effects in the exposed individuals.”¹⁰

Symptom prevalence as determined by our community surveys was significantly greater overall in the exposed communities than in the comparison community upstream from the spill. At the same time, there were some differences between the four communities regarding symptom prevalence. These differences may be associated with differences in geographical proximity to the river or health risk factors, including prevalence of chronic health conditions and smoking, both of which are inversely associated with socio-economic status. Symptom prevalence was lowest in the community (the Subdivision) with the lowest smoking and chronic disease prevalence, and the highest home values; and it was highest in the “Neighborhood”, which had the highest chronic disease prevalence as well as the lowest home values.

There are a number of potential biases and limitations to the data obtained using this surveillance system. Regarding health care provider reporting, it is very likely that there was a significant amount of under-reporting by clinicians, a common problem with public health surveillance systems based on health care provider reporting. Reasons for under-reporting may include: not making a diagnosis that associates the oil exposure (either to the oil itself or to odors from the spill) to the symptoms, lack of understanding of reporting requirements, or lack of compliance because of barriers (e.g., time, office staffing, or concerns about patient confidentiality).

In the community surveys, there may have been response biases in the exposed communities associated with exaggerated reporting of symptoms, due to the considerable publicity surrounding the event and attendant legal issues. At the same time, there could have been underreporting of symptoms given the possibility that most affected individuals and households had relocated and were not at home when the door-to-door surveys were completed. Additionally, underreporting could have occurred because the respondents at the households were not completely familiar with the range of symptoms experienced by other household members about whom they provided information during the survey.

The lower completion rates in the Village and Comparison communities may have been because the survey teams started earlier in the evening than at the other sites, and thus missed people not yet home from work. It is unknown how this might have affected results. However, the very low refusal rate in the exposed communities suggested that these individuals understood why they were being interviewed and that it may have been in their best interest to participate. There was a much higher refusal rate in the Comparison community than the exposed communities (15% vs. 0.5%). We did not determine the reasons for refusing and therefore we do not know how this would have biased results from the comparison community survey. It could have reflected that there was no self-motivation for individuals in the Comparison community to participate other than general concern and good will, and thus some people were not willing

to take the time to talk with the interviewers, but there could have been a variety of reasons.

The survey of the workers in the one small worksite should be interpreted with caution. Results are subject to the instability of small numbers and there are no comparison data by which to judge the significance of the findings. Additionally, like the community surveys, there are a number of factors that could have contributed to recall bias, resulting in over- or under-reporting of symptoms. Because these individuals worked closely together, individual responses could have been influenced by prior discussions and concerns about the release. Further, overstated reporting of symptoms could have resulted from the considerable publicity surrounding the event and attendant legal issues. On the other hand, the open-ended format of the questions, rather than a structured list of possible responses, could have resulted in individuals being less likely to remember and report on specific types of symptoms.

A number of studies of the health effects of previous oil spills have focused on acute and chronic health effects to responders.^{11,12,13} Current surveillance of response workers in the Deepwater Horizon spill in the Gulf of Mexico is tracking all injuries and illnesses of response workers, not just illnesses associated with oil exposure.¹⁴ Our surveillance system, which was established to provide rapid detection of and response to acute health effects of oil exposure, was not designed to evaluate all injuries and illnesses, short or long term, in response workers. Other systems were in place within the Unified Command structure of the response to track all illnesses, injuries and “near-misses” among the response workers. Nevertheless, approximately 18% of the health care provider reports were of response workers experiencing health effects apparently associated with exposure to the oil.

Mental health effects of disasters, including anxiety, post-traumatic stress disorder, and depression have been an area of particular concern. Studies following the *Exxon-Valdes* oil spill in Alaska¹⁵ and the *Sea Empress* in Wales⁶ found that post-spill prevalence of a number of psychiatric disorders was significantly higher in exposed populations than unexposed individuals. Likewise, there was a greater proportion of individuals with self-reported psychiatric symptoms in our exposed communities than our Comparison community (4.7% vs. 0%), but overall prevalence was much lower than other studies. Unlike some other studies, which used validated mental health survey methodologies, our survey included only an open-ended question about symptoms, thus psychological symptoms were captured only if volunteered. Therefore, our assessment may have not fully captured the mental health effects of the spill.

Use of the PCC as the surveillance data center was an effective and responsive approach to the need for a rapidly functioning data collection and analysis system. Daily reports of numbers and types of reports were thus able to be provided by the PCC to the Command Center from where the spill response was

coordinated. The ED syndromic surveillance system was not notably sensitive, but this was not surprising because the hospital ED closest to the spill site does not participate in the system.

Beyond the significance of the health data itself for documenting the health impacts of the spill, the value of the face-to-face encounters between public health officials and the families coping with feelings of ill health, plummeting home values, and anxieties about their safety should be noted. These personal encounters provided some assurance to families that their needs and concerns were being heard and provided public health with an in-depth understanding of the situation. Combining a rapid community needs assessment and a health assessment is an approach that is being used more and more frequently during disasters.¹⁶ Currently, the Centers for Disease Control and Prevention and the Council of State and Territorial Epidemiologists are organizing a series of trainings and workshops in “disaster epidemiology.”¹⁷ Results of these efforts will help inform future responses in Michigan to disasters.

IV. Conclusion

In response to concerns about acute health effects from exposure to spilled oil in this major disaster, state and local public health in Michigan quickly set up a multi-faceted public health surveillance system that included health care provider reporting, community surveys, calls from the public to the poison control center, and analysis of data submitted to the state’s syndromic surveillance system. In spite of the limitations noted above, these data appear to provide a reasonable picture of the oil spill’s acute health impacts, and these findings are consistent with other studies of oil spills.

A number of aspects to the public health surveillance response are noteworthy for consideration by public health agencies that are refining their non-infectious disease surveillance emergency response plans.

- A multi-component surveillance system was necessary to support the response.
- Chemical poisoning reporting regulations, which Michigan had put in place in 2007, were essential to support mandated health care provider reporting of oil-spill related illnesses.
- Use of the poison center as the data repository for reports by health care providers was an innovation that was effective and efficient. Daily summaries from the poison center provided the responders and public health agencies with sufficient information to understand the magnitude of the actual on-going health impacts of the spill, rather than relying on rumors or anecdotes.
- Epidemiologic competencies necessary for a quick response included survey design, data management, and analytic skills in descriptive epidemiology.
- Having the surveillance response take place in the oil-spill’s Command Center, rather than public health offices at the state or county level, was

critical for ensuring that surveillance activities supported the daily needs of the Unified Command.

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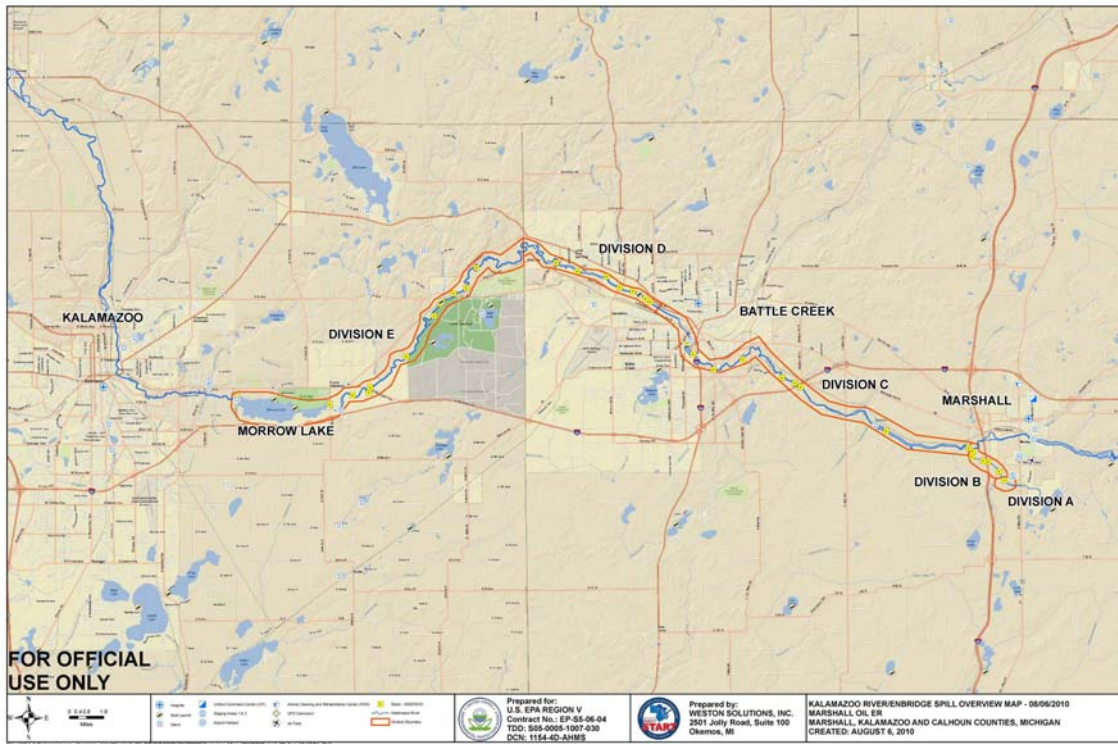
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Michigan State University: Joanna Kica

We also thank Matthew Davis of Rosemary Davis Realtors, Marshall MI for providing home price estimates.

Appendix: Map of the oil spill in Michigan (source: EPA¹⁸)

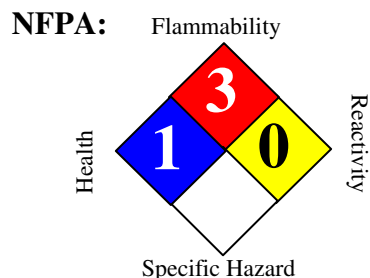


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- ¹⁷ See <http://www.cste.org/dnn/ProgramsandActivities/DisasterEpiWorkshop/tabid/404/Default.aspx>
- ¹⁸ http://www.epa.gov/enbridgespill/images/enbridge_overview_map_20100806.pdf

Material Safety Data Sheet

Naphtha



HMIS III:

| | |
|--------------|---|
| HEALTH | 1 |
| FLAMMABILITY | 3 |
| PHYSICAL | 0 |

0 = Insignificant, 1 = Slight, 2 = Moderate,
3 = High, 4 = Extreme

SECTION 1. PRODUCT AND COMPANY IDENTIFICATION

| | | | | | |
|-------------------------|---|---|---------------------------------|---|----------------|
| Product name | : | Naphtha | | | |
| Synonyms | : | Light Naphtha, Japan Open Spec Bonded Naphtha, SNG Naphtha, Light Cat Naphtha, Sweet Virgin Naphtha (SVN), Debutanized Naphtha, Atmospheric Naphtha (DAN), HCU Light Naphtha, Light CR Gasoline, Full Range Cracked Naphtha, Full Range Hydrocracked Naphtha, Full Range Reformulated Naphtha, Light Chemical Treated Naphtha, Light Cracked Naphtha, Light Hydrocracked Naphtha, Light Hydrotreated Naphtha, Aviation Alkylate Naphtha, 888100004450 | | | |
| MSDS Number | : | 888100004450 | Version | : | 2.12 |
| Product Use Description | : | Fuel Component, Refinery Intermediate Stream | | | |
| Company | : | For: Tesoro Refining & Marketing Co. 19100 Ridgewood Parkway, San Antonio, TX 78259 | | | |
| Tesoro Call Center | : | (877) 783-7676 | Chemtrec (Emergency Contact) | : | (800) 424-9300 |

SECTION 2. HAZARDS IDENTIFICATION

Emergency Overview

| | |
|--------------------------|---|
| Regulatory status | : This material is considered hazardous by the Occupational Safety and Health Administration (OSHA) Hazard Communication Standard (29 CFR 1910.1200). |
| Signal Word | : DANGER |
| Hazard Summary | : Extremely flammable. Irritating to eyes and respiratory system. Affects central nervous system. Harmful or fatal if swallowed. Aspiration Hazard. |

Potential Health Effects

| | |
|-------------------|---|
| Eyes | : High vapor concentration or contact may cause irritation and discomfort. |
| Skin | : Brief contact may cause slight irritation. Skin irritation leading to dermatitis may occur upon prolonged or repeated contact. Can be absorbed through skin. |
| Ingestion | : Aspiration hazard if liquid is inhaled into lungs, particularly from vomiting after ingestion. Aspiration may result in chemical pneumonia, severe lung damage, respiratory failure and even death. |
| Inhalation | : Vapors or mists from this material can irritate the nose, throat, and lungs, and can cause signs and symptoms of central nervous system depression, depending on the concentration and duration of exposure. Inhalation of high concentrations may cause central nervous system depression such as dizziness, |

drowsiness, headache, and similar narcotic symptoms, but no long-term effects.

Chronic Exposure

: Long-term exposure may cause effects to specific organs, such as to the liver, kidneys, blood, nervous system, and skin. Contains benzene, which can cause blood disease, including anemia and leukemia.

Target Organs

: Skin, Central nervous system, Liver, Kidney, Blood

SECTION 3. COMPOSITION/INFORMATION ON INGREDIENTS

| Component | CAS-No. | Weight % |
|------------------------------------|-----------|------------|
| Naphtha; Low boiling point naphtha | 8030-30-6 | 100% |
| N-hexane | 110-54-3 | 25 - 35% |
| Xylene | 1330-20-7 | 25 - 35% |
| Toluene | 108-88-3 | 15 - 20% |
| Cyclohexane | 110-82-7 | 15 - 20% |
| Pentane | 109-66-0 | 15 - 20% |
| Heptane [and isomers] | 142-82-5 | 12.5 - 15% |
| Ethylbenzene | 100-41-4 | 5 - 7% |
| Benzene | 71-43-2 | 3 - 5% |
| 1,2,4-Trimethylbenzene | 95-63-6 | 2 - 3% |
| Sulfur | 7704-34-9 | 0 - 1.5% |

SECTION 4. FIRST AID MEASURES
General advice

: Remove from exposure, lie down. In the case of accident or if you feel unwell, seek medical advice immediately (show the label where possible). When symptoms persist or in all cases of doubt, seek medical advice. Never give anything by mouth to an unconscious person. Take off all contaminated clothing immediately and thoroughly wash material from skin.

Inhalation

: If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Seek medical attention immediately.

Skin contact

: In case of contact, immediately flush skin with plenty of water. Take off contaminated clothing and shoes immediately. Wash contaminated clothing before re-use. Contaminated leather, particularly footwear, must be discarded. Note that contaminated clothing may be a fire hazard. Seek medical advice if symptoms persist or develop.

Eye contact

: Remove contact lenses. In the case of contact with eyes, rinse immediately with plenty of water and seek medical advice.

Ingestion

: If swallowed Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Seek medical attention immediately.

Notes to physician : Symptoms: Dizziness, Discomfort, Headache, Nausea, Kidney disorders, Liver disorders.

SECTION 5. FIRE-FIGHTING MEASURES

| | |
|---|--|
| Form | : Liquid |
| Flash point -typical | : -21.7 °C (-7.1 °F) |
| Auto Ignition temperature | : 225 °C (437 °F) |
| Lower explosive limit | : 1.2 %(V) |
| Upper explosive limit | : 6.9 % (V) |
| Suitable extinguishing media | : Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide. Do not use a solid water stream as it may scatter and spread fire. |
| Specific hazards during fire fighting | : SMALL FIRES: Any extinguisher suitable for Class B fires, dry chemical, CO ₂ , water spray, fire fighting foam, or Halon. LARGE FIRES: Water spray, fog or fire fighting foam. Water may be ineffective for fighting the fire, but may be used to cool fire-exposed containers. |
| Special protective equipment for fire-fighters | : Fire fighters should wear positive pressure self-contained breathing apparatus (SCBA) and full turnout gear. Firefighters' protective clothing will provide limited protection. |
| Further information | : Isolate area around container involved in fire. Cool tanks, shells, and containers exposed to fire and excessive heat with water. For massive fires the use of unmanned hose holders or monitor nozzles may be advantageous to further minimize personnel exposure. Major fires may require withdrawal, allowing the tank to burn. Large storage tank fires typically require specially trained personnel and equipment to extinguish the fire, often including the need for properly applied fire fighting foam. Exposure to decomposition products may be a hazard to health. Use extinguishing measures that are appropriate to local circumstances and the surrounding environment. Use water spray to cool unopened containers. Fire residues and contaminated fire extinguishing water must be disposed of in accordance with local regulations. |

SECTION 6. ACCIDENTAL RELEASE MEASURES

| | |
|----------------------------------|--|
| Personal precautions | : Evacuate personnel to safe areas. Ventilate the area. Remove all sources of ignition. Response and clean-up crews must be properly trained and must utilize proper protective equipment (see Section 8). |
| Environmental precautions | : Should not be released into the environment. Avoid subsoil penetration. If the product contaminates rivers and lakes or drains, inform respective authorities. |
| Methods for cleaning up | : Contain and collect spillage with non-combustible absorbent material, (e.g. sand, earth, diatomaceous earth, vermiculite) and place in container for disposal according to local / national regulations. |

SECTION 7. HANDLING AND STORAGE

| | |
|-----------------|--|
| Handling | : Keep away from fire, sparks and heated surfaces. No smoking near areas where material is stored or handled. The product should only be stored and handled in |
|-----------------|--|

areas with intrinsically safe electrical classification.

Advice on protection against fire and explosion

- : Hydrocarbon liquids including this product can act as a non-conductive flammable liquid (or static accumulators), and may form ignitable vapor-air mixtures in storage tanks or other containers. Precautions to prevent static-initiated fire or explosion during transfer, storage or handling, include but are not limited to these examples:
- (1) Ground and bond containers during product transfers. Grounding and bonding may not be adequate protection to prevent ignition or explosion of hydrocarbon liquids and vapors that are static accumulators.
 - (2) Special slow load procedures for "switch loading" must be followed to avoid the static ignition hazard that can exist when higher flash point material (such as fuel oil or diesel) is loaded into tanks previously containing low flash point products (such as gasoline or naphtha).
 - (3) Storage tank level floats must be effectively bonded.
- For more information on precautions to prevent static-initiated fire or explosion, see NFPA 77, Recommended Practice on Static Electricity (2007), and API Recommended Practice 2003, Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents (2008).

Dust explosion class

: Not applicable

Requirements for storage areas and containers

: Keep away from flame, sparks, excessive temperatures and open flame. Use approved containers. Keep containers closed and clearly labeled. Empty or partially full product containers or vessels may contain explosive vapors. Do not pressurize, cut, heat, weld or expose containers to sources of ignition. Store in a well-ventilated area. The storage area should comply with NFPA 30 "Flammable and Combustible Liquid Code". The cleaning of tanks previously containing this product should follow API Recommended Practice (RP) 2013 "Cleaning Mobile Tanks In Flammable and Combustible Liquid Service" and API RP 2015 "Cleaning Petroleum Storage Tanks".

Advice on common storage

: Keep away from food, drink and animal feed. Incompatible with oxidizing agents. Incompatible with acids.

Other data

: No decomposition if stored and applied as directed.

SECTION 8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Exposure Guidelines

| List | Components | CAS-No. | Type: | Value |
|---------|------------------------------------|-----------|---------|------------------------|
| OSHA | Benzene - 29 CFR 1910.1028 | 71-43-2 | TWA | 1 ppm |
| | | 71-43-2 | STEL | 5 ppm |
| | | 71-43-2 | OSHA_AL | 0.5 ppm |
| OSHA Z1 | Naphtha; Low boiling point naphtha | 8030-30-6 | PEL | 100 ppm 400 mg/m3 |
| | Xylene | 1330-20-7 | PEL | 100 ppm 435 mg/m3 |
| | N-hexane | 110-54-3 | PEL | 500 ppm 1,800 mg/m3 |
| | Cyclohexane | 110-82-7 | PEL | 300 ppm 1,050 mg/m3 |
| | Heptane [and isomers] | 142-82-5 | PEL | 500 ppm 2,000 mg/m3 |
| | Ethylbenzene | 100-41-4 | PEL | 100 ppm 435 mg/m3 |
| ACGIH | Naphtha; Low boiling point naphtha | 8030-30-6 | TWA | 400 ppm |

| | | | | |
|--|-----------------------|-----------|------|---------|
| | Xylene | 1330-20-7 | TWA | 100 ppm |
| | | 1330-20-7 | STEL | 150 ppm |
| | N-hexane | 110-54-3 | TWA | 50 ppm |
| | Toluene | 108-88-3 | TWA | 50 ppm |
| | Cyclohexane | 110-82-7 | TWA | 100 ppm |
| | Pentane | 109-66-0 | TWA | 600 ppm |
| | Heptane [and isomers] | 142-82-5 | TWA | 400 ppm |
| | | 142-82-5 | STEL | 500 ppm |
| | Ethylbenzene | 100-41-4 | TWA | 100 ppm |
| | | 100-41-4 | STEL | 125 ppm |
| | Benzene | 71-43-2 | TWA | 0.5 ppm |
| | | 71-43-2 | STEL | 2.5 ppm |

| | |
|---------------------------------|--|
| Engineering measures | : Use adequate ventilation to keep gas and vapor concentrations of this product below occupational exposure and flammability limits, particularly in confined spaces. Use only intrinsically safe electrical equipment approved for use in classified areas. |
| Eye protection | : Safety glasses or goggles are recommended where there is a possibility of splashing or spraying. Ensure that eyewash stations and safety showers are close to the workstation location. |
| Hand protection | : Gloves constructed of nitrile or neoprene are recommended. Consult manufacturer specifications for further information. |
| Skin and body protection | : If needed to prevent skin contact, chemical protective clothing such as of DuPont TyChem®, Saranex or equivalent recommended based on degree of exposure. The resistance of specific material may vary from product to product as well as with degree of exposure. |
| Respiratory protection | : A NIOSH/ MSHA-approved air-purifying respirator with organic vapor cartridges or canister may be permissible under certain circumstances where airborne concentrations are or may be expected to exceed exposure limits or for odor or irritation. Protection provided by air-purifying respirators is limited. Refer to OSHA 29 CFR 1910.134, ANSI Z88.2-1992, NIOSH Respirator Decision Logic, and the manufacturer for additional guidance on respiratory protection selection. Use a NIOSH/ MSHA-approved positive-pressure supplied-air respirator if there is a potential for uncontrolled release, exposure levels are not known, in oxygen-deficient atmospheres, or any other circumstance where an air-purifying respirator may not provide adequate protection. |
| Work / Hygiene practices | : Emergency eye wash capability should be available in the near proximity to operations presenting a potential splash exposure. Use good personal hygiene practices. Avoid repeated and/or prolonged skin exposure. Wash hands before eating, drinking, smoking, or using toilet facilities. Do not use as a cleaning solvent on the skin. Do not use solvents or harsh abrasive skin cleaners for washing this product from exposed skin areas. Waterless hand cleaners are effective. Promptly remove contaminated clothing and launder before reuse. Use care when laundering to prevent the formation of flammable vapors which could ignite via washer or dryer. Consider the need to discard contaminated leather shoes and gloves. |

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

| | |
|----------------------------------|---|
| Form | : Liquid |
| Appearance | : Colorless to light yellow |
| Odor | : Characteristic hydrocarbon-like |
| Flash point - typical | : -21.7 °C (-7.1 °F) |
| Auto Ignition temperature | : 225 °C (437 °F) |
| Thermal decomposition | : Heating can release hazardous gases, No decomposition if stored and applied as directed. |
| Lower explosive limit | : 1.2 % (V) |
| Upper explosive limit | : 6.9 % (V) |
| pH | : Not applicable |
| Specific gravity | : 0.77 (H2O=1) |
| Boiling point | : 26.7 - 148.9 °C(80.1 - 300.0 °F) |
| Vapor Pressure | : 758 - 896 hPa at 20 °C (68 °F) |
| Vapor Density (Air = 1) | : 3.5 |
| Water solubility | : Negligible |
| Viscosity, kinematic | : Not determined |
| Percent Volatiles | : 100 % |
| Work / Hygiene practices | Emergency eye wash capability should be available in the near proximity to operations presenting a potential splash exposure. Use good personal hygiene practices. Avoid repeated and/or prolonged skin exposure. Wash hands before eating, drinking, smoking, or using toilet facilities. Do not use as a cleaning solvent on the skin. Do not use solvents or harsh abrasive skin cleaners for washing this product from exposed skin areas. Waterless hand cleaners are effective. Promptly remove contaminated clothing and launder before reuse. Use care when laundering to prevent the formation of flammable vapors which could ignite via washer or dryer. Consider the need to discard contaminated leather shoes and gloves. |

SECTION 10. STABILITY AND REACTIVITY

| | |
|---|---|
| Conditions to avoid | : Avoid high temperatures, open flames, sparks, welding, smoking and other ignition sources. |
| Materials to avoid | : Strong acids and strong bases. Oxidizing agents. |
| Hazardous decomposition products | : Carbon monoxide, carbon dioxide and noncombusted hydrocarbons (smoke). |
| Thermal decomposition | : Heating can release hazardous gases. No decomposition if stored and applied as directed. |
| Hazardous reactions | : Vapors may form explosive mixture with air. Hazardous polymerization does not occur. Note: Stable under recommended storage conditions. |

SECTION 11. TOXICOLOGICAL INFORMATION**Carcinogenicity**

- NTP** : Benzene (CAS-No.: 71-43-2)
- IARC** : Ethylbenzene (CAS-No.: 100-41-4)
Benzene (CAS-No.: 71-43-2)
- OSHA** : Benzene (CAS-No.: 71-43-2)
- CA Prop 65** : WARNING! This product contains a chemical known to the State of California to cause cancer.
Ethylbenzene (CAS-No.: 100-41-4)
Benzene (CAS-No.: 71-43-2)
- : WARNING! This product contains a chemical known to the State of California to cause birth defects or other reproductive harm.
Toluene (CAS-No.: 108-88-3)
Benzene (CAS-No.: 71-43-2)
- Skin irritation** : Repeated or prolonged contact with the preparation may cause removal of natural fat from the skin resulting in desiccation of the skin.
The product may be absorbed through the skin.
- Eye irritation** : The liquid splashed in the eyes may cause irritation and reversible damage.
Strong lachrymation can make it difficult to escape
- Further information** : This product contains benzene. Human health studies indicate that prolonged and/or repeated overexposure to benzene may cause damage to the blood-forming system (particularly bone marrow), and serious blood disorders such as aplastic anemia and leukemia. Benzene is listed as a human carcinogen by the NTP, IARC, OSHA and ACGIH. Acute toxicity of benzene results primarily from depression of the central nervous system (CNS). Inhalation of concentrations over 50 ppm can produce headache, lassitude, weariness, dizziness, drowsiness, or excitation. Exposure to very high levels can result in unconsciousness and death. Symptoms of overexposure may be headache, dizziness, tiredness, nausea and vomiting.
Ingestion may cause gastrointestinal disturbances, including irritation, nausea, vomiting and diarrhea, and central nervous (brain) effects similar to alcohol intoxication. In severe cases, tremors, convulsions, loss of consciousness, coma, respiratory arrest and death may occur.

Component:

| | | |
|-------------|-----------|---|
| N-hexane | 110-54-3 | <u>Acute oral toxicity</u> : LD50 rat Dose: 25,000 mg/kg |
| | | <u>Acute dermal toxicity</u> : LD50 rabbit Dose: 2,001 mg/kg |
| | | <u>Acute inhalation toxicity</u> : LC50 rat Dose: 171.6 mg/l Exposure time: 4 h |
| | | <u>Skin irritation</u> : Classification: Irritating to skin. Result: Skin irritation |
| | | <u>Eye irritation</u> : Classification: Irritating to eyes. Result: Mild eye irritation |
| | | <u>Teratogenicity</u> : N11.00418960 |
| Xylene | 1330-20-7 | <u>Acute oral toxicity</u> : LD50 rat Dose: 2,840 mg/kg |
| | | <u>Acute dermal toxicity</u> : LD50 rabbit Dose: ca. 4,500 mg/kg |
| | | <u>Acute inhalation toxicity</u> : LC50 rat Dose: 6,350 mg/l Exposure time: 4 h |
| | | <u>Skin irritation</u> : Classification: Irritating to skin. Result: Mild skin irritation Repeated or prolonged exposure may cause skin irritation and dermatitis, due to degreasing properties of the product. |
| | | <u>Eye irritation</u> : Classification: Irritating to eyes. Result: Mild eye irritation |
| Toluene | 108-88-3 | <u>Acute oral toxicity</u> : LD50 rat Dose: 636 mg/kg |
| | | <u>Acute dermal toxicity</u> : LD50 rabbit Dose: 12,124 mg/kg |
| | | <u>Acute inhalation toxicity</u> : LC50 rat Dose: 49 mg/l Exposure time: 4 h |
| | | <u>Skin irritation</u> : Classification: Irritating to skin. Result: Mild skin irritation Prolonged skin contact may defat the skin and produce dermatitis. |
| | | <u>Eye irritation</u> : Classification: Irritating to eyes. Result: Mild eye irritation |
| Cyclohexane | 110-82-7 | <u>Acute dermal toxicity</u> : LD50 rabbit Dose: 2,001 mg/kg |
| | | <u>Acute inhalation toxicity</u> : LC50 rat Dose: 14 mg/l Exposure time: 4 h |
| | | <u>Skin irritation</u> : Classification: Irritating to skin. Result: Skin irritation |
| | | <u>Eye irritation</u> : Classification: Irritating to eyes. Result: Mild eye irritation |
| | | |
| Pentane | 109-66-0 | <u>Acute oral toxicity</u> : LD50 rat Dose: 2,001 mg/kg |
| | | <u>Acute inhalation toxicity</u> : LC50 rat |

Dose: 364 mg/l
Exposure time: 4 h

Skin irritation: Repeated or prolonged exposure may cause skin irritation and dermatitis, due to degreasing properties of the product.

Eye irritation: Classification: Irritating to eyes.
Result: Mild eye irritation

Heptane [and isomers] 142-82-5

Acute oral toxicity: LD50 rat
Dose: 15,001 mg/kg

Acute inhalation toxicity: LC50 rat
Dose: 103 g/m3
Exposure time: 4 h

Skin irritation: Classification: Irritating to skin.
Result: Skin irritation
Repeated or prolonged exposure may cause skin irritation and dermatitis, due to degreasing properties of the product.

Eye irritation: Classification: Irritating to eyes.
Result: Mild eye irritation

Ethylbenzene 100-41-4

Acute oral toxicity: LD50 rat
Dose: 3,500 mg/kg

Acute dermal toxicity: LD50 rabbit
Dose: 15,500 mg/kg

Acute inhalation toxicity: LC50 rat
Dose: 18 mg/l
Exposure time: 4 h

Skin irritation: Classification: Irritating to skin.
Result: Mild skin irritation

Eye irritation: Classification: Irritating to eyes.
Result: Risk of serious damage to eyes.

Benzene 71-43-2

Acute oral toxicity: LD50 rat
Dose: 930 mg/kg

Acute inhalation toxicity: LC50 rat
Dose: 44 mg/l
Exposure time: 4 h

Skin irritation: Classification: Irritating to skin.
Result: Mild skin irritation
Repeated or prolonged exposure may cause skin irritation and dermatitis, due to degreasing properties of the product.

Eye irritation: Classification: Irritating to eyes.
Result: Risk of serious damage to eyes.

1,2,4-Trimethylbenzene 95-63-6

Acute inhalation toxicity: LC50 rat
Dose: 18 mg/l
Exposure time: 4 h

Skin irritation: Classification: Irritating to skin.
Result: Skin irritation

Eye irritation: Classification: Irritating to eyes.
Result: Eye irritation

| | | |
|--------|-----------|---|
| Sulfur | 7704-34-9 | <u>Acute oral toxicity</u> : LD50 rat |
| | | Dose: 5,001 mg/kg |
| | | <u>Acute dermal toxicity</u> : LD50 rabbit |
| | | Dose: 2,001 mg/kg |
| | | <u>Acute inhalation toxicity</u> : LC50 rat |
| | | Dose: 9.24 mg/l |
| | | Exposure time: 4 h |
| | | <u>Eye irritation</u> : Classification: Irritating to eyes. |
| | | Result: Mild eye irritation |

SECTION 12. ECOLOGICAL INFORMATION

Additional ecological information : Keep out of sewers, drainage areas, and waterways. Report spills and releases, as applicable, under Federal and State regulations.

Component:

| | | |
|-----------------------|----------|---|
| N-hexane | 110-54-3 | <u>Toxicity to fish</u> : |
| | | LC50 |
| | | Species: Pimephales promelas (fathead minnow) |
| | | Dose: 2.5 mg/l |
| | | Exposure time: 96 h |
| | | <u>Acute and prolonged toxicity for aquatic invertebrates</u> : |
| | | EC50 |
| | | Species: Daphnia magna (Water flea) |
| | | Dose: 2.1 mg/l |
| | | Exposure time: 48 h |
| Toluene | 108-88-3 | <u>Toxicity to fish</u> : |
| | | LC50 |
| | | Species: Carassius auratus (goldfish) |
| | | Dose: 13 mg/l |
| | | Exposure time: 96 h |
| | | <u>Acute and prolonged toxicity for aquatic invertebrates</u> : |
| | | EC50 |
| | | Species: Daphnia magna (Water flea) |
| | | Dose: 11.5 mg/l |
| | | Exposure time: 48 h |
| | | <u>Toxicity to algae</u> : |
| | | IC50 |
| | | Species: Selenastrum capricornutum (green algae) |
| | | Dose: 12 mg/l |
| | | Exposure time: 72 h |
| Cyclohexane | 110-82-7 | <u>Acute and prolonged toxicity for aquatic invertebrates</u> : |
| | | EC50 |
| | | Species: Daphnia magna (Water flea) |
| | | Dose: 3.78 mg/l |
| | | Exposure time: 48 h |
| Pentane | 109-66-0 | <u>Acute and prolonged toxicity for aquatic invertebrates</u> : |
| | | EC50 |
| | | Species: Daphnia magna (Water flea) |
| | | Dose: 9.74 mg/l |
| | | Exposure time: 48 h |
| Heptane [and isomers] | 142-82-5 | <u>Toxicity to fish</u> : |
| | | LC50 |
| | | Species: Carassius auratus (goldfish) |
| | | Dose: 4 mg/l |
| | | Exposure time: 24 h |

Acute and prolonged toxicity for aquatic invertebrates:

EC50
Species: Daphnia magna (Water flea)
Dose: 1.5 mg/l
Exposure time: 48 h

1,2,4-Trimethylbenzene 95-63-6

Toxicity to fish:

LC50
Species: Pimephales promelas (fathead minnow)
Dose: 7.72 mg/l
Exposure time: 96 h

Acute and prolonged toxicity for aquatic invertebrates:

EC50
Species: Daphnia
Dose: 3.6 mg/l
Exposure time: 48 h

Sulfur 7704-34-9

Acute and prolonged toxicity for aquatic invertebrates:

EC0
Species: Daphnia magna (Water flea)
Dose: > 10,000 mg/l
Exposure time: 24 h

SECTION 13. DISPOSAL CONSIDERATIONS

Disposal : Dispose of container and unused contents in accordance with federal, state and local requirements.

SECTION 14. TRANSPORT INFORMATION

CFR

Proper shipping name : PETROLEUM DISTILLATES, N.O.S.
UN-No. : 1268
Class : 3
Packing group : II
Hazard inducer : (Naphtha; Low boiling point naphtha)

TDG

Proper shipping name : PETROLEUM DISTILLATES, N.O.S.
UN-No. : UN1268
Class : 3
Packing group : II
Hazard inducer : (Naphtha; Low boiling point naphtha)

IATA Cargo Transport

UN UN-No. : UN1268
Description of the goods : PETROLEUM DISTILLATES, N.O.S.
(Naphtha; Low boiling point naphtha)
Class : 3
Packaging group : II
ICAO-Labels : 3
Packing instruction (cargo aircraft) : 364
Packing instruction (cargo aircraft) : Y341

IATA Passenger Transport

| | |
|---|---|
| UN UN-No. | : UN1268 |
| Description of the goods | : PETROLEUM DISTILLATES, N.O.S. (Naphtha; Low boiling point naphtha) |
| Class | : 3 |
| Packaging group | : II |
| ICAO-Labels | : 3 |
| Packing instruction (passenger aircraft) | : 353 |
| Packing instruction (passenger aircraft) | : Y341 |

IMDG-Code

| | |
|--------------------------|---|
| UN-No. | : UN 1268 |
| Description of the goods | : PETROLEUM DISTILLATES, N.O.S. (Naphtha; Low boiling point naphtha) |
| Class | : 3 |
| Packaging group | : II |
| IMDG-Labels | : 3 |
| EmS Number | : F-E S-E |
| Marine pollutant | : No |

SECTION 15. REGULATORY INFORMATION

| | |
|--------------|--|
| OSHA Hazards | : Flammable liquid Moderate skin irritant Severe eye irritant Carcinogen Teratogen |
|--------------|--|

| | |
|-------------|---------------------|
| TSCA Status | : On TSCA Inventory |
|-------------|---------------------|

| | |
|------------|--|
| DSL Status | : All components of this product are on the Canadian DSL list. |
|------------|--|

| | |
|----------------------|---|
| SARA 311/312 Hazards | : Fire Hazard Acute Health Hazard Chronic Health Hazard |
|----------------------|---|

| | |
|----------|--|
| SARA III | US. EPA Emergency Planning and Community Right-To-Know Act (EPCRA) SARA Title III Section 313 Toxic Chemicals (40 CFR 372.65) - Supplier Notification Required |
|----------|--|

| <u>Components</u> | <u>CAS-No.</u> |
|-------------------------------|----------------|
| 1,2,4-Trimethylbenzene | 95-63-6 |
| Benzene | 71-43-2 |
| Ethylbenzene | 100-41-4 |
| Cyclohexane | 110-82-7 |
| Toluene | 108-88-3 |
| N-hexane | 110-54-3 |
| Xylene | 1330-20-7 |

| | |
|----------|---|
| PENN RTK | US. Pennsylvania Worker and Community Right-to-Know Law (34 Pa. Code Chap. 301-323) |
|----------|---|

| <u>Components</u> | <u>CAS-No.</u> |
|------------------------------------|----------------|
| Heptane [and isomers] | 142-82-5 |
| Ethylbenzene | 100-41-4 |
| Benzene | 71-43-2 |
| 1,2,4-Trimethylbenzene | 95-63-6 |
| Sulfur | 7704-34-9 |
| Pentane | 109-66-0 |
| Naphtha; Low boiling point naphtha | 8030-30-6 |
| Xylene | 1330-20-7 |
| N-hexane | 110-54-3 |
| Toluene | 108-88-3 |
| Cyclohexane | 110-82-7 |

MASS RTK

US. Massachusetts Commonwealth's Right-to-Know Law (Appendix A to 105 Code of Massachusetts Regulations Section 670.000)

| <u>Components</u> | <u>CAS-No.</u> |
|------------------------------------|----------------|
| Heptane [and isomers] | 142-82-5 |
| Ethylbenzene | 100-41-4 |
| Benzene | 71-43-2 |
| 1,2,4-Trimethylbenzene | 95-63-6 |
| Sulfur | 7704-34-9 |
| Naphtha; Low boiling point naphtha | 8030-30-6 |
| Xylene | 1330-20-7 |
| N-hexane | 110-54-3 |
| Toluene | 108-88-3 |
| Cyclohexane | 110-82-7 |

NJ RTK

US. New Jersey Worker and Community Right-to-Know Act (New Jersey Statute Annotated Section 34:5A-5)

| <u>Components</u> | <u>CAS-No.</u> |
|------------------------------------|----------------|
| Heptane [and isomers] | 142-82-5 |
| Ethylbenzene | 100-41-4 |
| Benzene | 71-43-2 |
| 1,2,4-Trimethylbenzene | 95-63-6 |
| Sulfur | 7704-34-9 |
| Naphtha; Low boiling point naphtha | 8030-30-6 |
| Xylene | 1330-20-7 |
| N-hexane | 110-54-3 |

Toluene 108-88-3

Cyclohexane 110-82-7

CERCLA SECTION 103 and SARA SECTION 304 (RELEASE TO THE ENVIRONMENT)

The CERCLA definition of hazardous substances contains a "petroleum exclusion" clause which exempts crude oil. Fractions of crude oil, and products (both finished and intermediate) from the crude oil refining process and any indigenous components of such from the CERCLA Section 103 reporting requirements. However, other federal reporting requirements, including SARA Section 304, as well as the Clean Water Act may still apply.

California Prop. 65 : WARNING! This product contains a chemical known to the State of California to cause cancer.

Ethylbenzene 100-41-4

Benzene 71-43-2

WARNING! This product contains a chemical known to the State of California to cause birth defects or other reproductive harm.

Toluene 108-88-3

Benzene 71-43-2

SECTION 16. OTHER INFORMATION

Further information

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

Template : GWU mbH
Prepared by Birkenbacher Str. 18
D-57078 Siegen
Germany
Telephone: +49-(0)271-88072-0

Revision Date : 01/27/2011

79, 80, 81, 83, 165, 264, 318, 1017, 1018, 1019, 1020, 1021, 1027, 1032, 1055, 1136, 1716

DILUTED BITUMEN

BACKGROUND ON DILUTED BITUMEN

One of the types of crude oil derived from the Canadian oil sands is bitumen, a heavy, sour oil. Bitumen would not flow through a pipeline efficiently, so it is mixed with diluents to be ready for pipeline transportation as diluted bitumen, or ‘dilbit.’ Diluents are usually natural gas condensate, naphtha or a mix of other light hydrocarbons.

Bitumen is a mixture of heavy oil, sand, clay and water. It is separated from the sand and water in a centrifuge prior to dilution for transportation.

CORROSIVITY OF DILUTED BITUMEN COMPARED TO OTHER CRUDE OILS

Diluted bitumen is no more corrosive in pipelines than other heavy crude oils. Diluted bitumen has characteristics similar to other heavy crude oils, such as those produced in Venezuela, Mexico, and California, which have been transported and refined in U.S. pipelines for decades.

The corrosivity of a crude oil type can be measured against other crude oils by the presence of sand and other sediments, sulfur, and salt. The Battelle Memorial Institute (Battelle) developed a pipeline oil comparison index (POCI) assessing seven types of diluted bitumen from Canada against heavy sour crudes from Canada, Mexico, and Colombia.

Corrosivity statistics of several types of diluted bitumen derived from the Canadian oil sands were compared against those of many other crude oils by Battelle, at the request of API. Six of the seven Canadian diluted bitumen crudes had a lower corrosivity than a blend of Western Canadian Blend, a conventional crude. All seven of the Canadian diluted bitumen crudes had a lower corrosivity than Mexican Maya crude and Colombian crude from the Rubiales Oil Field, which have been transported by U.S. pipelines for more than 40 years.

Corrosion experts support these facts and do not believe that diluted bitumen poses a unique threat to pipelines. In a recent statement, Oliver Moghissi, President of NACE International, said:

“Corrosivity of diluted bitumen is largely similar to crude oil, which is considered to be low. In addition, the threat of corrosion from diluted bitumen can be managed by conventional engineering practice in the same way as crude oil.”

Testing and studies conducted by Alberta Innovates, ASTM International (an internationally recognized testing and materials organization), and, most recently, Penspen (an English pipeline integrity engineering firm) all support the conclusion that diluted bitumen is not more corrosive than other crude oils.

PRODUCT SPECIFICATIONS FOR CRUDE OILS TRANSPORTED IN PIPELINES

Sediments, such as sand, can contribute to corrosion in a pipeline, as can water. Like other crude oils, diluted bitumen must meet standard product quality specifications for sediment and water content in Federal Energy Regulatory Commission (FERC) tariffs. Generally, these FERC tariffs prohibit crude oil from containing more than 0.5% of sediments and water. Tariffs are agreements between pipeline operators and pipeline customers, referred to as “shippers”, and are enforceable by FERC. Product specifications in FERC tariffs and other agreements protect shippers, including refinery customers that might receive the crude oil, and pipeline operators.

To verify product quality, pipeline operators take samples of incoming batches before accepting products for shipment. Operators also take samples during transit. Pipeline operators are responsible to deliver agreed-upon batch quality to the destination refinery.

PHMSA regulations require that pipeline operators have a corrosion management program in place for their pipelines. This includes consideration of the use of corrosion inhibitors and cleaning pigs to reduce the likelihood of internal corrosion in pipelines. These measures are especially important in pipelines where there is not turbulent flow, which keeps water and sediment which are common in crude oils from settling and promoting corrosion.

THE SAFETY RECORD OF TRANSPORTING DILUTED BITUMEN BY PIPELINE

Diluted bitumen has been transported safely in the U.S. for more than 40 years. PHMSA accident reports since 2002 show zero internal corrosion-related releases from pipelines carrying diluted bitumen.¹ Also, there are no known examples before 2002 of corrosion-caused failures on U.S. pipelines carrying diluted bitumen.

Statistics in Alberta also show no signs of additional corrosivity. The Alberta Energy Resources Conservation Board (ERCB) reported:

“Analysis of pipeline failure statistics in Alberta has not identified any significant differences in failure frequency between pipelines handling conventional crude versus pipelines carrying crude bitumen, crude oil or synthetic crude oil.”

The ERCB further noted that it is inappropriate to compare releases in Alberta’s data, where there is no reporting threshold, to PHMSA’s U.S. data, with a 5 barrel threshold.

PIPELINE PRESSURE AND DILUTED BITUMEN

Diluted bitumen is transported at comparable pipeline pressures as other heavy crude oils. All U.S. pipelines must operate under Maximum Operating Pressure requirements administered by PHMSA. Any pipeline operator seeking to transport crude oil at a higher pressure than other operators is choosing to do so for commercial reasons, and must comply with Maximum Operating Pressure determinations made by assessing the strength of the pipe.

TEMPERATURE OF DILUTED BITUMEN DURING PIPELINE TRANSPORTATION

Diluted bitumen is not heated for transportation in pipelines above the temperature of other crude oils. Any heating of the bitumen during the time it is processed into diluted bitumen terminates after the processing is complete. Diluted bitumen cools long before it is inserted into a pipeline for transportation. The range of temperatures for all crude oils from Canada is 40-135 degrees Fahrenheit. The temperature of crude can increase as it moves down a pipeline, especially just downstream of pumping stations, due to the extra energy imparted by pumps. The American Society of Mechanical Engineers (ASME) Code for *Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids* (ASME B31.4) does not consider pipeline temperatures to be elevated unless they exceed 150 degrees Fahrenheit. Much has been made about how increased temperatures in pipelines might increase the corrosivity of acids in crude, however, “[t]otal acid concentrations are a parameter that is important under refinery conditions where the product is exposed to temperatures in excess of 240C [464F]. It cannot be used to assess the likelihood of corrosion occurring in a transmission pipeline.”²

PIPELINE ECONOMICS SUPPORT MANAGING CORROSIVITY OF CRUDE OIL

Pipelines are very expensive to build, and are intended to have long useful lives. It would not be logical to place any commodity in the pipeline that would put that investment at risk.

¹ The review of PHMSA accident reports covers a period between 2002, when PHMSA accident reports became more comprehensive, and mid-2012.

² Penspen Integrity. *Dilbit Corrosivity*, February 2013, p. 35.

49-41B-22. Applicant's burden of proof. The applicant has the burden of proof to establish that:

- (1) The proposed facility will comply with all applicable laws and rules;
- (2) The facility will not pose a threat of serious injury to the environment nor to the social and economic condition of inhabitants or expected inhabitants in the siting area;
- (3) The facility will not substantially impair the health, safety or welfare of the inhabitants; and
- (4) The facility will not unduly interfere with the orderly development of the region with due consideration having been given the views of governing bodies of affected local units of government.

Source: SL 1977, ch 390, § 17; SL 1981, ch 340, § 3; SL 1991, ch 386, § 6.

Cindy43 - <http://goo.gl/0GxqoM> - Video interview of TransCanada's
Jeff Rauh and Andrew Craig

This video is located at: - <http://goo.gl/0GxqoM>

**IN THE MATTER OF THE PETITION
OF TRANSCANADA KEYSTONE
PIPELINE, LP FOR ORDER
ACCEPTING CERTIFICATION OF
PERMIT ISSUED IN DOCKET HP09-
001 TO CONSTRUCT THE KEYSTONE
XL PIPELINE**

**STAFF'S RESPONSE TO
INTERROGATORIES AND REQUESTS
FOR PRODUCTION OF DOCUMENTS
FROM CINDY MYERS, R.N.**

HP14-001

Edwards, and hereby provides the following response to Cindy Myers, R.N.'s Interrogatories and Requests for Production of Documents.

Kurt Lueders

022572

1-1) As a health professional, I'm concerned about the health community being educated and prepared to treat people adversely affected from tar sands spills. I've requested a copy of TransCanada's Emergency Response Plan to identify specific components of medical emergency response planning. This information was not divulged. How may I obtain a copy of the emergency health plan? If this hasn't been completed for KXL, would it be possible to obtain a copy of the ERP for Keystone I?

Who is responsible for emergency medical response planning in the situation of spillage from TransCanada's KXL project?

Response: OBJECTION. Staff objects to this question on the grounds that it attempts to shift the burden from the company to staff, as well as on the grounds that it attempts to shift the regulatory burden from the federal government to commission staff for the purpose of inspecting Emergency Response Plans of an interstate pipeline.

Subject to and without waiving its objection, staff provides the following answer. It is staff's understanding that the Emergency Response Plan is not completed until close to the time a pipeline is ready to begin operations. All information submitted to the PUC regarding Keystone I's ERP is available in 7.0 of the company's Quarterly Report. For the last Quarterly Report filed by TransCanada for Keystone I, view the report at

<http://www.puc.sd.gov/commission/dockets/HydrocarbonPipeline/2007/HP07-001/4thquarterly2010.pdf>.

Additionally, the final version of the Keystone Pipeline Emergency Response Plan will be amended to include Keystone XL. A redacted version of the ERP is available in Appendix I of the Final Supplemental Environmental Impact Study, which is publicly available. The company may choose to redact information for public viewing due to the sensitive nature of the information contained in the ERP.

1-2) Re. Amended Permit Condition #40: According to TransCanada, the SD PUC made the decision to designate the concern of BTEX being hazardous if polyethylene and PVC water pipe is being used near this compound of chemicals. Is this correct? How was it decided that residents could request for their water piping to be changed if they lived within 500 feet of the project? How come this idea was not mandatory, and instead only at the request of the landowner?

Response: OBJECTION. This question calls for a legal opinion from the commission, which Staff is unable to provide. Staff is unable to answer for the commission, as Staff is separate from the commissioners, who are the decision-makers in the process.

1-3) I understand that that TransCanada must obtain permits from the US Army Corps of Engineers before crossing water bodies with their project. Does the US Army Corps of Engineers document studies of benzene migration in water before granting these permits? Does the Army Corps of Engineers rely on the FSEIS for this information? Who will be enforcing the Clean Water Act regulations re. this project?

Response: OBJECTION. This question attempts to shift the regulatory burden from the US Army Corps of Engineers to PUC staff. Furthermore, this information is more appropriately sought from the company or from the US Army Corps of Engineers. Subject to and without waiving its objection, staff provides the following answer.

It is staff's understanding that TransCanada has not submitted any permit applications to the US Army Corps of Engineers. As such, staff does not have any information as to what information would be analyzed should the company apply for a permit.

Enforcement of the Clean Water Act does not fall under the PUC's purview, and therefore, will not be responsible for enforcing the Clean Water Act. It is Staff's understanding that enforcement of the Clean Water Act would be done by the SD DENR and the EPA.

1-4) How did the PUC determine "the facility will not substantially impair the health, safety or welfare of the inhabitants."?

Response: The Commission made that determination after carefully reviewing all of the evidence in HP09-001. See Amended Final Decision and Order and transcript of formal hearing available online in Docket No. HP09-001. However, in HP09-001, as in this and any proceeding before the Commission, staff is a party to the docket and does not take part in Commission decisions. Therefore, staff has no more information than any other party or member of the public.

1-5) Has the PUC considered that toxins from KXL spillage could migrate via flowing water into public water intakes along the Missouri River? Where can I discover information as to locations of public water intakes along the Missouri River?

Response: Staff would rely on DENR's expert testimony on this matter. Staff has not received this information from DENR as of the due date of these responses. However, Staff will supplement this answer if and when this information is received from Staff's DENR witness.

1-6) Who is responsible for testing water for those expected/undetected leaks? Particularly in Tripp County where the pipeline will be immersed in groundwater?

Response: Staff would rely on DENR's expert testimony on this matter. Staff has not received this information from DENR as of the due date of these responses. However, Staff will supplement this answer if and when this information is received from Staff's DENR witness.

1-7) If high consequence areas are kept confidential by TransCanada, how can residents be assured of their safety? I feel residents are entitled to know this information.

Response: Similar to the ERP, the Integrity Management Plan could also contain sensitive information that the company may choose to keep confidential. The HCAs per se are not confidential, but TransCanada could be choosing to keep confidential the locations of the sections of pipe that have the ability to impact an HCA due to the sensitive nature of the information. Per code, an HCA is defined as:

- (1) A commercially navigable waterway, which means a waterway where a substantial likelihood of commercial navigation exists;
- (2) A high population area, which means an urbanized area, as defined and delineated by the Census Bureau, that contains 50,000 or more people and has a population density of at least 1,000 people per square mile;
- (3) An other populated area, which means a place, as defined and delineated by the Census Bureau, that contains a concentrated population, such as an incorporated or unincorporated city, town, village, or other designated residential or commercial area;
- (4) An unusually sensitive area, as defined in §195.6.

This information is readily available on census bureau websites and other sources.

1-8) What actions has the PUC taken to assure the South Dakota Health Care Community has been educated and trained to treat patients adversely affected from KXL spillage? Has there been communication with IHS and other health centers in SD?

Response: OBJECTION. This question attempts to shift the regulatory burden from DENR and the federal government, specifically the EPA or PHMSA, to Staff. This information is covered by the Emergency Response Plan, which is under the jurisdiction of the aforementioned agencies.

1-9) What education and training has been completed for SD public water treatment utilities to prepare them for tar sands spillage into SD waterways?

Response: OBJECTION. This question attempts to shift the burden from the company to Staff. It is the burden of the company to produce this information. Subject to and without waiving its objection, should Staff acquire any information from our experts to answer this question, we may supplement this answer at that time.

1-10) Please explain the reroute in Tripp County. How did the reroute improve safety?

Response: OBJECTION. This question attempts to shift the burden from the company to staff. Subject to and without waiving its objection, staff provides the following answer.

It is staff's understanding that the each route revision in Tripp County was made for the follow reason or reasons:

1. To minimize landowner impacts and reduce crossing of varying terrain features;
2. To minimize constructability and safety concerns with current Interstate 90, Hwy 16, and State Railroad crossings;
3. Per landowner requests to avoid a row of trees and minimize landowner impacts;
4. To minimize multiple creek crossings;
5. To avoid a well and impacts to a fence;
6. To avoid road crossing within a wetland area;
7. To minimize side slope construction;
8. To avoid a well and construction footprint impacts to a fence surrounding a historical site;
9. To avoid a drainage crossing and accommodate a road crossing;
10. To avoid side slop construction and sudden terrain changes;
11. To accommodate pump station design;
12. To accommodate pump station design;
13. To avoid any well impacts;
14. To avoid any well impacts; and
15. To avoid swampy low lying area near a pond.

1-11) What information have you shared with water treatment plants which access the Missouri River about oil spills into the Missouri River or tributaries of the Missouri River?

Response: OBJECTION. This question is outside of the scope of discovery as established by the commission's order, dated, December 17, 2014. Furthermore, water system operators had the opportunity to intervene in this proceeding, as well as HP09-001 if they had concern that their potable water intakes could be adversely impacted by the pipeline. Subject to and without waiving its objection, Staff will provide more information from its DENR witness when such information is received.

1-12) What information about tar sands spills into waterways has TransCanada provided the Department of Environment and Natural Resources?

Response: OBJECTION. This question is outside of the scope of discovery as established by the commission's order, dated, December 17, 2014. This question does not draw from a condition change, as required by the commission Order. Subject to and without waiving its objection, Staff will provide more information from its DENR witness when such information is received.

1-13) What plan do you have in place to respond to tar sands oil spills into the Missouri River or tributaries of the Missouri River?

Response: OBJECTION. This question attempts to shift the regulatory burden from DENR, PHMSA, and the EPA to Staff. The PUC does not have jurisdiction over interstate pipelines and would, therefore, not be involved with spill cleanup. Subject to and without waiving its objection, Staff will provide more information from its DENR witness when such information is received.

1-14) What education and training has been provided to water treatment facilities accessing Missouri River water regarding how to adequately respond to tar sands oil spills into the Missouri River or tributaries of the Missouri River?

Response: OBJECTION. This question attempts to shift the burden from the company to Staff. It is the burden of the company to produce this information. Subject to and without waiving its objection, Staff has asked this question of its DENR witness and will supplement its response if and when that information is received.

1-15) How do you plan to clean up a tar sands spill into the High Plains Aquifer in Tripp County?

Response: The PUC is not involved in cleanup. This would be the responsibility of the company, with the oversight of DENR and the EPA. The company must have a plan, subject to the approval or agreement of DENR and the EPA.

1-16) Describe the experience the State of South Dakota has had using “sparging” to clean up an aquifer. Has “sparging” ever been used to clean tar sands oil product from an aquifer?

Response: This is outside the technical expertise of Staff. Staff does not have knowledge of sparging. Should we acquire such information from one of our experts, Staff may supplement this answer at that time.

Questions from Cindy Myers to PUC Staff

5) Has the PUC considered that toxins from KXL spillage could migrate via flowing water into public water intakes along the Missouri River? Where can I discover information as to locations of public water intakes along the Missouri River?

Information about public water intakes in South Dakota is available on DENR's website at <http://denr.sd.gov/des/dw/sysinfomap.aspx>.

6) Who is responsible for testing water for those expected/undetected leaks? Particularly in Tripp County where the pipeline will be immersed in groundwater?

TransCanada, with regulatory oversight by the U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration (PHMSA), will be responsible for the monitoring and operation of the proposed Keystone XL pipeline throughout South Dakota. PHMSA's construction, operation and monitoring requirements are outlined in the Code of Federal Regulations Title 49, Part 195 – Transportation of Hazardous Liquids by Pipeline.

If the pipeline leaked, South Dakota Codified Law (SDCL) 34A-18 requires crude oil pipeline operators to implement their response plan regardless of who caused the release. DENR has regulatory authority over the assessment and cleanup of pipeline spills and will ensure cleanup continues until all state requirements and standards are met. This would include sampling water supplies to ensure no water supply sources are impacted. If a water supply is impacted, TransCanada would be responsible for mitigating those impacts.

In addition, the federal Safe Drinking Water Act requires public water systems to periodically sample for volatile organic chemicals. Samples are collected by water systems operation specialists and analyzed in a laboratory certified to analyze drinking water samples for volatile organic chemicals. Samples are collected from the entry point to the distribution system at a frequency based on prior detections with all data reported to DENR's Drinking Water Program. If contamination is detected in a water supply above regulatory limits, operators work with DENR to correct the problem and identify the contaminant source.

9) What education and training has been completed for SD public water treatment utilities to prepare them for tar sands spillage into SD waterways?

DENR contracts for water system operation specialist certification training through the South Dakota Association of Rural Water Systems. The certification training includes information and education on emergency response activities resulting from a variety of scenarios including petroleum releases and other contamination events.

In addition, a research project was conducted through South Dakota's Regional Water System Research Consortium titled *Improving Safety of Crude Oil and Regional Water System Pipeline Crossings*. The report findings were presented at several conferences attended by water system

personnel. The study dealt specifically with crude oil pipelines and makes design recommendation for pipeline designs when crossing regional water systems distribution lines. The report is available on the internet at:

<http://www.sdarws.com/PDF/SDRWRC/PipelineCrossingSafetyFinalReport.pdf>

11) What information have you shared with water treatment plants which access the Missouri River about oil spills into the Missouri River or tributaries of the Missouri River?

DENR along with representatives from Iowa, Nebraska, local emergency managers, wildlife experts, EPA Region VII, and industry representatives including TransCanada are all participants in the Siouxland Sub-area Spill Contingency Committee who worked to develop a Siouxland Sub-area Spill Contingency Plan. As part of the implementation of this plan the group holds exercises, training sessions and meetings to discuss response and recovery efforts needed to respond to large oil or chemical releases. The plan addresses potential impacts to water supply intakes and notification procedures in the event of a release.

In addition, if there is a release into the Missouri River DENR's spill program works with the Drinking Water Program to ensure potentially impacted downstream facilities are notified and assisted as needed.

12) What information about tar sands spills into waterways has TransCanada provided the Department of Environment and Natural Resources?

TransCanada has not provided DENR with any specific information about tar sands spills into waterways from the proposed Keystone XL pipeline. However, SDCL 34A-18 requires crude oil pipeline operators to submit an oil spill response plan to DENR prior to operating the pipeline. The plan will address crude oil spills into waterways. DENR expects TransCanada to comply with SDCL 34A-18 prior to placing the Keystone XL pipeline into operation.

In compliance with SDCL 34A-18, TransCanada has provided DENR with an oil spill response plan for the existing Keystone pipeline and has conducted two full-scale spill response exercises in Yankton, SD where the pipeline crosses the Missouri River.

13) What plan do you have in place to respond to tar sands oil spills into the Missouri River or tributaries of the Missouri River?

SDCL 34A-18 requires crude oil pipeline operators to submit their oil spill response plan to DENR for approval and requires crude oil pipeline operators to implement their response plan in the event of a spill regardless of where the spill is or who caused the release.

In the event of a pipeline leak, DENR has regulatory authority over the assessment and cleanup of the spill and will ensure the cleanup continues until all state requirements and standards are met.

If the pipeline company did not respond to a spill, DENR has the authority to take legal action against the company to force their response, and while legal action is pending, has access to state and federal safety net clean up funds that could be used to initiate a response to protect against immediate threats to human health and the environment.

In addition DENR has been involved in the development of the following response plans and procedures which may be implemented in the event of a major crude oil spill: EPA Region VIII Emergency Response Plan, South Dakota Emergency Response Plan, South Dakota Disaster Recovery Plan, DENR Emergency Operations Plan, and DENR's Handbook for Reporting, Investigating, and Remediating Petroleum Releases in South Dakota.

14) What education and training has been provided to water treatment facilities accessing Missouri River water regarding how to adequately respond to tar sands oil spills into the Missouri River or tributaries of the Missouri River?

Education and training associated with spill response and other source water contamination events is included in DENR's contracted system operations specialist training as noted in question #9 above.

15) How do you plan to clean up a tar sands spill into the High Plains Aquifer in Tripp County?

SDCL 34A-18 requires crude oil pipeline operators to submit their oil spill response plan to DENR for approval and requires crude oil pipeline operators to implement their response plan in the event of a spill regardless of where the spill is or who caused the release. If the proposed Keystone XL pipeline leaked into the High Plains aquifer, TransCanada would be responsible for the cleanup.

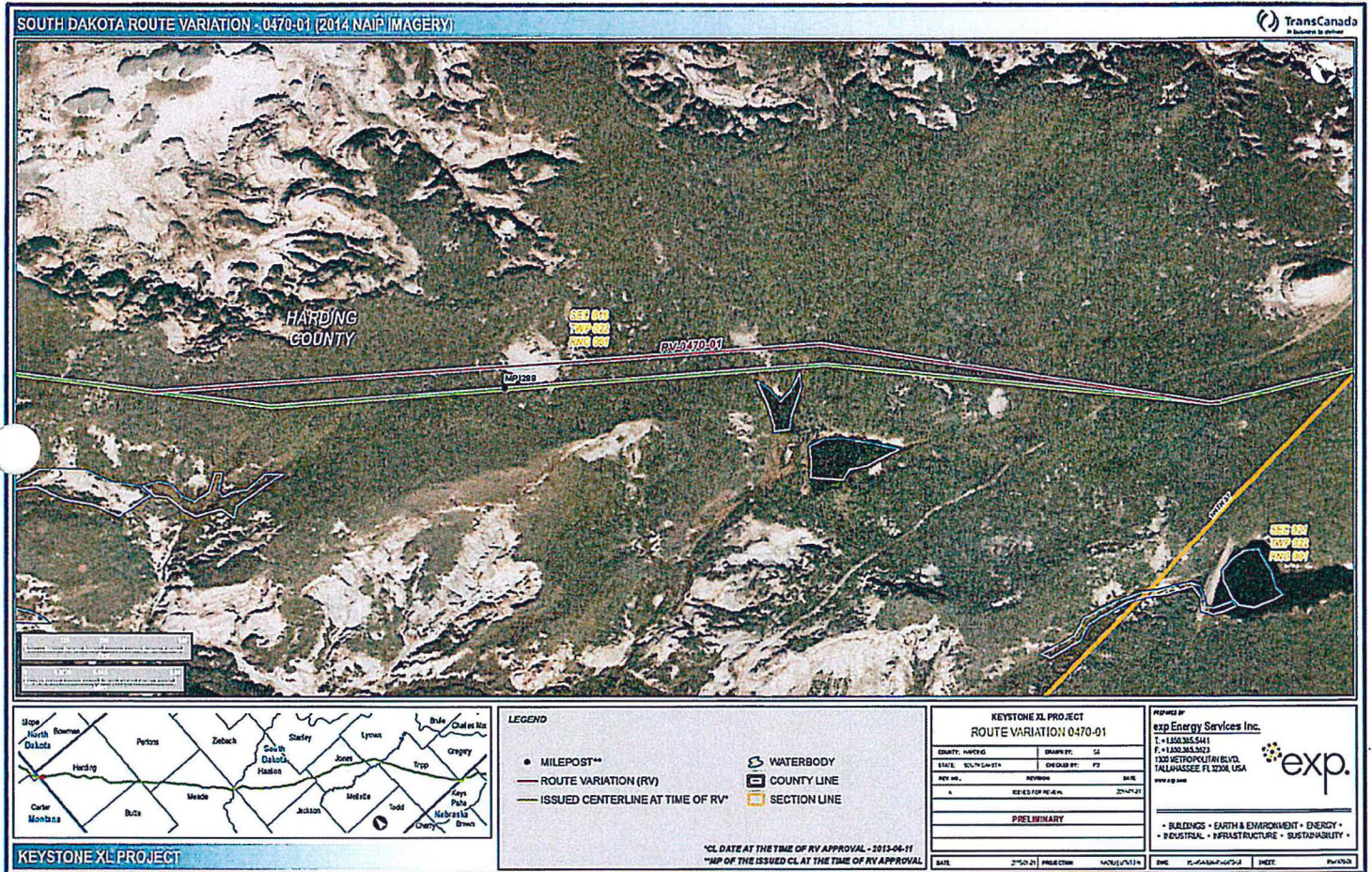
However, DENR has regulatory authority over the assessment and cleanup of the spill and will ensure the cleanup continues until all state requirements and standards are met. In general, required cleanup actions would include: stopping the release, removal of free product, sampling of soil, surface water and groundwater to define the nature and extent of the contamination, design and implementation of cleanup actions to remediate remaining contamination to levels below state standards.

If the pipeline company did not respond to a spill, DENR has the authority to take legal action against the company to force their response, and while legal action is pending, has access to state and federal safety net clean up funds that could be used to initiate a response to protect against immediate threats to human health and the environment.

16) Describe the experience the State of South Dakota has had using "sparging" to clean up an aquifer. Has "sparging" ever been used to clean tar sands oil product from an aquifer?

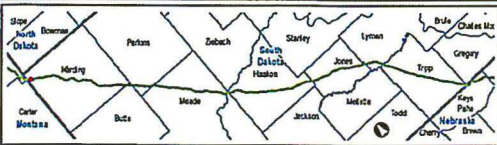
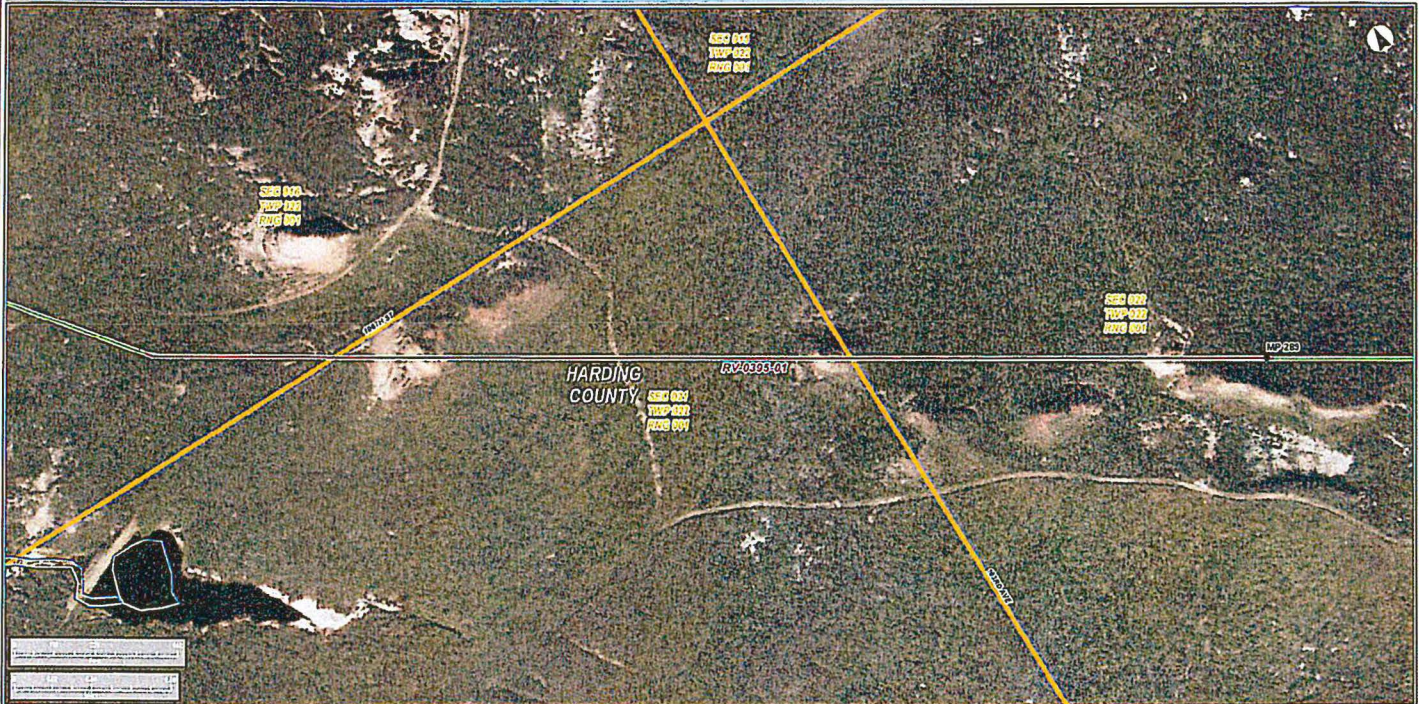
DENR has not used sparging to cleanup a tar sands oil spill in an aquifer because there has not been a tar sands oil spill that has impacted an aquifer in South Dakota. However, DENR staff do

have experience with the installation and operation of soil vapor extraction and sparging systems used to remediate aquifers contaminated with refined petroleum products such as gasoline and diesel fuel.



KEYSTONE 0470

022593



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2013-08-15
**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0395-01

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| COUNTY: HARDING | DRAWN BY: GJ |
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exp Energy Services Inc.
T: +1 303 363 5411
F: +1 303 363 5253
1000 METROPOLITAN BLVD.
DENVER, CO 80202, USA
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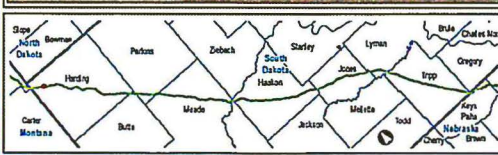


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KEYSTONE XL PROJECT

KEYSTONE 0471

022594



LEGEND

- MILEPOST**
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- ISSUED CENTERLINE AT TIME OF RV*
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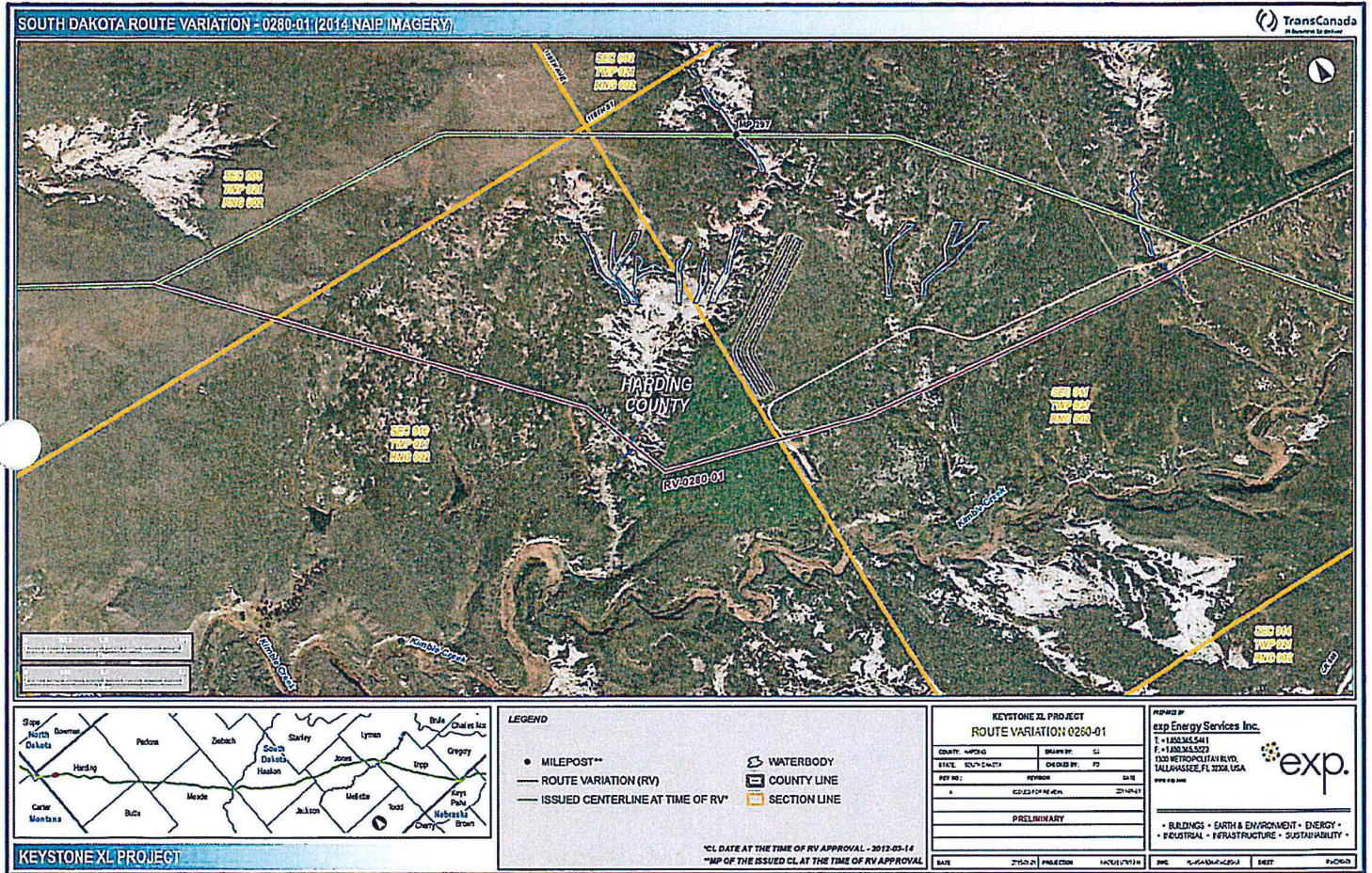
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F: +1.800.363.5413
1000 METROPOLITAN BLVD.
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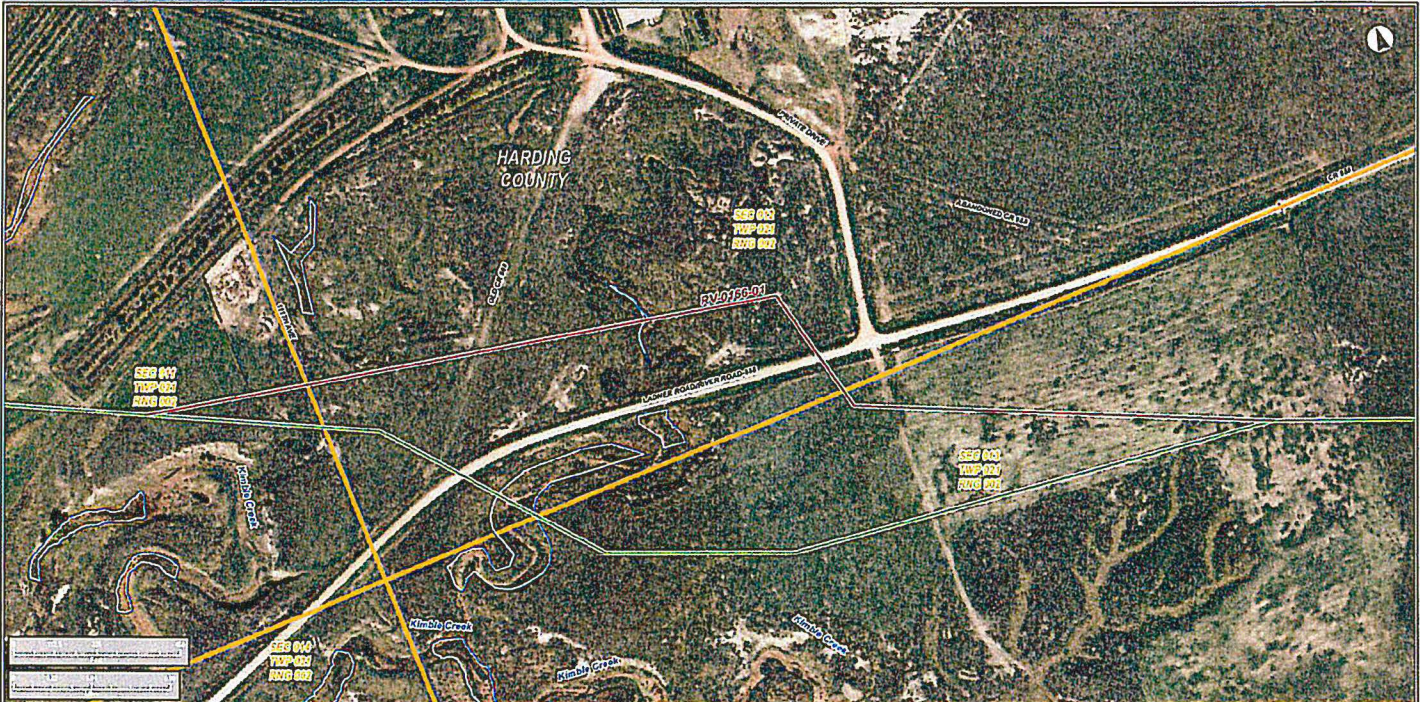


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KEYSTONE 0474

022597



LEGEND

● MILEPOST**

— ROUTE VARIATION (RV)

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WATERBODY

COUNTY LINE

SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2010-03-30

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KEYSTONE XL PROJECT
ROUTE VARIATION 0166-01

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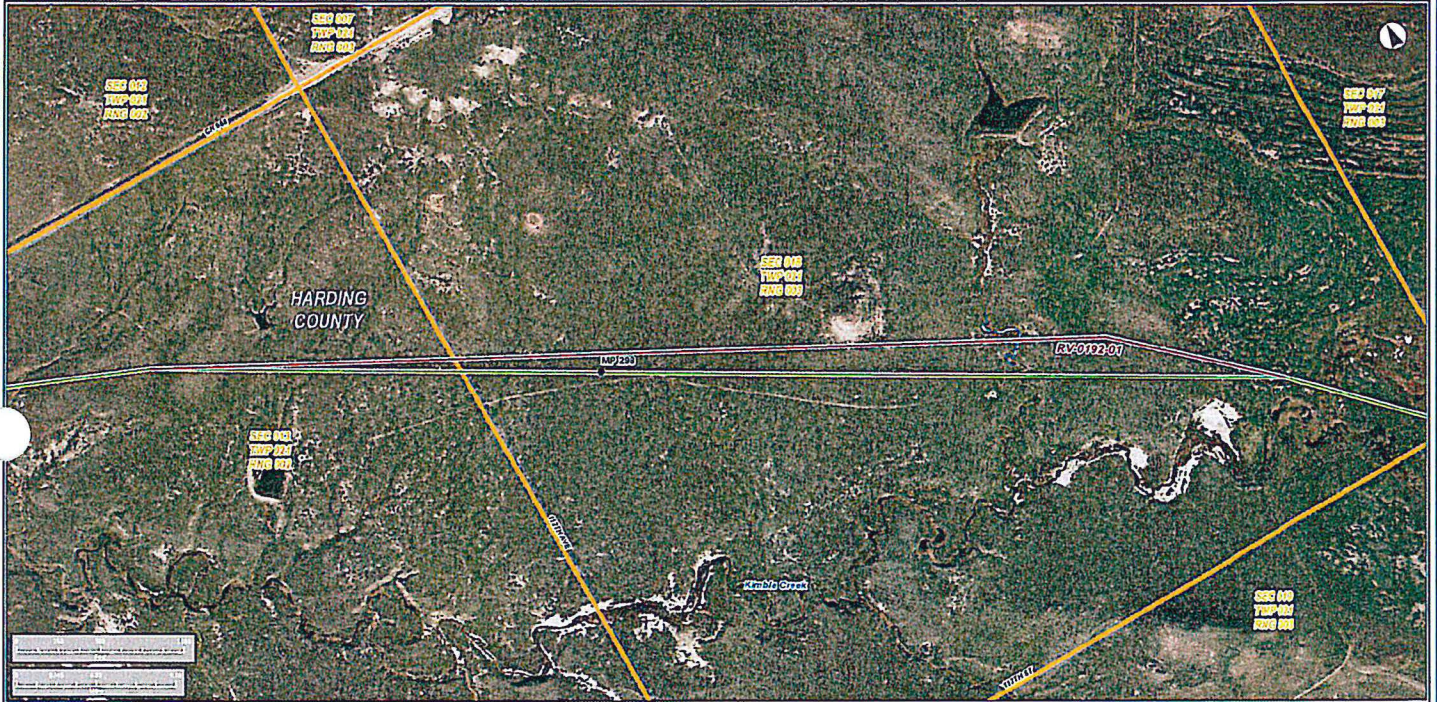
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SOUTH DAKOTA ROUTE VARIATION - 0192-01 (2014 NAIP IMAGERY)

TransCanada
an Enbridge company



LEGEND

- MILEPOST**
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- WATERBODY
- COUNTY LINE
- SECTION LINE

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KEYSTONE XL PROJECT
ROUTE VARIATION 0192-01

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| STATE: SOUTH DAKOTA | CHECKED BY: PJ |
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exp Energy Services Inc.
E: +1.888.345.5441
P: +1.888.345.5441
1320 METROPOLITAN BLVD.
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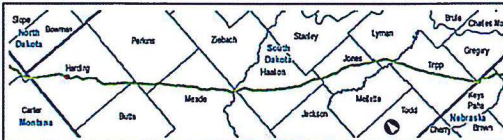
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SOUTH DAKOTA ROUTE VARIATION - 0269-01 (2014 NAIP IMAGERY)

TransCanada
of business to deliver



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- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2012-03-14
**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0269-01

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PREPARED BY
exp Energy Services Inc.
T: +1 800 365 5441
F: +1 800 365 5423
1000 METROPOLITAN BLVD.
TALLAHASSEE, FL 32304, USA
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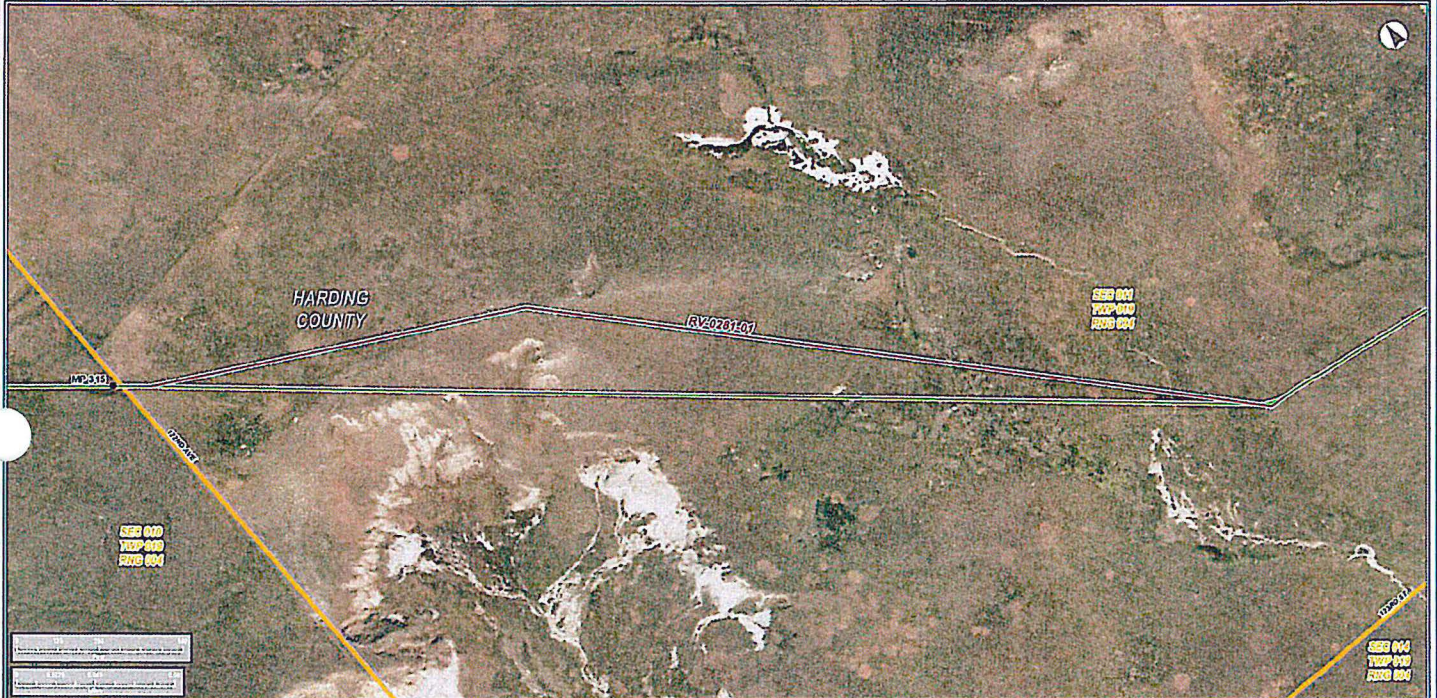
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SOUTH DAKOTA ROUTE VARIATION - 0281-01 (2014 NAIP IMAGERY)

TransCanada
En route à la réussite



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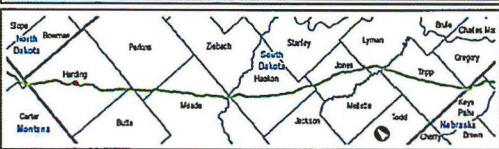
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PROPOSED BY:
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 T: +1 800 345 5411
 F: +1 800 345 5023
 1300 METROPOLITAN BLVD.
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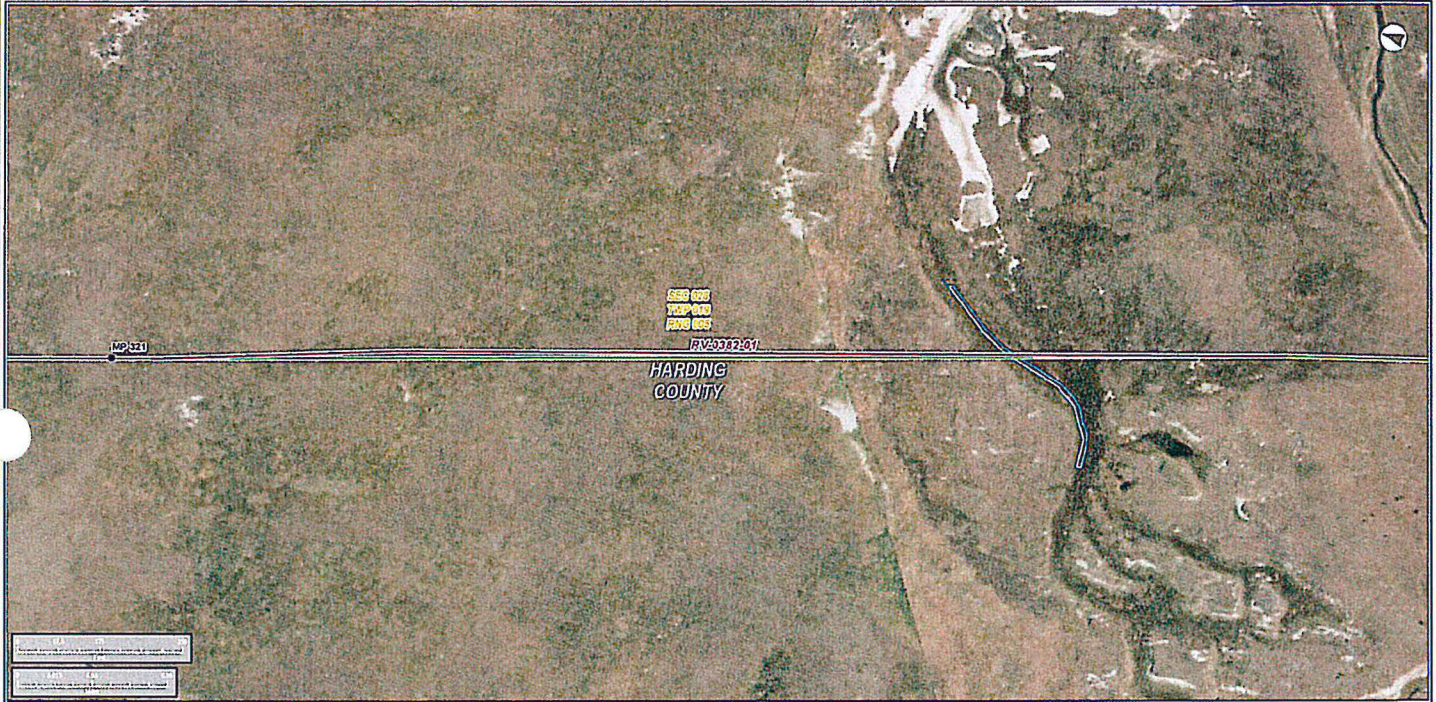
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exp Energy Services Inc.
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SOUTH DAKOTA ROUTE VARIATION - 0382-01 (2014 NAIP IMAGERY)



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KEYSTONE XL PROJECT
 ROUTE VARIATION 0382-01

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PREPARED BY:
exp Energy Services Inc.
 11000 W. 130th St. Suite 5411
 P.O. Box 1300, Omaha, NE 68144
 TALLAHASSEE, FL 32304, USA
 WWW.EXP-ENERGY.COM



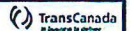
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KEYSTONE XL PROJECT

KEYSTONE 0482

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SOUTH DAKOTA ROUTE VARIATION - 0179-01 (2014 NAIP IMAGERY)



LEGEND

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- WATERBODY
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KEYSTONE XL PROJECT ROUTE VARIATION 0179-01

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| A | ISSUED FOR REVIEW | | 2010-03-28 |
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| DATE | 2010-03-28 | PROJECT | NATURAL GAS |

PROJECT BY
 exp Energy Services Inc.
 T: +1 800 365 5411
 F: +1 800 365 5229
 1330 METROPOLITAN BLVD.
 TALLAHASSEE, FL 32308, USA
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KEYSTONE XL PROJECT

KEYSTONE 0484

022607

SOUTH DAKOTA ROUTE VARIATION - 0527-01 (2014 NAIP IMAGERY)

TransCanada
An Enbridge Company



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2013-06-11
**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0527-01

| | | |
|---------------------|-------------------|-------------------------|
| COUNTY: | GRAND BY: | CL |
| STATE: SOUTH DAKOTA | DESIGNED BY: | PS |
| REV NO: | REVISION: | DATE |
| 1 | ISSUED FOR REVIEW | 2014-01-14 |
| PRELIMINARY | | |
| DATE: | 2/10/2014 | PROJECT NO: 140101/0114 |

PREPARED BY:
exp Energy Services Inc.
T: +1 888 333 5411
F: +1 888 333 5411
1300 METROPOLITAN BLVD.
TALLAHASSEE, FL 32310, USA
www.exp.com

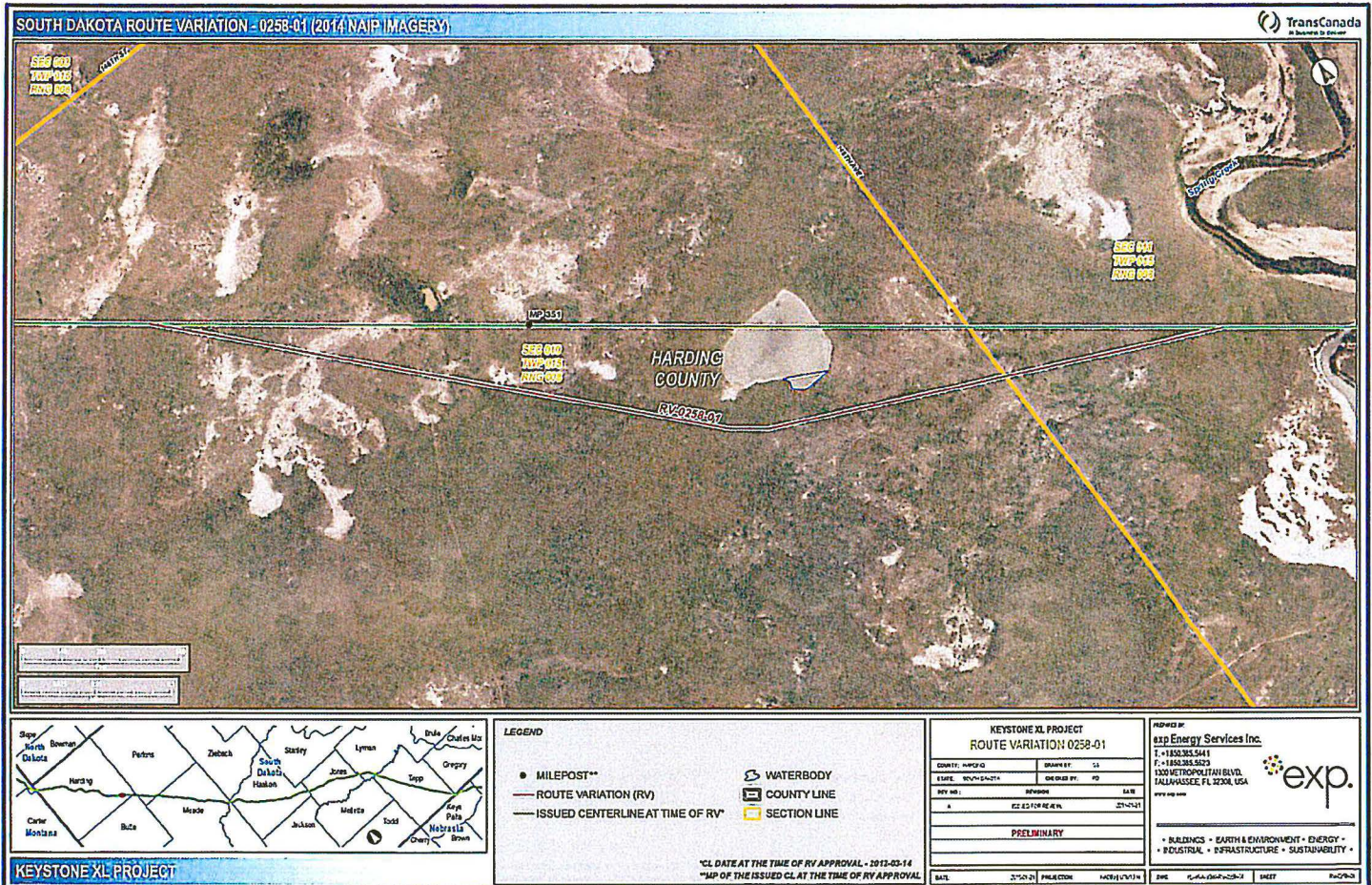
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• INDUSTRIAL • INFRASTRUCTURE • SUSTAINABILITY •

KEYSTONE XL PROJECT

KEYSTONE 0488

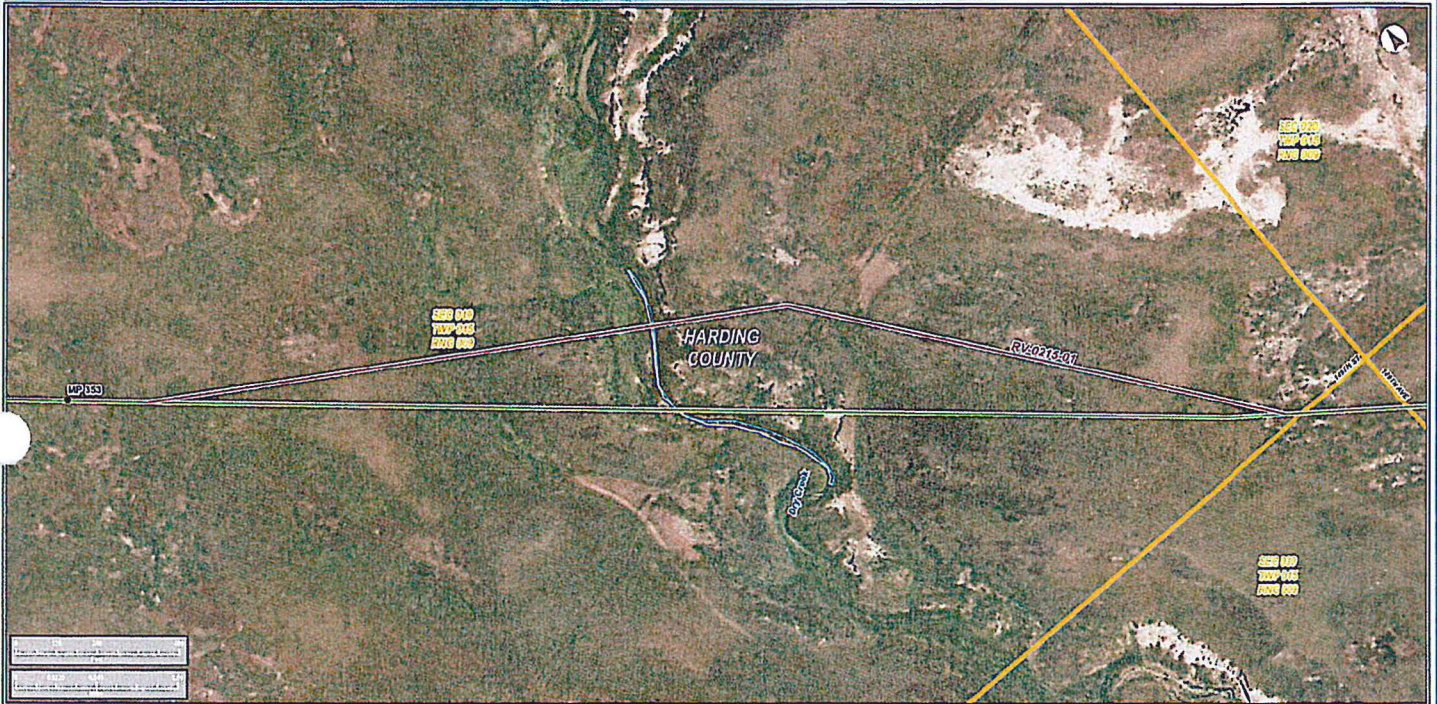
022611



KEYSTONE 0489

022612

SOUTH DAKOTA ROUTE VARIATION - 0215-01 (2014 NAIP IMAGERY)



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2010-11-18
 **MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

| KEYSTONE XL PROJECT | | | |
|-------------------------|-----------------|-----------------------------|-----------------------------|
| ROUTE VARIATION 0215-01 | | | |
| COUNTY: HARTS | DESIGNED BY: SA | DATE: 2/14/14 | REVISED FOR REVIEW: 2/14/14 |
| STATE: SOUTH DAKOTA | DESIGNED BY: PY | DATE: 2/14/14 | REVISED FOR REVIEW: 2/14/14 |
| REVISED BY: PY | DATE: 2/14/14 | REVISED FOR REVIEW: 2/14/14 | REVISED FOR REVIEW: 2/14/14 |
| PRELIMINARY | | | |
| DATE: 2/14/14 | PROJECT: KEYS | DATE: 2/14/14 | DATE: 2/14/14 |

PREPARED BY
exp Energy Services Inc.
 T: +1 888 388 5441
 F: +1 888 388 5442
 1300 METROPOLITAN BLVD.
 TALLAHASSEE, FL 32310, USA
 www.exp.com

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LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2013-03-14
 **MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0291-01

| | |
|---------------------|--------------------|
| COUNTY: HWY0291 | DRAWN BY: JG |
| STATE: SOUTH DAKOTA | DESIGNED BY: JP |
| REV: 00 | REVISION |
| A | REVISED FOR REVIEW |
| DATE | 27-NOV-14 |
| PRELIMINARY | |

PROJW01P
 exp Energy Services Inc.
 T. +1.888.363.5411
 F. +1.888.363.5411
 1000 METROPOLITAN BLVD.
 TALLAHASSEE, FL 32301, USA

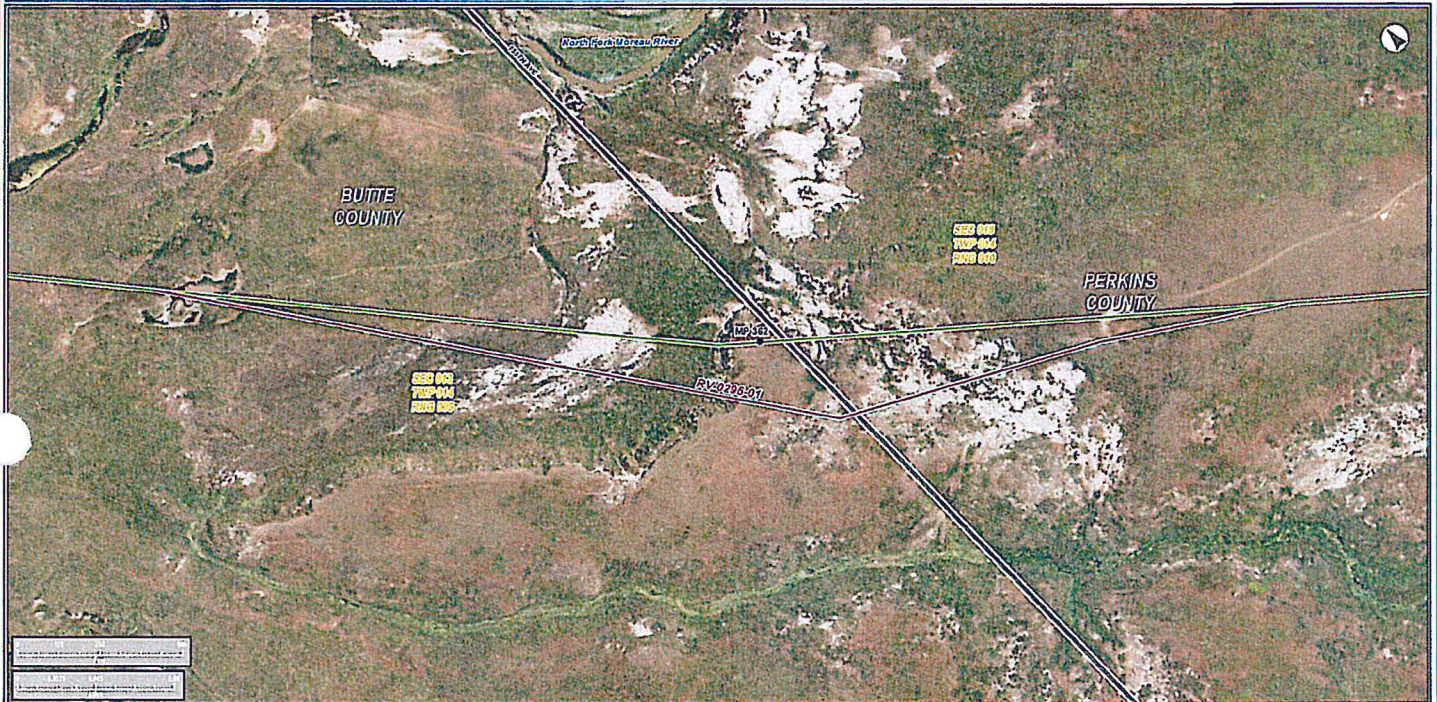


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KEYSTONE XL PROJECT

SOUTH DAKOTA ROUTE VARIATION - 0296-01 (2014 NAIP IMAGERY)

TransCanada
Infrastructure Services



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2012-03-14
**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0296-01

| | |
|-------------------------|-------------------------------|
| COMMITTEE: SOUTH DAKOTA | DESIGNED BY: SA |
| DATE: 2012-03-14 | CHECKED BY: PT |
| REV NO: 1 | REVISION: 2012-03-14 |
| DATE: 2012-03-14 | ISSUED FOR REVIEW: 2012-03-14 |
| PRELIMINARY | |
| DATE: 2012-03-14 | PROJECTION: NAD 83 / UTM 18N |

PREPARED BY
exp Energy Services Inc.
T: +1 888 363 5411
P: +1 888 363 5411
1300 METROPOLITAN BLVD.
TALLAHASSEE, FL 32304, USA
WWW.EXP.ENERGY.COM



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KEYSTONE XL PROJECT

KEYSTONE 0492

022615



KEYSTONE XL PROJECT

LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2013-06-11

**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0514-01

| | |
|---------------------|-----------------|
| COUNTY: HAWKES | DESIGNED BY: JG |
| STATE: SOUTH DAKOTA | CHECKED BY: JS |
| REV NO: | REVISION |
| DATE: | DATE |
| 1 | 02 03/10/10 |
| 2 | 02 03/10/10 |
| 3 | 02 03/10/10 |
| 4 | 02 03/10/10 |
| 5 | 02 03/10/10 |
| 6 | 02 03/10/10 |
| 7 | 02 03/10/10 |
| 8 | 02 03/10/10 |
| 9 | 02 03/10/10 |
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| 13 | 02 03/10/10 |
| 14 | 02 03/10/10 |
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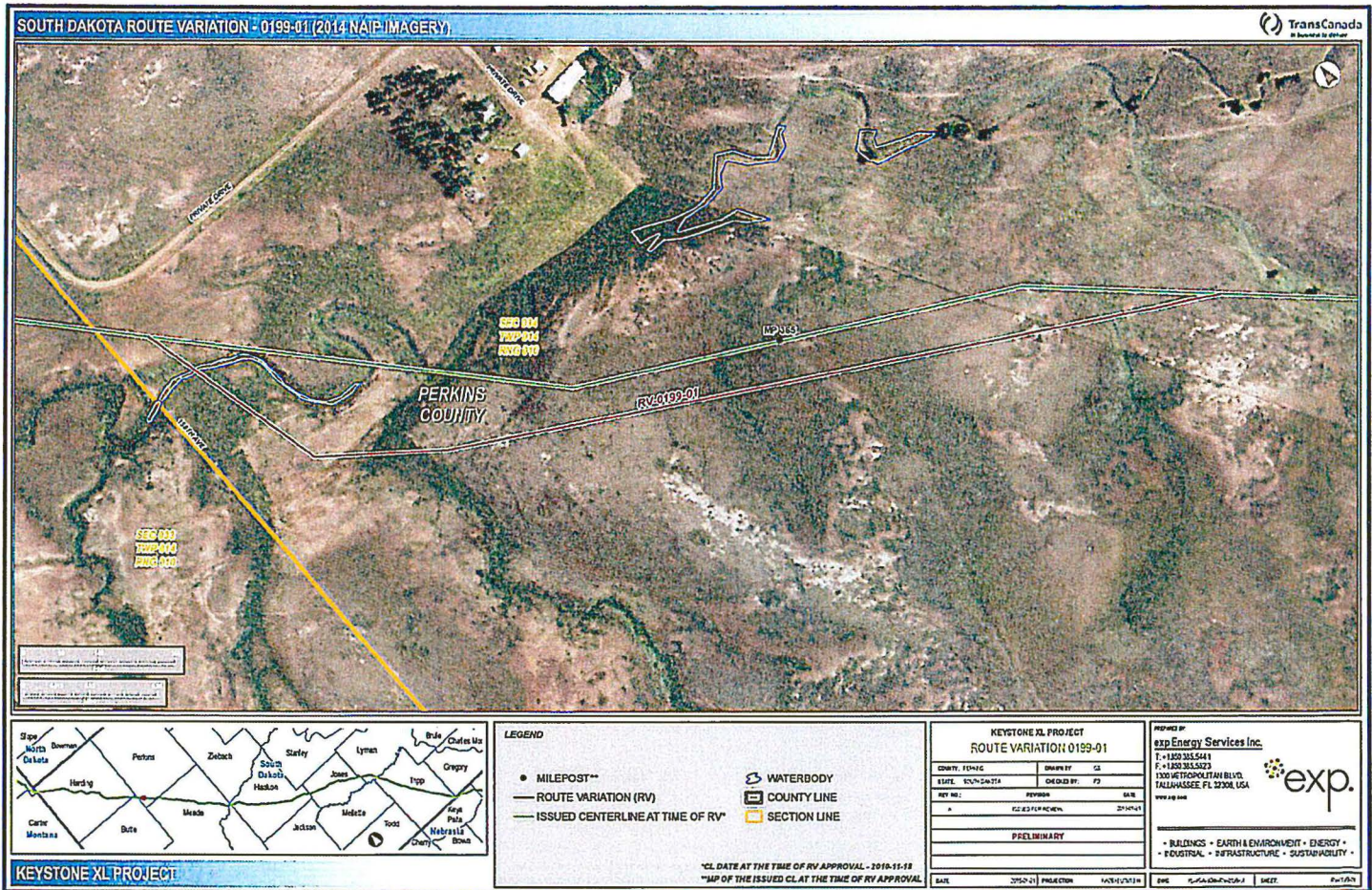
PRELIMINARY

DATE: 2/15/2011 PROJECT: KEYSTONE XL PROJECT SHEET: 0514-01

DESIGNED BY
exp Energy Services Inc.
T: 1-800-385-5411
F: 1-800-385-5123
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TALLAHASSEE, FL 32304, USA
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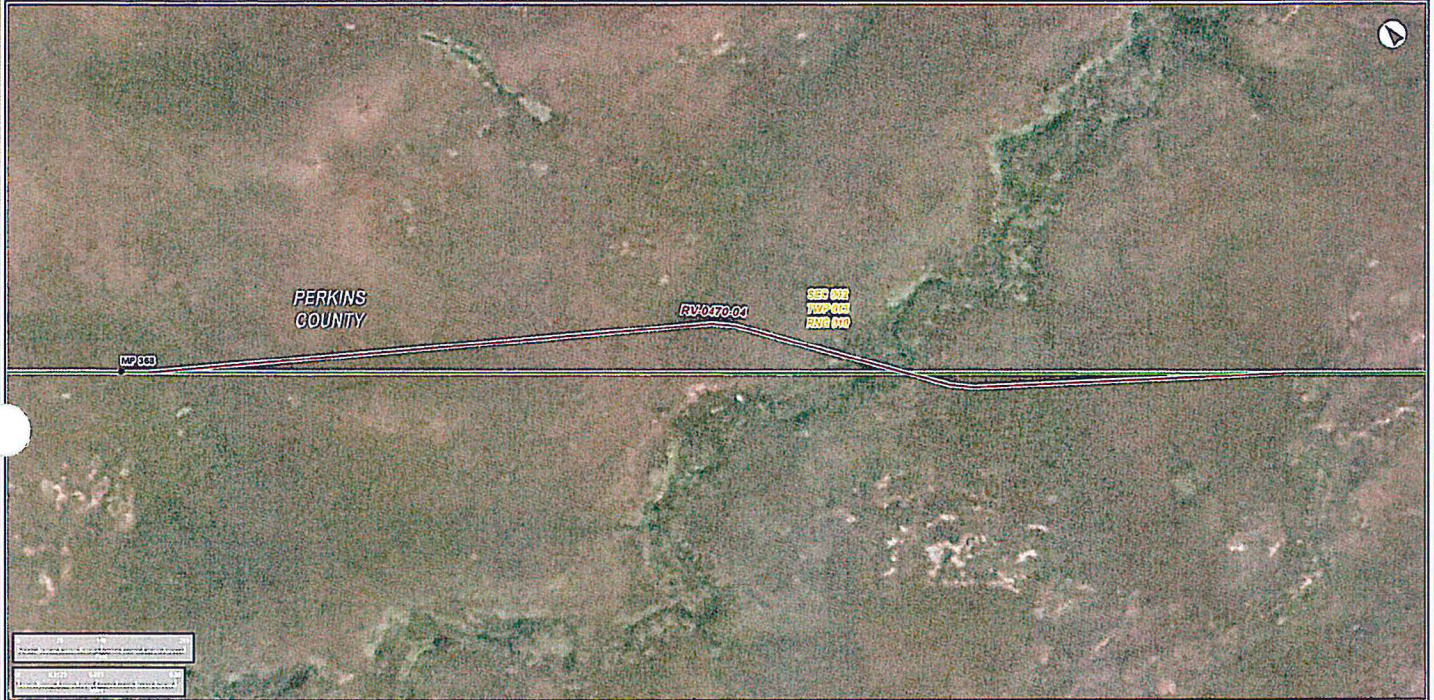


KEYSTONE 0495

022618

SOUTH DAKOTA ROUTE VARIATION - 0470-04 (2014 NAIP IMAGERY)

TransCanada
It takes us to where we're going



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2013-06-11
 **MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
 ROUTE VARIATION 0470-04

| | |
|----------------------|----------------------|
| COUNTY: PERKINS | DRAWN BY: GJ |
| STATE: SOUTH DAKOTA | CHECKED BY: PJ |
| REV NO: 1 | REVISION: 01/10 |
| DATE: 2013-06-11 | |
| PROJECT: PRELIMINARY | |
| DATE: 2013-06-11 | PROJECT: PRELIMINARY |
| DATE: 2013-06-11 | PROJECT: PRELIMINARY |

PREPARED BY
exp Energy Services Inc.
 T: +1 800 345 5441
 F: +1 800 345 5223
 5500 METROPOLITAN BLVD.
 TALLAHASSEE, FL 32301, USA
 WWW.EXP.ENERGY.COM

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KEYSTONE XL PROJECT



KEYSTONE XL PROJECT

LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*

- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2013-06-11

**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0470-05

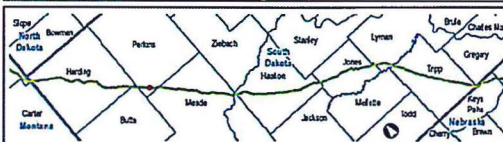
| | |
|----------------------|---|
| COUNTY: TONKAWA | DRAWN BY: SS |
| STATE: SOUTHERN S.D. | CHECKED BY: PP |
| REV NO: | REVISION |
| A | CL DATE AT THE TIME OF RV APPROVAL - 2013-06-11 |
| PRELIMINARY | |

DATE: 2/28/21 PROJECT: TONKAWA XL PROJECT SHEET: 0470-05

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exp Energy Services Inc.T: +1 282 365 5411
F: +1 282 365 5003
1005 METROPOLITAN BLVD.
DALLAMAS, TX 75048, USA
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SOUTH DAKOTA ROUTE VARIATION - 0311-01 (2014 NAIP IMAGERY)

TransCanada
As Shown In Detail



LEGEND

- MILEPOST
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2012-07-12
 **MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

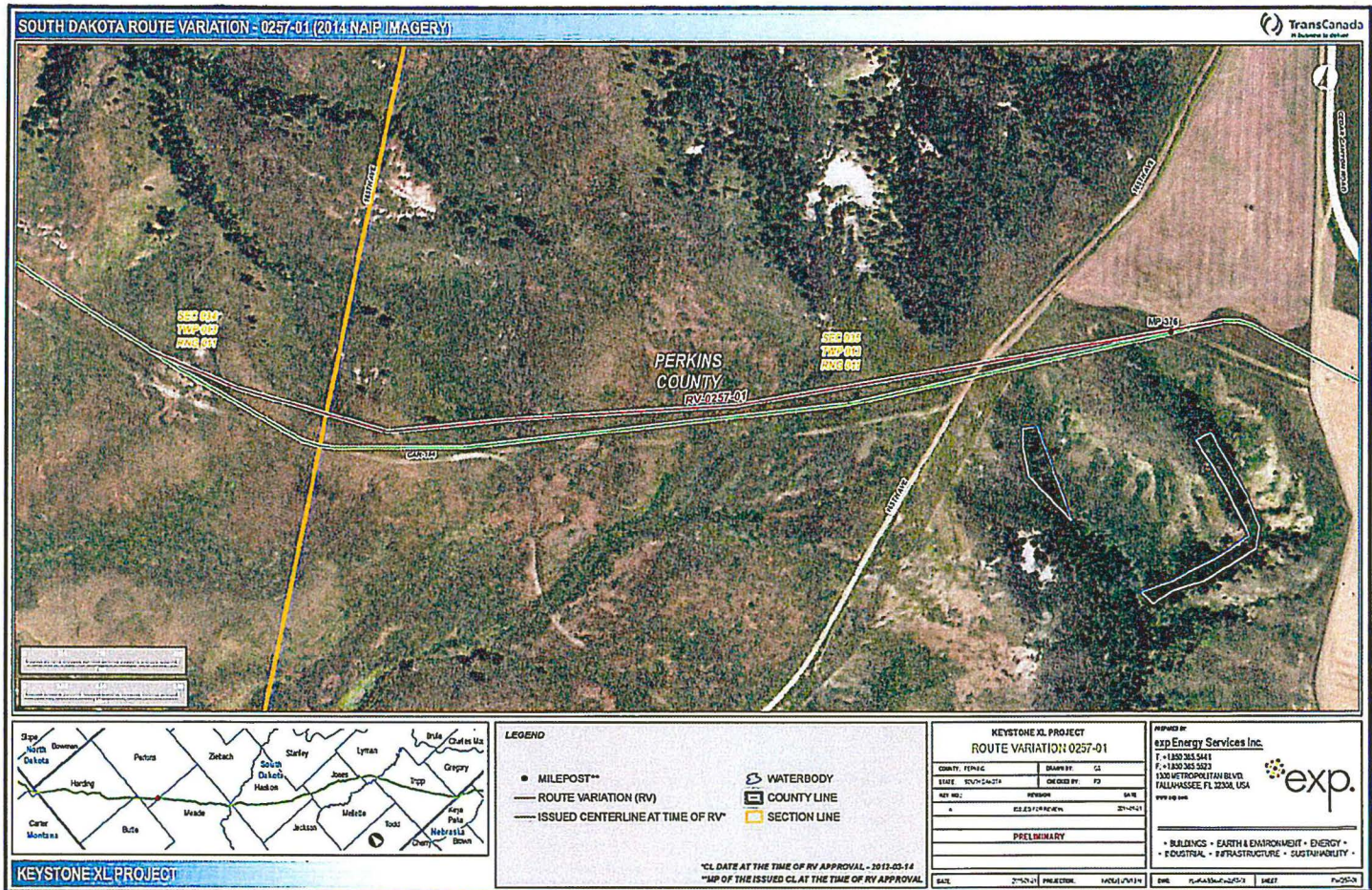
| KEYSTONE XL PROJECT ROUTE VARIATION 0311-01 | | | |
|--|---------------------|----------------|------------------|
| COUNTY: EDWARDS | DRAWN BY: SL | DATE: 07/12/12 | PROJECT: PD |
| STATE: SOUTH DAKOTA | DESIGNED BY: PD | DATE: 07/12/12 | PROJECT: PD |
| REV NO: | REVISION | DATE | |
| 1 | REVISED FOR PERMITS | 07/12/12 | |
| PRELIMINARY | | | |
| DATE: 7/12/12 | PROJECT: PERMITS | DATE: 7/12/12 | PROJECT: PERMITS |

PREPARED BY:
exp Energy Services Inc.
 T: +1 850 325 5411
 F: +1 850 325 5033
 1000 VICTORHOLM AVE. SUITE 100
 TALLAHASSEE, FL 32308, USA
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KEYSTONE XL PROJECT



KEYSTONE 0499

022622



LEGEND

- MILEPOST
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2013-06-11

**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0470-10

| | |
|---------------------|----------------------|
| COUNTY: PERKINS | SHOWN BY: SD |
| STATE: SOUTH DAKOTA | DESIGNED BY: PT |
| REV NO: 1 | REVISION: 2014-01-11 |
| A | ISSUED FOR REVIEW |
| PRELIMINARY | |

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KEYSTONE XL PROJECT

SOUTH DAKOTA ROUTE VARIATION - 0199-02 (2014 NAIP IMAGERY)

TransCanada
a business of enbridge



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2016-11-18
**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0199-02

| | | | |
|-------------|-------------------|------------|------------|
| COUNTY | MEADE | DRAWN BY | CS |
| STATE | SOUTH DAKOTA | CHECKED BY | PS |
| REV. NO. | 1 | REVISION | DATE |
| 1 | ISSUED FOR REVIEW | | 2016-11-18 |
| PRELIMINARY | | | |
| DATE | 2/25/21 | PROJECT | 1476147434 |
| SHEET | 15-0000000000-2 | SHEET | 15/142 |

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expEnergy Services Inc.
T: +1 850 385 5411
F: +1 850 385 5023
1350 VICTORIOLETTI BLVD.
TALLAHASSEE, FL 32304, USA
www.exp.com

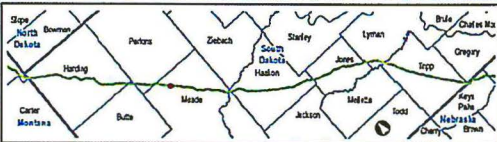


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KEYSTONE XL PROJECT

KEYSTONE 0502

022625



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2013-06-11

**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0491-01

| | |
|---------------------|--------------------------------|
| COUNTY: MEADE | DRAWN BY: CJ |
| STATE: SOUTH DAKOTA | DESIGNED BY: PJ |
| REV NO: 1 | REVISED FOR REVIEW: 2014-01-11 |
| PRELIMINARY | |

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exp Energy Services Inc.
T: +1 800 345 5411
F: +1 800 345 5423
1000 METROPOLITAN BLVD.
TALLAHASSEE, FL 32308, USA
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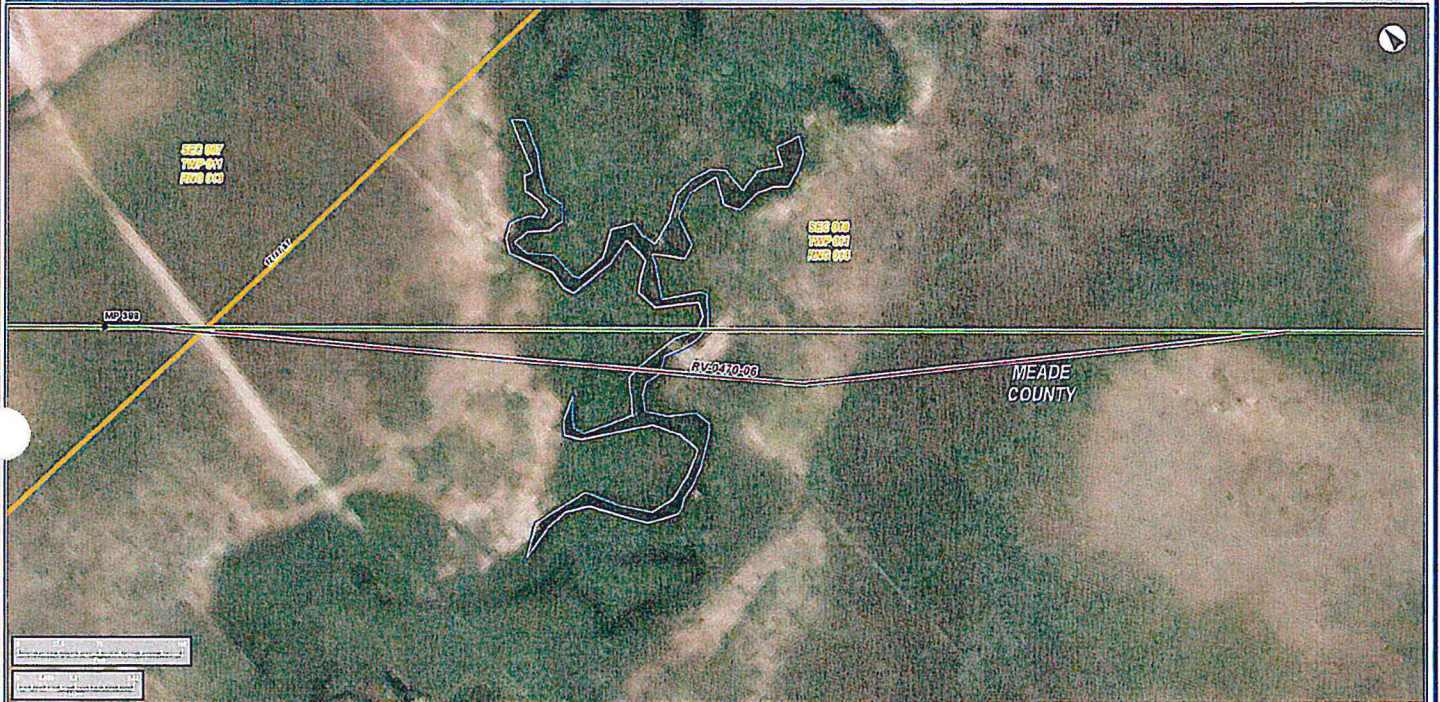


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KEYSTONE XL PROJECT

SOUTH DAKOTA ROUTE VARIATION - 0470-06 (2014 NAIP IMAGERY)

TransCanada
Infrastructure Solutions



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2013-04-11
**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0470-06

COUNTY: MEADE DRAWN BY: SL
STATE: SOUTH DAKOTA CHECKED BY: JT DATE: 2/15/2014

REV NO.: 1 REVISION: 02/15/2014 REVIEW: 2/15/2014

PRELIMINARY

DATE: 2/15/2014 PROJECT: 1409110711 SHEET: 05 OF 05

PREPARED BY:
exp Energy Services Inc.
T: +1.800.365.5411
F: +1.800.365.5223
100 WESTPORTER BLVD.
TALLAHASSEE, FL 32308, USA



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KEYSTONE XL PROJECT

KEYSTONE 0504

022627

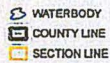


LEGEND

- MILEPOST**

— ROUTE VARIATION (RV)

— ISSUED CENTERLINE AT TIME OF RV*



*CL DATE AT THE TIME OF RV APPROVAL - 2016-11-18

**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0214-01

| | |
|---------------------|----------------|
| COUNTY: MEADE | DRAWN BY: GJ |
| STATE: SOUTH DAKOTA | CHECKED BY: PJ |
| RD NO.: 214 | SECTION: 36 |
| S: 22 E31N42W4N | 214N21 |

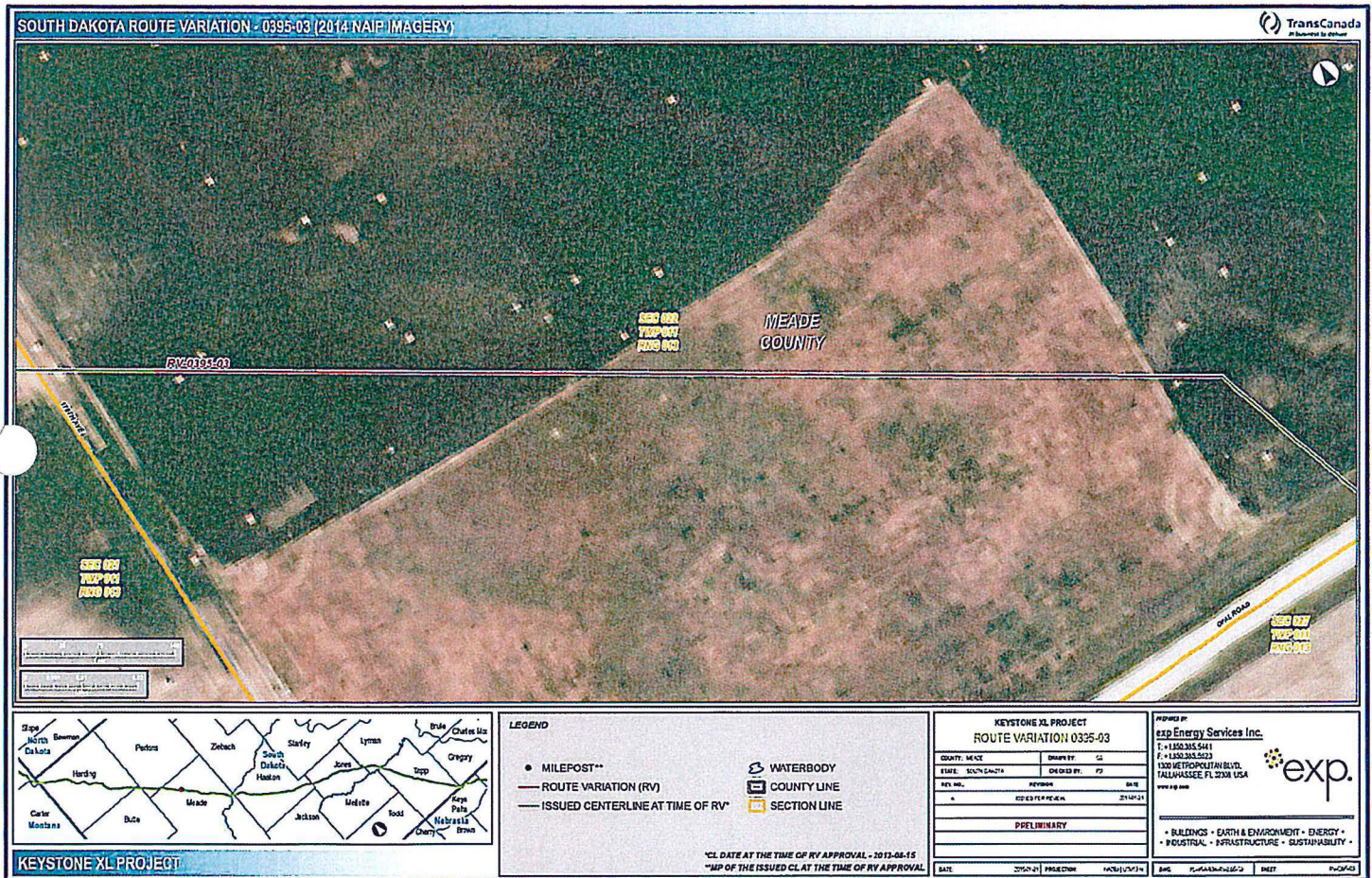
PRELIMINARY

| | | | | |
|---------------|----------------|-------------|---------------|----------------|
| DATE: 2/25/21 | PROJECT: MEADE | FILE: MEADE | DATE: 2/25/21 | SHEET: 0214-01 |
|---------------|----------------|-------------|---------------|----------------|

PROPOSED BY
expEnergy Services Inc.
T: +1.800.361.5441
F: +1.800.361.5442
1301 METROPOLITAN BLVD.
TALLAHASSEE, FL 32304, USA
www.exp.com



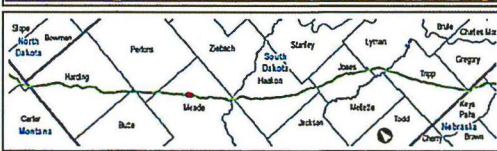
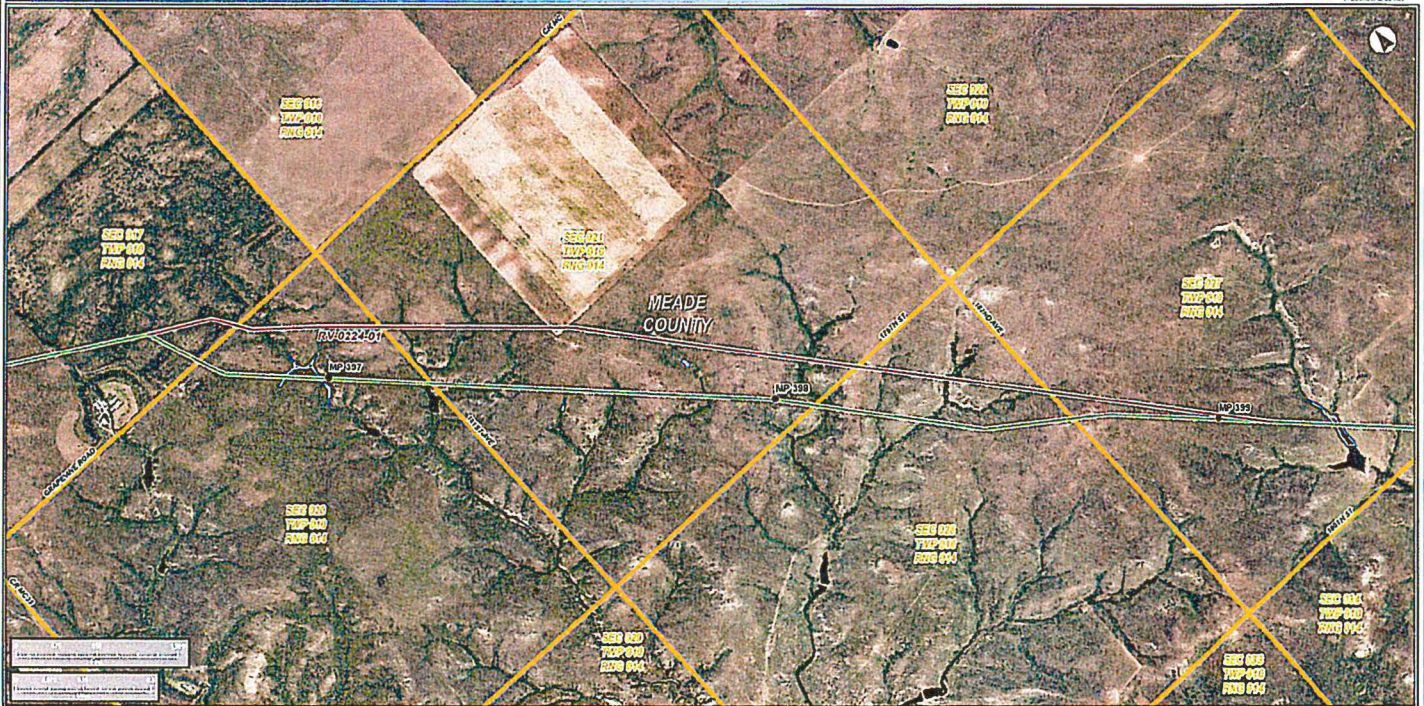
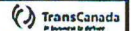
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KEYSTONE 0506

022629

SOUTH DAKOTA ROUTE VARIATION - 0224-01 (2014 NAIP IMAGERY)



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2010-10-12
 **MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
 ROUTE VARIATION 0224-01

| | | | |
|-------------|--------------------|-----------|------------|
| COUNTY | MEADE | SHEET NO. | 02 |
| STATE | SOUTH DAKOTA | DRAWN BY | JP |
| REV. NO. | 01 | DATE | 2014-01-21 |
| DESCRIPTION | REVISED FOR REVIEW | | |
| DATE | 2014-01-21 | | |
| PREPARED BY | PRELIMINARY | | |

PREPARED BY
exp Energy Services Inc.
 7-1350 WIS 5411
 P.O. BOX 1000
 TALLAHASSEE, FL 32304 USA
 904-896-0000

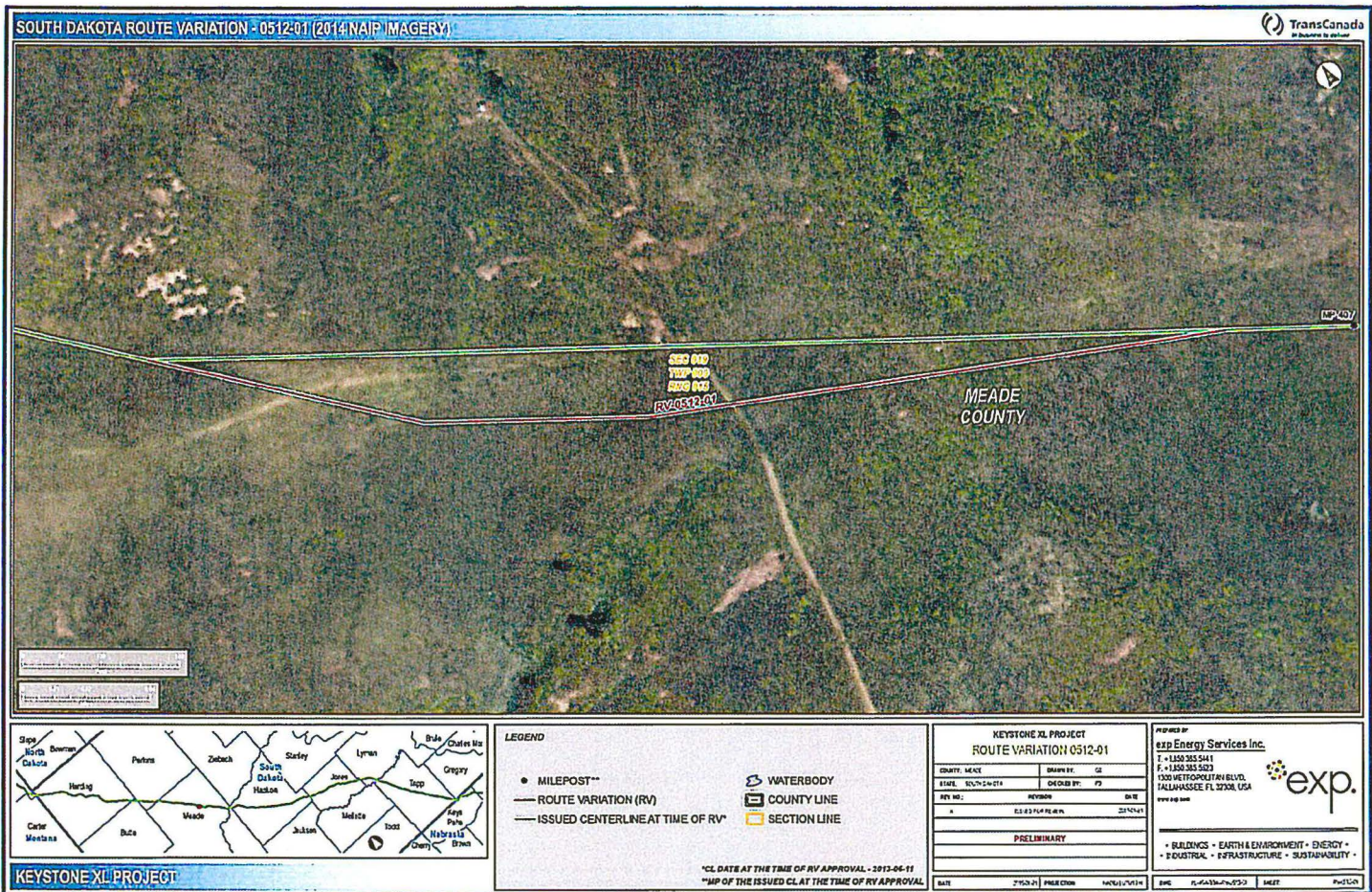


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KEYSTONE XL PROJECT

KEYSTONE 0507

022630



KEYSTONE 0509

022632

SOUTH DAKOTA ROUTE VARIATION - 0470-07 (2014 NAIP IMAGERY)

TransCanada
Infrastructure Solutions



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2013-06-11
**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0470-07

| | |
|----------------------|-----------------------|
| COUNTY: MEADE | DRAWN BY: LC |
| STATE: SOUTH DAKOTA | CHECKED BY: PJ |
| REV. NO.: 1 | REVISION: 2/14/2014 |
| PRELIMINARY | |
| DATE: 2/14/2014 | PROJECT: MEADE COUNTY |
| DWG. NO.: 0510-07-01 | SHEET: 1 OF 1 |

PREPARED BY:
exp Energy Services Inc.
T: +1.800.363.5441
F: +1.800.363.5223
1900 METROPOLITAN BLVD.
TALLAHASSEE, FL 32308 USA
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KEYSTONE XL PROJECT

KEYSTONE 0510

022633



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2018-11-18
 **MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0215-02

| | |
|-----------------|-------------------|
| COUNTY: 04-02 | DRAWN BY: 12 |
| STATE: SOUTHERN | CHECKED BY: PD |
| REV: 001 | REVISION |
| A | 21/11/18 |
| PRELIMINARY | |
| DATE | 21/11/18 |
| TIME | 14:00:00 |
| FILE | 14-00-00-00-00-00 |
| SHEET | 001-02 |

PREPARED BY:
expEnergy Services Inc.
 1-1500-361-5411
 1300 VICTORIAN BLVD.
 TALLAHASSEE, FL 32301, USA
 WWW.EXP-ENERGY.COM



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 • INDUSTRIAL • INFRASTRUCTURE • SUSTAINABILITY •

KEYSTONE XL PROJECT








LEGEND

- MILEPOST**

— ROUTE VARIATION (RV)

— ISSUED CENTERLINE AT TIME OF RV*

-  WATERBODY
-  COUNTY LINE
-  SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2013-03-14

**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0257-02

| | |
|---------------|----------------|
| COUNTY: MEADE | DRAWN BY: G |
| STATE: SD | CHECKED BY: PS |
| REV: 001 | REVISION: 001 |
| A | 02/23/14 |
| PRELIMINARY | |

DESIGNED BY
 exp Energy Services Inc.
 P.O. Box 381541
 1300 VICTORIAN BLVD.
 TALLAHASSEE, FL 32308, USA
 www.exp.com



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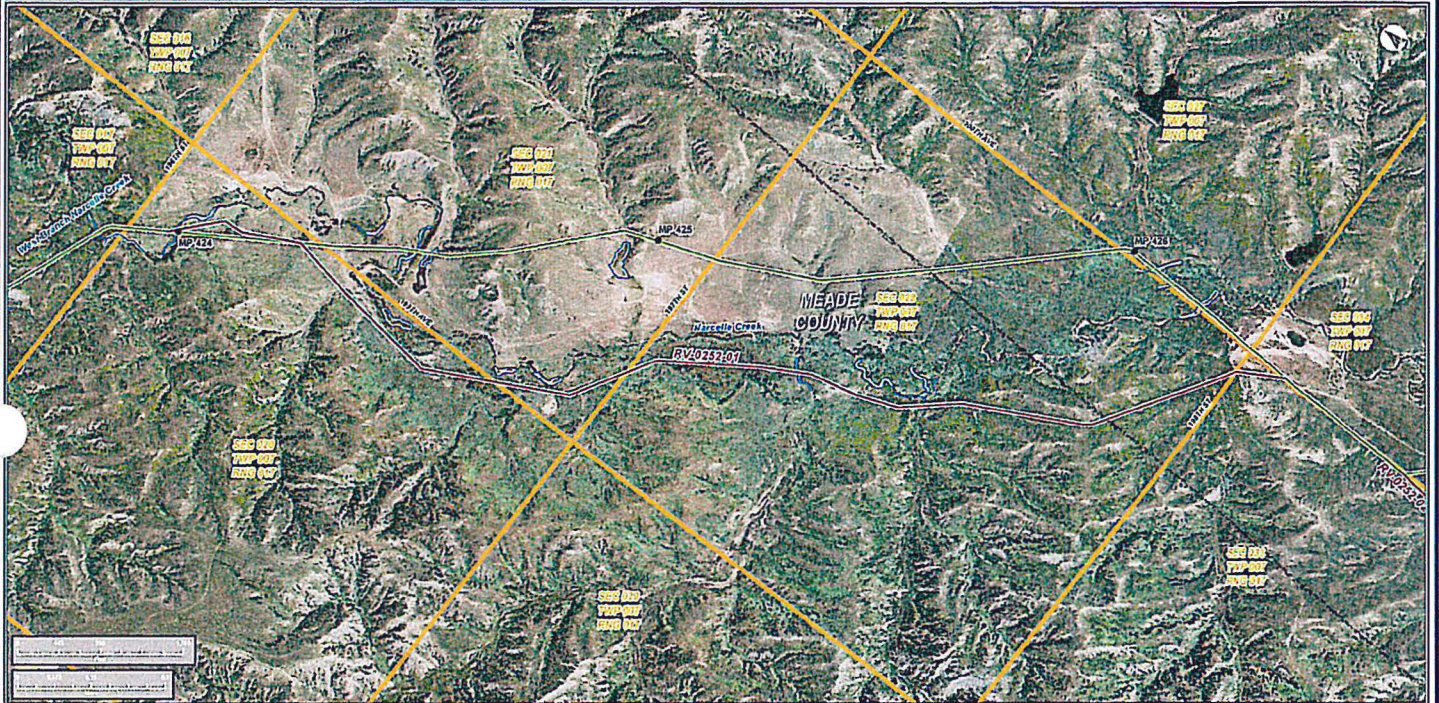
KEYSTONE XL PROJECT

KEYSTONE 0513

022636

SOUTH DAKOTA ROUTE VARIATION - 0252-01 (2014 NAIP IMAGERY)

TransCanada
As license to others



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2013-07-13
 **MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0252-01

| | |
|---------------------|----------------|
| COUNTY: MEADE | DRAWN BY: SL |
| STATE: SOUTH DAKOTA | CHECKED BY: PJ |
| REV NO: 1 | REVISION |
| DATE | DATE |
| 2013-07-13 | 2013-07-13 |
| PRELIMINARY | |

DESIGNED BY
exp Energy Services Inc.
 T: +1 850 345 5411
 F: +1 850 345 5223
 1300 METROPOLITAN BLVD.
 TALLAHASSEE, FL 32304 USA
 www.exp.com

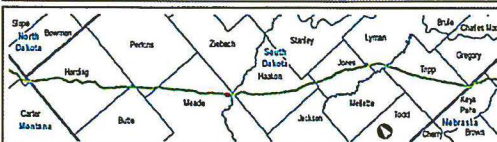
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KEYSTONE XL PROJECT

KEYSTONE 0514

022637



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2013-04-18
 **MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0384-01

| | |
|---------------------|----------------|
| COUNTY: MEADE | DRAWN BY: SA |
| STATE: SOUTH DAKOTA | CHECKED BY: JS |
| REV: 001 | DATE: 2/14/14 |
| BY: SA | DATE: 2/14/14 |

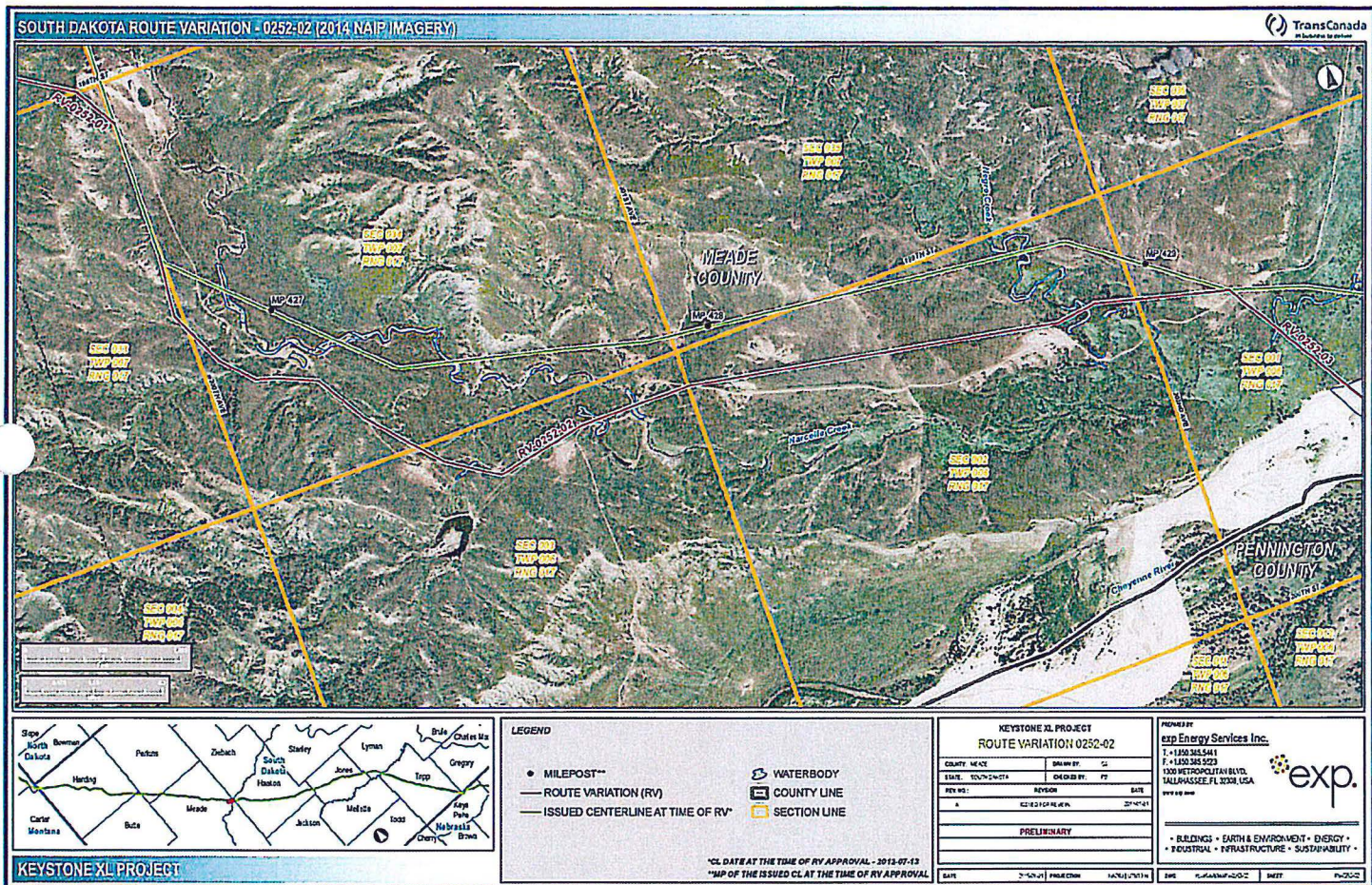
PRELIMINARY

DATE: 2/14/14 PROJECT: KEYSTONE XL PROJECT SHEET: 001 OF 001

PREPARED BY
 exp Energy Services Inc.
 T: +1 850 363 5411
 F: +1 850 363 5023
 1300 WETMORE BLVD.
 TALLAHASSEE, FL 32308, USA
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KEYSTONE 0516

022639



SOUTH DAKOTA ROUTE VARIATION - 0543-01 (2014 NAIP IMAGERY)



KEYSTONE XL PROJECT

LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2012-06-11
 **MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

| KEYSTONE XL PROJECT ROUTE VARIATION 0543-01 | | | |
|--|-------------------|-------------|--------------|
| COUNTY | BRULE | BY | CS |
| STATE | SOUTH DAKOTA | DESIGNED BY | PT |
| REV. NO. | REVISION | DATE | |
| 1 | ISSUED FOR REVIEW | 2012-06-11 | |
| PRELIMINARY | | | |
| DATE | 2012-06-11 | PROJECT | 142012-06-11 |
| DRG | 142012-06-11 | SHEET | 142012-06-11 |

PREPARED BY
expEnergy Services Inc.
 T. +1.800.365.5411
 F. +1.800.365.5023
 1300 METROPOLITAN BLVD.
 TALLAHASSEE, FL 32304 USA
 www.exp.com

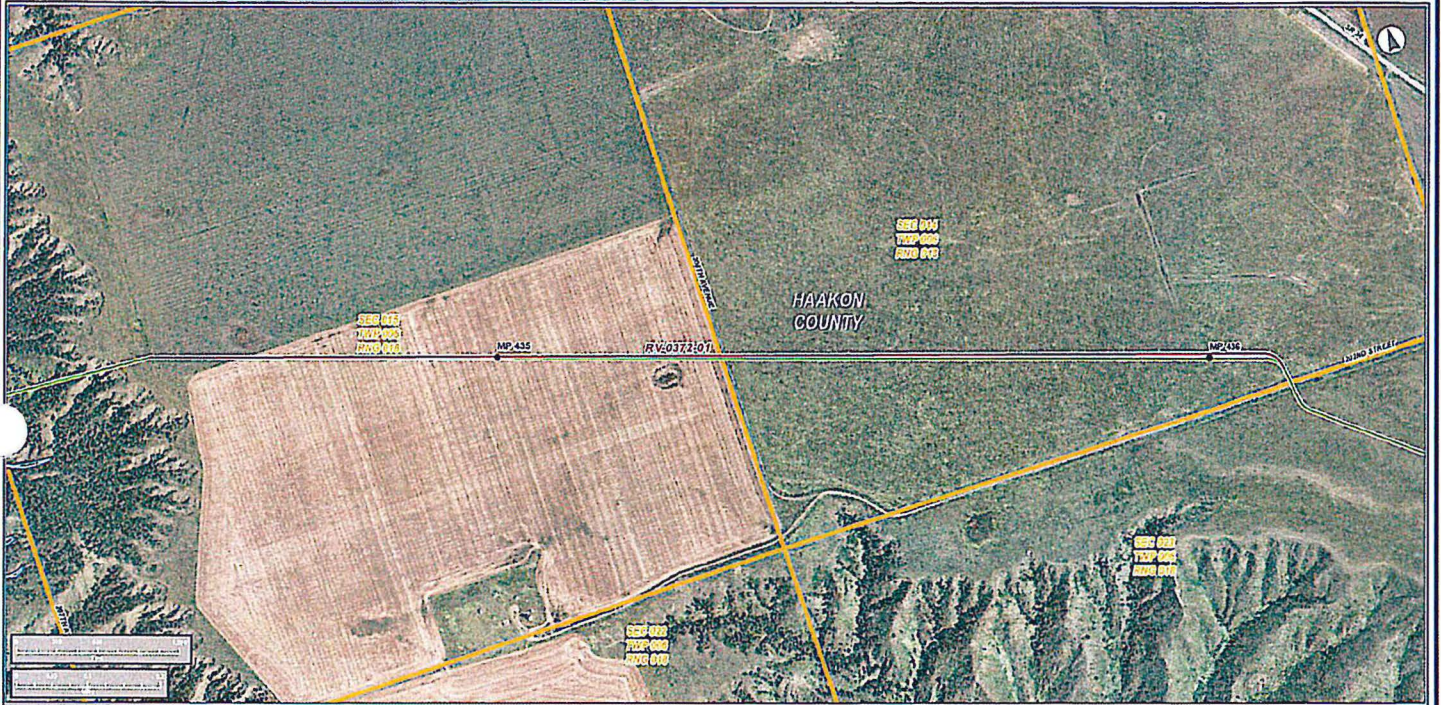
exp.

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 • ECOSYSTEM • INFRASTRUCTURE • SUSTAINABILITY •

KEYSTONE 0519

022642

SOUTH DAKOTA ROUTE VARIATION - 0372-01 (2014 NAIP IMAGERY)



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 10-15-08-15
 **MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
 ROUTE VARIATION 0372-01

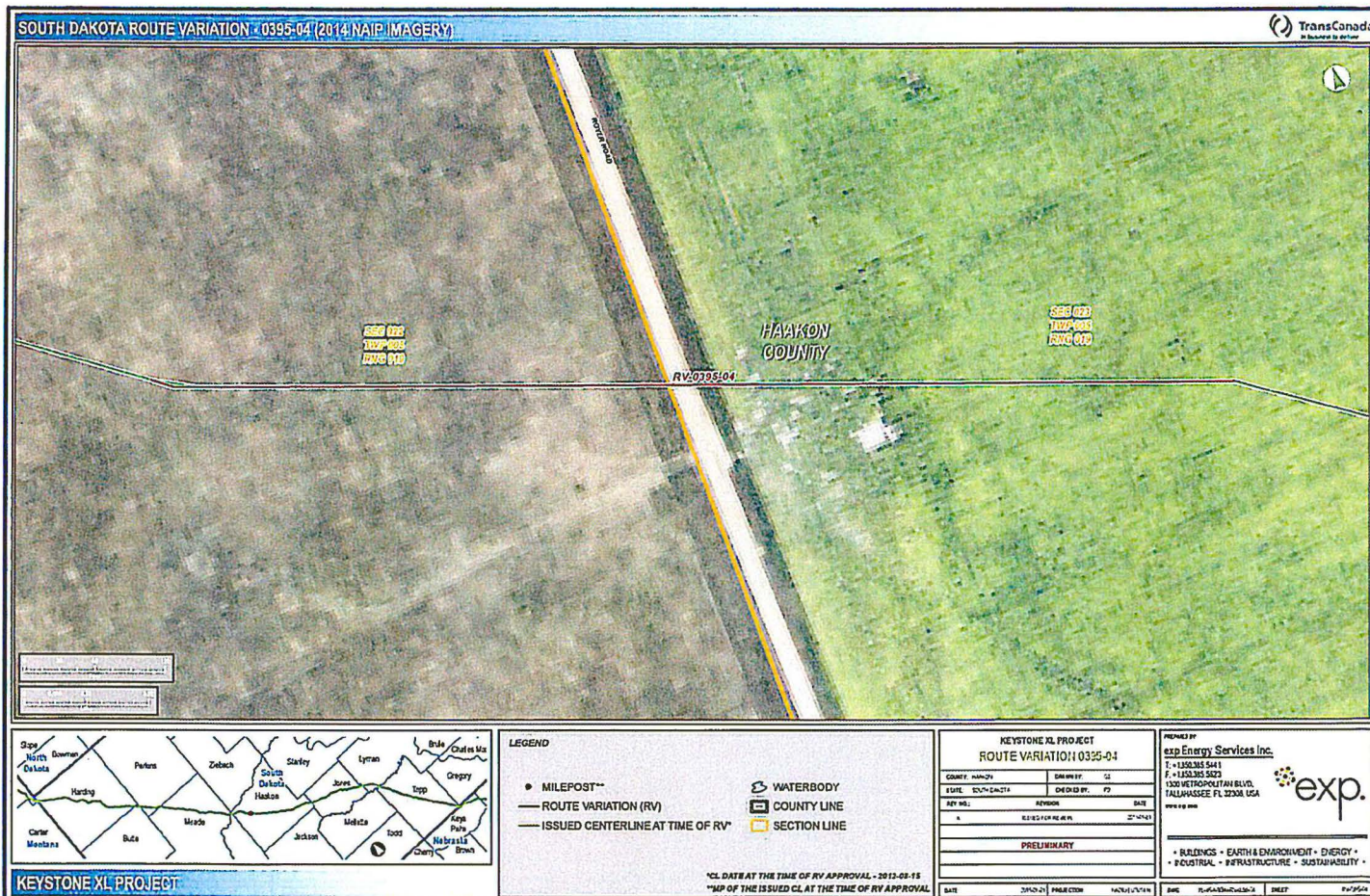
| | |
|---------------------|----------------|
| COUNTY: HAAKON | DRAWN BY: CL |
| STATE: SOUTH DAKOTA | CHECKED BY: PJ |
| REV NO: | REVISION |
| DATE: | DATE: |
| DATE: | DATE: |
| DATE: | DATE: |
| DATE: | DATE: |
| DATE: | DATE: |
| DATE: | DATE: |

PREPARED BY:
 exp Energy Services Inc.
 1-1-1500-365-5411
 1300 WILSON AVENUE, SUITE 100
 TALLAHASSEE, FL 32308 USA
 WWW.EXP.COM



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 • INDUSTRIAL • INFRASTRUCTURE • SUSTAINABILITY •

KEYSTONE XL PROJECT

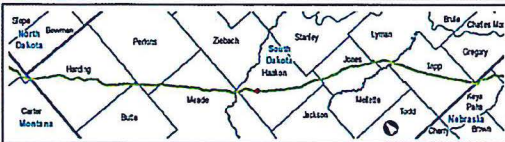


KEYSTONE 0523

022646

SOUTH DAKOTA ROUTE VARIATION - 0289-01 (2014 NAIP IMAGERY)

TransCanada
An Enbridge Company



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*

- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2013-03-14
**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0289-01

| | |
|----------------|----------------|
| COUNTY: HAakon | DRAWN BY: GJ |
| STATE: SD | CHECKED BY: PS |
| REV: 01 | DATE: 03/14/14 |
| BY: GJ | DATE: 03/14/14 |
| PRELIMINARY | |

PROPOSED BY
exp Energy Services Inc.
T: +1 800 365 5411
F: +1 800 365 5023
1500 METROPOLITAN BLVD.
TALLAHASSEE, FL 32308, USA
www.exp.com



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KEYSTONE XL PROJECT

KEYSTONE 0524

022647

SOUTH DAKOTA ROUTE VARIATION - 0199-03 (2014 NAIP IMAGERY)

TransCanada
BY ORDER OF THE BOARD



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2010-11-18
**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0199-03

| | |
|---------------------|---------------------|
| COUNTY: HAakon | DRAWN BY: CL |
| STATE: SOUTH DAKOTA | CHECKED BY: PS |
| REV NO: 1 | REVISED: 02/27/2014 |
| DATE: 02/27/2014 | |

PRELIMINARY

| | | | | | |
|------------------|---------------|----------------|--------|------------|------------|
| DATE: 02/27/2014 | PROJECT: KEYS | SCALE: 1"=1/4" | REV: 1 | SHEET: 001 | TOTAL: 001 |
|------------------|---------------|----------------|--------|------------|------------|

DESIGNED BY
exp Energy Services Inc.
T: 1.800.365.5411
F: 1.800.365.5223
1200 METROPOLITAN BLVD.
TALLAHASSEE, FL 32301 USA
www.exp.com

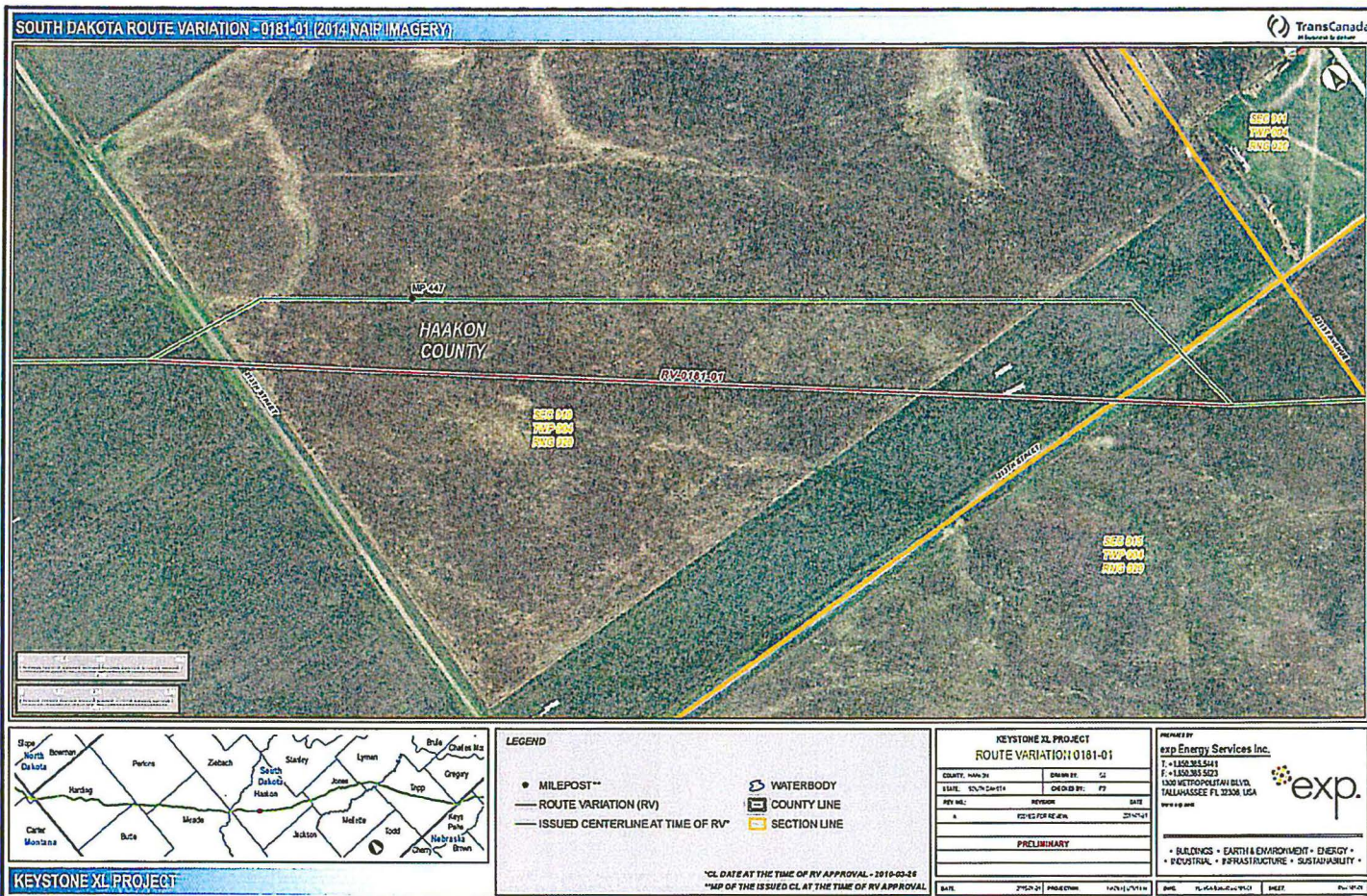


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• INDUSTRIAL • INFRASTRUCTURE • SUSTAINABILITY •

KEYSTONE XL PROJECT

KEYSTONE 0526

022649

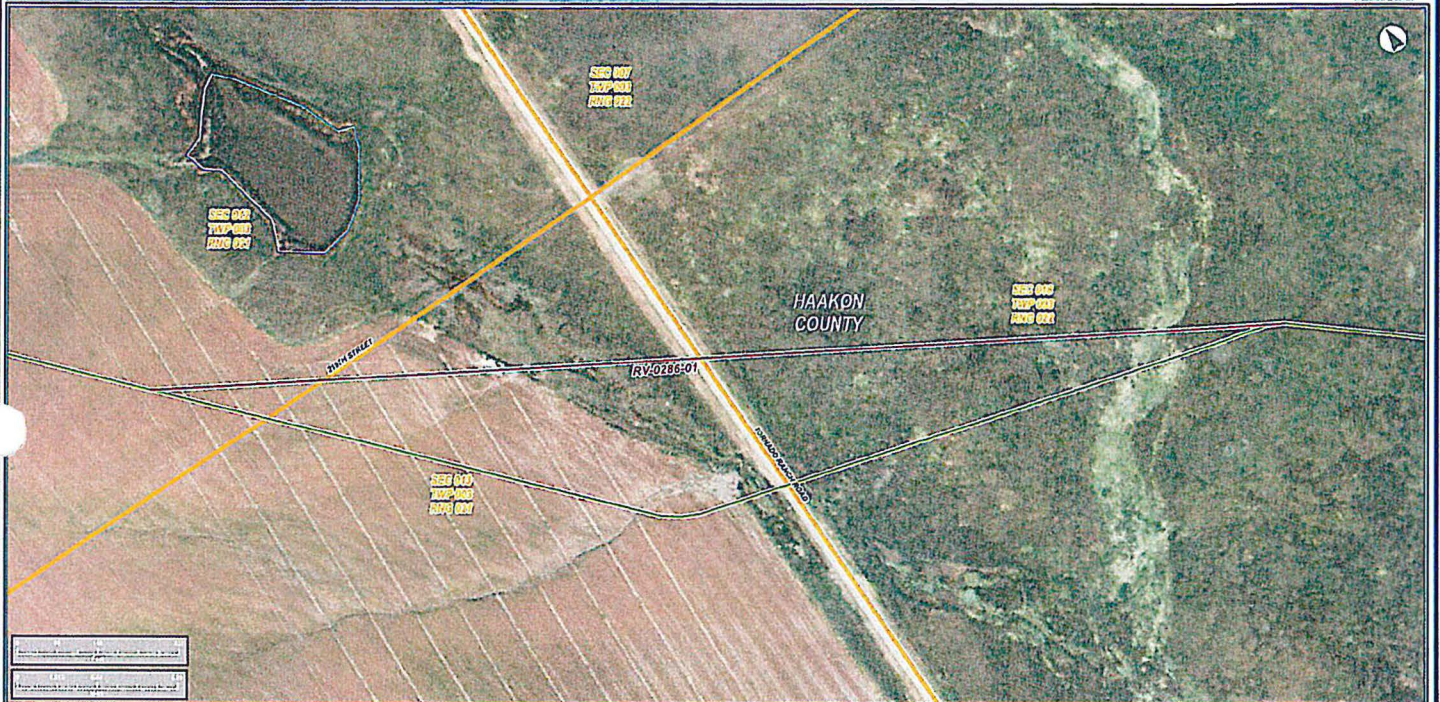


KEYSTONE 0527

022650

SOUTH DAKOTA ROUTE VARIATION - 0285-01 (2014 NAIP IMAGERY)

TransCanada
by Enbridge in Canada



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2013-03-14
**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0285-01

| | |
|----------------|---------------------|
| COUNTY: Haakon | GROUP: G1 |
| STATE: SD | CHECKED BY: PJ |
| REV NO: 1 | REVISION: DATE |
| 1 | FOR REVIEW: 2/24/14 |

PRELIMINARY

| | | | |
|---------------|--------------------------|---------------|-------------|
| DATE: 2/24/14 | PREPARED BY: 1407-1-1/14 | DATE: 2/24/14 | 1407-1-1/14 |
|---------------|--------------------------|---------------|-------------|

DESIGNED BY
exp Energy Services Inc.
T: +1 850 365 5411
F: +1 850 365 5323
1200 METROPOLITAN BLVD.
TALLAHASSEE, FL 32308, USA
www.exp.com

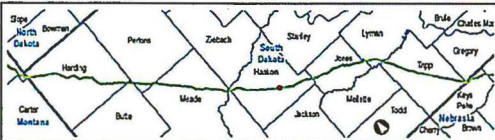


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KEYSTONE XL PROJECT

KEYSTONE 0530

022653



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

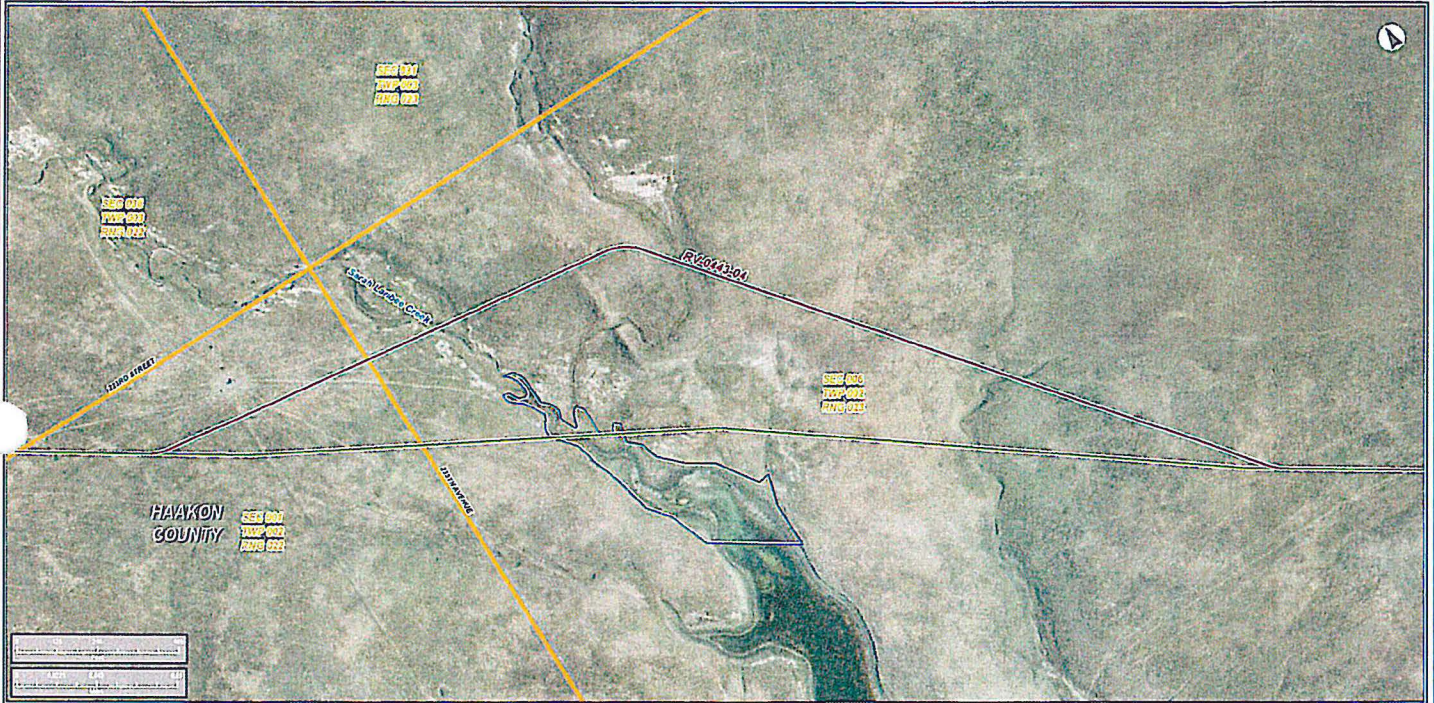
*CL DATE AT THE TIME OF RV APPROVAL - 2013-06-11
**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

| KEYSTONE XL PROJECT ROUTE VARIATION 0497-01 | | | |
|--|----------------|------------------|------------------|
| COUNTY: HAWKON | SHOWN BY: 52 | DATE: 05/24/2014 | DESIGNED BY: PT |
| FILE NO: 0497-01 | REVISED BY: 52 | DATE: 05/24/2014 | DESIGNED BY: PT |
| 4 | 02/23/2014 | REVISED BY: 52 | DATE: 05/24/2014 |
| PRELIMINARY | | | |
| DATE: 05/24/2014 PROJECT: HAWKON XL SHEET: 001 OF 01 | | | |

| | |
|--|--|
| PREPARED BY: exp Energy Services Inc. T: +1 800 361 5441 F: +1 800 361 5442 1000 METROPOLITAN BLVD. TALLAHASSEE, FL 32308 USA www.exp.com | |
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SOUTH DAKOTA ROUTE VARIATION - 0443-04 (2014 NAIP IMAGERY)

TransCanada
BY AGREEMENT WITH



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2013-04-11
 **MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0443-04

| | |
|---------------------|------------------|
| COUNTY: HAAKON | DRAWN BY: SL |
| STATE: SOUTH DAKOTA | CHECKED BY: PS |
| REL. NO.: KEYSTONE | DATE: 2013-04-11 |
| E.C. FOR READY | |
| PRELIMINARY | |

expEnergy Services Inc.
 T: +1 320.365.5441
 F: +1 320.365.5273
 1320 WESTPHALIA BLVD.
 TALLMASSIEE, FL 32060, USA

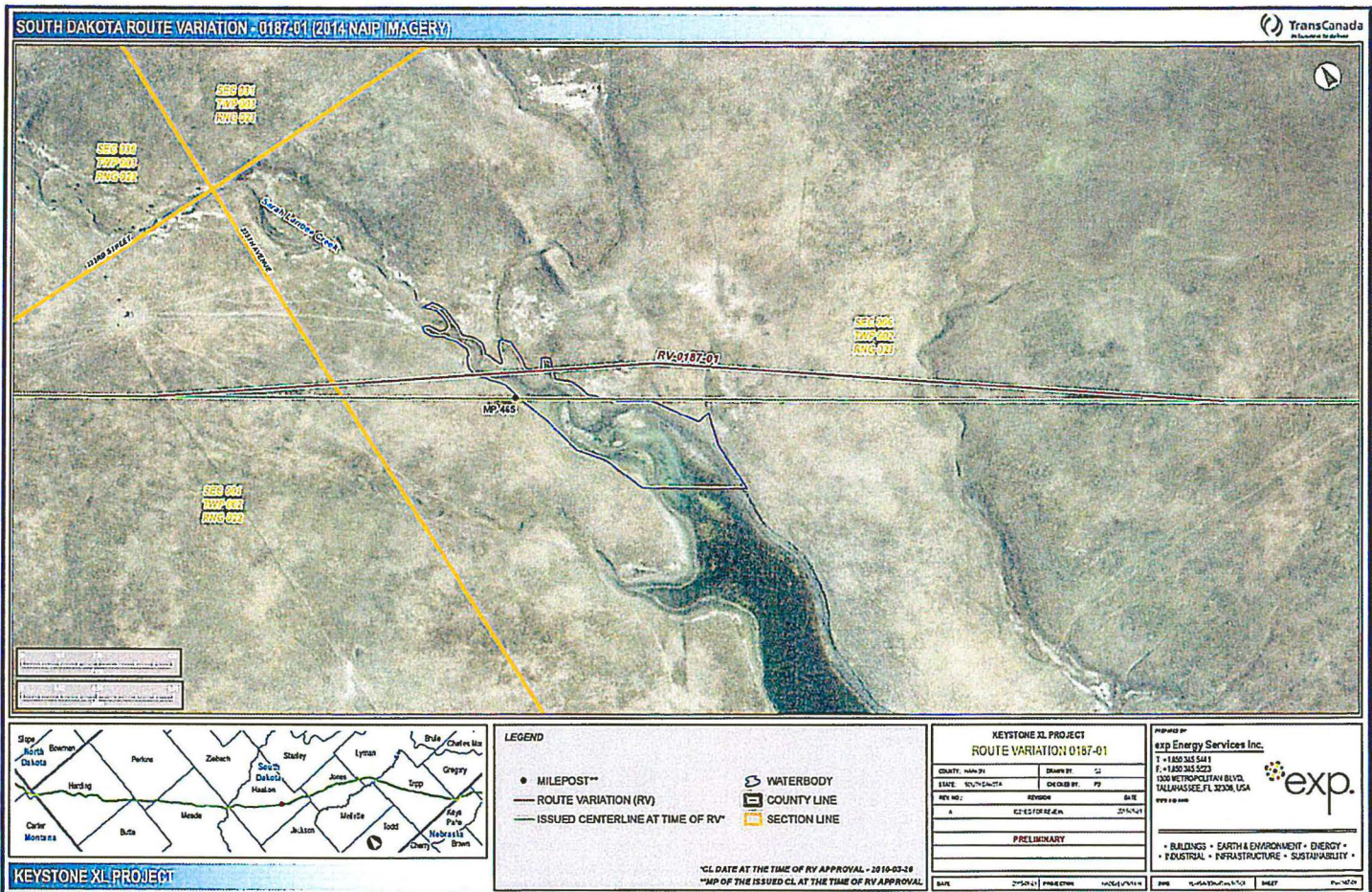
exp.

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 • INDUSTRIAL • INFRASTRUCTURE • SUSTAINABILITY •

KEYSTONE XL PROJECT

KEYSTONE 0532

022655



KEYSTONE 0533

022656

SOUTH DAKOTA ROUTE VARIATION - 0199-05 (2014 NAIP IMAGERY)

TransCanada
BY PERMISSION OF THE STATE



LEGEND

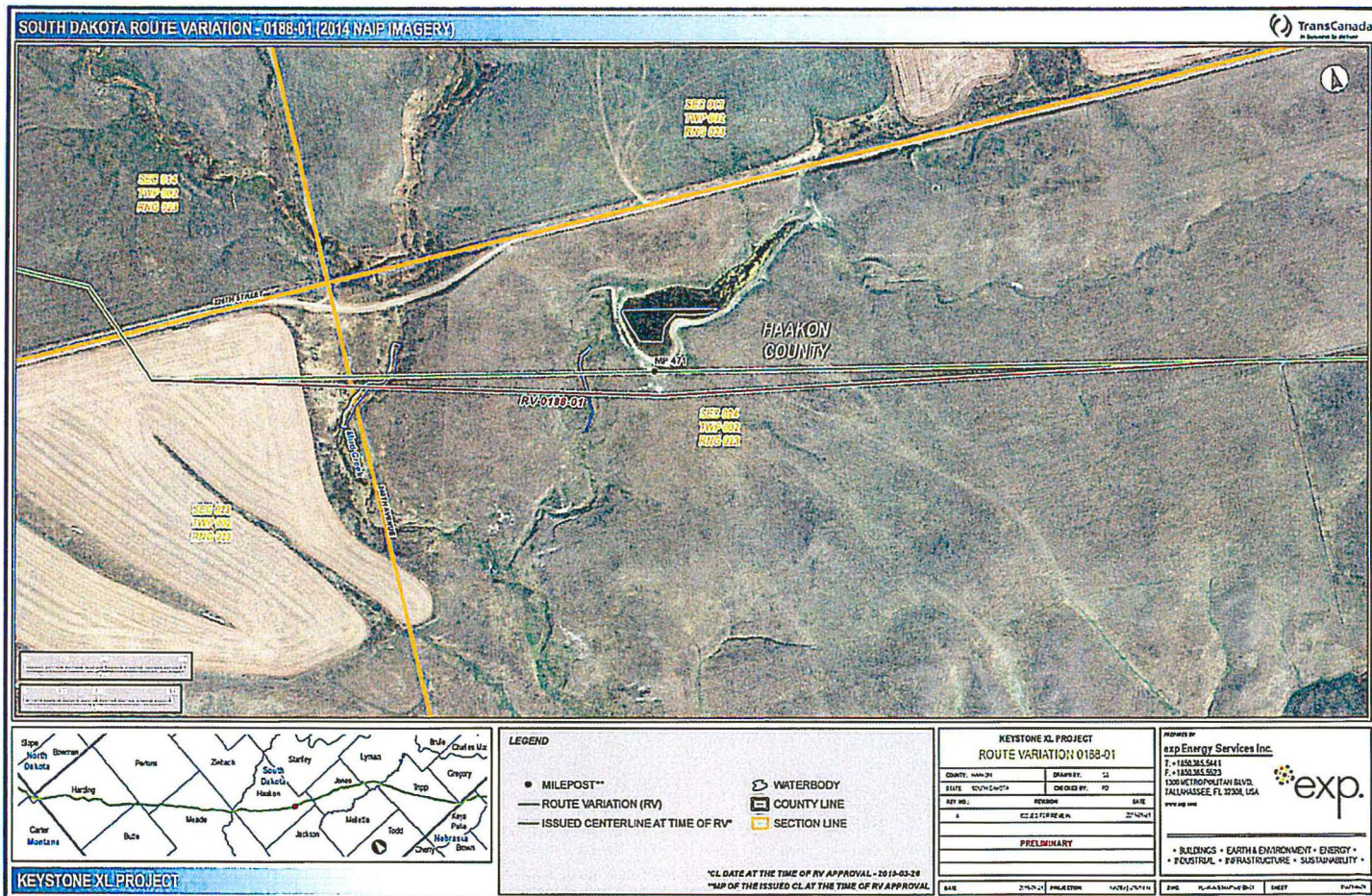
- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2016-10-18
 **MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

| KEYSTONE XL PROJECT ROUTE VARIATION 0199-05 | | | |
|--|-------------------|-------------------|---------------|
| COUNTY: HAAGON | DRAWN BY: CJ | | |
| STATE: S.D. | CHECKED BY: JF | | |
| REV NO: 1 | REVISED: 02/14/17 | DATE: 02/14/17 | |
| PRELIMINARY | | | |
| DATE: 02/14/17 | PROJECT: 0199-05 | REVISED: 02/14/17 | SHEET: 1 OF 1 |

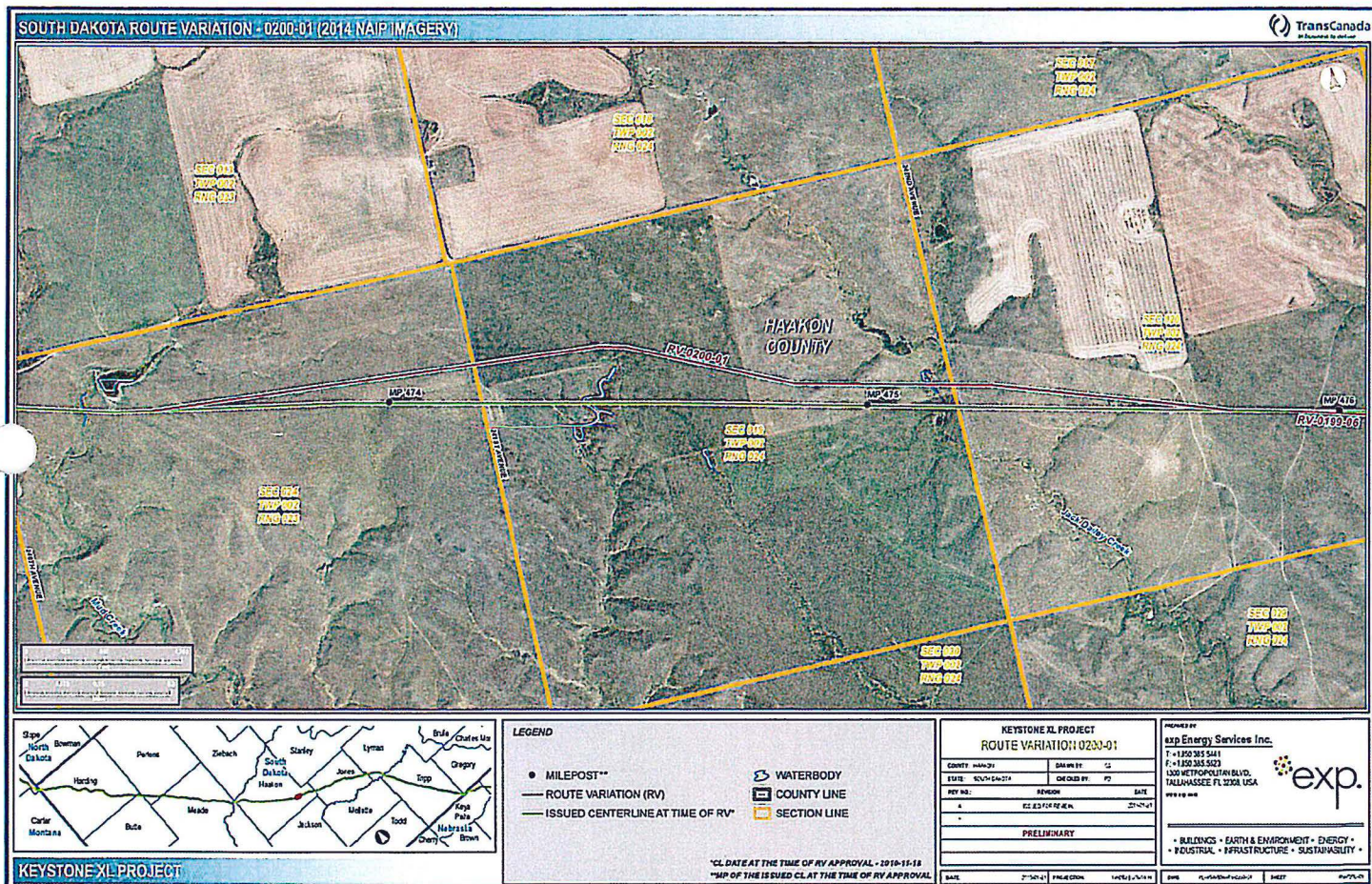
exp. Energy Services Inc.
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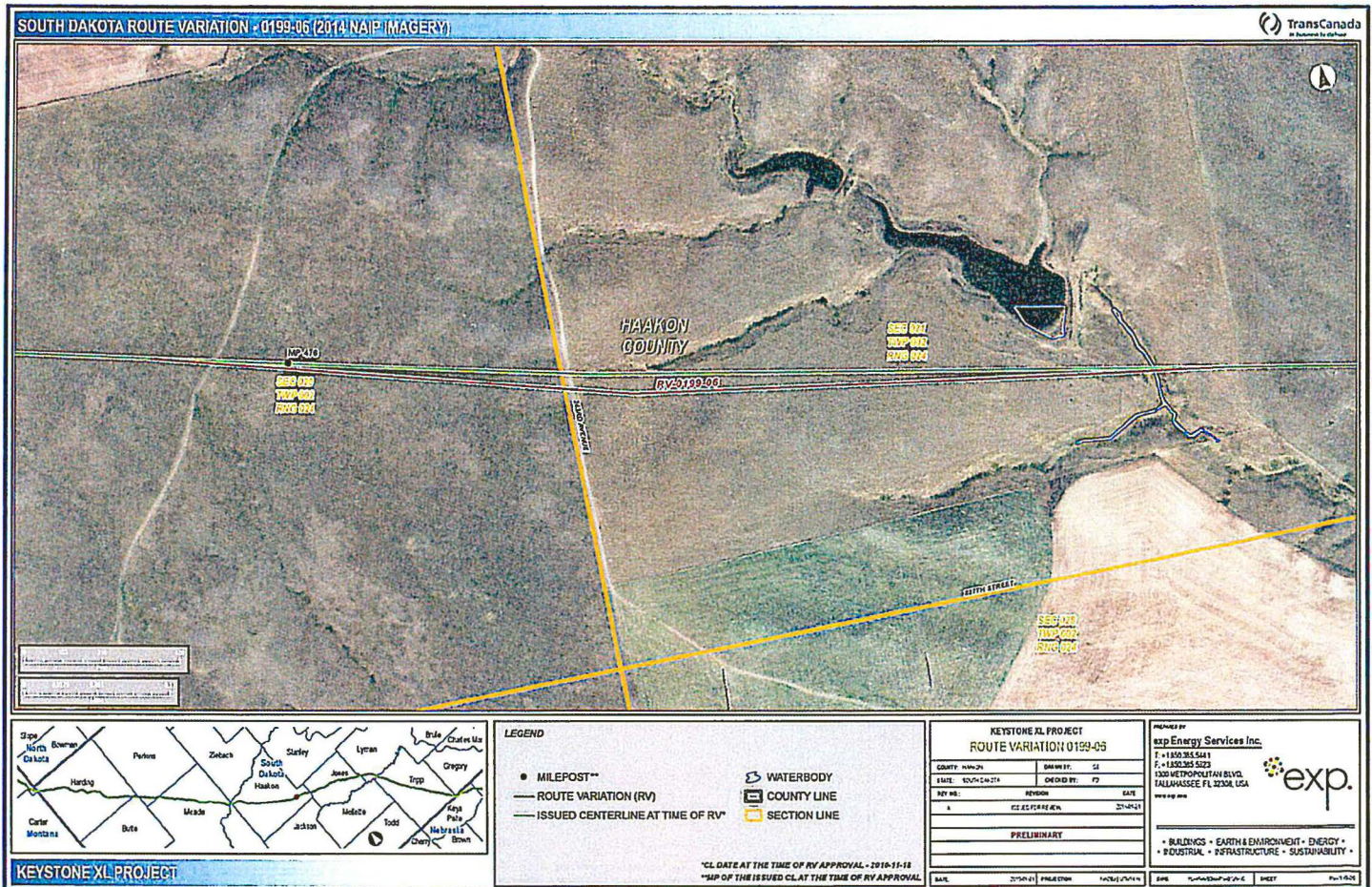
KEYSTONE 0535

022658



KEYSTONE 0536

022659



KEYSTONE 0537

022660

SOUTH DAKOTA ROUTE VARIATION - 0262-01 (2014 NAIP IMAGERY)

TransCanada
an Enbridge company



KEYSTONE XL PROJECT

LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2013-03-14
**MAP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0262-01

| | |
|---------------------|----------------------|
| COUNTY: Minn 25 | DRAWN BY: SL |
| STATE: SOUTH DAKOTA | CHECKED BY: PS |
| REV NO: 1 | REVISION: 02/24/2014 |
| PRELIMINARY | |
| DATE: 2/24/2014 | PROJECT: 14061/14014 |

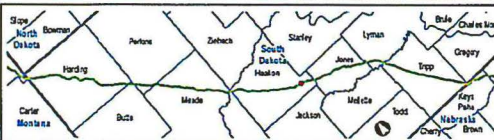
exp Energy Services Inc.
1 + 1.800.365.5411
F + 1.800.365.5411
1320 METROPOLITAN BLVD.
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KEYSTONE 0538

022661



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*

- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2013-03-14
 **MAP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0260-01

| | |
|----------------|----------------|
| COUNTY: HAAKON | DRAWN BY: GJ |
| STATE: SD | CHECKED BY: PJ |
| REV NO: 1 | DATE: 2/24/14 |
| ED: 02/24/14 | DATE: 2/24/14 |

PRELIMINARY

| | | | |
|---------------|-----------------|---------------|---------------|
| DATE: 2/24/14 | PROJECT: HAAKON | FILE: 0260-01 | DATE: 2/24/14 |
|---------------|-----------------|---------------|---------------|

DESIGNED BY
 exp Energy Services Inc.
 T: +1 850 345 5481
 F: +1 850 345 5023
 1350 METROPOLITAN BLVD.
 TALLAHASSEE, FL 32308, USA
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HAWKON
COUNTY
RV-0260-02SEG 001
TWP-002
RND-024

LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 10-13-03-14
 **AP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0260-02

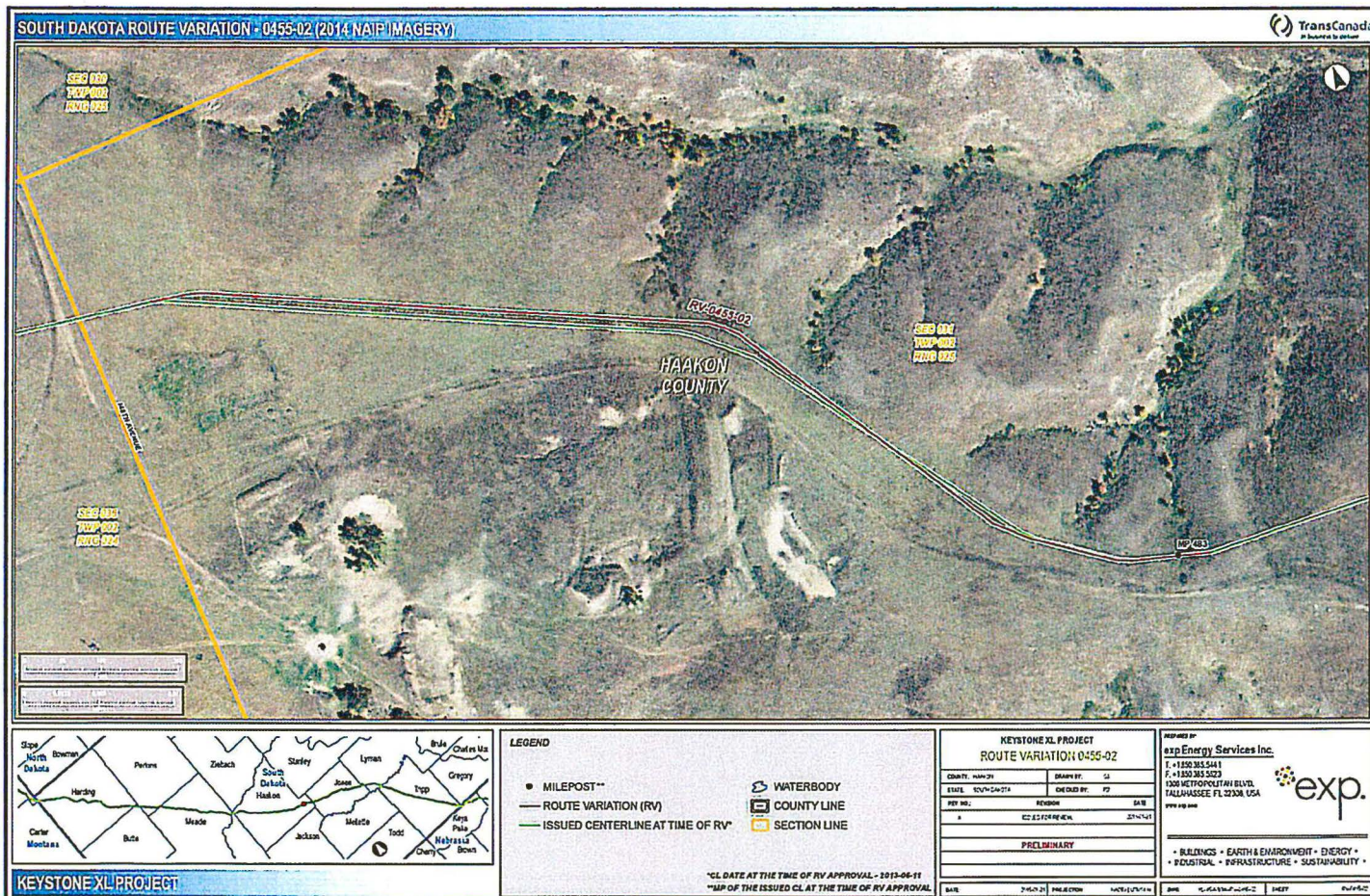
| | |
|---------------------|----------------|
| COUNTY: HAWKON | DRAWN BY: CJ |
| STATE: SOUTH DAKOTA | CHECKED BY: FJ |
| REV NO: | REVISION |
| 1 | ED: 10-10-03 |
| PRELIMINARY | |
| DATE: | 2/10/14 |

DESIGNED BY:
 exp Energy Services Inc.
 T: 1-800-365-5481
 F: 1-800-365-5029
 1326 METROPOLITAN BLVD.
 TALLAHASSEE, FL 32308 USA



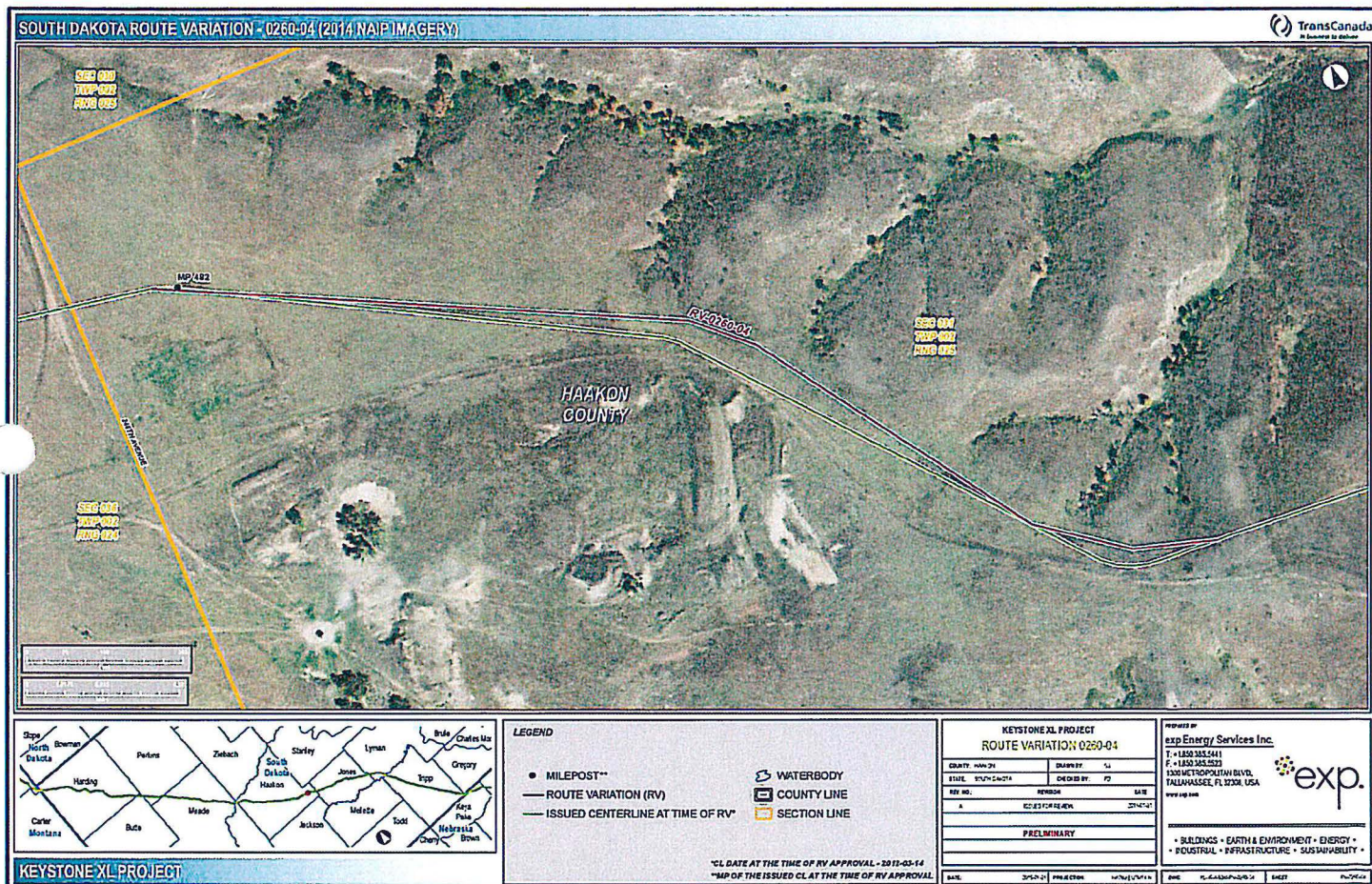
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 • INDUSTRIAL • INFRASTRUCTURE • SUSTAINABILITY •

KEYSTONE XL PROJECT



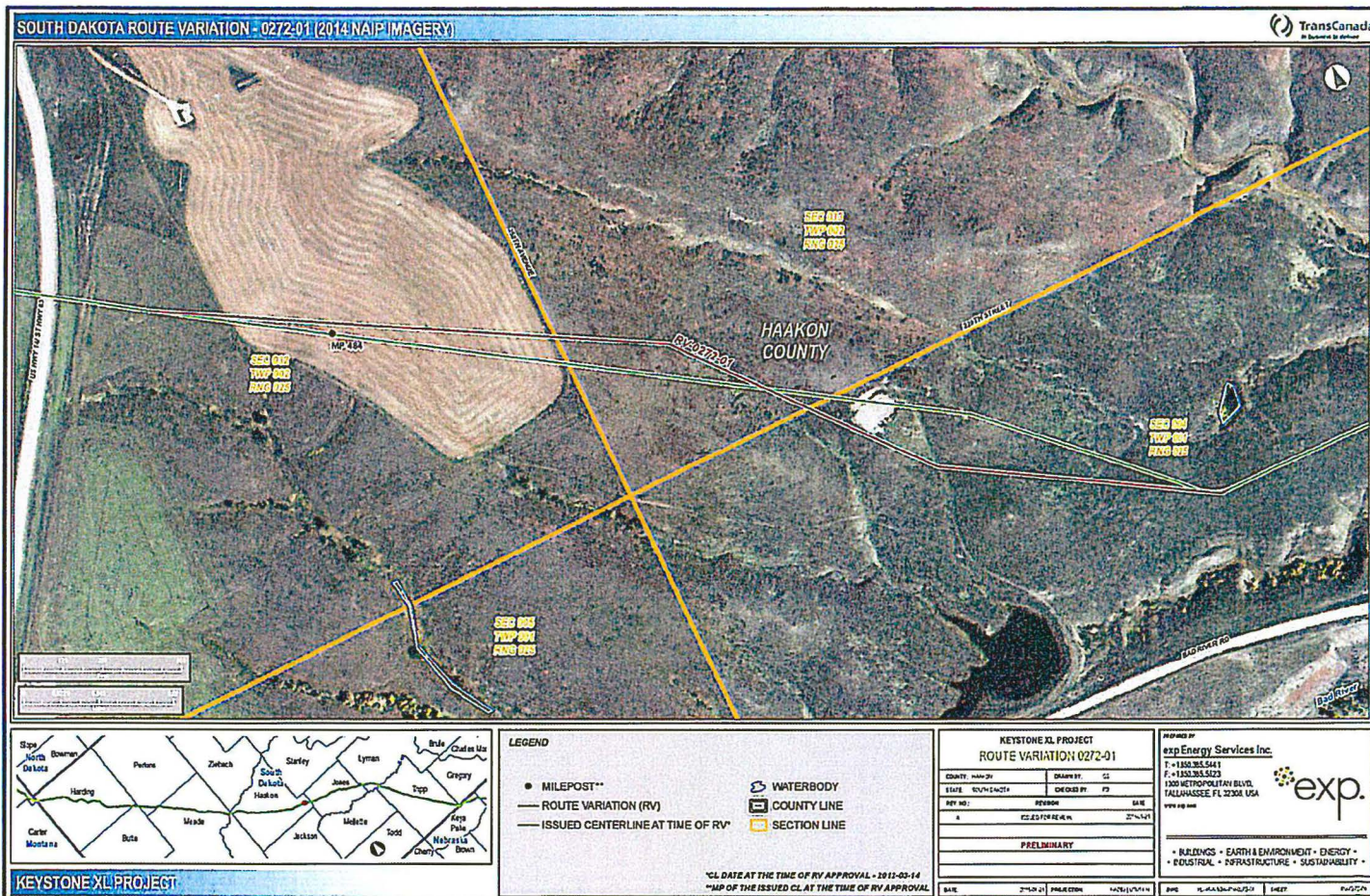
KEYSTONE 0541

022664



KEYSTONE 0542

022665



KEYSTONE 0543

022666



LEGEND

● MILEPOST**

— ROUTE VARIATION (RV)

— ISSUED CENTERLINE AT TIME OF RV*

WATERBODY

COUNTY LINE

SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2011-06-14
 **MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0239-01

| | |
|---------------------|------------------|
| COUNTY: HAakon | SHOWN BY: 12 |
| STATE: SOUTH DAKOTA | CHECKED BY: PT |
| REV NO: 1 | DATE: 02/14/14 |
| DATE: 02/14/14 | PROJECT: 0239-01 |
| DATE: 02/14/14 | PROJECT: 0239-01 |
| DATE: 02/14/14 | PROJECT: 0239-01 |
| DATE: 02/14/14 | PROJECT: 0239-01 |

PRELIMINARY

PROPOSED BY
exp Energy Services Inc.
 T +1 800 365 5411
 F +1 800 365 5523
 600 METROPOLITAN BLVD.
 TALLAHASSEE, FL 32308, USA
 WWW.EXP.ENERGY.COM



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 • FLEXIBILITY • INFRASTRUCTURE • SUSTAINABILITY •

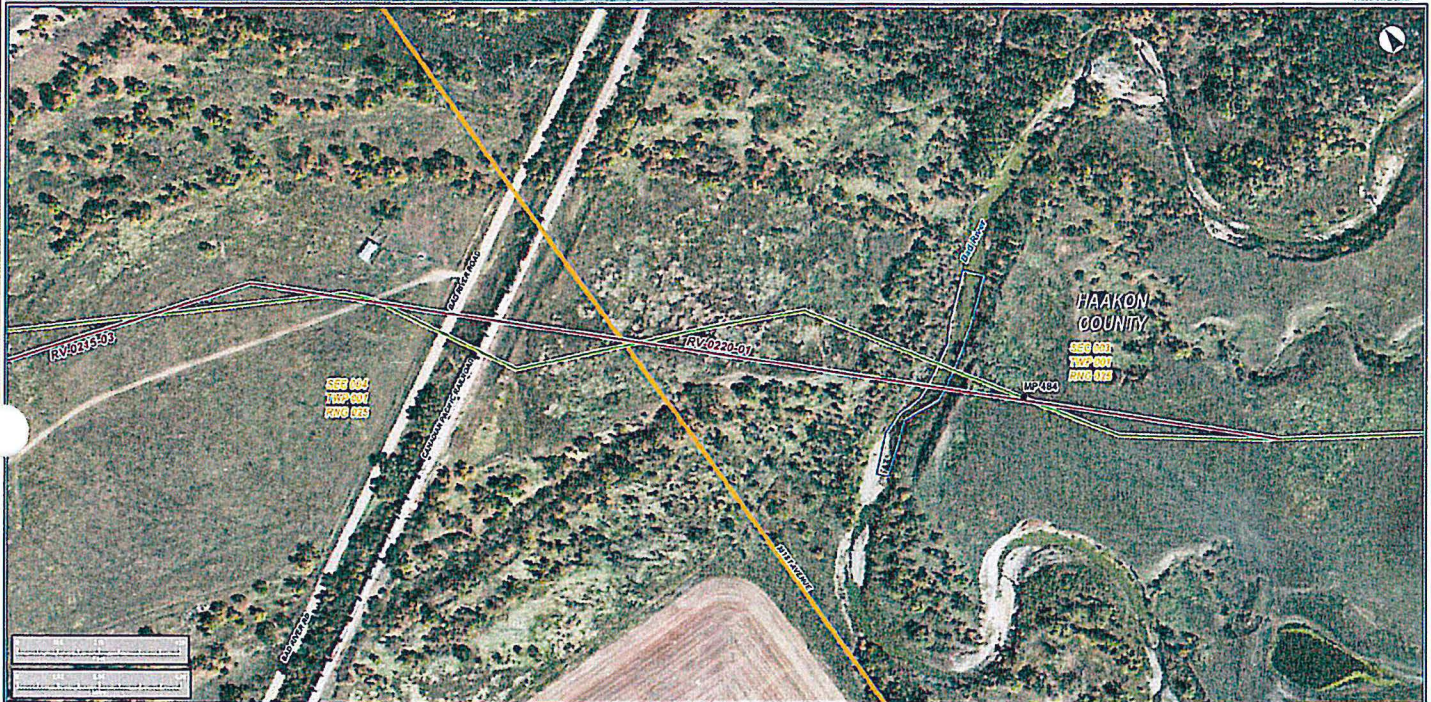
KEYSTONE XL PROJECT

KEYSTONE 0545

022668

SOUTH DAKOTA ROUTE VARIATION - 0220-01 (2014 NAIP IMAGERY)

TransCanada
A Division of Baker Hughes



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2010-11-18
**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0220-01

| | |
|---------------------|----------------------|
| COUNTY: HAAKON | DRAWN BY: SL |
| STATE: SOUTH DAKOTA | CHECKED BY: FY |
| REV NO: 1 | REVISION: 2010-11-18 |

PRELIMINARY

| | | | |
|---------------|-----------------------------|------------------|-----------------|
| DATE: 2/15/21 | PROJECT NO: 142761-01-11-18 | DATE: 10/14/2020 | SHEET: 10/27/20 |
|---------------|-----------------------------|------------------|-----------------|

PROPOSED BY
exp Energy Services Inc.
T: +1 800 365 5411
F: +1 800 365 5273
100 WESTPORT HILL BLVD.
TALLAHASSEE, FL 32308 USA
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KEYSTONE XL PROJECT

KEYSTONE 0546

022669

SOUTH DAKOTA ROUTE VARIATION - 0260-03 (2014 NAIP IMAGERY)

TransCanada
BY AGREEMENT TO CONTRACT



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- ☒ WATERBODY
- ☒ COUNTY LINE
- ☒ SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 10-15-03-14
**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0260-03

| | |
|-------------------|-------------------|
| COUNTY: HAKON | DRAWN BY: CS |
| STATE: S.D. 26-03 | CHECKED BY: FJ |
| REV. NO.: 1 | REVISED: 10/15/03 |
| DATE: 10/15/03 | DATE: 10/15/03 |

PRELIMINARY

DATE: 10/15/03 PROJECT: 10/15/03-14

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exp Energy Services Inc.
T. +1 352.355.5411
F. +1 352.355.5222
1300 METROPOLITAN BLVD.
TALLAHASSEE, FL 32304, USA
www.exp.us

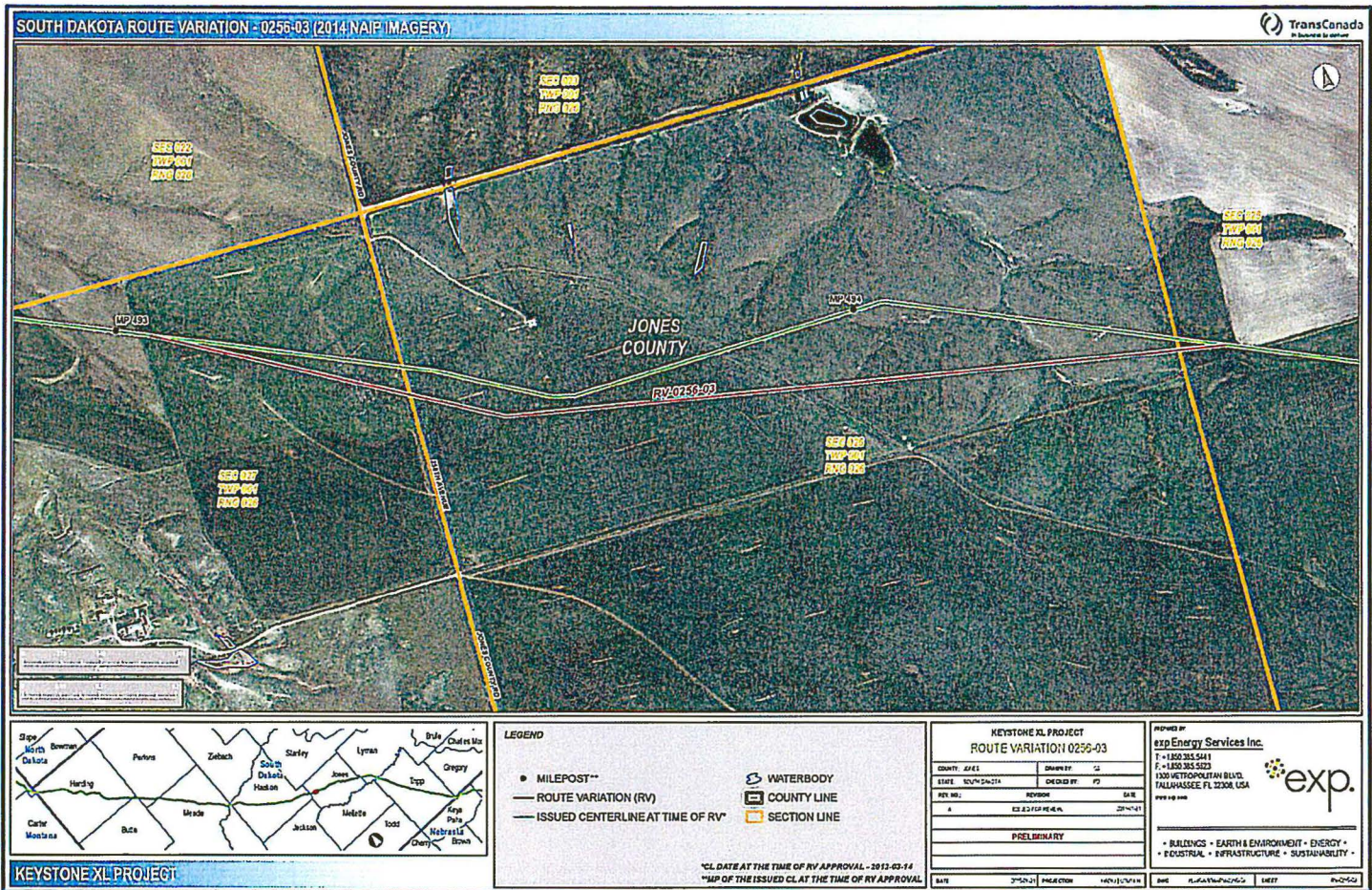


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• INDUSTRIAL • INFRASTRUCTURE • SUSTAINABILITY •

KEYSTONE XL PROJECT

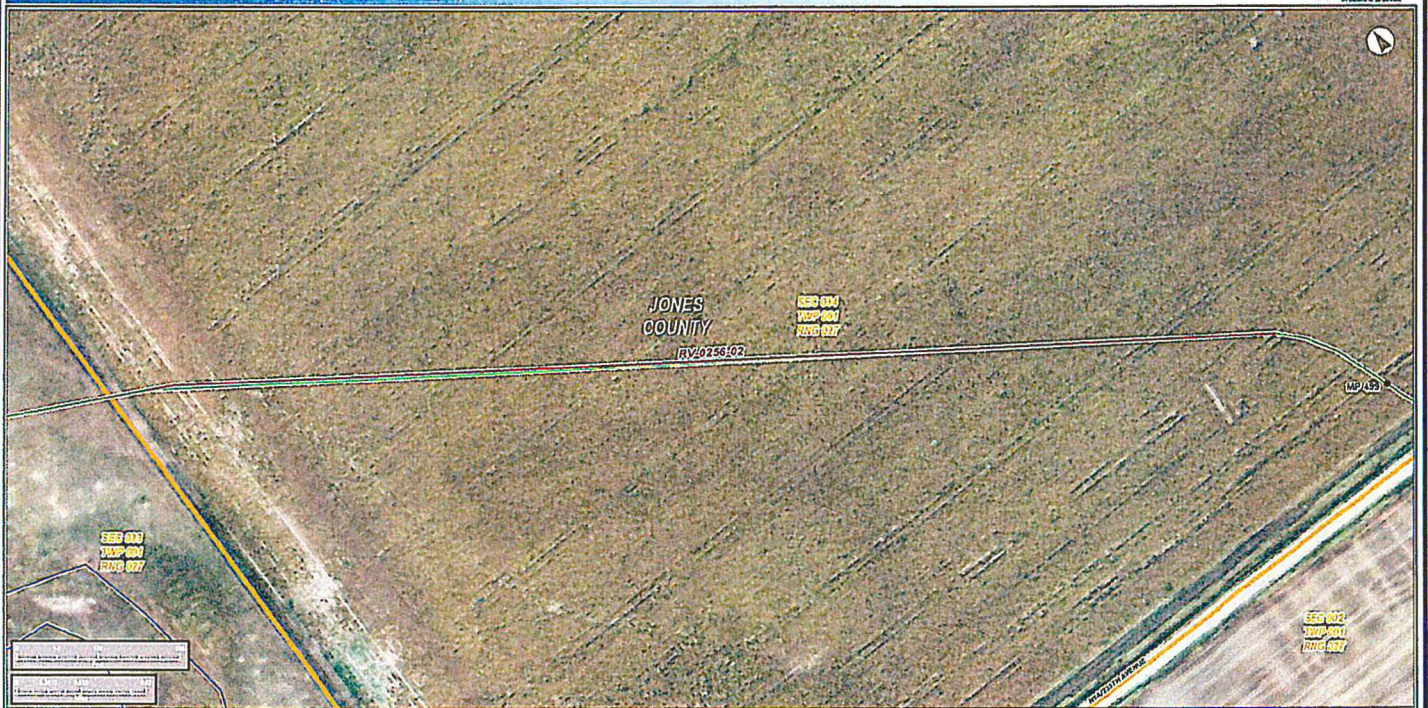
KEYSTONE 0548

022671



KEYSTONE 0549

022672



LEGEND

- MILEPOST**

— ROUTE VARIATION (RV)

— ISSUED CENTERLINE AT TIME OF RV*

- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2013-03-14

**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0255-02

| | |
|---------------------|----------------|
| COUNTY: SD-01 | SHOWN BY: 52 |
| STATE: SOUTH DAKOTA | CHANGED BY: 79 |
| REV NO: 1 | DATE: 2/14/14 |
| ED: ESTHAR/ACN | 2/14/14 |
| PRELIMINARY | |

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F: +1 800 345 5023
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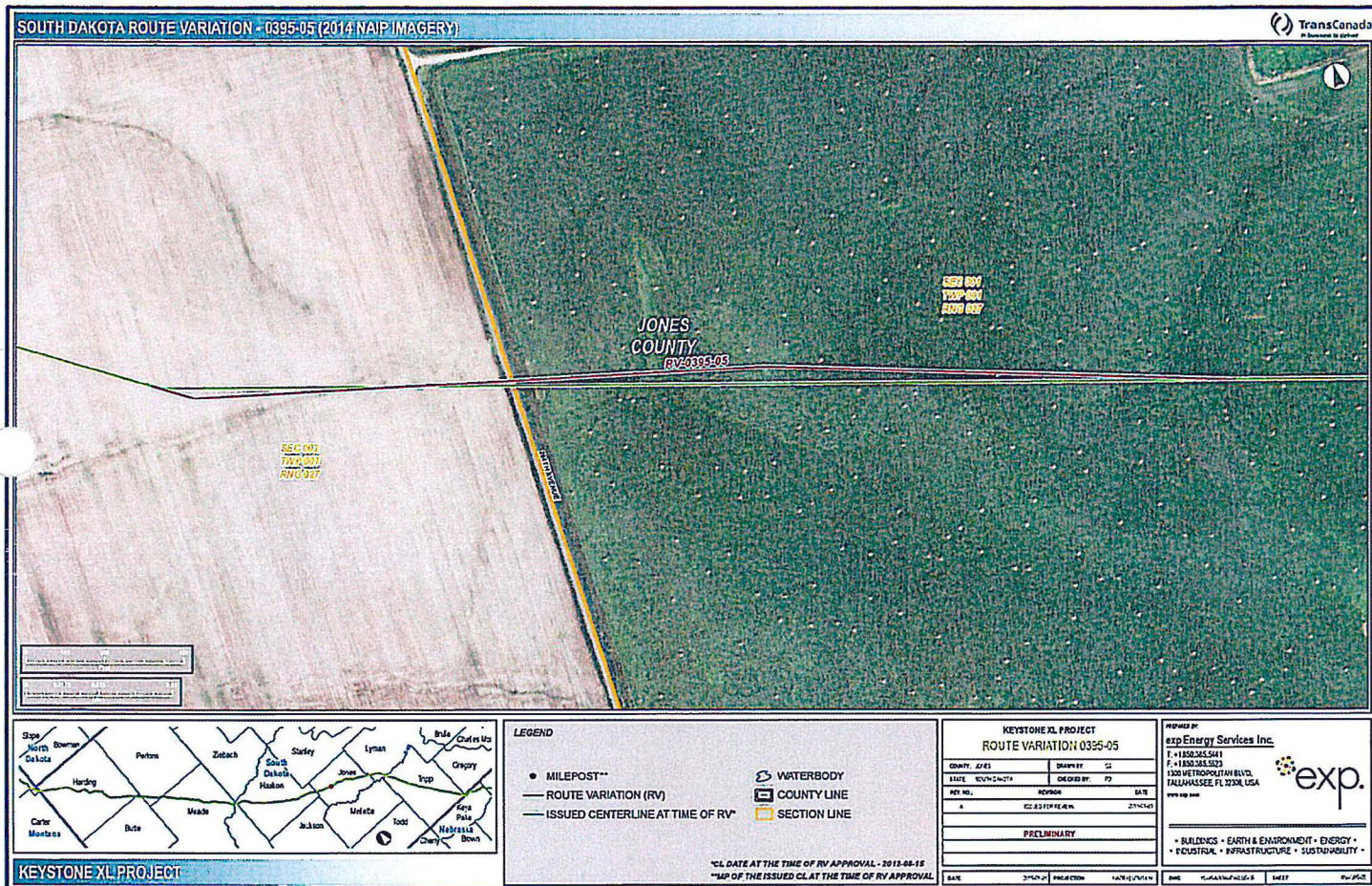


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KEYSTONE XL PROJECT

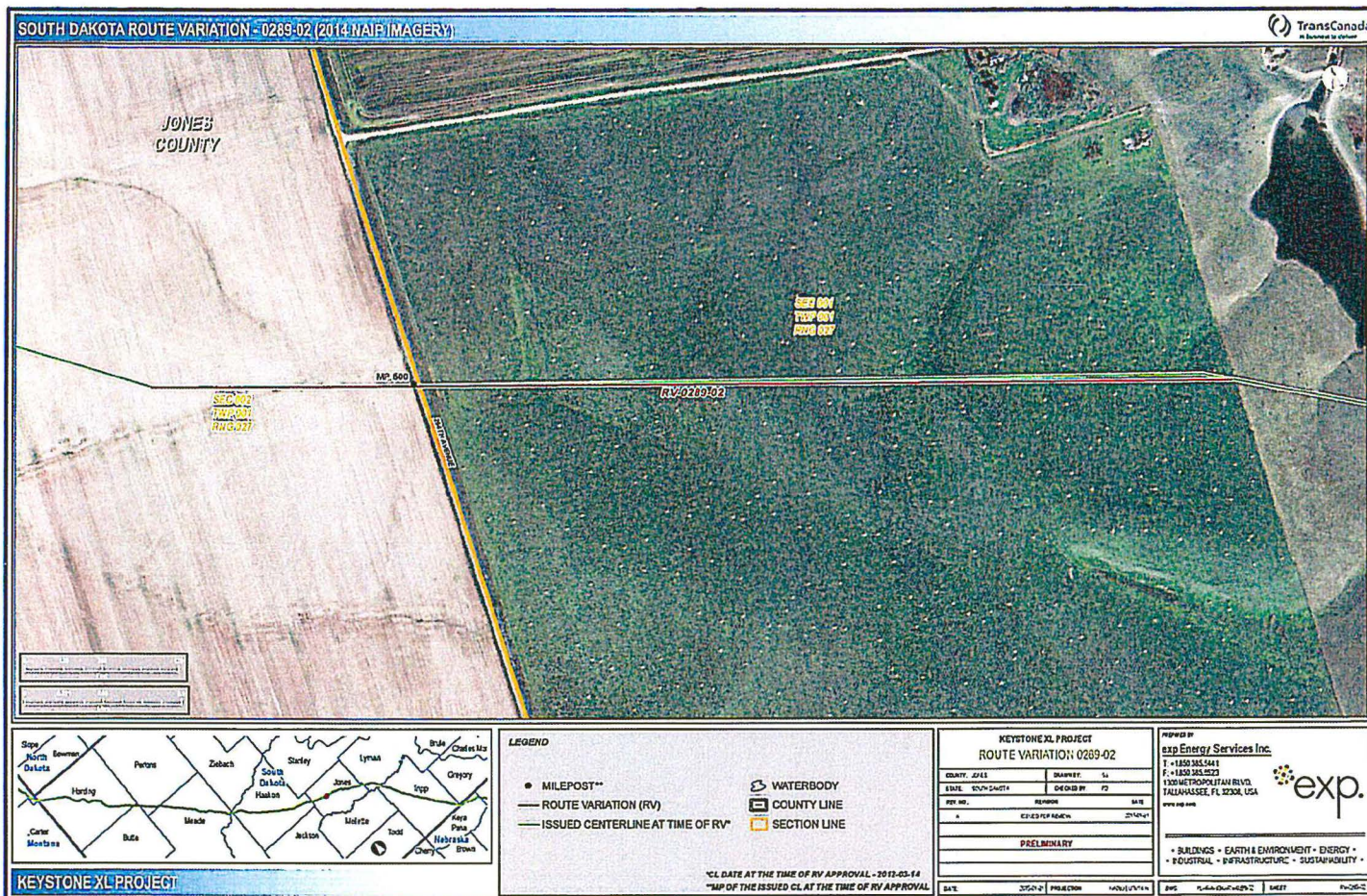
KEYSTONE 0551

022674



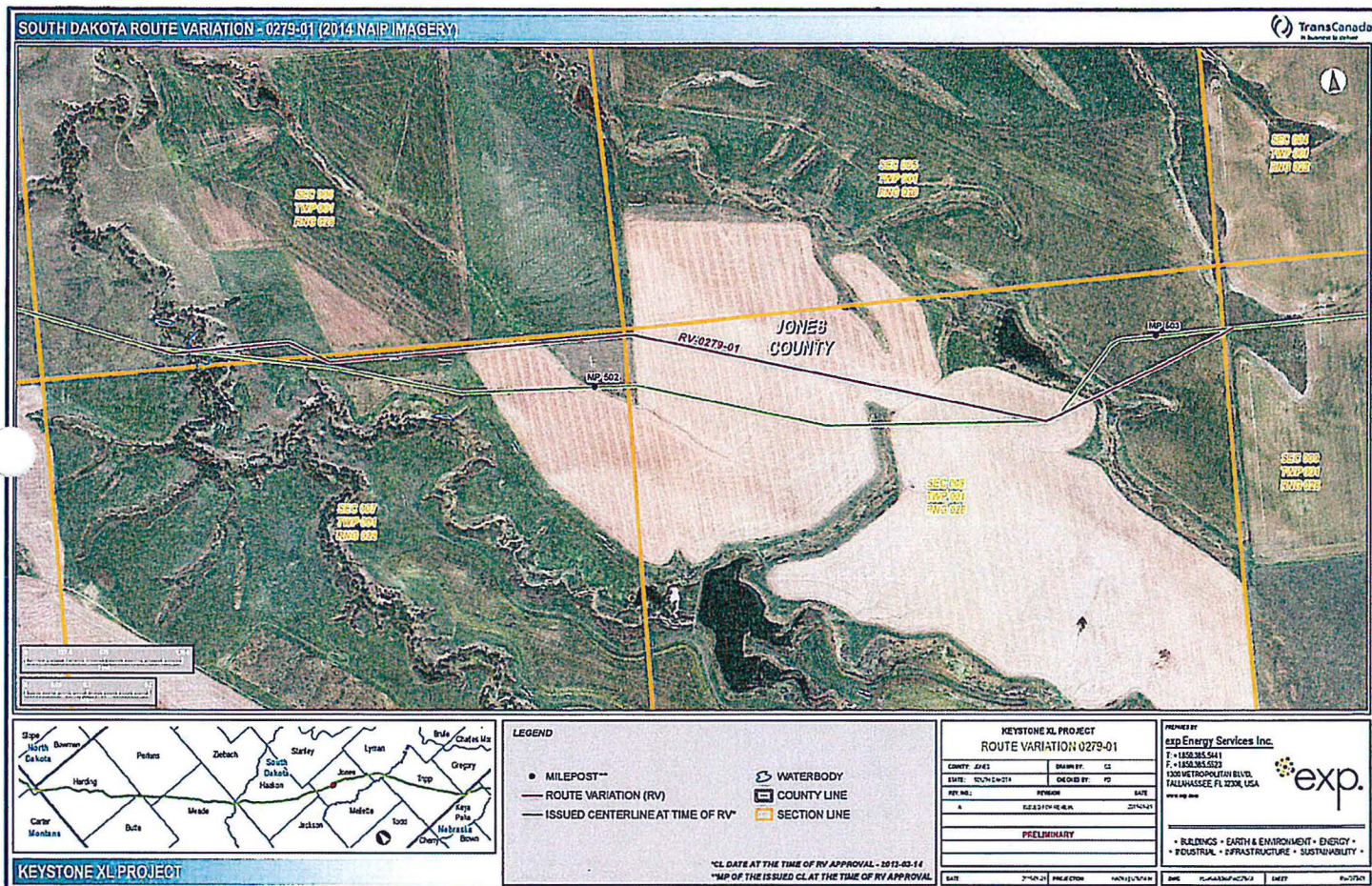
KEYSTONE 0552

022675



KEYSTONE 0553

022676

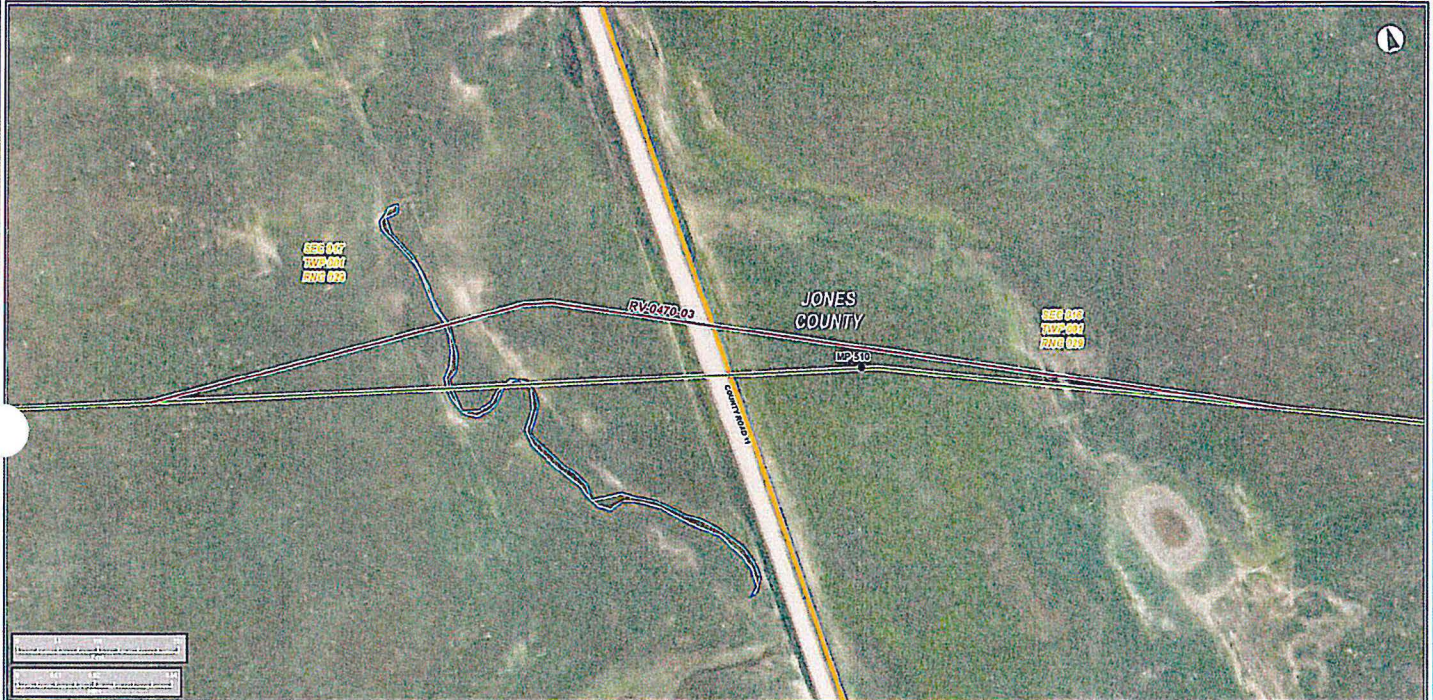


KEYSTONE 0554

022677

SOUTH DAKOTA ROUTE VARIATION - 0470-03 (2014 NAIP IMAGERY)

TransCanada
A Division of Enbridge



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2013-06-11
**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0470-03

| | |
|---------------------|-------------------|
| COUNTY: SD-01 | DRAWN BY: SA |
| STATE: SOUTH DAKOTA | CHECKED BY: PT |
| REV NO. | REVISION |
| 1 | ISSUED FOR REVIEW |
| DATE | DATE |
| | 2/2/2014 |

PRELIMINARY

| | | | | | | | |
|------|----------|---------|---------------|------|----------|-------|---------------|
| DATE | 2/2/2014 | PROJECT | 140741-001-14 | TIME | 15:45:00 | SHEET | 140741-001-14 |
|------|----------|---------|---------------|------|----------|-------|---------------|

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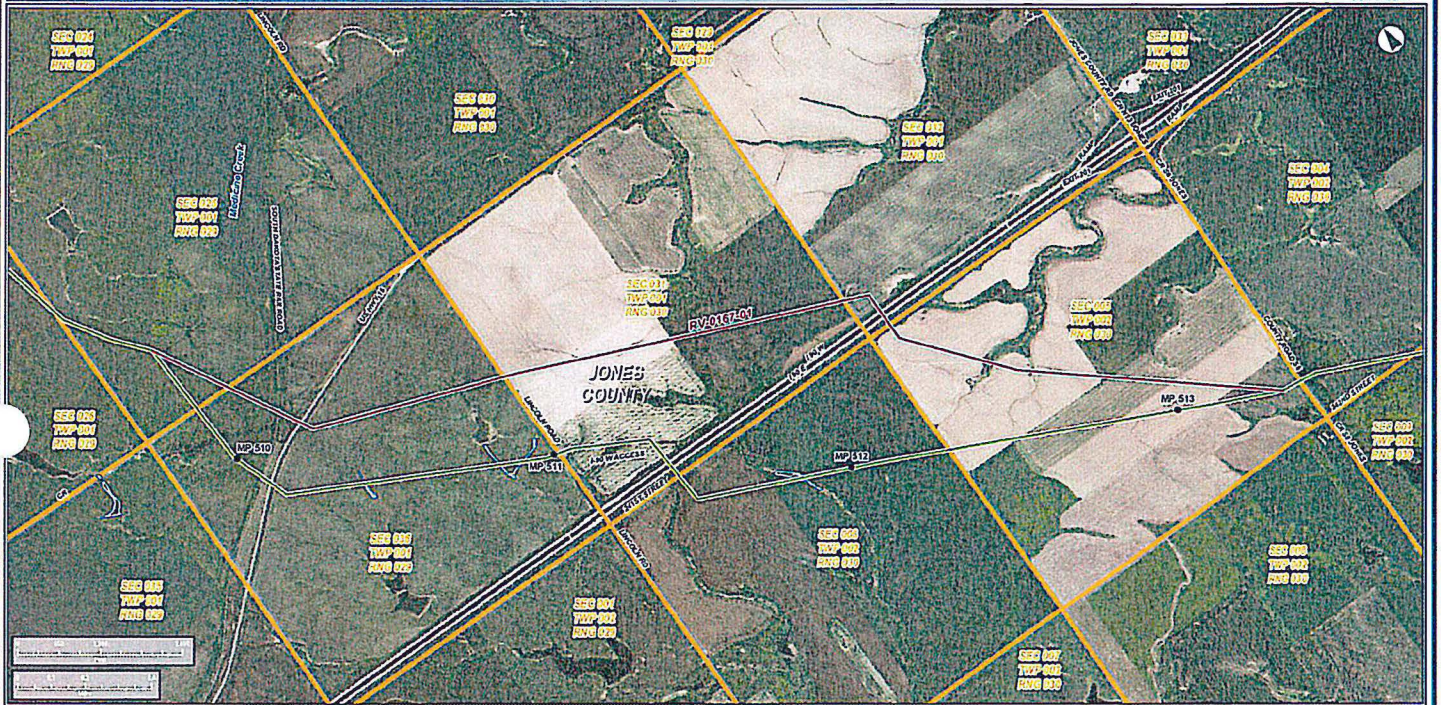
KEYSTONE XL PROJECT

KEYSTONE 0556

022679

SOUTH DAKOTA ROUTE VARIATION - 0167-01 (2014 NAIP IMAGERY)

TransCanada
In partnership with the state



KEYSTONE XL PROJECT

LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2010-03-28
**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

| KEYSTONE XL PROJECT ROUTE VARIATION 0167-01 | | | |
|--|---------------------|-----------------|-------------------|
| COUNTY: DEKES | DRAWN BY: CJ | CHECKED BY: PJ | DATE: 2/15/2011 |
| STATE: SOUTH DAKOTA | DESIGN: PRELIMINARY | DATE: 2/15/2011 | PROJECT: 0167-01 |
| REV NO: | REV DATE: | REV BY: | REV DESCRIPTION: |
| 1 | 2/15/2011 | CJ | ISSUED FOR REVIEW |
| 2 | 2/15/2011 | PJ | ISSUED FOR REVIEW |
| 3 | 2/15/2011 | PJ | ISSUED FOR REVIEW |
| 4 | 2/15/2011 | PJ | ISSUED FOR REVIEW |
| 5 | 2/15/2011 | PJ | ISSUED FOR REVIEW |
| 6 | 2/15/2011 | PJ | ISSUED FOR REVIEW |
| 7 | 2/15/2011 | PJ | ISSUED FOR REVIEW |
| 8 | 2/15/2011 | PJ | ISSUED FOR REVIEW |
| 9 | 2/15/2011 | PJ | ISSUED FOR REVIEW |
| 10 | 2/15/2011 | PJ | ISSUED FOR REVIEW |

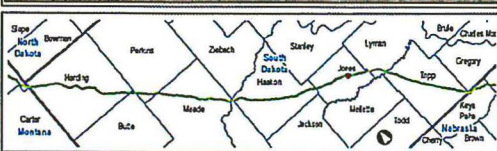
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F: +1.800.365.5423
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KEYSTONE 0558

022681



LEGEND

- MILEPOST**

— ROUTE VARIATION (RV)

— ISSUED CENTERLINE AT TIME OF RV*

- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2013-06-11

**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0442-01

| | |
|---------------------|--------------------|
| COUNTY: JONES | SHOWN BY: 25 |
| STATE: SOUTH DAKOTA | CREATED BY: PT |
| REV NO: | REVISION |
| A | CREATED FOR REVIEW |
| DATE: | 2/24/2011 |
| PRELIMINARY | |

DESIGNED BY
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KEYSTONE XL PROJECT

KEYSTONE 0559

022682



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2010-11-18
 **MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0199-08

| | | |
|-------------|-----------|---------|
| COUNTY LINE | BRIDGE BY | SS |
| STATE | SD | SD |
| REV NO. | REVISION | DATE |
| A | 12/15/14 | 2/15/14 |
| PRELIMINARY | | |

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 F. +1.800.345.5023
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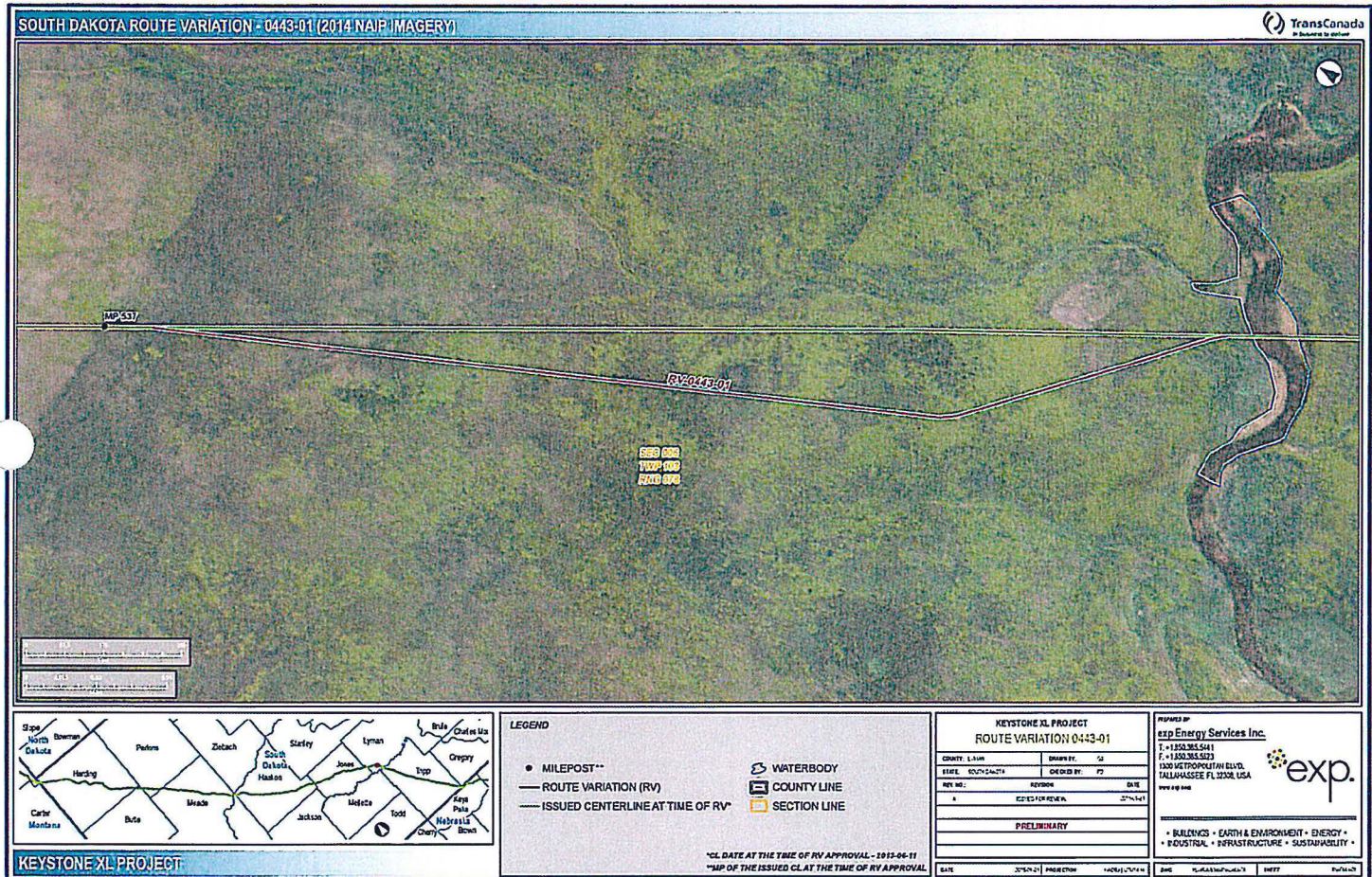


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KEYSTONE XL PROJECT

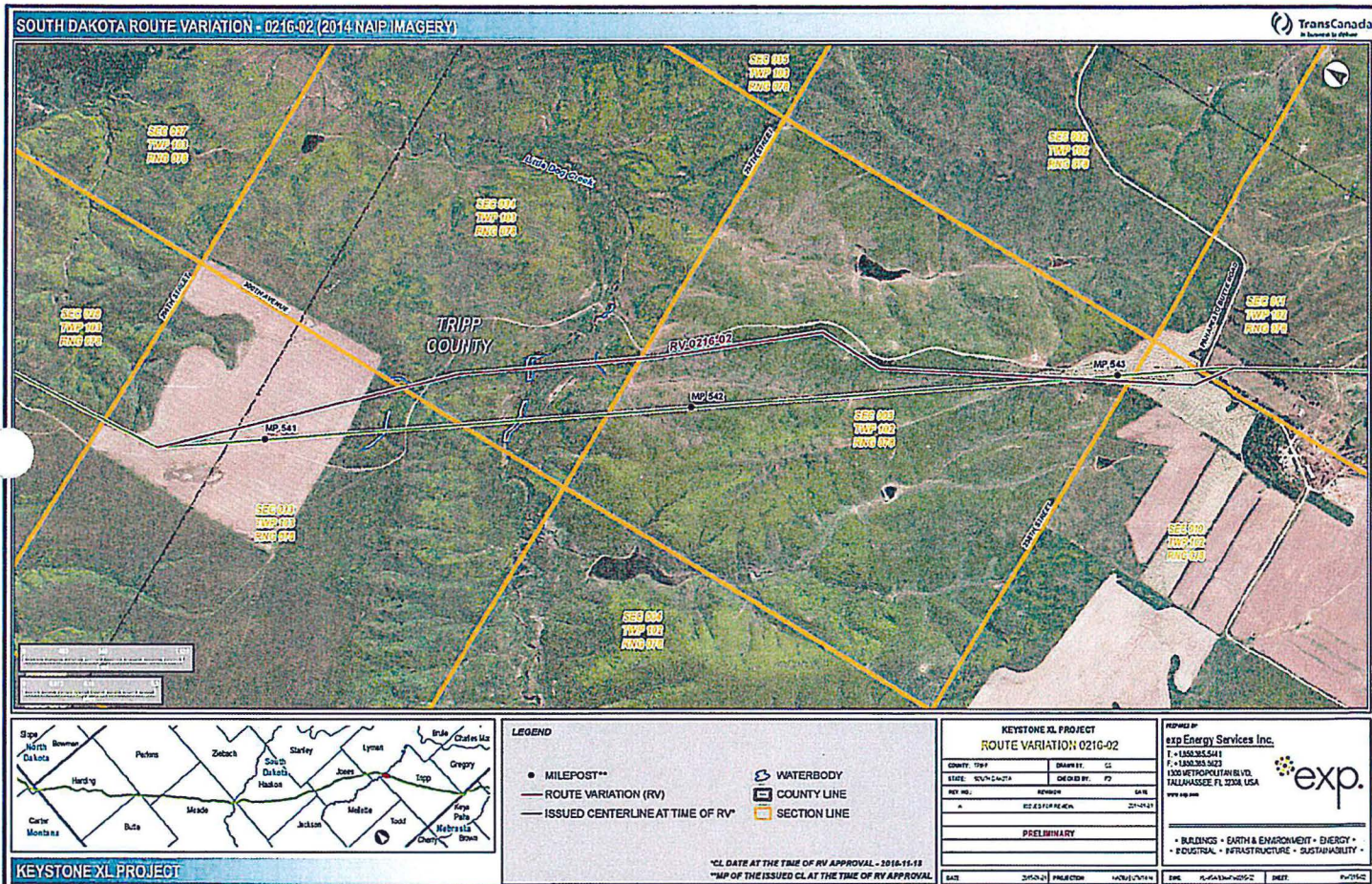
KEYSTONE 0563

022686



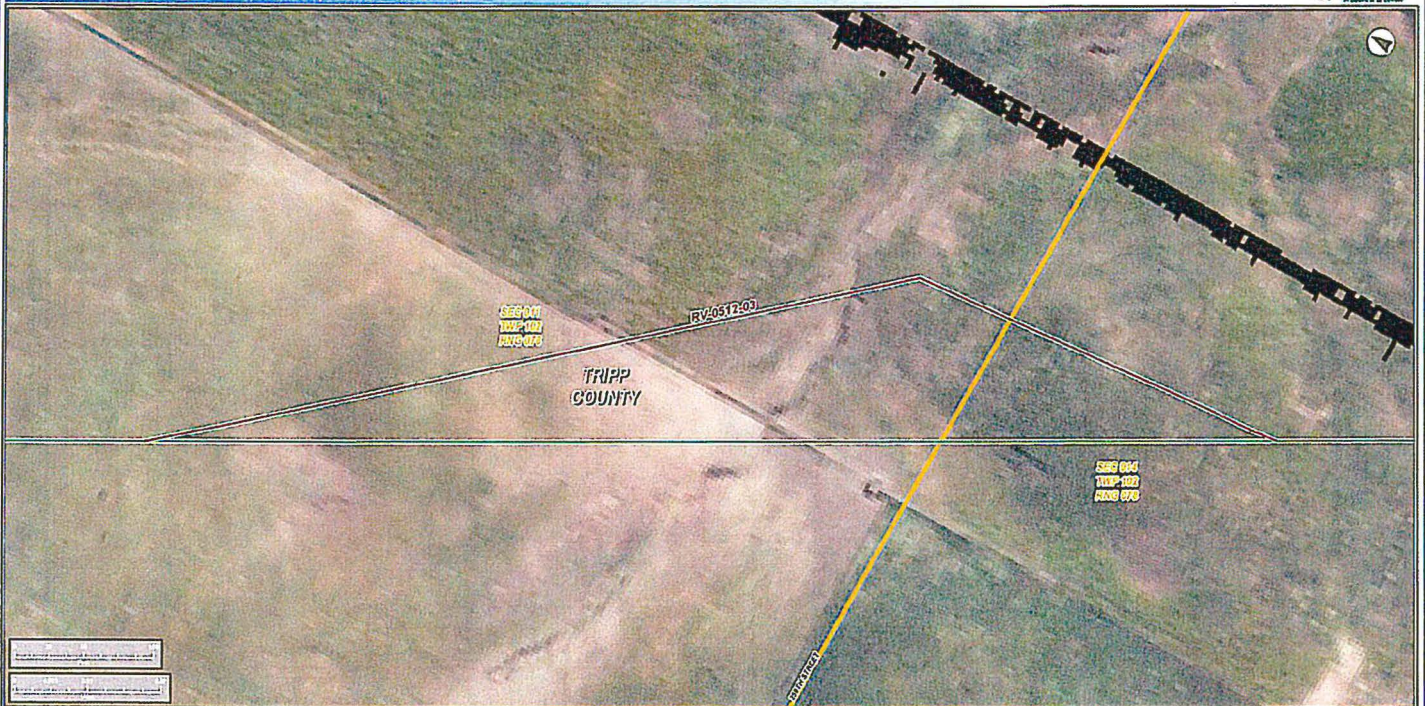
KEYSTONE 0564

022687



KEYSTONE 0566

022689



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*

- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2013-06-11

**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0512-03

| | |
|---------------------|-------------------|
| COUNTY: TRIPP | SHOWN BY: 25 |
| STATE: SOUTH DAKOTA | DATE: 07/25/13 |
| REV: 001 | REV: 001 |
| A | CL: 03 FOR REVIEW |
| PRELIMINARY | |

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F: +1 800 343 5423
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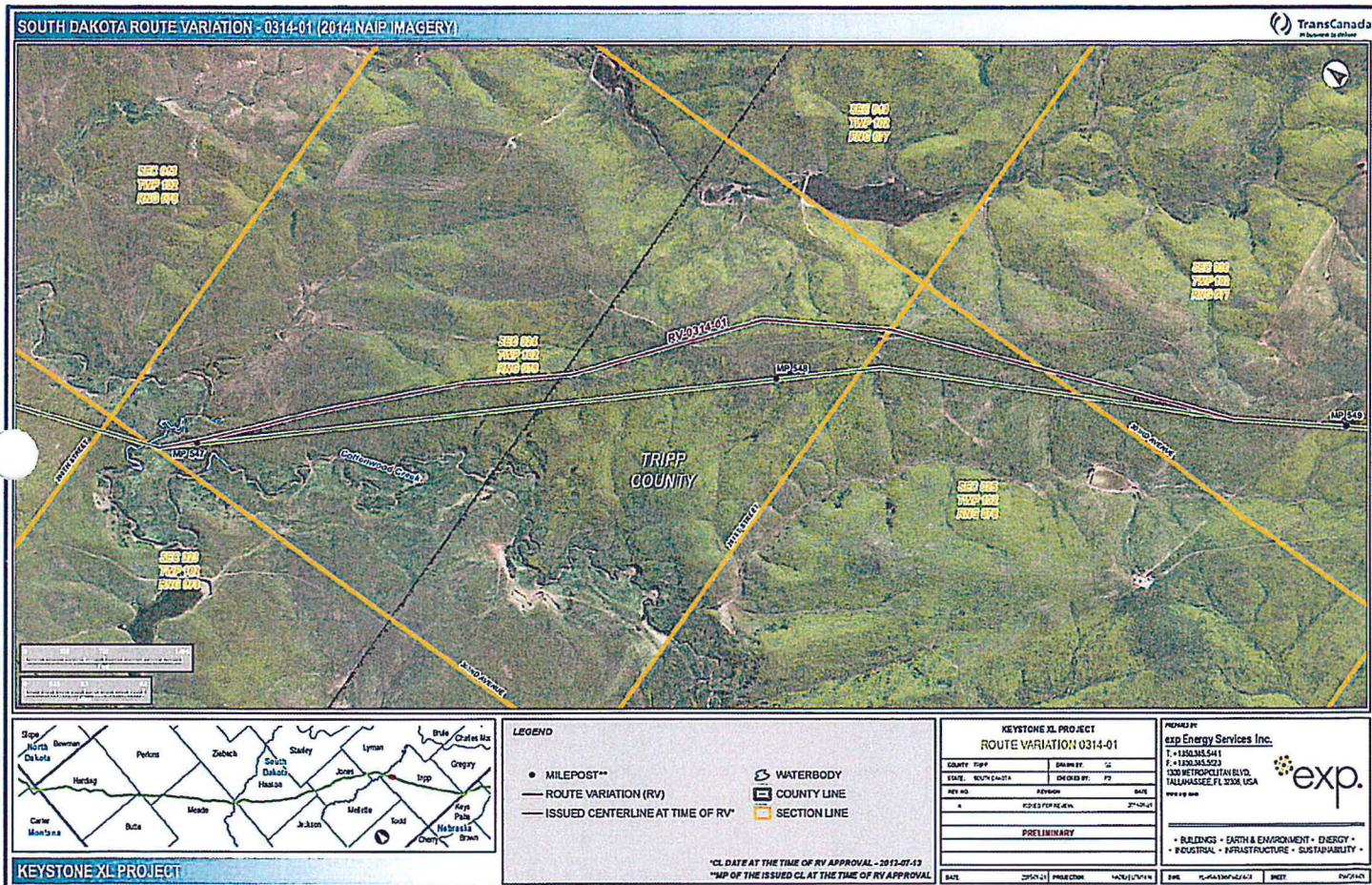


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KEYSTONE XL PROJECT

KEYSTONE 0567

022690



KEYSTONE 0568

022691



KEYSTONE XL PROJECT

LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2013-06-15
 **MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

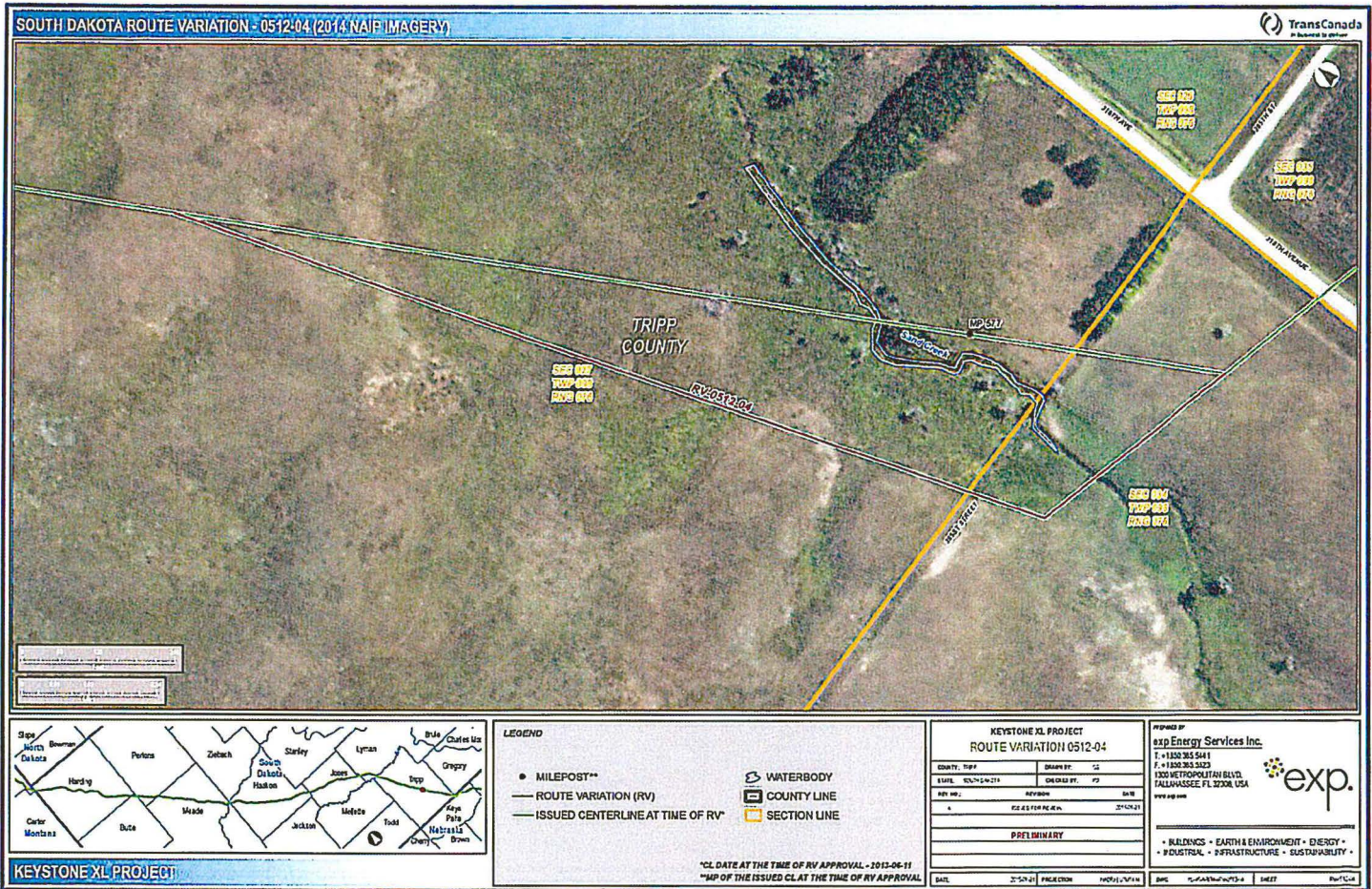
KEYSTONE XL PROJECT
ROUTE VARIATION 0325-05

| | |
|---------------------|-------------------|
| COUNTY: TRIP | DRAWN BY: 12 |
| STATE: SOUTH DAKOTA | CREATED BY: P2 |
| REV. NO. | ADDITION |
| A | ISSUED FOR REVIEW |
| DATE | 2013-06-15 |
| PRELIMINARY | |

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exp Energy Services Inc.
 T: +1.800.365.5411
 F: +1.800.365.5403
 1300 METROPOLITAN BLVD.
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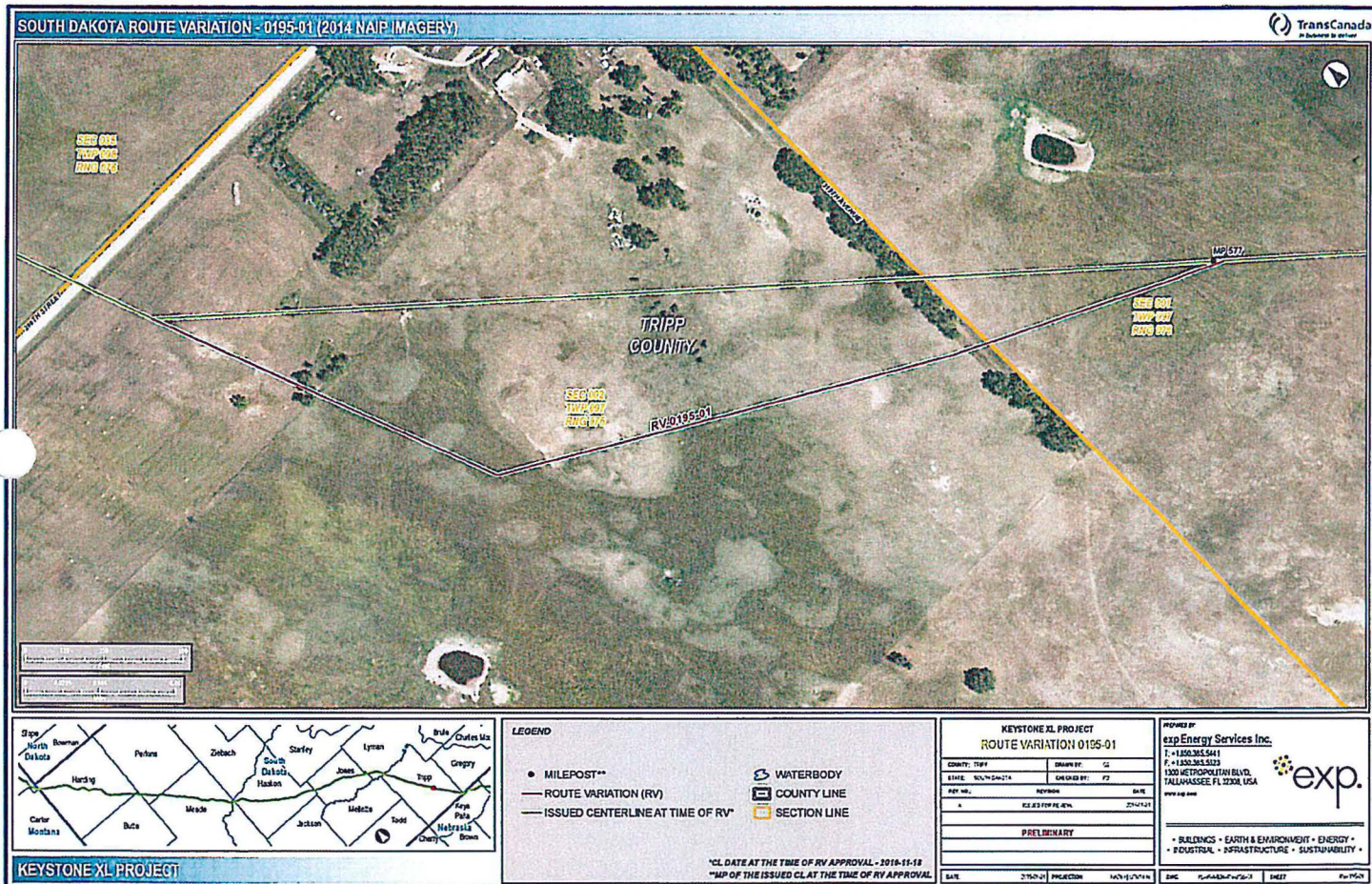


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KEYSTONE 0571

022694



KEYSTONE 0572

022695



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2010-11-18
 **MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0215-04

| | |
|---------------------|------------------|
| COUNTY: T399 | DRAWN BY: LS |
| STATE: SOUTH DAKOTA | CHECKED BY: PT |
| REV NO: 1 | REVISION |
| DATE | DATE |
| BY: LS | DATE: 02/24/2014 |

PRELIMINARY

| | | |
|------------------|-------------------------|----------------|
| DATE: 02/24/2014 | PROJECT: 140701-0215-04 | SHEET: 0215-04 |
|------------------|-------------------------|----------------|

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 1330 METROPOLITAN BLVD.
 TALLAHASSEE, FL 32302, USA
 WWW.EXP-USA.COM



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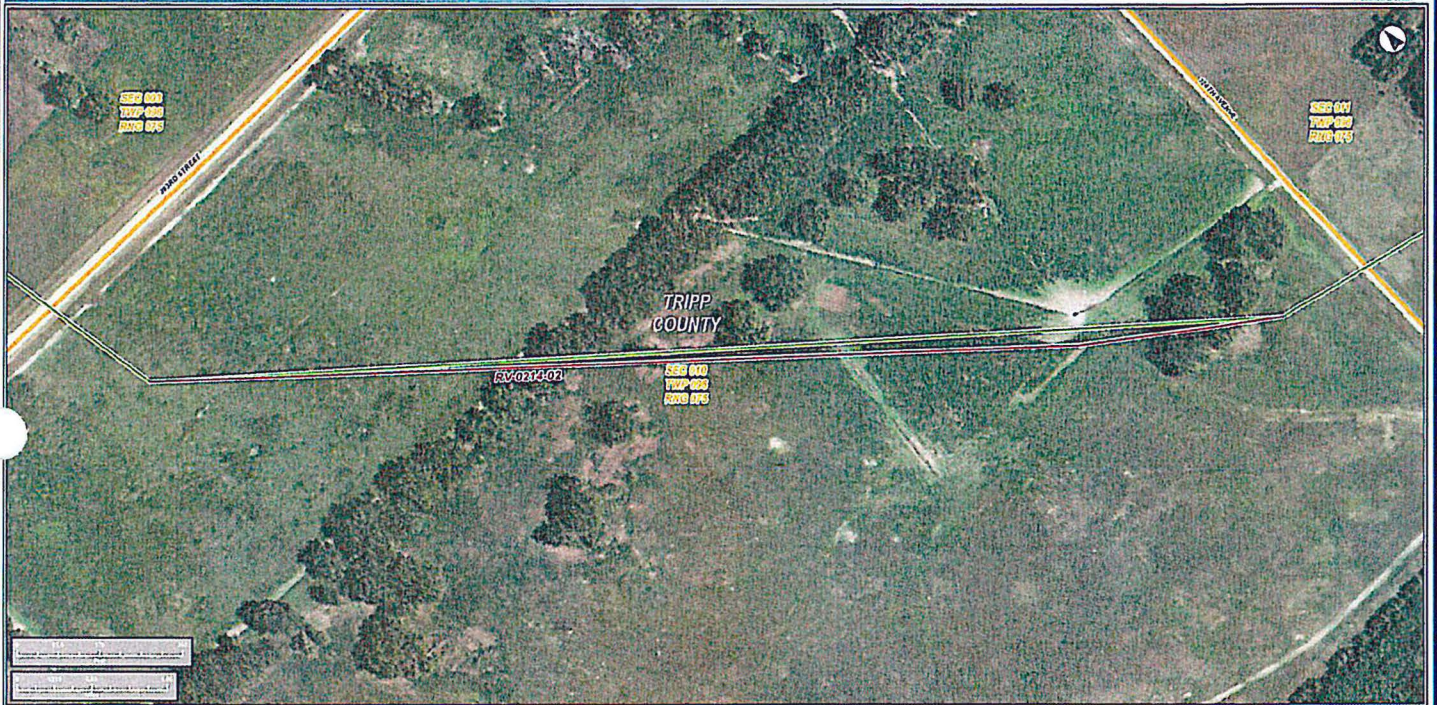
KEYSTONE XL PROJECT

KEYSTONE 0574

022697

SOUTH DAKOTA ROUTE VARIATION - 0214-02 (2014 NAIP IMAGERY)

TransCanada
A subsidiary of Enbridge



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2016-11-18
**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0214-02

| | |
|---------------------|------------------------------|
| COUNTY: TRIPP | DRAWN BY: CS |
| STATE: SOUTH DAKOTA | CREATED BY: PD |
| REV NO: 1 | REVISION DATE |
| 1 | ISSUED FOR REVIEW 2016-11-18 |
| PRELIMINARY | |
| DATE: 2016-11-18 | PROJECT: 140114-02 |
| SHEET: 1 | SHEET: 1 |

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TALLAHASSEE, FL 32304, USA
www.exp.com

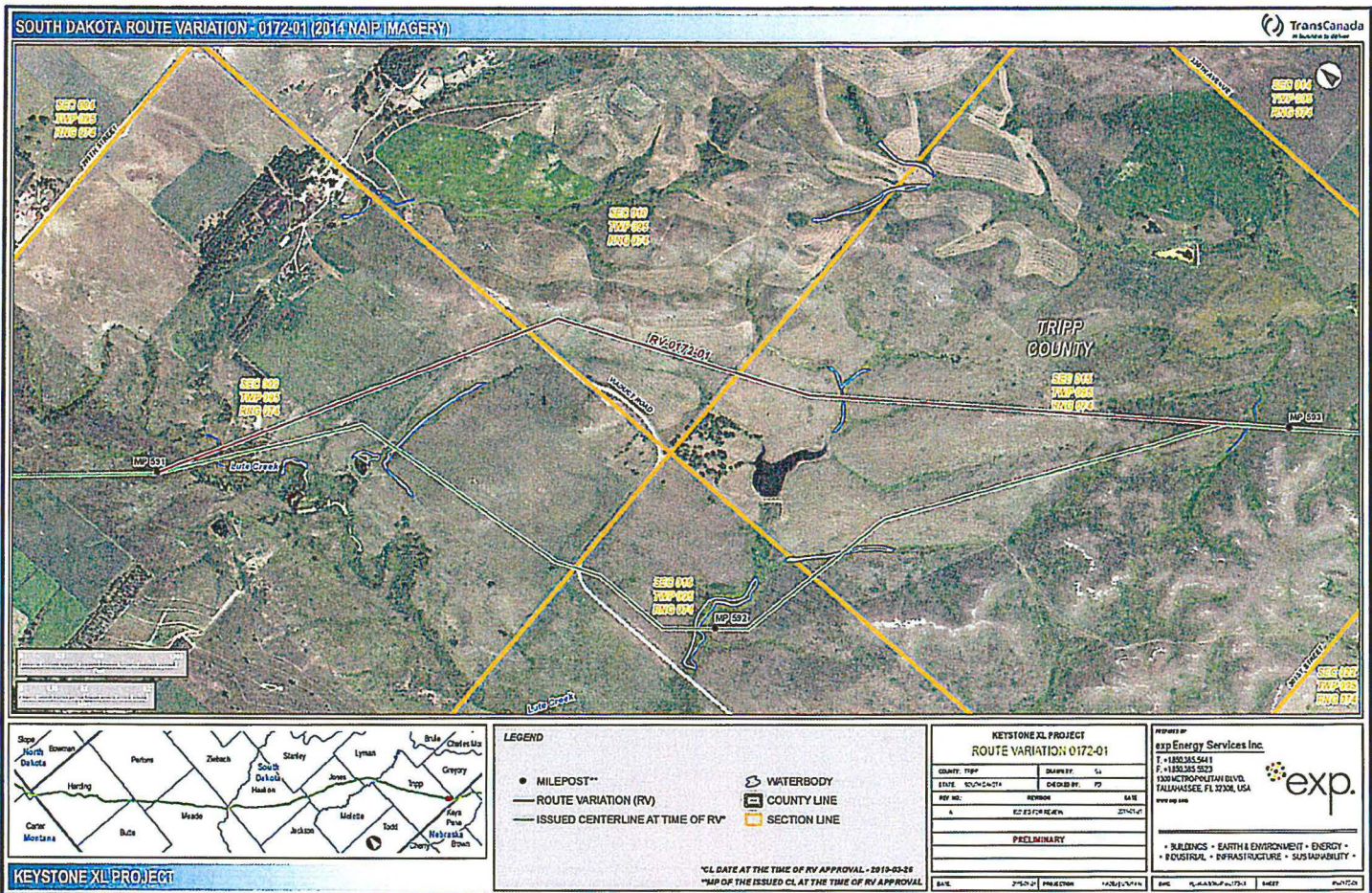


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KEYSTONE XL PROJECT

KEYSTONE 0576

022699

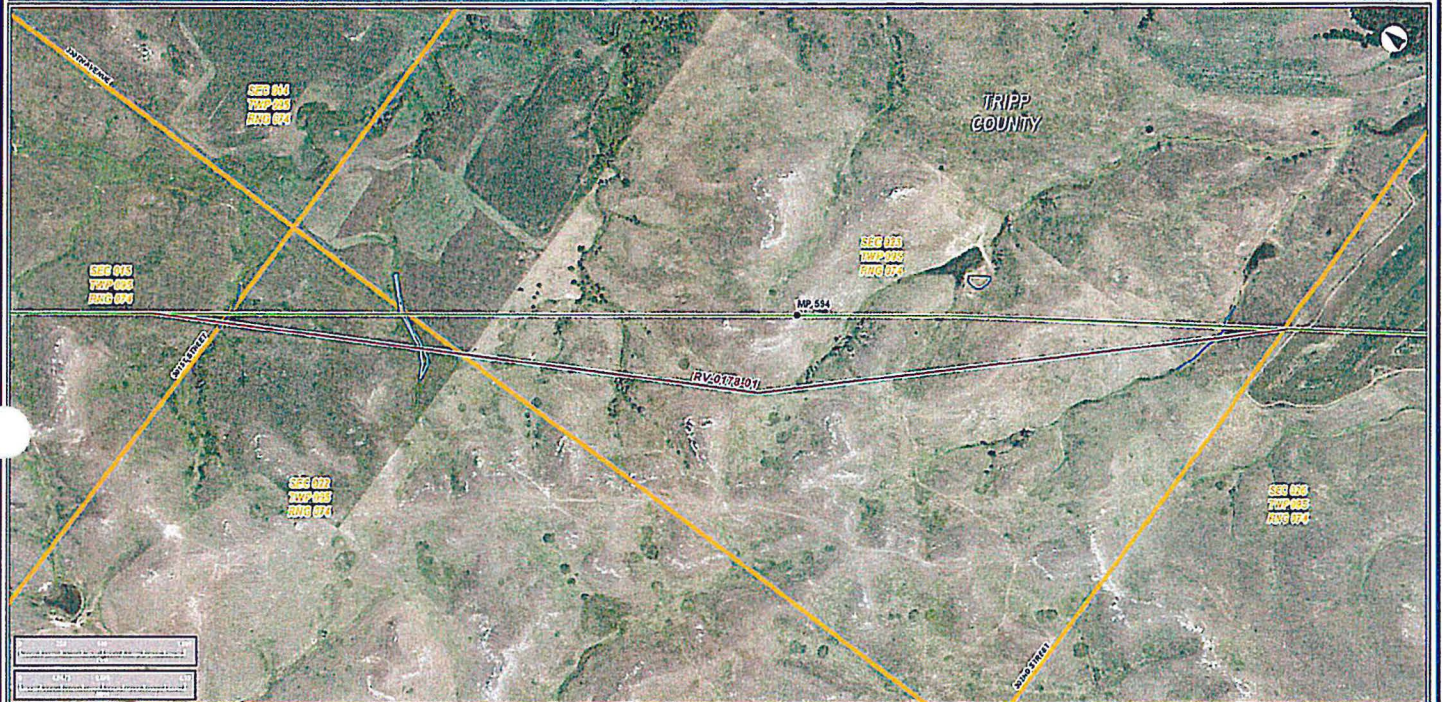


KEYSTONE 0577

022700

SOUTH DAKOTA ROUTE VARIATION - 0178-01 (2014 NAIP / MAGERY)

TransCanada
BY LICENSE TO THE PUBLIC



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 10/19/2014
**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0178-01

COUNTY: TRIPP
STATE: SOUTH DAKOTA
REV NO.: 1
REVISION: 02/23/2014
DATE: 02/23/2014

PRELIMINARY

DATE: 02/23/2014 PROJECT: 0178-01 DRAWN BY: 0178-01

DESIGNED BY
expEnergy Services Inc.
T: +1 800 365 5411
F: +1 800 365 5823
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TALLAHASSEE, FL 32304, USA
www.exp.com

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KEYSTONE XL PROJECT

KEYSTONE 0578

022701

SOUTH DAKOTA ROUTE VARIATION 0395-07 (2014 NAIP IMAGERY)

TransCanada
In business to deliver



LEGEND

- MILEPOST**
- ROUTE VARIATION (RV)
- ISSUED CENTERLINE AT TIME OF RV*
- WATERBODY
- COUNTY LINE
- SECTION LINE

*CL DATE AT THE TIME OF RV APPROVAL - 2012-06-15
**MP OF THE ISSUED CL AT THE TIME OF RV APPROVAL

KEYSTONE XL PROJECT
ROUTE VARIATION 0395-07

| | |
|----------------|----------------|
| COUNTY: TRIPP | DRAWN BY: SJ |
| STATE: SD | CHECKED BY: PS |
| REV: 01 | REVISION: 01 |
| DATE: 12/24/14 | DATE: 12/24/14 |

PRELIMINARY

| | | | | | |
|----------------|---------------------|---------|----------------|-------------------|---------|
| DATE: 12/24/14 | PROJECT: 14014-0114 | REV: 01 | DATE: 12/24/14 | SHEET: 14014-0114 | REV: 01 |
|----------------|---------------------|---------|----------------|-------------------|---------|

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exp Energy Services Inc.
T: +1.800.365.5411
F: +1.800.365.5023
1500 METROPOLITAN BLVD.
TALLAHASSEE, FL 32308 USA
www.exp.com

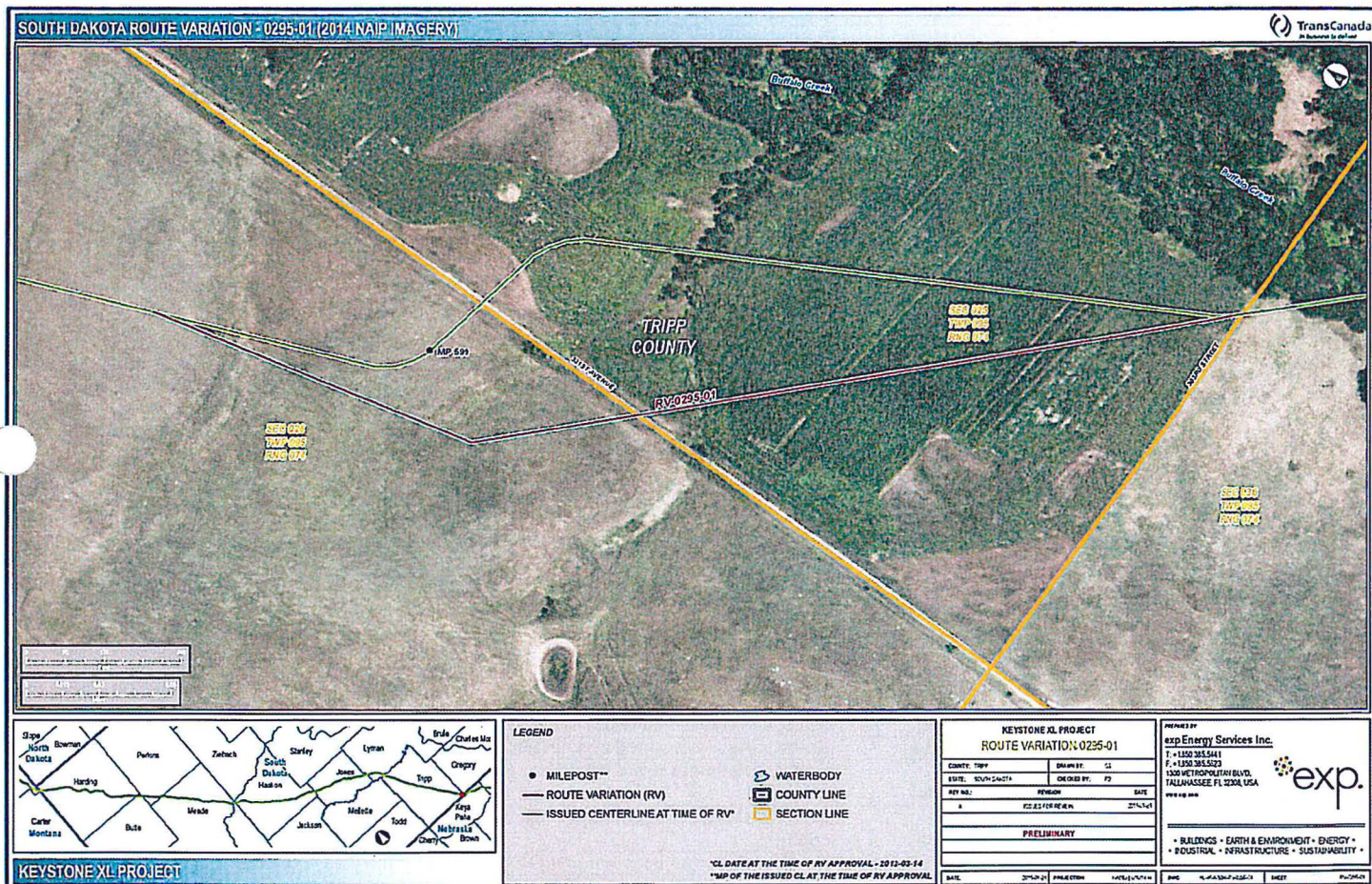


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KEYSTONE XL PROJECT

KEYSTONE 0579

022702



KEYSTONE 0580

022703

South Dakota Route Variations

| Route Variation Number | State | County | Reason |
|------------------------|-------|---------|--|
| 0166-01 | SD | Harding | Route variation to minimize constructability and safety concerns with current County Road 988 crossing. |
| 0167-01 | SD | Jones | Route variation to minimize constructability and safety concerns with current Interstate 90, Hwy 16 and State Railroad crossings. |
| 0172-01 | SD | Tripp | Route variation to minimize landowner impacts and reduce crossing of varying terrain features. |
| 0178-01 | SD | Tripp | Route variation to minimize constructability and safety concerns with current Interstate 90, Hwy 16 and State Railroad crossings. |
| 0179-01 | SD | Harding | Route variation to avoid endangered species. |
| 0181-01 | SD | Haakon | Route variation to remove unnecessary points of inflection in the route and reduce the route length. |
| 0187-01 | SD | Haakon | Route variation per landowner request and to avoid crossing a pond. |
| 0188-01 | SD | Haakon | Route variation per landowner request to minimize construction impacts to a pond. |
| 0190-01 | SD | Harding | Route variation to avoid paleontological features. |
| 0192-01 | SD | Harding | Route variation to minimize multiple crossing of a waterline. |
| 0195-01 | SD | Tripp | Route variation per landowner requests to avoid a row of trees and minimize landowner impacts. |
| 0196-01 | SD | Haakon | Route variation to minimize crossing length of Hwy 73 and constructability concerns. |
| 0199-01 | SD | Perkins | Route variation to minimize multiple creek crossings. |
| 0199-02 | SD | Meade | Route variation to minimize multiple creek crossings and avoid paralling drainage feature. |
| 0199-03 | SD | Haakon | Route variation to avoid paralling drainage feature. |
| 0199-05 | SD | Haakon | Route variation to minimize creek crossings and adjust for better constructability of creek crossing. |
| 0199-06 | SD | Haakon | Route variation to avoid drainage feature and eliminate construction impacts to the levee. |
| 0199-08 | SD | Lyman | Route variation to avoid drainage features. |
| 0199-09 | SD | Tripp | Route variation to minimize multiple creek crossings. |
| 0200-01 | SD | Haakon | Route variation to minimize creek crossings, adjust for better constructability of creek crossing and minimize construction impacts to a pond. |
| 0212-01 | SD | Harding | Route variation to accommodate HDD design for the Little Missouri River. |
| 0214-01 | SD | Meade | Route variation to avoid a well and levee. |
| 0214-02 | SD | Tripp | Route variation to avoid a well and impacts to a fence. |
| 0215-01 | SD | Harding | Route variation to avoid varying terrain features. |
| 0215-02 | SD | Meade | Route variation to avoid paralling a creek. |
| 0215-03 | SD | Haakon | Route variation to avoid sudden terrain change. |
| 0215-04 | SD | Tripp | Route variation to avoid road crossing within a wetland area. |
| 0216-01 | SD | Lyman | Route variation to minimize side slope construction. |
| 0216-02 | SD | Tripp | Route variation to minimize side slope construction. |
| 0220-01 | SD | Haakon | Route variation to accommodate HDD design for the Bad River. |
| 0224-01 | SD | Meade | Route variation to minimize multiple creek crossings. |
| 0239-01 | SD | Haakon | Route variation to avoid sudden terrain change. |
| 0252-01 | SD | Meade | Route variation to avoid ridge lines, varying terrain and sudden terrain changes. |
| 0252-02 | SD | Meade | Route variation to avoid ridge lines, varying terrain and sudden terrain changes. |
| 0252-03 | SD | Haakon | Route variation to accommodate HDD design for the Cheyenne River. |
| 0256-01 | SD | Haakon | Route variation to remove unnecessary points of inflection in the route and reduce the route length. |
| 0256-02 | SD | Haakon | Route variation to accommodate a road crossing. |
| 0256-03 | SD | Jones | Route variation to minimize the route length. |
| 0257-01 | SD | Perkins | Route variation to avoid construction foot print impacts paralleling a road. |
| 0257-02 | SD | Meade | Route variation to avoid route and construction foot print impacts paralleling a road. |
| 0258-01 | SD | Harding | Route variation to avoid crossing a pond. |
| 0260-01 | SD | Haakon | Route variation to accommodate waterline crossings. |
| 0260-02 | SD | Haakon | Route variation to accommodate waterline crossings. |
| 0260-03 | SD | Haakon | Route variation to avoid construction foot print on waterline. |
| 0260-04 | SD | Haakon | Route variation to avoid crossing waterlines. |
| 0262-01 | SD | Haakon | Route variation to increase separation of route and pond spillway due to constructability and avoid potential future concerns. |
| 0269-01 | SD | Harding | Route variation to avoid cultural site. |

South Dakota Route Variations

| Route Variation Number | State | County | Reason |
|------------------------|-------|-----------------|---|
| 0270-01 | SD | Meade | Route variation to avoid construction foot print impacts to cattle guard and fence. |
| 0272-01 | SD | Haakon | Route variation to minimize side slope construction and varying terrain. |
| 0279-01 | SD | Jones | Route variation to remove unnecessary points of inflection in the route and reduce the route length. |
| 0280-01 | SD | Harding | Route variation to avoid varying terrain and sudden terrain changes. |
| 0281-01 | SD | Harding | Route variation to avoid side slope construction. |
| 0282-01 | SD | Harding | Route variation to minimize drainage crossings and avoid paralleling a drainage. |
| 0285-01 | SD | Haakon | Route variation to accommodate road and creek crossings. |
| 0286-01 | SD | Haakon | Route variation to remove unnecessary points of inflection in the route, reduce the route length and better valve location. |
| 0287-01 | SD | Lyman | Route variation to accommodate road crossing and better valve location. |
| 0289-01 | SD | Haakon | Route variation to accommodate pump station design. |
| 0289-02 | SD | Jones | Route variation to accommodate pump station design. |
| 0291-01 | SD | Harding | Route variation to avoid paralleling and minimize multiple creek crossings. |
| 0292-01 | SD | Harding | Route variation to avoid paralleling a creek. |
| 0293-01 | SD | Jones | Route variation to avoid construction impacts to a pond and levee. Also, minimize varying terrain features. |
| 0294-01 | SD | Tripp | Route variation to avoid a well and construction foot print impacts to a fence surrounding a historical site. |
| 0295-01 | SD | Tripp | Route variation to avoid a drainage crossing and accommodate a road crossing. |
| 0296-01 | SD | Butte / Perkins | Route variation to avoid terrain feature. |
| 0310-01 | SD | Jones | Route variation to avoid paralleling a drainage and increase separation at a washout at a creek crossing. |
| 0311-01 | SD | Perkins | Route variation to avoid a cultural site and accommodate a creek crossing. |
| 0314-01 | SD | Tripp | Route variation to avoid side slope construction and sudden terrain changes. |
| 0372-01 | SD | Haakon | Route variation to accommodate valve placement. |
| 0381-01 | SD | Harding | Route variation to avoid crossing a pond. |
| 0382-01 | SD | Harding | Route variation to minimize construction foot print on adjacent landowner property. |
| 0384-01 | SD | Meade | Route variation to avoid impacts to adjacent property. |
| 0383-01 | SD | Jones | Route variation to accommodate waterline crossing. |
| 0385-01 | SD | Haakon | Route variation to minimize multiple crossing of a waterline. |
| 0395-01 | SD | Harding | Route variation to accommodate pump station design. |
| 0395-02 | SD | Harding | Route variation to accommodate pump station design. |
| 0395-03 | SD | Meade | Route variation to accommodate pump station design. |
| 0395-04 | SD | Haakon | Route variation to accommodate pump station design. |
| 0395-05 | SD | Jones | Route variation to accommodate pump station design. |
| 0395-06 | SD | Tripp | Route variation to accommodate pump station design. |
| 0395-07 | SD | Tripp | Route variation to accommodate pump station design. |
| 0413-01 | SD | Harding | Route variation to avoid washouts and sudden terrain changes. |
| 0442-01 | SD | Jones | Route variation to accommodate waterline crossing. |
| 0443-01 | SD | Lyman | Route variation to avoid paralleling a creek. |
| 0443-02 | SD | Jones | Route variation to avoid paralleling a creek. |
| 0443-04 | SD | Haakon | Route variation to avoid waterbody crossing. |
| 0443-05 | SD | Jones | Route variation to avoid paralleling a creek. |
| 0455-01 | SD | Haakon | Route variation to increase parallel separation of route and waterline. |
| 0455-02 | SD | Haakon | Route variation to increase parallel separation of route and waterline. |
| 0456-01 | SD | Harding | Route variation to avoid an oil well. |
| 0470-01 | SD | Harding | Route variation to avoid creek crossing. |
| 0470-02 | SD | Haakon | Route variation to minimize multiple creek crossings. |
| 0470-03 | SD | Jones | Route variation to minimize multiple creek crossings. |
| 0470-04 | SD | Perkins | Route variation to avoid paralleling a creek. |
| 0470-05 | SD | Perkins | Route variation to avoid paralleling a creek. |
| 0470-06 | SD | Meade | Route variation to accommodate creek crossing. |
| 0470-07 | SD | Meade | Route variation to avoid a pond. |
| 0470-09 | SD | Perkins | Route variation to avoid ravine. |
| 0470-10 | SD | Perkins | Route variation to avoid paralleling a creek. |

South Dakota Route Variations

| Route Variation Number | State | County | Reason |
|------------------------|-------|---------|---|
| 0478-01 | SD | Meade | Route variation to accommodate road crossing. |
| 0491-01 | SD | Meade | Route variation to avoid drainage. |
| 0497-01 | SD | Haakon | Route variation to accommodate road crossing. |
| 0512-01 | SD | Meade | Route variation to avoid any well impacts. |
| 0512-02 | SD | Meade | Route variation to avoid any well impacts. |
| 0512-03 | SD | Tripp | Route variation to avoid any well impacts. |
| 0512-04 | SD | Tripp | Route variation to avoid any well impacts. |
| 0514-01 | SD | Butte | Route variation to avoid cultural site. |
| 0515-01 | SD | Harding | Route variation to avoid cultural site. |
| 0527-01 | SD | Harding | Route variation to avoid cultural site. |
| 0527-02 | SD | Perkins | Route variation to avoid cultural site. |
| 0528-01 | SD | Tripp | Route variation to avoid swampy low lying area near a pond. |
| 0543-01 | SD | various | Route variation to accommodate HDD designs. |

http://bismarcktribune.com/news/state-and-regional/unusual-alliance-on-oil-spill-cleanup-near-tioga/article_75164d8e-4b8f-11e4-bf7b-93e46e70604c.html

spill cleanup

Unusual alliance on oil spill cleanup near Tioga

By KATHLEEN J. BRYAN | Forum News Service Oct 4, 2014



Forum News Service

Farmer Steve Jensen harvests durum adjacent to his wheat field, where cleanup is underway on the site of one of N largest oil spills near Tioga on Sept. 16.

TIOGA, N.D. — On Monday, Patty Jensen delivered a treat to the workers doing the

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cleanup on the site of one of North Dakota's largest oil spills.

For husband Steve, it was just another day at the end of a busy harvest. But a year ago, his discovery of oil in their wheat field near Tioga set off a media frenzy and an outcry over the 11-day delay by state officials in notifying the public.

The initial report filed by the North Dakota Department of Health on the morning of Sept. 30, 2013, estimated the amount spilled as 750 barrels. Eight days later, pipeline owner San Antonio, Texas-based Tesoro Logistics called Kris Roberts, an environmental geologist with the state Health Department's Division of Water Quality, with a revised spill estimate of 20,600 barrels.

"It was pretty stressful for me, it's taken a pretty long time to go with the flow and accept it," said Patty Jensen, who admitted that a medical scare in April deepened her stress.

"Life just doesn't stop to deal with an oil spill," she said.

Cleaning up the more than 20,000 barrels — or 865,200 gallons — will cost about \$20.6 million and is expected to take another 12 to 18 months, Tesoro spokeswoman Tina Barbee said.

"It's a disappointing event for the company. We're committed to getting this land back to its original condition, so that the Jensens can start farming again," said Eric Haugstad, Tesoro's director of contingency planning and emergency response.

Steve Jensen started farming in high school on land homesteaded by his family in the early 1900s.

The Jensens, known for their hospitality and her homemade pie, have forged an unusual alliance with Tesoro and the workers on the spill site.

"They (Tesoro) really are trying to work with us. If something bothers us, we bring it right up," Patty Jensen said. "It's been pretty open — we stress communication.

The cleanup

The farmland that is contaminated is about 2.5 acres within an 8-acre site. Some contamination extends 30 feet below ground, with contamination as deep as 50 feet below ground in some areas, said David Glatt, chief of the Health Department's environmental health section.

The department announced April 25 it had approved a remediation plan for the spill site that would involve excavating the contaminated soil and heating it to high temperatures to remove the oil.

Several mounds of dirt rise high above a field dotted with hay bales. Contractor Nelson Environmental Remediation began working at the site in the spring.

A thermal desorption unit, or TDU, powered by natural gas, removes hydrocarbons from the contaminated soil, which is then quenched with water, during a 12-minute process. The treated soil is then returned to the excavation site separate from the contaminated piles.

Josh Clifford, of Minnesota-based QualiTech, is the site project manager for decontaminating the soil.

The TDU was assembled in May, reaching full capacity of more than 1,000 tons of soil per day by mid-May, and is modified to work in all seasons, Clifford said.

He said the 130-ton stainless steel TDU has a 180-foot-by-180-foot footprint. The roar of the 50-foot-high TDU requires ear protection.

A work crew of 16 operates 24 hours a day, seven days a week as heavy equipment scrapes, carries and dumps soil, maneuvering between and around massive mounds of soil.

Workers and visitors to the site are required to wear personal protective equipment including a hard hat and a clip-on meter to detect hydrogen sulfide gas.

Haugstad said he started to see real progress on the site by mid-August after a damp summer.

The plan for winter, Clifford said, is to continue “full speed ahead until the job’s done. We don’t slow down because of the cold.”

‘Watershed moment’

Wayde Schafer of the Dacotah Chapter of the Sierra Club called the spill a “watershed moment” for the Health Department, saying its response has been an important step forward.

Glatt said the department’s policy changed “pursuant to the leak,” and its website now provides environmental incident reports. Press releases are issued for spills in which 150 barrels or more are released as well as those that migrate toward water or wetlands.

Paying attention to details, along with greater accountability, is the message Glatt said he wants energy companies to grasp.

“Development of the oil field is dynamic, not static. ... As we go out for inspections, (if we see) continuing violations we will target you until we don’t find any, until they get the message,” he said.

The spill, which Tesoro blames on a lightning strike, focused new attention on pipeline safety in the state, which has about 20,000 miles of crude and natural gas pipelines, according to the North Dakota Pipeline Authority

The state Public Service Commission is requesting in its 2015 budget an additional 1.5 inspectors for natural gas pipelines and 3.5 for hazardous liquids (crude oil and byproducts). If approved by the Legislature, it would take effect Aug. 15, 2015. An emergency provision would allow for immediate action.

The federal Pipeline and Hazardous Materials Safety Administration is struggling with similar staffing challenges, PSC Chairman Brian Kalk said, noting the agency only has 25 inspectors in the central region of the country, with none in North Dakota.

Don Morrison is executive director of the Dakota Resource Council, an environmental group that monitors the effects of oil development.

While the Jensens could be the faces for the negative impacts of oil, Morrison said after speaking with the couple late last year, he sensed their concern over “speaking out too much.”

“Their intentions aren’t to make waves, their intention is to fix the problem. People who do speak out get ostracized — very lonely place to be when something goes wrong with oil on your land,” Morrison said.

Said Steve Jensen: “When people ask you about it, you don’t dwell on it. You just keep it short and simple.”

Monitoring

After the cleanup crews leave, there will be groundwater and topsoil monitoring at the spill site, as determined by the health department.

Soil scientists from North Dakota State University have been invited to do a study for future industry and possibly farm the Jensens’s wheat field the first year it’s back in production.

In a few weeks the Jensens will be offered a slice of hope and a glimpse into their future.

“When Tesoro is ready to put the first clean soil back into the ground,” Patty Jensen said with a smile, “they will let me and Steve operate the excavator and put the first scoopful back into the ground.”

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Invited Review Article

Current understandings and perspectives on non-cancer health effects of benzene: A global concern

Haji Bahadar^{a, b}, Sara Mostafalou^b, Mohammad Abdollahi^b[Show more](#)

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Highlights

- Benzene is a volatile organic compound and established blood carcinogen.
- Exposure to benzene needs to be evaluated in related chronic diseases.
- Cigarette smoke is the main source for indoor benzene exposure.
- Health outcomes associated with air pollutants are poorly characterized due to lack of comprehensive monitoring system.

Abstract

Objective

Benzene, as a volatile organic compound, is known as one of the main air pollutants in the environment. The aim of this review is to summarize all available evidences on non-cancerous health effects of benzene providing an overview of possible association of exposure to benzene with human chronic diseases, specially, in those regions of the world where benzene concentration is being poorly monitored.

Methodology

A bibliographic search of scientific databases including PubMed, Google Scholar, and Scirus was conducted with key words of “benzene toxic health effects”, “environmental volatile organic compounds”, “diabetes mellitus and environmental pollutants”, “breast cancer and environmental pollution”, “prevalence of lung cancer”, and “diabetes prevalence”. More than 300 peer reviewed papers were examined. Experimental and epidemiologic studies reporting health effects of benzene and volatile organic compounds were included in the study.

Results

Epidemiologic and experimental studies suggest that benzene exposure can lead to numerous non-cancerous health effects associated with functional aberration of vital

systems in the body like reproductive, immune, nervous, endocrine, cardiovascular, and respiratory.

Conclusion

Chronic diseases have become a health burden of global dimension with special emphasis in regions with poor monitoring over contents of benzene in petrochemicals. Benzene is a well known carcinogen of blood and its components, but the concern of benzene exposure is more than carcinogenicity of blood components and should be evaluated in both epidemiologic and experimental studies. Aspect of interactions and mechanism of toxicity in relation to human general health problems especially endocrine disturbances with particular reference to diabetes, breast and lung cancers should be followed up.

Abbreviations

AChE, Acetyl cholinesterase; ADA, Adenosine deaminase; ALP, Alkaline phosphatase; ALT, Alanine aminotransferase; AST, Aspartate transaminase; BUN, Blood urea nitrogen; DNA, DeoxyRibo Nucleic Acid; DOPA, Dopamine; EDCs, Endocrine disrupting chemicals; ERK1/2, Extracellular signal-regulated kinases 1 and 2; Hb, Hemoglobin; IL-2, Interleukin 2; Kg, kilogram; LDH, Lactate dehydrogenase; LINE-1, Long interspersed nuclear element-1; MCHC, Mean Corpuscular Hemoglobin Concentration; MPV, Mean platelet volume; Mg, Milligram; OSHA, Occupational Safety and Health Administration; ROS, Reactive oxygen species; VOCs, Volatile Organic Compounds; WBCs, White blood cells

Keywords

Benzene; Disease; Glucose homeostasis; Hepatotoxicity; Hematotoxicity; Immunotoxicity; Nephrotoxicity; Neurotoxicity

Corresponding author at: Department of Toxicology and Pharmacology, Faculty of Pharmacy and Pharmaceutical Sciences Research Center, Tehran University of Medical Sciences, Tehran 1417614411, Iran. Tel./fax: + 98 21 66959104.
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Advances in Understanding Benzene Health Effects and Susceptibility

Martyn T. Smith

Superfund Research Program, Division of Environmental Health Sciences, School of Public Health, University of California, Berkeley, California 94720-7356

Martyn T. Smith: martynts@berkeley.edu

Abstract

Benzene is a ubiquitous chemical in our environment that causes acute leukemia and probably other hematological cancers. Evidence for an association with childhood leukemia is growing. Exposure to benzene can lead to multiple alterations that contribute to the leukemogenic process, indicating a multimodal mechanism of action. Research is needed to elucidate the different roles of multiple metabolites in benzene toxicity and the pathways that lead to their formation. Studies to date have identified a number of polymorphisms in candidate genes that confer susceptibility to benzene hematotoxicity. However, a genome-wide study is needed to truly assess the role of genetic variation in susceptibility. Benzene affects the blood-forming system at low levels of occupational exposure, and there is no evidence of a threshold. There is probably no safe level of exposure to benzene, and all exposures constitute some risk in a linear, if not supralinear, and additive fashion.

Keywords

leukemia; hematology; molecular epidemiology; genetic polymorphism; risk assessment

INTRODUCTION

Benzene is widely used in the United States and ranks in the top 20 chemicals for production volume (see ATSDR Toxicological Profile of Benzene, <http://www.atsdr.cdc.gov/toxprofiles/tp3.pdf>). It is the primary starting material for chemicals used to make plastics, resins, synthetic fibers, dyes, detergents, drugs, and pesticides. Natural sources of benzene include emissions from fires. Benzene is also a component of crude oil, gasoline, and cigarette smoke. Occupational exposures in the developing world are sometimes very high because of the continuing presence of benzene in industrial solvents and glues. In the United States, workers continue to be exposed to potentially high levels of benzene in the chemical industry, in petroleum refineries, in oil pipelines, on ships and tankers, in auto repair shops,

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DISCLOSURE STATEMENT

The author has received consulting and expert testimony fees from lawyers representing both plaintiffs and defendants in cases involving claims related to exposure to benzene. The author has also received consulting fees from the governments of Australia, Norway, and the United States.

and in bus garages. Shipping may be particularly hazardous because there is little awareness or regulation, and exposures can be considerable. For example, on marine vessels benzene air concentrations typically range from 0.2–2.0 ppm during closed loading and 2–10 ppm during open-loading operations (121). The general public is exposed mainly from mobile sources, such as automobiles. The benzene content of gasoline is, therefore, strictly regulated in the United States and Europe, with limits typically around 1%. The U.S. Environmental Protection Agency (EPA) recently set new regulations that will lower the benzene content in gasoline to 0.62% in 2011 (20).

HISTORICAL OVERVIEW OF THE HEMATOTOXIC EFFECTS OF BENZENE

Benzene is the simplest aromatic chemical and an excellent solvent. Its toxicity to the blood-forming organs was realized soon after its industrial use began. In 1897, Santesson described nine cases of chronic benzene hematotoxicity (88). The hematotoxic effects of benzene were further documented in studies by Selling (90) and Weiskotten (114, 115). This research led Alice Hamilton (35) and others to warn about the occupational dangers of benzene (98).

The first case of benzene-associated leukemia was described by Delore & Borgomano in 1928 (16). Many leukemia cases associated with benzene exposure were reported between 1930 and the 1960s (3, 4, 30, 109), and by 1961 benzene had been identified as one of two industrial leukemogens, the other being ionizing radiation (15). Reports of multiple cases of leukemia and other hematological disorders among shoe workers using benzene as a solvent and in glues were generated by Vigliani and colleagues in Italy (23) and by Aksoy and coworkers in Turkey in the 1960s and 1970s (1, 2), confirming the association with leukemia.

TRADITIONAL EPIDEMIOLOGICAL STUDIES OF THE CARCINOGENIC EFFECTS OF BENZENE EXPOSURE

It was not until 1977 that the first positive finding of increased leukemia risk in an epidemiological cohort study of workers in the U.S. rubber industry was published, by Infante et al. (43). They reported that workers occupationally exposed to benzene between 1940 and 1949 had at least a fivefold excess risk of all leukemias and a tenfold excess of deaths from myeloid and monocytic leukemias combined compared with controls. The environment of the workers in the study population was not contaminated with solvents other than benzene, showing that benzene must be the cause. This study became known as the Pliofilm study because it investigated workers exposed to benzene in rubber hydrochloride (the Goodyear trade name for which was Pliofilm) manufacturing plants in Ohio. Subsequent follow-ups of this cohort were published by Rinsky and coworkers, with the most recent being in 2002, which reaffirmed the leukemogenic effects of benzene exposure in this cohort (83, 84). Because of its importance as the first epidemiological study to provide quantitative estimates of leukemia risk from benzene exposure, as well as its role in the lowering of the Occupational Safety and Health Administration (OSHA) permissible exposure level to 1 ppm, the Pliofilm study has been the subject of much reanalysis by consultants to the oil and chemical industry (e.g., 73, 74) with the intention of influencing regulatory or legal

proceedings as described in detail by Michaels (68). However, subsequent studies in China and Australia have confirmed and expanded on its findings, as described below.

After President Nixon's visit to China in 1972, China became much more open to trade with the west and became much more industrialized. The manufacturing of shoes and leather goods increased dramatically, along with exposure to benzene through its use as a solvent and as a contaminant in glues. Reports of significant health problems associated with benzene in workplaces in China soon began to appear. These reports led to pioneering studies of benzene-exposed workers in China by Songnian Yin and colleagues of the Chinese Academy of Preventive Medicine (CAPM), who identified more than 500,000 workers exposed to benzene (124). A follow-up survey of 28,460 benzene-exposed and 28,257 unexposed workers from 1972 through 1981 found an increased risk of mortality due to leukemia [standardized mortality ratio (SMR) = 5.7] (123). In 1987, the U.S. National Cancer Institute (NCI) began collaborating with the CAPM team to identify all incident cases of hematologic neoplasms and related disorders in an expanded study cohort of 74,828 benzene-exposed and 35,805 unexposed workers employed from 1972 through 1987 in 12 cities in China (37, 122). The study confirmed increased risks of acute myeloid leukemia (AML) and other malignant and non-malignant hematopoietic disorders associated with benzene exposure and found evidence for hematopoietic cancer risks at levels substantially lower than had previously been established. In contrast to the findings among rubber hydrochloride workers, the NCI-CAPM study showed excess risk at relatively low levels of exposure (<10 ppm average and <40 ppm-years cumulative) but found a relatively modest dose-response effect, with proportionally smaller increases in risk at increasing levels of exposure. The study also reported that workers with 10 or more years of benzene exposure had a relative risk (RR) of developing non-Hodgkin lymphoma (NHL) of 4.2 [95% confidence interval (CI) 1.1–15.9] and an excess risk of myelodysplastic syndromes (MDS) (36, 37, 104). This study considerably expanded the health effects associated with benzene beyond AML and suggested benzene produced effects at levels lower than previously thought. It has again been the subject of much criticism by industry consultants to which the NCI-CAPM investigators have responded (36). They will soon report on an additional 10 years of follow-up through 1997.

Glass and coworkers performed a nested case-control study of lympho-hematopoietic cancer nested within the existing Healthwatch cohort study to examine the role of benzene exposure (26, 28, 36). Cases identified between 1981 and 1999 ($n = 79$) were age-matched to five control subjects from the cohort. Each subject's benzene exposure was estimated using occupational histories, local site-specific information, and an algorithm using Australian petroleum industry-monitoring data. This exposure assessment is probably the best of any epidemiological study of benzene to date (25, 27). Matched analyses showed that the risk of leukemia was increased at cumulative exposures above 2 ppm-years and with intensity of exposure of highest exposed job more than 0.8 ppm. Risk increased with higher exposures; for the 13 case-sets with greater than 8 ppm-years cumulative exposure, the odds ratio (OR) was 11.3 (95% CI 2.85–45.1). The risks for acute nonlymphocytic leukemia (ANLL) and chronic lymphocytic leukemia (CLL) were raised for the highest exposed workers. A cumulative exposure of >8 ppm-years was associated with a sevenfold significantly

increased risk specifically of ANLL. No association was found between NHL or multiple myeloma and benzene exposure, but this finding may have been due to limited follow-up. The Glass et al. study is important because it found an excess risk of leukemia associated with cumulative benzene exposures and benzene exposure intensities that were considerably lower than reported in previous studies. Furthermore, no evidence was found of a threshold cumulative exposure below which there was no risk. However, it has been suggested that the high incidence of CLL may be due to a surveillance bias (29).

Apart from these three important studies, there have been many other epidemiological studies of the carcinogenicity of benzene, which are too numerous to review here. For reviews, see recent articles in References 10, 48, and 120. The consensus clearly shows that benzene causes AML/ANLL and MDS, even at relatively low doses, and that AML often arises secondary to MDS. However, a series of questions important to the risk assessment of benzene remain (Table 1).

IS IT ONLY ACUTE MYELOID LEUKEMIA THAT IS PRODUCED BY BENZENE?

The evidence for other forms of leukemia apart from AML being caused by benzene exposure as well as different forms of NHL has grown steadily over the years. Lymphomas were reported long ago in experimental animals given long-term exposure to benzene. Because all leukemias arise in the stem and progenitor cells of the bone marrow, which are clearly damaged by benzene, there is a biologically plausible basis for suggesting benzene as a causal factor for acute lymphoblastic leukemia (ALL) and chronic myeloid leukemia (CML). Some studies of benzene-exposed workers have reported such an increased risk, but the assessment of the association of benzene with these malignancies is hampered mainly by their rarity and is certainly stronger for ALL than CML. Several epidemiological studies, including the above study by Glass et al. (26), have reported an association between benzene exposure and CLL. The main problems in assessing the risk of CLL are the different disease classifications used by investigators over time, the fact that the disease is present with only very low incidence in Asians, and the lack of specific information on CLL in most studies. CLL is now classified as a form of NHL along with multiple myeloma because they are now considered subclassifications of mature B-cell neoplasms (107). Mechanistic and molecular epidemiology studies may contribute to our understanding of the association of benzene with these neoplasms. For example, both CLL and multiple myeloma have precursor forms: Almost all CLL patients are preceded by a monoclonal B-cell lymphocytosis precursor state (54), and monoclonal gammopathy of undetermined significance (MGUS) is a common precursor to myeloma (116). Demonstration that these precursors were elevated in benzene-exposed populations would add support to the hypothesis that benzene was causatively linked to CLL and myelomagenesis, as has recently been shown for certain pesticides (55).

Epidemiological studies on the association between benzene and NHL have produced mixed results. For example, in the NCI-CAPM cohort study discussed above, a relative risk of 4.7 (95% CI 1.2 to 18.1) for NHL was reported (37). In contrast, Sorahan et al. reported a relative risk of 1.00 for NHL in a cohort study of benzene-exposed workers in England and Wales (100). The reasons for these discrepancies are not entirely clear but could be related

to differences in study populations, exposure levels, lack of statistical power, and study designs leading to biases such as the healthy worker effect. We systematically reviewed the evidence relating to benzene and NHL and noted problems of bias due to the healthy worker effect (95). We performed formal meta-analysis of studies of NHL and occupational exposure to benzene in work settings other than refineries and formal meta-analysis of NHL and refinery work, a setting that has historically been associated with benzene exposure (101). These were done separately because refinery work can be associated with many chemical exposures other than benzene. In 22 studies of benzene exposure, the summary relative risk for NHL was 1.22 (95% CI 1.02 to 1.47; $p = 0.01$). When studies that likely included unexposed subjects in the exposed group were excluded, the summary relative risk increased to 1.49 (95% CI 1.12 to 1.97, $n = 13$), and when studies based solely on self-reported work history were excluded, the relative risk rose to 2.12 (95% CI 1.11 to 4.02, $n = 6$). In refinery workers, the summary relative risk for NHL in all 21 studies was 1.21 (95% CI 1.00 to 1.46; $p = 0.02$). When adjusted for the healthy worker effect, this relative risk estimate increased to 1.42 (95% CI 1.19 to 1.69) (101). The finding of elevated relative risks in studies of both benzene exposure and refinery work provides further evidence that benzene exposure is associated with an increased risk of NHL. There are many similarities between cancer chemotherapy drugs and benzene in their abilities to produce both AML and NHL. Both appear to be highly efficient at producing AML with high relative risks and both also produce NHL, but with lower relative risks and a longer latency period than for AML (49). The lower relative risks observed may be due to the fact that NHL is a diverse set of tumors and that benzene and chemotherapy drugs produce only certain subtypes of NHL.

German researchers have concluded that benzene could cause any malignant hemato-logic disease because these diseases all arise from damaged omnipotent stem cells (9). More recently, Beelte et al. convened a committee of experts to evaluate the international literature (10). They concluded that “all kinds of myeloid and lymphoid malignancies including their prestages can be caused by occupational benzene exposure” (p. 197).

EVIDENCE FOR AN ASSOCIATION WITH CHILDHOOD LEUKEMIA

Multiple studies have shown an increase in childhood leukemia risk in relation to air pollution sources emitting benzene, such as gas stations and traffic. For example, a recent nationwide study in France of 765 acute leukemia cases and 1681 controls found that acute leukemia was significantly associated with residence next to gasoline stations or automotive repair garages (OR 1.6, 95% CI 1.2 to 2.2) (12). Furthermore, in a study of the area around Houston, Texas, census tracts with the highest benzene levels, estimated by EPA models, had elevated rates of all leukemias (RR = 1.37; 95% CI 1.05, 1.78), with the association being stronger for AML (117). More studies of pediatric cancers are needed that include estimates of environmental benzene exposure, rather than surrogate exposures such as proximity to gasoline stations or traffic.

Recent mechanistic work adds support to the potential association between benzene exposure and childhood leukemia. Because the genotoxic action of benzene metabolites on pluripotent bone marrow precursor cells appears promiscuous, producing multiple genetic abnormalities, it seems probable that benzene exposure can initiate both AML and ALL by

causing the chromosomal rearrangements and mutations that are on the causal pathway to these malignancies. For childhood ALL and AML, studies have shown that the disease is usually initiated in utero because the leukemic translocations and other genetic changes are present in blood spots collected at birth (32, 66, 118, 119). Thus, exposure of the mother, and perhaps the father, to benzene could be just as important as childhood exposures in producing childhood AML and ALL, as has been suggested by epidemiological studies (67, 89, 92, 106). Supporting this hypothesis are animal studies demonstrating that in utero exposure to benzene increases the frequency of micronuclei and DNA recombination events in hematopoietic tissue of fetal and postnatal mice (6, 57). Studies also show that oxygen radicals play a key role in the development of in utero-initiated benzene toxicity through disruption of hematopoietic cell signaling pathways (6). These studies support the idea that genotoxic and nongenotoxic events following benzene exposure may be initiators of childhood leukemia in utero.

MECHANISMS OF BENZENE CARCINOGENICITY: MECHANISMS OF MYELOID LEUKEMIA DEVELOPMENT

AML and MDS are closely related diseases of the bone marrow that arise de novo in the general population or following therapy with alkylating agents, topoisomerase II inhibitors, or ionizing radiation [therapy-related AML and MDS (t-AML and t-MDS)] (75, 76). Occupational exposure to benzene is widely thought to cause leukemias that are similar to t-AML and t-MDS (44, 56, 128). AML and MDS both arise from genetically altered CD34+ stem or progenitor cells in the bone marrow (70) and are characterized by many different types of recurrent chromosome aberrations (71, 76). These aberrations often result in the genetic mutations that produce leukemia. Cytogenetic analysis of chromosome number and structure has therefore become important in diagnosing and treating MDS and AML (71, 76). The chromosome aberrations and gene mutations detected in therapy-related and de novo MDS and AML are very similar, although the frequencies with which they are observed in different subtypes may differ (75). Hence, therapy-related and de novo MDS and AML are considered very similar diseases (75).

At least three cytogenetic subtypes of AML and MDS are commonly observed.

1. Unbalanced aberrations. Cases with unbalanced chromosome aberrations, primarily 5q-/-5 or 7q-/-7 and +8, represent the first subtype (75, 76). They often present with a complex karyotype and point mutations of p53 or AML1 and are common after therapy with alkylating agents.
2. Balanced rearrangements. Cases with the recurrent balanced translocations [e.g., t(11q23), t(8;21) and t(15;17)] or inversions [e.g., inv(16)] represent the second subtype and arise, at least in the therapy-related subset, as illegitimate gene recombinations related to the inhibition of topoisomerase II (75).
3. Normal karyotype. Cases with a normal karyotype comprise the third subtype and often harbor mutations of *NPM1*, internal tandem duplications of *FLT3*, and/or point mutations or altered methylation status of *C/EBPα* (75).

Within these three cytogenetic categories there are at least eight different genetic pathways to MDS and AML, as defined by the specific chromosome aberrations present in each (Pathways I–VIII in Figure 1). As more information is revealed about the molecular cytogenetics of leukemia, it seems likely that numerous other pathways to AML and MDS will be discovered. For example, recent unbiased high-resolution genomic screens have identified many genes that were not previously implicated in AML and which may be relevant for pathogenesis, along with many known oncogenes and tumor suppressor genes (58, 64, 111).

An important role for epigenetic changes is also emerging in the development of leukemia. Functional loss of the *CCAAT/enhancer binding protein* (*C/EBP α*), a master regulatory transcription factor in the hematopoietic system, can result in a differentiation block in granulopoiesis and thus contribute to leukemic transformation (24). Recent work has shown that epigenetic alterations of *C/EBP α* are a frequent event in AML (34). *C/EBP α* can also steer *miRNA-223* expression, which is vital in granulocytic differentiation (22).

Referring to Figure 1, extensive evidence indicates that benzene can induce AML via Pathways I, II, and IV and demonstrates considerable support for Pathway V. There is some evidence for Pathway III but little information regarding Pathways VI–VIII. Benzene exposure has been associated with higher levels of chromosomal changes commonly observed in AML, including 5q–/–5 or 7q–/–7, +8, and t(8;21) in the blood cells of highly exposed workers (97, 127, 129). Its metabolites also produce these same changes in human cell cultures, including cultures of CD34+ progenitor cells (96, 102). This research provides strong evidence for benzene's role in the production of AML by Pathways I, II, and IV (Figure 1).

Pathways III, IV, and V are related to the inhibition of the DNA-related enzyme topoisomerase II (topo II), which is essential for the maintenance of proper chromosome structure and segregation. There are different types of topo II inhibitors. Epidophyllotoxins, such as etoposide, cause chromosome damage and kill cells by increasing physiological levels of topoisomerase II-DNA cleavage complexes (17). These drugs are referred to as topoisomerase II poisons to distinguish them from catalytic inhibitors of the enzyme because they convert this essential enzyme to a potent cellular toxin. Other drugs, such as merbarone, act as inhibitors of topo II activity; however, in contrast to etoposide, they do not stabilize topo II-DNA cleavable complexes but are still potent clastogens both in vitro and in vivo (112).

Several studies have shown that benzene in vivo and its reactive benzene metabolites hydroquinone (HQ) and 1,4-benzoquinone (BQ) in vitro inhibit the functionality of topo II and enhance DNA cleavage (13, 60). Bioactivation of HQ by peroxidase to BQ enhances topo II inhibition (19). Indeed, BQ is a more potent topo II inhibitor than is HQ in a cell-free assay system (7, 42). These findings demonstrate that benzene, through its reactive quinone metabolites, can inhibit topo II and probably cause leukemias with chromosome translocations and inversions known to be caused by topo II inhibitors, including AMLs harboring t(21q22), t(15;17), and inv(16) in a manner consistent with Pathways IV and V (69, 75). The evidence for rearrangements of the *MLL* gene through t(11q23) via Pathway

III in benzene-induced leukemia is less convincing but may occur through an apoptotic pathway (108).

AML can arise de novo via Pathways VII and VIII without apparent chromosome abnormalities, but molecular analysis has revealed many genetic changes in these apparently “normal” leukemias, including mutations of *NPM1*, *AML1*, *FLT3*, *RAS*, and *C/EBPα* (Figure 1) (21, 64). Research is needed to clarify the ability of benzene and its metabolites to produce mutations of the types found in these leukemias.

The ability of benzene and/or its metabolites to induce epigenetic changes related to the development of leukemia, such as altered methylation status of *C/EBPα*, is unclear at this time. A recent study reported that hypermethylation in *p15* (+0.35%; $p = 0.018$) and hypomethylation in *MAGE-1* (-0.49%; $p = 0.049$) were associated with very low benzene exposures (~22 ppb) in healthy subjects, including gas station attendants and traffic police officers, although the corresponding effects on methylation were very low (11). Further study of the role epigenetics plays in the hematotoxicity and carcinogenicity of benzene is warranted, including studies of aberrant DNA methylation and altered microRNA expression.

Although benzene and its metabolites are clearly capable of producing multiple forms of chromosomal mutation, including various translocations, deletions, and aneuploidies, these are usually insufficient as a single event to induce leukemia. Other secondary events, such as specific gene mutations and/or other chromosome changes, are usually required (33, 61). Thus, benzene-induced leukemia probably begins as a mutagenic event in the stem or progenitor cell, and subsequent genomic instability allows for sufficient mutations to be acquired in a relatively short time period. Studies have shown that the benzene metabolite HQ is similar to ionizing radiation because it induces genomic instability in the bone marrow of susceptible mice (31). Recent findings showing the importance of DNA repair and maintenance genes, such as *WRN*, in genetic susceptibility to benzene toxicity also support this mechanism (52, 82).

Thus, benzene exposure can lead to multiple alterations that contribute to the leukemogenic process. Benzene may act by causing chromosomal damage (aneuploidy, deletions, and translocations) through the inhibition of topo II; disrupting microtubules; generating oxygen radicals that lead to point mutations, strand breaks, and oxidative stress; causing immune system dysfunction that leads to decreased immunosurveillance (14, 59); altering stem cell pool sizes through hematotoxicity (45); inhibiting gap-junction intercellular communication (85); and altering DNA methylation and perhaps specific microRNAs. This multimodal mechanism of action suggests that the effects of benzene on the leukemogenic process are not singular and can occur throughout the process. This finding implies that both background and added exposures from occupation and hobbies will have similar impacts on the process and that the effects will be additive. Thus, given the high background exposure to benzene as a combustion by-product in our environment, it seems unlikely that any practical threshold exists, and the effects of each molecule of benzene will be additive in a linear fashion.

METABOLISM OF BENZENE AND ITS RELEVANCE TO BENZENE CARCINOGENICITY

Benzene must be metabolized to become carcinogenic (86, 99). Its metabolism is summarized in Figure 2. The initial step involves cytochrome P450 (CYP)-dependent oxidation of benzene to benzene oxide, which exists in equilibrium with its tautomer oxepin. Most benzene oxide spontaneously rearranges to phenol (PH), which is either excreted or further metabolized to HQ and 1,4-BQ. The remaining benzene oxide is either hydrolyzed to produce catechol (CA) and 1,2-BQ or reacts with glutathione to produce S-phenylmercapturic acid (SPMA). Metabolism of oxepin is thought to open the aromatic ring, yielding the reactive muconaldehydes and *E,E*-muconic acid (MA). Human exposures to benzene at air concentrations between 0.1 and 10 ppm result in urinary metabolite profiles with 70%–85% PH, 5%–10% each of HQ, MA, and CA, and less than 1% of SPMA (47). Benzene oxide, the BQs, muconaldehydes, and benzene diol epoxides (formed from CYP oxidation of benzene dihydrodiol) are electrophiles that readily react with peptides and proteins (8, 39, 65, 110) and can thereby interfere with cellular function (94). It remains unclear what role these different metabolites play in benzene carcinogenicity, but BQ formation from HQ via myeloperoxidase in the bone marrow may be key (94). Considerable evidence indicates that this pathway plays an important role in BQ formation because the BQ-detoxifying enzyme NQO1 protects mice against benzene-induced myelodysplasia (46, 62) and protects humans against benzene hematotoxicity (87). However, this protection does not rule out adverse effects from other metabolites.

Benzene is most likely metabolized initially to PH and MA via two enzymes rather than just one CYP enzyme, and the putative high-affinity enzyme is active primarily below 1 ppm (79). Because CYP2E1 is the primary enzyme responsible for mammalian metabolism of benzene (72, 105), it is reasonable to assume that the low-affinity enzyme is responsible for benzene metabolism mainly at higher levels of exposure. CYP2F1 and CYP2A13 are reasonable candidates for the high-affinity metabolic enzymes, which are active at environmental levels of exposure below 1 ppm (77, 79, 91). Interestingly, these CYPs are highly expressed in the human lung. Despite much research, more work is needed to elucidate the different roles of multiple metabolites in benzene toxicity and the pathways that lead to their formation.

EMERGING ROLE OF THE ARYL HYDROCARBON RECEPTOR

The aryl hydrocarbon receptor (AhR) is known mainly as the mediator for the toxicity of certain xenobiotics. However, this transcription factor has many important biological functions, and emerging evidence indicates that it has a significant role in the regulation of hematopoietic stem cells (HSCs) (40, 93). AhR expression may be necessary for the proper maintenance of quiescence in HSCs, and AhR downregulation is essential for the stem cells to “escape” from quiescence and undergo subsequent proliferation (93). This hypothesis implicates the AhR as a negative regulator of hematopoiesis to curb excessive proliferation. This, in turn, prevents the premature exhaustion of HSCs and sensitivity to genetic alterations, thus preserving HSC function over the organism’s life span. However, AhR

dysregulation may result in the altered ability of HSCs to sense appropriate signals in the bone marrow microenvironment, leading to hematopoietic disease.

Inoue and colleagues have shown that AhR-knockout (KO) mice do not show any hematotoxicity after benzene exposure (125). Follow-up studies showed that mice that had been lethally irradiated and repopulated with marrow cells from AhR-KO mice essentially did not have signs of benzene-induced hematotoxicity (41). The most likely explanation for these findings is that the absence of AhR removes HSCs from their quiescent state and makes them susceptible to DNA damage from benzene exposure and subsequent cell death through apoptosis. Further research is needed to examine the effects of benzene and its metabolites on cycling and quiescent HSCs.

SUSCEPTIBLE SUBPOPULATIONS

Aksoy (1) reported striking variation in benzene toxicity among workers with comparable levels of occupational exposure. The reasons underlying this variation are unknown. Part of the variation may be caused by biological factors such as gender, age, genetics, and amount of adipose tissue, with the remainder being due to environmental influences such as routes of exposure, physical activity, coexposures, smoking, alcohol consumption, and dietary habits.

Studies to date have identified a number of single-nucleotide polymorphisms (SNPs) in candidate genes that appear to confer susceptibility to benzene hematotoxicity. The first ones identified were related to metabolism, including polymorphisms in cytochrome P450 2E1 (CYP2E1), NAD(P)H:quinone oxidoreductase 1 (NQO1), myeloperoxidase (MPO), glutathione-S-transferases (GSTs), and microsomal epoxide hydrolase (mEH) in Figure 2. The role of metabolizing enzyme polymorphisms was reviewed by Dougherty et al. (18) in 2008. They concluded that the polymorphisms produced a modest effect on the biomarkers of benzene exposure and effect analyzed in 22 studies; GSTM1 and GSTT1 showed some consistent associations.

In a study of 1395 SNPs in 411 cancer-related genes on lowered white blood cell (WBC) counts in benzene-exposed workers, highly significant findings were clustered in genes (BLM, TP53, RAD51, WDR79, and WRN) that play a critical role in DNA repair and genomic maintenance (52). In vitro functional studies revealed that deletion of SGS1 in yeast, equivalent to lacking BLM and WRN function in humans, caused reduced cellular growth in the presence of the toxic benzene metabolite HQ, and knockdown of WRN increased susceptibility of human lymphoid TK6 and myeloid HL60 cells to HQ toxicity (52, 82). Thus, SNPs in genes involved in DNA repair and genomic maintenance play an important role in susceptibility to benzene-induced hematotoxicity. Other possible associations with DNA repair and genome maintenance include the recent findings that polymorphisms in the p53-dependent genes p21 and p14(ARF) may play a role in susceptibility to chronic benzene poisoning (103).

The other class of genetic polymorphisms associated with benzene toxicity is in cytokine and chemokine genes. Associations have been reported with SNPs in VEGF, IL-1A, IL-4,

IL-10, IL-12A, VCAM1, and lowered WBC counts (53) and with an SNP in TNF-alpha and chronic benzene poisoning (63). Additional studies are needed to confirm these associations.

Thus, genetic polymorphisms that confer susceptibility to benzene toxicity should be taken into account when assessing the risks of benzene exposure. Select combinations of genetic polymorphisms may increase susceptibility of individuals and/or population subgroups. However, gene-gene interactions are not yet analyzed in well-designed studies that incorporate multiple biological end points and multiple genes, and a genome-wide study is needed to truly assess the role of genetic variation in conferring susceptibility.

WHAT IS THE DOSE-RESPONSE CURVE? IS IT LINEAR AND IS THERE A FUNCTIONAL THRESHOLD IN THE LOW-DOSE REGION?

Although there is undoubtedly a causal link between benzene exposure and leukemia, the shape of the exposure-response relationship is controversial, particularly at low doses at or below 1 ppm in air. Indeed, when considering regulatory actions, litigation, and potential clean-up costs in the billions of dollars, this uncertainty represents a major challenge for environmental toxicology and epidemiology. Recent action by the U.S. EPA to reduce cancer risks from mobile sources underscores this point (see 20). In justifying its decision to lower the benzene content of gasoline, the EPA cited studies pointing to supralinear (greater-than-proportional) production of benzene-related protein adducts at air concentrations below 1 ppm (80, 81). Such behavior would likely result from saturation of the metabolism of benzene to benzene oxide-oxepin. Because the EPA had previously assumed that human benzene metabolism proceeded according to nonsaturating (first-order) kinetics at exposure concentrations well above 10 ppm, saturation of metabolism below 1 ppm “could lead to substantial underestimation of leukemia risks” in the general population (20).

Traditional epidemiology is unlikely to determine the shape of the dose-response curve for benzene-induced leukemia in the low-dose region, although the Glass et al. study shows effects at 1–2 ppm in air and no sign of a threshold. Chronic animal toxicity studies are also unlikely to be informative for two reasons: (a) no accepted animal model of benzene-induced leukemia exists at the present time, and (b) low-dose studies would require a prohibitively large number of animals. In situations like this, where traditional epidemiology and toxicology are of limited value, investigators have proposed that nontumor data such as biological markers (biomarkers) be employed in the risk-assessment process (5).

The most appropriate biomarker of leukemia risk appears to be lowered WBC counts because this factor has been associated with an increased risk of hematological malignancies. Ward et al. (113) found no evidence of a threshold for hematotoxic effects of benzene and suggested that exposure to <5 ppm benzene could result in hematologic suppression. Occupational exposure decreased WBC count in petrochemical workers exposed to <10 ppm benzene (126), and Qu et al. reported that depressions in blood cell counts in benzene-exposed Chinese workers were not only exposure dependent, but also significantly different in the lowest exposed group (at or below 0.25 ppm) compared with unexposed subjects (78). In a large study of more than 400 workers, hematotoxicity occurred

in workers exposed to <1 ppm benzene (51). Further analysis of this data showed a linear monotonicity of the association between lowered blood cell counts and benzene exposure by spline regression analyses (50). Thus, the literature shows that benzene affects the blood-forming system at low levels of occupational exposure, at or below 1 ppm, and that there is no evidence of a threshold. As a result, the threshold limit value has recently been lowered by the ACGIH to 0.5 ppm, and various government agencies and scientific bodies have recommended the 8-hour time-weighted average standard be lowered to 0.1 ppm. The latest research indicates that there is likely no safe level of exposure to benzene and that all exposures constitute some risk in a linear, if not supralinear, and additive fashion. Public health agencies should act accordingly.

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Glossary

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|-------------|--|
| EPA | Environmental Protection Agency |
| CAPM | Chinese Academy of Preventive Medicine |
| NCI | National Cancer Institute |
| AML | acute myeloid leukemia |
| NHL | non-Hodgkin lymphoma |
| MDS | myelodysplastic syndromes |
| OR | odds ratio |
| HQ | hydroquinone |
| SNP | single nucleotide polymorphism |

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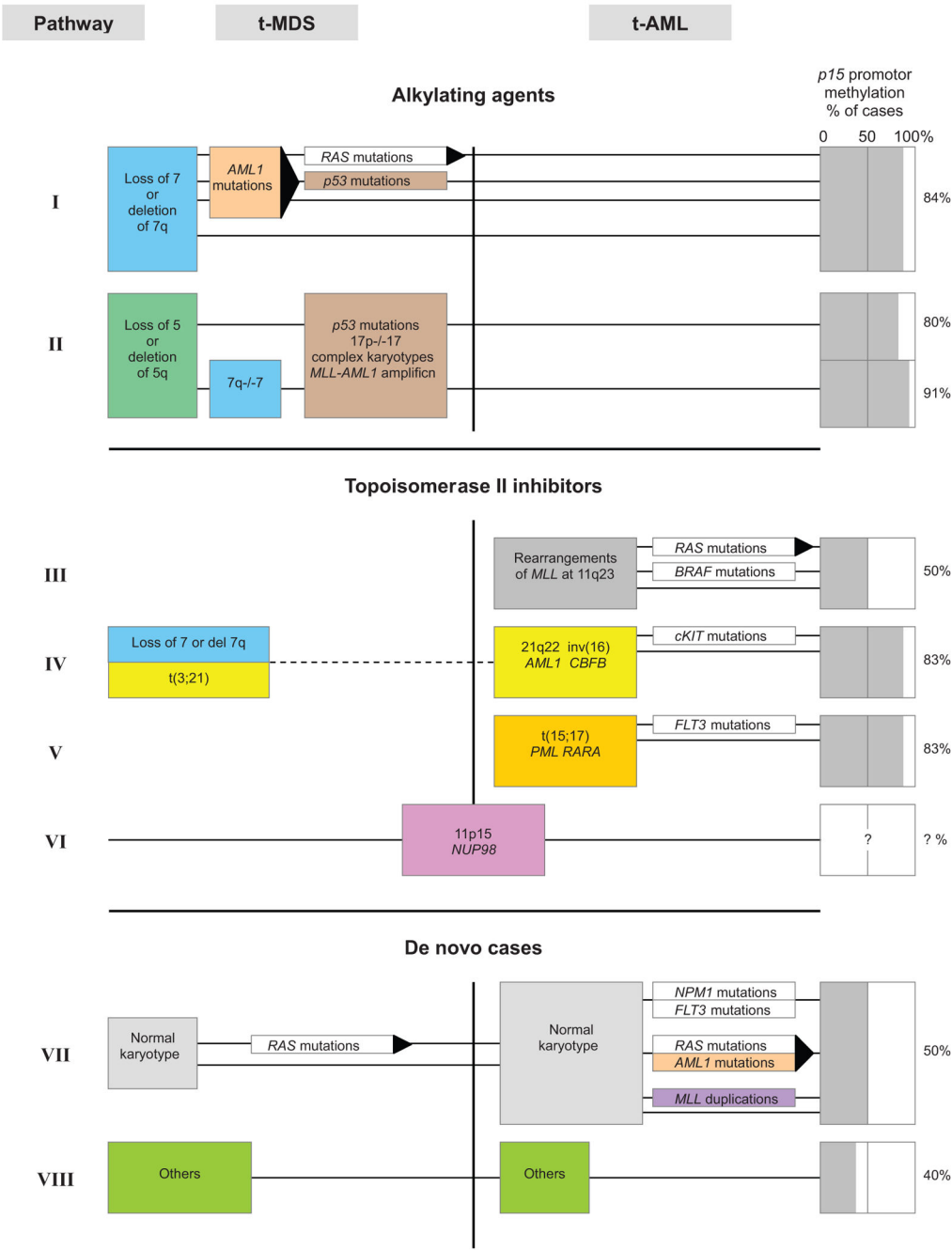


Figure 1. Genetic pathways to myeloid leukemia (adapted from Reference 76).

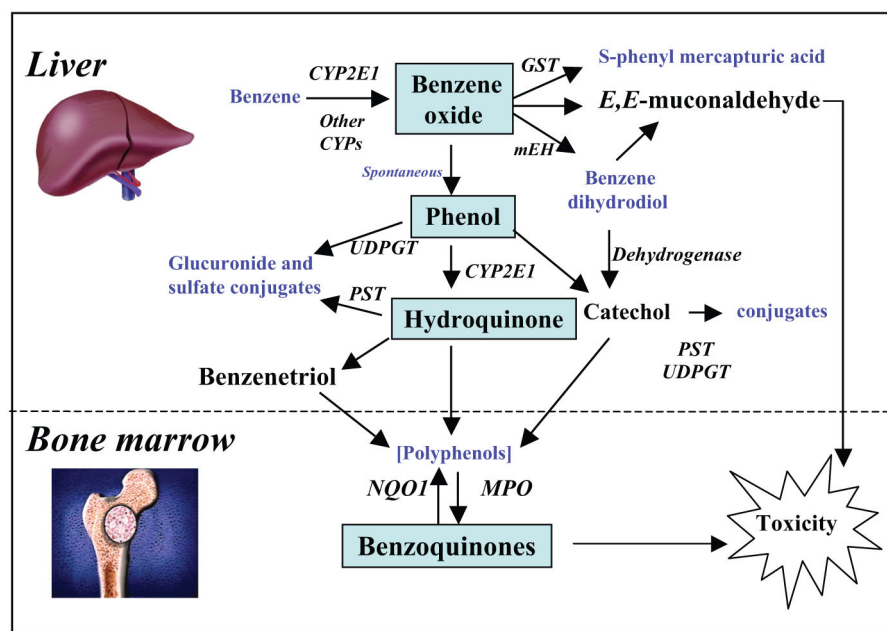


Figure 2.

Simplified metabolic scheme for benzene showing major pathways and metabolizing enzymes leading to toxicity. CYP2E1, cytochrome P450 2E1; GST, glutathione-S-transferase; NQO1, NAD(P)H:quinone oxidoreductase 1; MPO, myeloperoxidase; UDPGT, uridine diphosphate glucuronyl transferase; PST, phenol sulfotransferase; mEH, microsomal epoxide hydrolase.

Table 1

Current issues in the risk assessment of benzene

| |
|---|
| Is it only acute myeloid leukemia that is produced by benzene? |
| What is the mechanism(s) of benzene carcinogenicity? |
| Are there susceptible subpopulations? |
| What is the dose-response curve? Is it linear, and is there a functional threshold? |

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Systems biology of human benzene exposure

Luoping Zhang^{a,*}, Cliona M. McHale^a, Nathaniel Rothman^b, Guilan Li^c, Zhiying Ji^a, Roel Vermeulen^d, Alan E. Hubbard^a, Xuefeng Ren^a, Min Shen^b, Stephen M. Rappaport^a, Matthew North^e, Christine F. Skibola^a, Songnian Yin^c, Christopher Vulpe^e, Stephen J. Chanock^b, Martyn T. Smith^a, and Qing Lan^b

^a Division of Environmental Health Sciences, School of Public Health, University of California, Berkeley, CA 94720-7356, USA ^b Division of Cancer Epidemiology and Genetics, National Cancer Institute, NIH, 6120 Executive Boulevard, MSC 7242, Bethesda, MD 20892, USA ^c Chinese Center for Disease Control and Prevention, 27 Nan Wei Road, Beijing 100050, China ^d Environmental Epidemiology, Institute of Risk Assessment Sciences, Jenalaan 18d, 3584 CK, Utrecht, Netherlands ^e Department of Nutritional Science and Toxicology, University of California, Berkeley, 119 Morgan Hall #3104, Berkeley, CA 94720, USA

Abstract

Toxicogenomic studies, including genome-wide analyses of susceptibility genes (genomics), gene expression (transcriptomics), protein expression (proteomics), and epigenetic modifications (epigenomics), of human populations exposed to benzene are crucial to understanding gene-environment interactions, providing the ability to develop biomarkers of exposure, early effect and susceptibility. Comprehensive analysis of these toxicogenomic and epigenomic profiles by bioinformatics in the context of phenotypic endpoints, comprises systems biology, which has the potential to comprehensively define the mechanisms by which benzene causes leukemia. We have applied this approach to a molecular epidemiology study of workers exposed to benzene. Hematotoxicity, a significant decrease in almost all blood cell counts, was identified as a phenotypic effect of benzene that occurred even below 1ppm benzene exposure. We found a significant decrease in the formation of progenitor colonies arising from bone marrow stem cells with increasing benzene exposure, showing that progenitor cells are more sensitive to the effects of benzene than mature blood cells, likely leading to the observed hematotoxicity. Analysis of transcriptomics by microarray in the peripheral blood mononuclear cells of exposed workers, identified genes and pathways (apoptosis, immune response, and inflammatory response) altered at high (>10ppm) and low (<1ppm) benzene levels. Serum proteomics by SELDI-TOF-MS revealed proteins consistently down-regulated in exposed workers. Preliminary epigenomics data showed effects of benzene on the DNA methylation of specific genes. Genomic screens for candidate genes involved in susceptibility to benzene toxicity are being undertaken in yeast, with subsequent confirmation by RNAi in human cells, to expand upon the findings from candidate gene analyses. Data on these and future biomarkers will be used to populate a large toxicogenomics database, to which we will apply bioinformatic approaches to understand the interactions among benzene toxicity, susceptibility genes, mRNA, and DNA methylation through a systems biology approach.

*Corresponding Author: Tel: (510) 643-5189; Fax: (510) 642-0427 luoping@berkeley.edu (Luoping Zhang).

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Keywords

benzene; toxicogenomics; epigenetics; systems biology; hematotoxicity; human

Introduction to Systems Biology

Systems biology is a recent and evolving interdisciplinary field that focuses on the systematic study of complex interactions in biological systems [1,2]. Systems biology employs a holistic approach to study all components and interactions in the network of DNA (genes), RNA, proteins and biochemical reactions within a cell or organism. This new field utilizes powerful tools that include toxicogenomics, epigenomics, bioinformatics, and phenomics, classical toxicological or phenotypic endpoints (Figure 1).

Toxicogenomics combines toxicology with molecular profiling technologies, including genomics (DNA), transcriptomics (mRNA), proteomics (proteins) and metabolomics (chemical metabolites) to elucidate molecular mechanisms involved in chemically-induced toxicity. Chemically-induced alterations in the transcriptome, proteome, and metabolome are analyzed in the context of the stable, inherited genome, which is assessed by genomics. Toxicogenomic studies of human populations are crucial to understanding gene-environment interactions, and can provide the ability to develop novel biomarkers of exposure (exposome), early effect (responsome), and susceptibility (genome) [3–5]. Epigenomics is the study of epigenetic elements, including DNA methylation (methylomics), non-coding microRNA (miRNAomics) along with small interfering RNA (siRNA) and short hairpin RNA (shRNA) for RNA interference (RNAi), and histone modification. Epigenetic modifications play an essential role in regulating gene expression and biological and molecular functions in living cells, without altering the genome.

Another tool central to systems biology is bioinformatics, the application of computational information technology to the field of molecular biology to understand how cells and cell systems work [6,7]. Bioinformatics facilitates the analysis of complex biological data (toxicogenomic and epigenomic endpoints) and applies knowledge from annotated functions, pathways and networks to describe normal and perturbed biological states, also known as phenomics, the study of outcomes (phenotypic endpoints). Together, these omic technologies can each provide a “molecular signature” or “fingerprint” of chemical exposure, early effect or genetic susceptibility, which may enhance our understanding of gene-environment interactions. Thus, this holistic approach known as systems biology has the potential to comprehensively define the mechanisms contributing to disease. The purpose of this review paper is to describe how and why it is important to apply the “Systems Biology” approach to benzene mechanistic studies and future directions.

Application of Systems Biology in Studies of Benzene Toxicity

Benzene, a ubiquitous chemical, is an established cause of acute myeloid leukemia (AML), myelodysplastic syndromes (MDS), and probably lymphocytic leukemias and non-Hodgkin lymphoma (NHL) in humans [8–11]. Benzene-induced toxicity in blood-forming systems has been known for more than a century [12]. In 1982, the International Agency for Research on Cancer (IARC) stated, “*There is sufficient evidence that benzene is carcinogenic to man*” [13], and when a new IARC classification system was established in 1987, benzene was immediately placed in the Group 1 human carcinogen category [14].

Potential mechanisms of benzene toxicity have been investigated primarily in the following areas [15]: 1) benzene metabolism in the liver (CYP2E1, etc.) and transportation to the bone

marrow for secondary metabolism (MPO, NQO1) [16,17]; 2) oxidative stress from reactive oxygen species generated by redox cycling [18,19]; 3) chromosome alterations including translocations, deletions, and aneuploidy [12]; 4) protein damage to tubulin, histone proteins, topoisomerase II, etc. [15]; and 5) immune system dysfunction (TNF- α , INF- γ , AhR, etc.) [20–22]. Benzene induces chromosomal alterations similar to those found in therapy-related MDS and AML (t-MDS/AML), and in *de novo* leukemia [23]. Distinct chromosome effects arise following exposure to alkylating agents (5q-/-5 or 7q-/-7 and associated genetic abnormalities) and topoisomerase II inhibitors (recurrent balanced translocations or inversions) used in chemotherapy treatment. Exposure to benzene or its metabolites has been associated with loss and long (q) arm deletion of chromosomes 5 and 7 [24] and translocations involving t(21q) [25,26], further suggesting that benzene induces leukemia through multiple different mechanisms.

Studies to date have provided evidence for multiple potential mechanisms using approaches that rely on limited research tools that analyze only one or a few, *a priori* selected genes, pathways or metabolites at a time. A systems biology approach is necessary to interrogate all potential mechanisms by which benzene exposure contributes to disease, through the application of unbiased omic-based technologies in an integrated manner. Since the last international benzene conference at Munich in 2004, we have adopted such an approach to understand the mechanisms underlying human benzene toxicity. This review summarizes our findings published over the last 5 years and preliminary data from recent pilot studies (Table 1). It also provides an overview of our current understanding of benzene-induced hematotoxicity and suggestions for further research.

We describe the studies in the context of systems biology as defined in Figure 1. First, we discuss hematotoxicity as a phenotypic outcome of benzene exposure, with implications for adverse future health effects. We then discuss findings from two toxicogenomic studies, transcriptomics and proteomics, followed by preliminary epigenomics data. As these toxicogenomic and epigenomic responses to exposure are likely influenced by susceptibility, next we describe how we investigated human susceptibility genes using a yeast genomic screening approach with validation of homologous human genes in human cells. We also describe genotyping studies of candidate genes in human exposed populations. Finally, we discuss how the current and future omic datasets could be integrated, using sophisticated bioinformatics approaches in progress, into one consolidated model of the perturbations effected by benzene. This could identify robust biomarkers and help to clarify the molecular and cellular networks impacted by benzene, yielding a more comprehensive understanding of the mechanistic effects of benzene.

Hematotoxicity as a Phenotypic Outcome of Benzene Exposure

Although benzene was known to have toxic effects on the hematopoietic system (hematotoxicity) at high, occupational doses for over a century [12], the degree of hematotoxicity at low levels of exposure was largely unknown. Recently, a study of 250 workers exposed to varying levels of benzene and 140 unexposed controls in Tianjin, China, during which benzene and other chemical exposure levels were monitored repeatedly for up to 12 months, was conducted. Air, urine and blood samples were collected and complete blood counts (CBC) analyzed [27]. In comparison with the non-exposed controls (n=140), a significant decrease was observed in almost all blood cell counts, such as white blood cells (WBC), granulocytes, lymphocytes, platelets etc, in workers exposed to benzene (n=250), even at exposures below 1 ppm (n=109), the current occupational standard in the U.S. Additionally, lymphocyte subset analysis showed significant, dose-dependent, decreases in CD4⁺-T cells, CD4⁺/CD8⁺ ratio, and B cells at < 1 ppm benzene exposures. These findings, based on the

differentiated blood cell counts, provide evidence of bone marrow toxicity in workers exposed to benzene at or below 1 ppm [27].

Because all types of WBC counts were suppressed, it was suspected that the number or functionality of hematopoietic stem and/or progenitor cells generated in the bone marrow had been reduced by benzene. To test this hypothesis, we cultured the progenitor cells circulating in peripheral blood and examined the effects of benzene on different types of progenitor cell colony formation (CFU-GM, BFU-E, CFU-GEMM). The results showed highly significant dose-dependent decreases in colony formation from all three types of progenitor cells, especially when compared to the corresponding decreased levels of differentiated WBC and granulocytes [27]. This suggests that early myeloid progenitor cells are more sensitive than mature cells to the effects of benzene, and clarifies the role of benzene in reduced blood cell counts.

Overall, these hematologic effects could reflect events in the bone marrow that may be associated with adverse health effects in the future [28]. Having established that hematotoxicity, specifically effects myeloid progenitor cells, as a phenotypic anchor of benzene toxicity, we began to examine the molecular mechanisms underlying these effects, through the comprehensive systems biology approach proposed above.

Gene Expression Profiling by Transcriptomics

Transcriptomic studies are useful in determining the impact of environmental or occupational exposure to chemicals on the transcriptome, the set of all mRNA transcripts expressed within a cell. To better understand the risks of benzene in humans, the peripheral blood mononuclear cell (PBMC) transcriptomes from occupationally exposed workers in China were examined by microarray (Affymetrix). Analysis of six exposed-control pairs revealed differential expression in 29 genes in the exposed individuals, compared to the controls. Four genes, *CXCL16*, *ZNF331*, *JUN*, and *PF4*, were shown to be potential biomarkers of early response to benzene exposure as they were confirmed by quantitative-polymerase chain reaction (q-PCR) [29].

A later study of 8 exposed-control pairs confirmed these results, using 2 different microarray platforms (Affymetrix & Illumina) to identify global gene expression changes. The differential expression of 2692 genes and 1828 genes was found by Affymetrix and Illumina, respectively, and the 4 genes, *CXCL16*, *ZNF331*, *JUN*, and *PF4*, were among the most significantly altered, validating the findings from the earlier Forrest *et al.* study. This study additionally identified biological pathways that were associated with high benzene exposure, including genes involved in apoptosis and lipid metabolism. This study used a two-platform approach that identified robust changes in the PBMC transcriptome of benzene-exposed individuals [30].

The effects of exposure to high levels of benzene are well documented compared to low-level exposure, the latter being more challenging due to confounders. More recently, we have shown, in an expanded study of 125 factory workers, that low-dose benzene exposure (<1 ppm, n=59) can also cause widespread subtle, yet highly significant, perturbation of gene expression in PBMC. This study was designed with sufficient power to detect robust expression changes, accounting for technical variability as well as age, gender and other confounders. Our microarray analysis revealed significant dysregulation of more than 2500 genes by low dose benzene exposure, over 70 of which had differential expression ratios exceeding 1.5. Several of the detected genes exhibited significantly altered expression only at low levels of benzene exposure, and are thus potential biomarkers of low-dose exposure. The findings show that even low levels of occupational benzene exposure cause a significant perturbation of expression of genes involved in immune and inflammatory responses [31].

Proteomic Biomarkers of Benzene

Another important toxicogenomic tool, proteomics, can be used to measure alterations in the proteome (e.g. protein levels, posttranslational modifications) associated with exogenous chemical exposure. Effects on the blood proteome may reflect effects at distal body sites. As with transcriptomics, proteomics can be used to discover biomarkers of exposure and early effect, as well as increase our understanding of the mechanisms underlying disease.

We examined the impact of benzene on the human serum proteome in exposed factory workers and controls to obtain insight into the mechanism of action of benzene [32]. Serum samples were fractionated and proteins were bound to surface-enhanced laser desorption/ionization time-of-flight mass spectrometry (SELDI-TOF-MS) chips. Three proteins (4.1, 7.7, and 9.3 kDa) were consistently down-regulated in the exposed (n=10) compared to the control (n=10) individuals in two separate sets of study subjects (40 subjects total). All proteins were highly inversely correlated with individual estimates of benzene exposure. The 7.7- and 9.3-kDa proteins were identified as platelet factor 4 (PF4), also down-regulated at the gene expression level described above, and connective tissue activating peptide CTAP-III, respectively, both platelet-derived CXC chemokines. Thus, reduced protein levels of PF4 or CTAP-III are potential biomarkers of the early biologic effects of benzene. Future proteomic studies could identify further biomarkers of benzene exposure, and elucidate the mechanisms underlying benzene toxicity and associated disease.

Epigenomics in Pilot Benzene Studies

Gene expression and ultimately protein expression is regulated at the epigenetic level by processes including DNA methylation, histone modification and miRNA (microRNA) expression. The epigenome, while stable through cell division and even in some cases reproduction, can be reprogrammed by nutritional, chemical, and physical factors [33]. Thus, the study of toxic effects on the epigenome is crucial to understanding mechanisms of action. Further, epigenetic modifications represent more stable biomarkers and fingerprints of exposure than altered gene or protein expression [34]. While epigenetics refers to the study of individual or specific gene activity, epigenomics focuses on global analyses of epigenetic changes across the entire genome. A recent study reported that hyper-methylation in *p15* and genome-wide hypo-methylation assessed by LINE-1 (Long Interspersed Nuclear Element-1) were associated with very low benzene exposures (~22 ppb), in healthy subjects including gas station attendants and traffic police officers, although the corresponding effects on methylation were very low [35]. To determine whether epigenetics plays a role in the hematotoxicity of benzene, we have recently performed several pilot epigenomic studies including DNA methylation and miRNA expression arrays in the blood of workers occupationally exposed to benzene. The results described below are very preliminary, and serve mainly as a proof of principle of this epigenomic approach.

DNA Methylation Array

A DNA methylation array (GoldenGate Methylation Cancer Panel I, Illumina) was applied to determine the methylation status of the CpG islands of >800 genes in DNA isolated from the buffy coats of 6 benzene-exposed workers (2 male, 4 female) and 4 unexposed controls (2 male, 2 female). As expected gender-specific methylation patterns were seen for numerous genes including *ELK1*, *EFNB1*, *MYCL2*, *VBPI*, *DNASE1L1*, *DKC1* and *CDM*. This pilot study also found altered methylation induced by benzene at many CpG sites. Decreased methylation of *RUNX3* (*AML2*), a gene whose altered expression has been associated with myeloproliferative disorders [36] occurred at three different CpG sites (Figure 2A). Increased methylation of *MSH3*, a critical gene in the maintenance of genome integrity, and *Sema3C*, a secreted guidance protein implicated in tumorigenesis [37], was also observed (Figure 2A).

There appeared to be a gender-specific effect of benzene on the methylation of several genes, although the sample number was small.

We examined the methylation status of the same panel of genes in DNA from TK6 cells treated *in vitro* with hydroquinone (HQ) at 10, 15, and 20 μ M, for 48 h. The most significantly hyper-methylated gene was *IL12* (Figure 2B), whose expression has previously been shown to be down-regulated by HQ in mouse macrophages [38]. *RUNX1T1* (runt-related transcription factor 1, also known as *ETO*), was hypo-methylated by HQ *in vitro* (Figure 2B). The protein encoded by this gene is commonly fused to *RUNX1* (*AML1*) in the t(8;21)(q22;q22) translocation, which is one of the most frequent karyotypic abnormalities in AML [39]. *MAGEA1* (melanoma antigen family A, 1), also known as *MAGE-1*, was also hypo-methylated by HQ in the present study (data not shown). Interestingly, this gene was reported recently to be hypo-methylated weakly in subjects exposed to increasing airborne benzene levels [35].

miRNA Microarrays

Human miRNA microarrays (Agilent), containing probes for 470 human and 64 human viral miRNAs, were used to analyze the differential expression of miRNAs in the total PBMC RNA from 7 exposed-control matched pairs, in a pilot study. Preliminary analysis showed upregulation of 4 miRNAs (miR-154*; miR-487a; miR-493-3p; and, miR-668) by benzene exposure. Upregulation of miR-154* expression, possibly through a change in the methylation and acetylation status of the 14q32 region, has been reported in patients with acute promyelocytic leukemia bearing the t(15;17) translocation [40].

While both of these studies are relatively small, and the data are very preliminary, the findings suggest that further studies to examine the epigenetic effects of benzene on gene-specific promoter methylation and miRNA expression, in a larger study of exposed workers, are warranted.

Identification of Susceptibility Genes by Genomics

Genome-wide association studies (GWAS) are a well-established means to examine the association of genetic susceptibility, i.e. single-nucleotide polymorphisms (SNPs), with disease. Such studies have been performed for two diseases related to benzene toxicity, NHL [41] and t-AML [42]. A very small number of pharmacogenomic GWAS have been reported [43], while to our knowledge, no GWAS on occupational or environmental exposure and associated toxic outcomes have been performed. Given the relatively small effects observed in disease GWAS, such studies are very expensive to undertake for less well-defined, pre-disease, toxicological outcomes. We adopted an alternative genomic approach to discover human susceptibility genes, the aims of which are: 1) to discover/screen susceptible genes in yeast by genomics; 2) to select human homolog genes using bioinformatics; 3) to test identified gene (e.g. *WRN* etc) functions by RNAi in human cells; 4) to identify human susceptible genes by SNP genotyping in population studies.

Genomic screening in yeast

In order to reduce the complexity and expense of analyzing the human genome, while retaining the ability to systematically screen a genome highly relevant to human biology, we chose a screening system in yeast (*Saccharomyces cerevisiae*). As we reported recently, this genomics approach has been employed to discover novel biomarkers of benzene toxicity in yeast cells exposed to the major active metabolites of benzene, hydroquinone (HQ), catechol (CAT), and 1,2,4-benzenetriol (BT) [44]. Using a collection of yeast strains representing a complete set of non-essential gene deletions, genetically tagged so that individual strains can be identified in competitive growth experiments, fitness assays were performed to identify mutant strains

whose fitness is significantly altered following treatment with benzene metabolites. A comparison of the global deletome profiles of the metabolites revealed that deletion of certain genes rendered yeast cells sensitive to all three compounds. Several of the genes identified in the yeast studies have human orthologs with conserved biological function, supporting the notion that the mechanisms of toxicity identified in yeast are relevant to human disease.

Selection of homologous human genes by bioinformatics

To select and prioritize likely human candidate genes from complex yeast genomic data, we applied bioinformatic analyses using specific computational programs including “clustering” by HOPACH (Hierarchical Ordered Partitioning And Collapsing Hybrid) algorithm methods [45], pathway analysis using Cytoscape with the BiNGO Gene Ontology identification plugin [46,47] and a comparative genomics approach. It is suggested that toxicants of similar mechanisms of action most likely have similar profiles of genes required for tolerance. We thus employed a variety of computational “clustering” methods to analyze the sensitivity and resistance data and to identify yeast strains most sensitive to each of the benzene metabolites tested as well as the genes specifically involved in sensitivity to each toxicant. We also set out to identify biologically significant patterns and features involved in toxicant response between metabolites. Similarly, a comparative genomics approach has been applied to identify functional orthologs and pathways between evolutionarily distant organisms. This approach assists in the identification of yeast and subsequently human candidate genes and pathways for further evaluation in the mammalian cell culture system.

Functional testing of candidate genes by RNAi in human cells

The roles of the human homologs of selected genes in benzene toxicity have been examined through mechanistic studies in human cell lines. SNPs in WRN, an important protein that plays a role in the maintenance of genomic stability, have been associated with an increased risk for some cancers and benzene hematotoxicity. We knocked down WRN protein using siRNA in HeLa cells and examined sensitivity to toxicity following exposure to the benzene metabolite, HQ [48]. Depletion of WRN led to decreased cell proliferation and increased HQ cytotoxicity, evident by increased necrosis. Additionally, these cells displayed increased DNA double-strand breaks (DSB), a potential biomarker of benzene hematotoxicity. Together, the results showed that WRN plays an important role in resistance to benzene toxicity in HeLa, and perhaps other cells.

More recently, we used shRNA to silence WRN in the human HL60 acute promyelocytic cell line [49]. Upon exposure to HQ, HL60 cell growth rates were accelerated, and DNA breaks and sensitivity to HQ-induced cytotoxicity and genotoxicity were increased, similar to the findings in HeLa cells. Loss of WRN also resulted in higher levels of early apoptosis. An accumulation of such genetic lesions can lead to the development of AML. The data from this study provides mechanistic support for the link between WRN and benzene-induced hematotoxicity, and possibly even benzene-induced leukemia. Studies are underway to confirm the role of other susceptibility genes in benzene toxicity.

Genotyping results in human population studies

In addition to the yeast genomic studies, large-scale human population genotyping studies have also been conducted. In collaboration between the National Cancer Institute and China CDC, such a study analyzed 1,395 SNPs in 411 potential carcinogenesis-related genes using an Illumina GoldenGate assay in 250 benzene-exposed workers and 140 unexposed controls in China [50]. One or more SNPs in five genes (*WRN*, *BLM*, *TP53*, *RAD51*, and *WDR79*) which play critical roles in DNA repair and genomic maintenance, were associated with highly significant 10–20% reductions (*p* values ranged from 0.0011 to 0.0002) in the WBC count among benzene-exposed workers but not controls, with evidence for gene-environment

interactions for SNPs in *BLM*, *WRN* and *RAD51*. Earlier candidate gene studies identified a small number of SNPs in genes involved in benzene metabolism, cytokine and cellular adhesion molecules [51], and DNA DBS repair [52], which appear to confer susceptibility to benzene hematotoxicity. These studies were the first to provide evidence that genetic polymorphisms in certain genomic stability maintenance genes, like *WRN* [53], impact benzene-induced phenotypic outcomes such as hematotoxicity.

The human population studies confirm a critical role for DNA repair and genomic maintenance in susceptibility, and further support these effects as benzene-induced phenotypic outcomes. In addition, genetic variants in metabolizing enzymes responsible for activating and detoxifying benzene, in particular *MPO* and *NQO1*, have also been linked to increased susceptibility to benzene hematotoxicity [27]. Together, these genomic and genotyping studies provide important information regarding benzene toxicity and disease pathways.

Systems Biology Approach in Current and Future Studies

From our omic studies to date, benzene appears to cause hematotoxicity through multiple mechanisms that may involve alterations in the expression of multiple genes and proteins, DNA methylation patterns and miRNA profiles even at low-doses. Transcriptomics has identified many genes, functions and pathways altered by benzene, offering insight into mechanisms and providing potential signatures of benzene exposure, and/or early effect. These data could be integrated with information on susceptibility genes to further understand gene-environment interactions and perhaps to identify the most susceptible individuals. We will expand our proteomic studies by conducting further analyses on different protein fractions and affinity chips to identify more altered proteins. As discussed earlier, expanded DNA methylation and miRNA profiling studies are necessary in larger populations of exposed individuals. All studies will be performed at a range of benzene exposures to examine dose-response effects. Several of these individual omic datasets are large, measuring e.g. the expression level of ~24,000 genes or the methylation status of >14,000 genes at multiple CpG islands and bioinformatic methods to analyze them continue to be refined.

Each individual omic dataset is anticipated to provide information on the effects of benzene, and potentially identify biomarkers of exposure and early effect. Through our systems biology approach, we will use sophisticated bioinformatics to integrate individual datasets into one consolidated model of the perturbations effected by benzene. From this model we will make inferences, specifically, we will aim to understand the interactions between benzene toxicity, SNPs, mRNA, miRNA, protein, and DNA methylation. This could identify robust biomarkers and help to clarify the molecular and cellular networks impacted by benzene, yielding a more comprehensive understanding of the mechanistic effects of benzene. While all the toxicogenomic endpoints have the potential to yield biomarkers, some endpoints such as DNA methylation and gene expression may reflect more upstream mechanistic effects while others such as proteomics may reflect more downstream, phenotypic effects, and might be more informative of actual molecular and cellular processes affected. Multiple regulatory mechanisms probably determine the phenotypic outcome (e.g. a gene could be up-regulated by DNA methylation and down-regulated by miRNA). The systems biology approach will require a high level of computing power and will capitalize on the ever-expanding knowledge of biological pathways and networks. In order to realize this approach, future studies need to be designed with sufficient power to robustly detect effects of benzene and to allow for analysis of the interrelationship among the different endpoints. With respect to sample processing, the ideal scenario is to analyze DNA, RNA and protein from the same cell population but this remains challenging with existing protocols and sample availability.

The findings from the systems biology study of benzene could also contribute more generally to the field of risk assessment. Comparison of the toxicogenomic, epigenomic and genomic profiles associated with different exposures, e.g. suspected leukemogens or carcinogens, and diseases (NHL, AML), may help to clarify the connection between chemicals, genes/proteins, pathways/networks, and disease. Initiatives such as the Comparative Toxicogenomics Database [54] and Chemical Effects in Biological Systems [55] have been developed towards this goal. It has been also discussed how omic data/measurements obtained through a systems biology approach can be applied to identify all potential mechanisms of action and serve as an information base for subsequent evaluation of these mechanisms when conducting risk assessment [56].

In conclusion, the systems biology approach described here should help inform the mechanisms underlying benzene hematoxicity and associated disease, and identify robust biomarkers of exposure, early effect, susceptibility and disease development.

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Abbreviations

| | |
|-------------|---|
| AML | Acute Myeloid Leukemia |
| BFU-E | Burst Forming Unit – Erythroid |
| BiNGO | Biological Network Gene Ontology |
| BT | 1,2,4-Benzenetriol |
| CAT | Catechol |
| CBC | Complete Blood Counts |
| CFU-GEMM | Colony Forming Unit – Granulocyte, Erythrocyte, Monocyte, Megakaryocyte |
| CFU-GM | Colony Forming Unit – Granulocyte, Monocyte |
| CYP2E1 | Cytochrome P450 2E1 |
| GWAS | Genome-Wide Association Studies |
| HQ | Hydroquinone |
| IARC | International Agency for Research on Cancer |
| MDS | Myelodysplastic Syndromes |
| miRNA | microRNA |
| <i>MPO</i> | Myeloperoxidase |
| NHL | Non-Hodgkin Lymphoma |
| <i>NQO1</i> | NAD(P): HQuinone Oxidoreductase 1 |
| PBMC | Peripheral Blood Mononuclear Cells |

| | |
|--------------|---|
| PF4 | Platelet Factor 4 |
| q-PCR | Quantitative-Polymerase Chain Reaction |
| RNAi | RNA Interference |
| SELDI-TOF-MS | Surface-Enhanced Laser Desorption/Ionization Time-Of-Flight Mass Spectrometry |
| shRNA | short hairpin RNA |
| siRNA | small interfering RNA |
| SNPs | Single-Nucleotide Polymorphism |
| t-MDS/AML | therapy-related MDS and AML |
| WBC | White Blood Cells |

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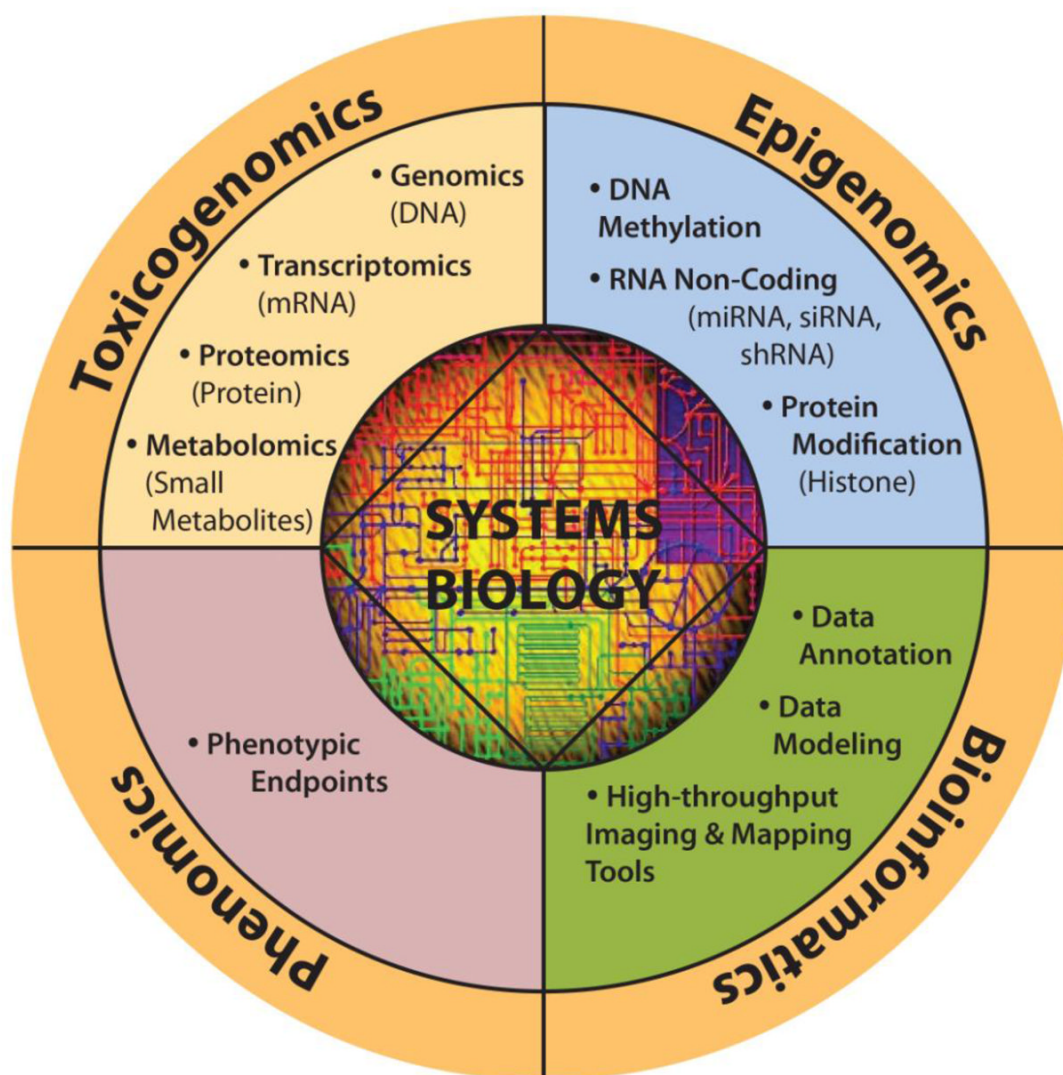


Figure 1. Overview of systems biology and its components

(Center of image, Wired Systems Biology, adapted from *Chemical & Engineering News*, 81 (20), 2003)

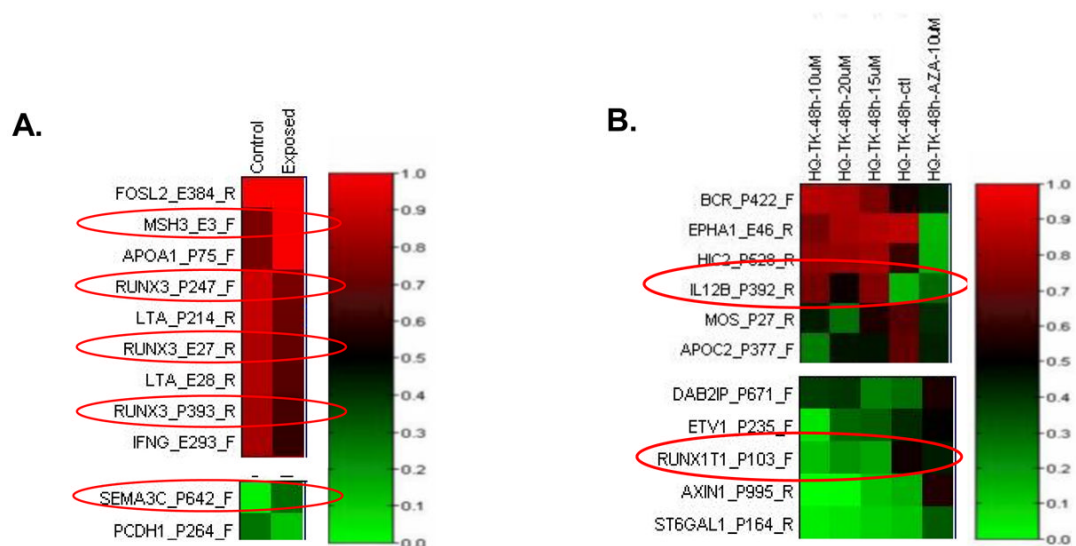


Figure 2. Heatmap of methylation profiles of (A) workers exposed to benzene and controls, and (B) TK6 cells exposed to hydroquinone (HQ)

A. A total of 6 benzene exposed subjects and 4 controls were analyzed. **B:** Human TK 6 cells were treated with HQ at 0, 10, 15 and 20 μ M for 48 hrs. 5-azacytidine, a demethylating agent, was included as a positive control. Examples of genes with methylation levels significantly altered by benzene or HQ are shown. Values range from 1.0 fully methylated (Red) to 0 fully unmethylated (Green)

Table 1

Summary of benzene studies applying systems biology approach

| Systems Biology | Study Method | Study Size | | Benzene Exposure (ppm) | Major Findings | Reference |
|-----------------|-----------------------|-----------------------------------|----------|------------------------|--|---|
| | | Exposed | Controls | | | |
| Phenomics | | | | | | |
| Hematotoxicity | CBC | 250 | 140 | <1, <10, >10 | Decrease in all blood cell counts | Lan et al. 2004 [27] |
| | Colony | 24 | 29 | <10, >10 | Decrease in colony formation | Lan et al. 2004 [27] |
| Toxicogenomics | | | | | | |
| Transcriptomics | Affymetrix | 6 | 6 | ≥10 | 29 genes differentially expressed | Forrest et al. 2005 [29] |
| | & q-PCR | 13 | 15 | ≥10 | Validated 6 of 29 genes | |
| | Affymetrix & Illumina | 8 | 8 | | Confirms Forrest findings | McHale et al. 2009 [30] |
| | Illumina | 83 | 42 | <1, <10, >10 | Different gene pathways identified at low and high exposures | McHale et al. 2008 [31] |
| Proteomics | SELDI-TOF | 20 | 20 | 31.3 & 37.9 (mean) | Identified two down-regulated proteins as PF4 and CTAP-III | Vermelen et al. 2005 [32] |
| | | (2 sets of 10) | | | | |
| Epigenomics | | | | | | |
| DNA Methylation | Illumina (GoldenGate) | 6 | 4 | 8.9±9.1 (mean±sd) | Results preliminary (MSH3, RUNX3) | Pilot Study |
| | | Human TK6 Cells | | HQ (0, 10, 15, 20 µM) | Results preliminary (RUNX1, IL12) | |
| miRNA | Agilent | 7 | 7 | <1 ppm | Results preliminary (4 miRNAs) | Pilot Study |
| Genomics | | | | | | |
| | PDA in Yeast | ~4600 homozygous deletion strains | | HQ, CAT, BT | Oxidative stress response | North 2009 [44] |
| | RNAi | WRN | | HQ | DNA repair HR pathway | Galvan 2008, Ren 2009 [48,49] |
| Genotyping | | | | | | |
| | Illumina (GoldenGate) | 250 | 140 | 0, < 1, < 10, > 10 | Identified <i>MPO</i> , <i>NQO1</i> , and a group of DNA repair & cytokine genes | Lan 2004, 2005, 2009, Shen 2006 [50–52] |



Agency for Toxic Substances & Disease Registry

Public Health Statement for Benzene

(*Benceno*)

August 2007

CAS#: 71-43-2

PDF Version, 46 KB

This Public Health Statement is the summary chapter from the Toxicological Profile for Benzene. It is one in a series of Public Health Statements about hazardous substances and their health effects. A shorter version, the ToxFAQs™, is also available. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present. For more information, call the ATSDR Information Center at 1-800-232-4636.

This public health statement tells you about benzene and the effects of exposure to it.

The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. These sites are then placed on the National Priorities List (NPL) and are targeted for long-term federal clean-up activities. Benzene has been found in at least 1,000 of the 1,684 current or former NPL sites. Although the total number of NPL sites evaluated for this substance is not known, the possibility exists that the number of sites at which benzene is found may increase in the future as more sites are evaluated. This information is important because these sites may be sources of exposure and exposure to this substance may harm you.

When a substance is released either from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment. Such a release does not always lead to exposure. You can be exposed to a substance only when you come in contact with it. You may be exposed by breathing, eating, or drinking the substance, or by skin contact.

If you are exposed to benzene, many factors will determine whether you will be harmed. These factors include the dose (how much), the duration (how long), and how you come in contact with it. You must also consider any other chemicals you are exposed to and your age, sex, diet, family traits, lifestyle, and state of health.

1.1 What is benzene?

Benzene, also known as benzol, is a colorless liquid with a sweet odor. Benzene evaporates into air very quickly and dissolves slightly in water. Benzene is highly flammable. Most people can begin to smell benzene in air at approximately 60 parts of benzene per million parts of air (ppm) and recognize it as benzene at 100 ppm. Most people can begin to taste benzene in water at 0.5–4.5 ppm. One part per million is approximately equal to one drop in 40 gallons. Benzene is found in air, water, and soil. Benzene comes from both industrial and natural

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sources.

Industrial Sources and Uses. Benzene was first discovered and isolated from coal tar in the 1800s. Today, benzene is made mostly from petroleum. Because of its wide use, benzene ranks in the top 20 in production volume for chemicals produced in the United States. Various industries use benzene to make other chemicals, such as styrene (for Styrofoam® and other plastics), cumene (for various resins), and cyclohexane (for nylon and synthetic fibers). Benzene is also used in the manufacturing of some types of rubbers, lubricants, dyes, detergents, drugs, and pesticides.

Natural Sources. Natural sources of benzene, which include gas emissions from volcanoes and forest fires, also contribute to the presence of benzene in the environment. Benzene is also present in crude oil and gasoline and cigarette smoke.

1.2 What happens to benzene when it enters the environment?

Benzene is commonly found in the environment. Industrial processes are the main sources of benzene in the environment. Benzene levels in the air can be elevated by emissions from burning coal and oil, benzene waste and storage operations, motor vehicle exhaust, and evaporation from gasoline service stations. Tobacco smoke is another source of benzene in air, particularly indoors. Industrial discharge, disposal of products containing benzene, and gasoline leaks from underground storage tanks release benzene into water and soil.

Benzene can pass into air from water and soil surfaces. Once in the air, benzene reacts with other chemicals and breaks down within a few days. Benzene in the air can also be deposited on the ground by rain or snow.

Benzene in water and soil breaks down more slowly. Benzene is slightly soluble in water and can pass through the soil into underground water. Benzene in the environment does not build up in plants or animals.

1.3 How might I be exposed to benzene?

Everyone is exposed to a small amount of benzene every day. You are exposed to benzene in the outdoor environment, in the workplace, and in the home. Exposure of the general population to benzene mainly occurs through breathing air that contains benzene. The major sources of benzene exposure are tobacco smoke, automobile service stations, exhaust from motor vehicles, and industrial emissions. Vapors (or gases) from products that contain benzene, such as glues, paints, furniture wax, and detergents, can also be a source of exposure. Auto exhaust and industrial emissions account for about 20% of the total national exposure to benzene. About half of the exposure to benzene in the United States results from smoking tobacco or from exposure to tobacco smoke. The average smoker (32 cigarettes per day) takes in about 1.8 milligrams (mg) of benzene per day. This amount is about 10 times the average daily intake of benzene by nonsmokers.

Measured levels of benzene in outdoor air have ranged from 0.02 to 34 parts of benzene per billion parts of air (ppb) (1 ppb is 1,000 times less than 1 ppm). People living in cities or industrial areas are generally exposed to higher levels of benzene in air than those living in rural areas. Benzene levels in the home are usually higher than outdoor levels. People may be

exposed to higher levels of benzene in air by living near hazardous waste sites, petroleum refining operations, petrochemical manufacturing sites, or gas stations.

For most people, the level of exposure to benzene through food, beverages, or drinking water is not as high as through air. Drinking water typically contains less than 0.1 ppb benzene. Benzene has been detected in some bottled water, liquor, and food. Leakage from underground gasoline storage tanks or from landfills and hazardous waste sites that contain benzene can result in benzene contamination of well water. People with benzene-contaminated tap water can be exposed from drinking the water or eating foods prepared with the water. In addition, exposure can result from breathing in benzene while showering, bathing, or cooking with contaminated water.

Individuals employed in industries that make or use benzene may be exposed to the highest levels of benzene. As many as 238,000 people may be occupationally exposed to benzene in the United States. These industries include benzene production (petrochemicals, petroleum refining, and coke and coal chemical manufacturing), rubber tire manufacturing, and storage or transport of benzene and petroleum products containing benzene. Other workers who may be exposed to benzene include coke oven workers in the steel industry, printers, rubber workers, shoe makers, laboratory technicians, firefighters, and gas station employees.

1.4 How can benzene enter and leave my body?

Benzene can enter your body through your lungs, gastrointestinal tract, and across your skin. When you are exposed to high levels of benzene in air, about half of the benzene you breathe in passes through the lining of your lungs and enters your bloodstream. When you are exposed to benzene in food or drink, most of the benzene you take in by mouth passes through the lining of your gastrointestinal tract and enters your bloodstream. A small amount will enter your body by passing through your skin and into your bloodstream during skin contact with benzene or benzene-containing products. Once in the bloodstream, benzene travels throughout your body and can be temporarily stored in the bone marrow and fat. Benzene is converted to products, called metabolites, in the liver and bone marrow. Some of the harmful effects of benzene exposure are caused by these metabolites. Most of the metabolites of benzene leave the body in the urine within 48 hours after exposure.

1.5 How can benzene affect my health?

Scientists use many tests to protect the public from harmful effects of toxic chemicals and to find ways for treating persons who have been harmed.

One way to learn whether a chemical will harm people is to determine how the body absorbs, uses, and releases the chemical. For some chemicals, animal testing may be necessary. Animal testing may also help identify health effects such as cancer or birth defects. Without laboratory animals, scientists would lose a basic method for getting information needed to make wise decisions that protect public health. Scientists have the responsibility to treat research animals with care and compassion. Scientists must comply with strict animal care guidelines because laws today protect the welfare of research animals.

After exposure to benzene, several factors determine whether harmful health effects will occur, as well as the type and severity of such health effects. These factors include the amount of

benzene to which you are exposed and the length of time of the exposure. Most information on effects of long-term exposure to benzene are from studies of workers employed in industries that make or use benzene. These workers were exposed to levels of benzene in air far greater than the levels normally encountered by the general population. Current levels of benzene in workplace air are much lower than in the past. Because of this reduction and the availability of protective equipment such as respirators, fewer workers have symptoms of benzene poisoning.

Brief exposure (5–10 minutes) to very high levels of benzene in air (10,000–20,000 ppm) can result in death. Lower levels (700–3,000 ppm) can cause drowsiness, dizziness, rapid heart rate, headaches, tremors, confusion, and unconsciousness. In most cases, people will stop feeling these effects when they are no longer exposed and begin to breathe fresh air.

Eating foods or drinking liquids containing high levels of benzene can cause vomiting, irritation of the stomach, dizziness, sleepiness, convulsions, rapid heart rate, coma, and death. The health effects that may result from eating foods or drinking liquids containing lower levels of benzene are not known. If you spill benzene on your skin, it may cause redness and sores. Benzene in your eyes may cause general irritation and damage to your cornea.

Benzene causes problems in the blood. People who breathe benzene for long periods may experience harmful effects in the tissues that form blood cells, especially the bone marrow. These effects can disrupt normal blood production and cause a decrease in important blood components. A decrease in red blood cells can lead to anemia. Reduction in other components in the blood can cause excessive bleeding. Blood production may return to normal after exposure to benzene stops. Excessive exposure to benzene can be harmful to the immune system, increasing the chance for infection and perhaps lowering the body's defense against cancer.

Long-term exposure to benzene can cause cancer of the blood-forming organs. This condition is called leukemia. Exposure to benzene has been associated with development of a particular type of leukemia called acute myeloid leukemia (AML). The Department of Health and Human Services has determined that benzene is a known carcinogen (can cause cancer). Both the International Agency for Cancer Research and the EPA have determined that benzene is carcinogenic to humans.

Exposure to benzene may be harmful to the reproductive organs. Some women workers who breathed high levels of benzene for many months had irregular menstrual periods. When examined, these women showed a decrease in the size of their ovaries. However, exact exposure levels were unknown, and the studies of these women did not prove that benzene caused these effects. It is not known what effects exposure to benzene might have on the developing fetus in pregnant women or on fertility in men. Studies with pregnant animals show that breathing benzene has harmful effects on the developing fetus. These effects include low birth weight, delayed bone formation, and bone marrow damage.

We do not know what human health effects might occur after long-term exposure to food and water contaminated with benzene. In animals, exposure to food or water contaminated with benzene can damage the blood and the immune system and can cause cancer.

1.6 How can benzene affect children?

This section discusses potential health effects in humans from exposures during the period from conception to maturity at 18 years of age.

Children can be affected by benzene exposure in the same ways as adults. Benzene can pass from the mother's blood to a fetus. It is not known if children are more susceptible to benzene poisoning than adults.

1.7 How can families reduce the risk of exposure to benzene?

If your doctor finds that you have been exposed to substantial amounts of benzene, ask whether your children might also have been exposed. Your doctor might need to ask your state health department to investigate.

Gasoline and cigarette smoke are two main sources of human exposure to benzene. Benzene exposure can be reduced by limiting contact with these sources. People are exposed to benzene from both active and passive second hand smoke. Average smokers take in about 10 times more benzene than nonsmokers each day. Families are encouraged not to smoke in their house, in enclosed environments, or near their children.

Benzene is a major component of gasoline and used in many manufacturing processes. Increased levels of benzene can be found at fueling stations, and in air emissions from manufacturing plants and hazardous waste sites. Living near gasoline fueling stations or hazardous waste sites may increase exposure to benzene. People are advised not to have their families play near fueling stations, manufacturing plants, or hazardous waste sites.

1.8 Is there a medical test to determine whether I have been exposed to benzene?

Several tests can show whether you have been exposed to benzene. Some of these tests may be available at your doctor's office. All of these tests are limited in what they can tell you. The test for measuring benzene in your breath must be done shortly after exposure. This test is not very helpful for detecting very low levels of benzene in your body. Benzene can be measured in your blood. However, because benzene rapidly disappears in the blood, measurements may be useful only for recent exposures.

In the body, benzene is converted to products called metabolites. Certain metabolites of benzene, such as phenol, muconic acid, and S-phenyl-mercapturic acid can be measured in the urine. The amount of phenol in urine has been used to check for benzene exposure in workers. The test is useful only when you are exposed to benzene in air at levels of 10 ppm or greater. However, this test must also be done shortly after exposure, and it is not a reliable indicator of how much benzene you have been exposed to, because phenol is present in the urine from other sources (diet, environment). Measurements of muconic acid or S phenylmercapturic acid in the urine are more sensitive and reliable indicators of benzene exposure. The measurement of benzene in blood or of metabolites in urine cannot be used for making predictions about whether you will experience any harmful health effects. Blood counts of all components of the blood and examination of bone marrow are used to determine benzene exposure and its health effects.

For people exposed to relatively high levels of benzene, complete blood analyses can be used to monitor possible changes related to exposure. However, blood analyses are not useful when exposure levels are low.

1.9 What recommendations has the federal government made to protect human health?

The federal government develops regulations and recommendations to protect public health. Regulations *can* be enforced by law. The EPA, the Occupational Safety and Health Administration (OSHA), and the Food and Drug Administration (FDA) are some federal agencies that develop regulations for toxic substances. Recommendations provide valuable guidelines to protect public health, but *cannot* be enforced by law. The Agency for Toxic Substances and Disease Registry (ATSDR) and the National Institute for Occupational Safety and Health (NIOSH) are two federal organizations that develop recommendations for toxic substances.

Regulations and recommendations can be expressed as “not-to-exceed” levels, that is, levels of a toxic substance in air, water, soil, or food that do not exceed a critical value that is usually based on levels that affect animals; they are then adjusted to levels that will help protect humans. Sometimes these not-to-exceed levels differ among federal organizations because they used different exposure times (an 8-hour workday or a 24-hour day), different animal studies, or other factors.

Recommendations and regulations are also updated periodically as more information becomes available. For the most current information, check with the federal agency or organization that provides it. Some regulations and recommendations for benzene include the following:

EPA has set 5 ppb as the maximum permissible level of benzene in drinking water. EPA has set a goal of 0 ppb for benzene in drinking water and in water such as rivers and lakes because benzene can cause leukemia. EPA estimates that 10 ppb benzene in drinking water that is consumed regularly or exposure to 0.4 ppb in air over a lifetime could cause a risk of one additional cancer case for every 100,000 exposed persons. EPA recommends 200 ppb as the maximum permissible level of benzene in water for short-term exposures (10 days) for children.

EPA requires that the National Response Center be notified following a discharge or spill into the environment of 10 pounds or more of benzene.

OSHA regulates levels of benzene in the workplace. The maximum allowable amount of benzene in workroom air during an 8-hour workday, 40-hour workweek is 1 ppm. Because benzene can cause cancer, NIOSH recommends that all workers wear special breathing equipment when they are likely to be exposed to benzene at levels exceeding the recommended (8-hour) exposure limit of 0.1 ppm.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2007. Toxicological profile for Benzene. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information?

If you have questions or concerns, please contact your community or state health or

environmental quality department or:

For more information, contact:

Agency for Toxic Substances and Disease Registry
Division of Toxicology and Human Health Sciences
1600 Clifton Road NE, Mailstop F-57
Atlanta, GA 30329-4027
Phone: 1-800-CDC-INFO · 888-232-6348 (TTY)
Email: Contact CDC-INFO

ATSDR can also tell you the location of occupational and environmental health clinics. These clinics specialize in recognizing, evaluating, and treating illnesses resulting from exposure to hazardous substances.

Information line and technical assistance:

Phone: 888-422-8737

To order toxicological profiles, contact:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Phone: 800-553-6847 or 703-605-6000

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The information contained here was correct at the time of publication. Please check with the appropriate agency for any changes to the regulations or guidelines cited.

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Centers for Disease Control and Prevention 1600 Clifton Road Atlanta, GA
30329-4027, USA
800-CDC-INFO (800-232-4636) TTY: (888) 232-6348 - [Contact CDC-INFO](#)



List of IARC Group 1 carcinogens

From Wikipedia, the free encyclopedia

Substances, mixtures and exposure circumstances in this list have been classified by the IARC as **Group 1**: *The agent (mixture) is carcinogenic to humans. The exposure circumstance entails exposures that are carcinogenic to humans.* This category is used when there is *sufficient evidence* of carcinogenicity in humans. Exceptionally, an agent (mixture) may be placed in this category when evidence of carcinogenicity in humans is less than sufficient but there is *sufficient evidence* of carcinogenicity in experimental animals and strong evidence in exposed humans that the agent (mixture) acts through a relevant mechanism of carcinogenicity.

Contents

- 1 Agents and groups of agents
- 2 Mixtures
- 3 Exposure circumstances
- 4 Notes
- 5 References
- 6 External links

Agents and groups of agents

- 2-Naphthylamine
- Acetaldehyde^[1]
- 4-Aminobiphenyl
- Aflatoxins
- Aristolochic acids, and plants containing them
- Arsenic and arsenic compounds¹
- Asbestos
- Azathioprine
- Benzene
- Benzidine
- Benzo[*a*]pyrene
- Beryllium and beryllium compounds²
- Chlornapazine (*N,N*-Bis(2-chloroethyl)-2-naphthylamine)
- Bis(chloromethyl)ether
- Chloromethyl methyl ether
- 1,3-Butadiene
- 1,4-Butanediol dimethanesulfonate (Busulphan, Myleran)
- Cadmium and cadmium compounds²
- Chlorambucil
- Methyl-CCNU (1-(2-Chloroethyl)-3-(4-methylcyclohexyl)-1-nitrosourea; Semustine)

- Chromium(VI) compounds²
- Ciclosporin
- Contraceptives, hormonal, combined forms (those containing both estrogen and a progestogen)³
- Contraceptives, oral, sequential forms of hormonal contraception (a period of estrogen-only followed by a period of both estrogen and a progestogen)
- Cyclophosphamide
- Diethylstilboestrol
- Dyes metabolized to benzidine
- Epstein-Barr virus
- Estrogens, nonsteroidal¹
- Estrogens, steroidal¹
- Estrogen therapy, postmenopausal
- Ethanol in alcoholic beverages^{4[1]}
- Erionite
- Ethylene oxide
- Etoposide alone and in combination with cisplatin and bleomycin
- Formaldehyde
- Gallium arsenide
- *Helicobacter pylori* (infection with)
- Hepatitis B virus (chronic infection with)
- Hepatitis C virus (chronic infection with)
- Human herpesvirus 8
- Human immunodeficiency virus type 1 (infection with)
- Human papillomavirus type 16, 18, 31, 33, 35, 39, 45, 51, 52, 56, 58, 59 and 66
- Human T-cell lymphotropic virus type 1
- Meats (processed)
- Melphalan
- Methoxsalen (8-Methoxypsoralen) plus ultraviolet A radiation
- 4,4'-Methylenebis(2-chloroaniline) (MOCA)
- MOPP and other combined chemotherapy including alkylating agents
- Mustard gas (Sulfur mustard)
- 2-Naphthylamine
- Neutron radiation
- Nickel compounds²
- 4-(*N*-Nitrosomethylamino)-1-(3-pyridyl)-1-butanone (NNK)
- *N*-Nitrosornicotine (NNN)
- *Opisthorchis viverrini* (infection with)
- Outdoor air pollution
- Particulate matter in outdoor air pollution
- Phosphorus-32, as phosphate
- Plutonium-239 and its decay products (may contain plutonium-240 and other isotopes), as aerosols
- Radioiodines, short-lived isotopes, including iodine-131, from atomic reactor accidents and nuclear weapons detonation (exposure during childhood)
- Radionuclides, α -particle-emitting, internally deposited⁵

- Radionuclides, β -particle-emitting, internally deposited⁵
- Radium-224 and its decay products
- Radium-226 and its decay products
- Radium-228 and its decay products
- Radon-222 and its decay products
- *Schistosoma haematobium* (infection with)
- Sawdust
- Silica, crystalline (inhaled in the form of quartz or cristobalite from occupational sources)
- Solar radiation
- Talc containing asbestiform fibres
- Tamoxifen⁶
- 2,3,7,8-Tetrachlorodibenzo-*p*-dioxin
- Thiotepa (1,1',1''-Phosphinothioylidynetrisaziridine)
- Thorium-232 and its decay products, administered intravenously as a colloidal dispersion of thorium-232 dioxide
- Treosulfan
- *o*-Toluidine
- Vinyl chloride
- Ultraviolet Radiation
- X-Radiation and Gamma radiation

Mixtures

- Aflatoxins (naturally occurring mixtures of)
- Alcoholic beverages
- Areca nut
- Betel quid with tobacco
- Betel quid without tobacco
- Coal-tar pitches
- Coal-tars
- Household combustion of coal, indoor emissions from
- Diesel exhaust^[2]
- Mineral oils from radionuclides, untreated and mildly treated
- Paints containing benzene
- Phenacetin, analgesic mixtures containing
- Plants containing aristolochic acid
- Polychlorinated biphenyls
- Processed meat^[3]
- Salted fish (Chinese-style)
- Shale-oils
- Soots
- Tobacco products
- Wood dust

Exposure circumstances

- Aluminium production
- Arsenic in certain drinking water
- Auramine O, manufacture of
- Boot and shoe manufacture and repair
- Chimney sweeping
- Coal gasification
- Coal tar distillation
- Coke (fuel) production
- Haematite mining (underground) with exposure to radon
- Secondhand smoke
- Iron and steel founding
- Isopropanol manufacture (strong-acid process)
- Glass, making of
- Magenta dyes, manufacture of
- Making of wooden furniture
- Painting (occupational exposure to benzene paints as a painter)
- Paving and roofing with coal tar pitch
- Rubber industry
- Strong inorganic acid mists containing sulfuric acid (occupational exposure to)
- Sunlamps and sunbeds (use of)
- Sandblasting
- Tobacco smoking

Notes

1. This evaluation applies to the group of compounds as a whole and not necessarily to all individual compounds within the group.
2. Evaluated as a group.
3. There is also conclusive evidence that these agents have a protective effect against cancers of the ovary and endometrium.
4. Ethanol is not carcinogenic, but is metabolised to acetaldehyde, which is carcinogenic.
5. Specific radionuclides for which there is sufficient evidence for carcinogenicity to humans are also listed individually as Group 1 agents.
6. There is also conclusive evidence that this agent (tamoxifen) reduces the risk of contralateral breast cancer.

References

1. "IARC: IARC STRENGTHENS ITS FINDINGS ON SEVERAL CARCINOGENIC PERSONAL HABITS AND HOUSEHOLD EXPOSURES" (Press release). International Agency for Research on Cancer (IARC). Retrieved August 1, 2014. "November 2, 2009 -- IARC has updated the cancer assessments of several personal habits and household exposures that cause cancer, including tobacco, areca nut, alcohol, and household coal smoke. The update was conducted with the advice of 30 scientists from 10 countries who met at IARC in October 2009. [...] The Working Group concluded that acetaldehyde associated with alcohol

consumption is carcinogenic to humans (Group 1) and confirmed the classification in Group 1 of alcohol consumption and of ethanol in alcoholic beverages."

2. "IARC: DIESEL ENGINE EXHAUST CARCINOGENIC" (Press release). International Agency for Research on Cancer (IARC). Retrieved June 12, 2012. "June 12, 2012 -- After a week-long meeting of international experts, the International Agency for Research on Cancer (IARC), which is part of the World Health Organization (WHO), today classified diesel engine exhaust as carcinogenic to humans (Group 1), based on sufficient evidence that exposure is associated with an increased risk for lung cancer"
3. "IARC Monographs evaluate consumption of red meat and processed meat" (PDF). Retrieved 26 October 2015.

External links

- IARC Monographs - Classifications - Group1 (<http://monographs.iarc.fr/ENG/Classification/ClassificationsGroupOrder.pdf>)

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Categories: Carcinogens | IARC Group 1 carcinogens

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Paul Seamans' Statement
07-16-15

The sleeves are a big plastic pipe that a contractor came in and installed underneath where the Keystone XL route will go. So essentially this pipe, which is probably 10 to 12 inch diameter is already over 7 feet in the ground so that the KXL pipe would be able to cross over it without disturbing the water line. The theory is if any work needs to be done near the KXL line in the future on the water lines the the water district would be able to slip a new water line through the sleeve without digging to close to the oil pipeline.

A contractor came in and installed these sleeves at all spots where the KXL would cross a West River/Lyman Jones water line a couple of years ago. I am fairly sure that all the WR/LJ water lines are PVC. Permit condition #40 says that existing pipe will be replaced with BTEX resistant pipe (as you well know) within 500 feet of the oil line or a total length of 1000 feet for a line that crosses under the KXL. This has not been done as the area near my pasture where the sleeve was installed was only dug up for a length of 40 feet. There is no way that TC could have replaced 1000 feet of PVC pipe with BTEX resistant pipe in these spots.

Nexen spill discovered by worker walking by



BILL MAH

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Crews work to clean an oil spill near Nexen's Long Lake facility by Fort McMurray on Friday July 17, 2015. The spill was discovered by a contractor after the safety system designed to detect ruptures failed. *GARRETT BARRY / FORT MCMURRAY TODAY*

Technology designed to detect leaks failed to alert Nexen of a pipeline break that spilled five million litres of bitumen and water south of Fort McMurray, the company said Friday.

"We did have a contractor actually walking the pipeline and that's how we discovered it," said Ron Bailey, senior vice-president of Canadian operations for Nexen Energy ULC, which was acquired by China's CNOOC Ltd. in 2013.

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The company is investigating why a warning system designed to detect ruptures did not work and how a double-walled pipe less than a year old broke, he said.

After the worker found the break on Wednesday, which Bailey described as looking like a “fish mouth,” the high-pressure line was shut down and the Alberta Energy Regulator notified. The Long Lake Kinosis operation where the leak occurred was also shut down.

Advertisement

The pipeline goes from Kinosis, a set of well pads drilled about 10 or 12 kilometres south of the Long Lake facility. The line transports the emulsion from that operation to Long Lake. The operation uses steam to heat up the oilsands bitumen deep underground, enabling it to flow to the surface.

“We’ve walked the entire pipeline length looking for signs of any other leaks and there aren’t any,” Bailey said.

The rupture occurred in a double-layered, 20-inch pipe that was laid in 2014, Bailey said.

There have been no other incidents on that line, he added.

The emulsion contained about 33 per cent bitumen. Water and materials such as sand make up the rest.

The spill was mostly contained to the pipeline right of way by remaining berms left over from construction. The affected area includes muskeg.

The spill, covering an area of about 16,000 square metres, has been “stabilized,” Bailey told reporters in the company’s first news conference since the spill was revealed on Thursday.

“Our response team has been on-site 24-7 since we identified this, looking to minimize the environmental damage and to work on-site cleanup.”

It's not known how long cleanup will take.

“When bitumen cools, it solidifies so the bitumen is on the surface (of the ground). There's produced water with it and the produced water is in a pool and we're looking to get that off as quickly as possible.”

Although a lake is situated about 100 metres from the pipeline, Bailey said there's no immediate impact to it.

Because of the remoteness of the site at Nexen's Long Lake steam-assisted gravity drainage operation about 36 kilometres southeast of Fort McMurray, there was no immediate human impact, Bailey said.

The closest aboriginal community of Anzac, part of Fort McMurray First Nation's Reserve #176, 15 kilometres north of the spill, was notified, Bailey said.

In a statement, Counc. Byron Bates said the spill occurred on traditional territory, “where members of [the] Nation have hunted, fished, trapped and gathered for over a 1000 years.”

The statement from the community also stated that the First Nation community must be included “more directly” in the response.

The spill site is accessible by winter-access road only so crews had to construct an all-weather road to reach the spill.

“That's taken us some time. We do have that now and we will be starting to vacuum here this morning to take up the spill,” Bailey said.

Another road is being constructed directly to the break to bring in equipment. The company has hired pipeline spill response experts and is setting up equipment to keep wildlife away.

Bailey promised a transparent response to the spill.

“We are deeply concerned with this. I'd just say we sincerely apologize for the impact that this has caused.

“We will take every step that we see as reasonable and as the regulators help us decide what to do to respond to this.”

Melina Laboucan-Massimo, a Greenpeace campaigner, said Nexen's spill is even bigger than the one in 2011 near her home community of Little Buffalo that spilled about 4.5 million litres into marshland when a Plains Midstream pipe ruptured.

It was then the largest spill on an Energy Resources Conservation Board-regulated pipeline in Alberta in more than three decades.

"It's quite concerning that they don't know what the root cause is or how long it was leaking even when companies have newly built pipelines," she said.

The Athabasca Chipewyan First Nation called the break a milestone in the oilsands.

"It is now home to the largest spill in Canadian history," the First Nation said in a release.

"A spill this size into the muskeg, which is an important part of the eco-system and houses many of our medicines, berries and habitat for species our people rely on for sustenance, is extremely serious," said Chief Allan Adam in the statement.

The muskeg feeds into the groundwater system and the spill is dangerously close to the Clearwater River, he said.

Alberta Energy Regulator (AER) staff are at the Nexen spill to assess the situation, investigate and ensure all safety and environmental requirements are met, the agency has said.

There are no Alberta Environment and Parks staff at the scene and AER is taking the lead according to protocol, said spokeswoman Lisa Glover.

Alberta Premier Rachel Notley called the pipeline break "very troubling."

Notley was in St. John's, NL for a meeting of premiers and territorial leaders who agreed to a new national energy strategy when news of the spill broke.

"What we need to do is have a rigorous and fulsome investigation into what went wrong here and ensure it is sufficiently rigorous that it can produce clear, meaningful recommendations to ensure that it doesn't happen again," she said.

She said it was premature to talk about penalties and enforcement.

The leaders' agreement won't force other provinces to automatically accept pipelines across their jurisdictions, but sets out the importance of the energy industry to all of Canada.

While the Nexen break was bad timing and unfortunate, it didn't alter the views of her fellow premiers that pipelines are still the safest way to transport hydrocarbon products, Notley said.

Notley, who has raised concerns about the "conflicting mandates" of the AER, said she has confidence in the ability of the oilpatch watchdog to conduct a thorough investigation.

"Going forward is there work that can be done to beef up the enforcement and environmental protection work that is done through the AER? Probably," she said.

With files from Darcy Henton, Calgary Herald

bmah@edmontonjournal.com (mailto:bmah@edmontonjournal.com)

Twitter.com/mahspace

Edmonton Flyers




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**BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA**

| | |
|--|---|
| IN THE MATTER OF TRANSCANADA KEYSTONE PIPELINE, LP FOR ORDER ACCEPTING CERTIFICATION OF PERMIT ISSUED IN DOCKET HP- 09-001 TO CONSTRUCT THE KEYSTONE XL PIPELINE | Surrebuttal to Darren Kearney's rebuttal to Cindy Myers' testimony regarding Dr. Madden's socio- economic analysis HP14-001 |
|--|---|

I am responding to Darren Kearney's rebuttal to my direct testimony. My testimony stated:

"testimonial analysis by Dr. Madden is woefully inadequate to meet SDCL 49-416-22, which requires the project must protect the health, safety and welfare of SD residents. He is not a medical doctor, but an economist."

Mr. Kearney states I misunderstood the purpose of Dr. Madden's testimony.

I understand that Dr. Madden is an economist and his testimony reflects a very brief socio-economic analysis of the project.

However, as written, the HP09-001 document, specifically Finding of Fact #107, implies that Dr. Madden's analysis from a socioeconomic standpoint was also meant to support the subpart of SDCL 49-41 B-22 which states:

"The facility will not substantially impair the health, safety or welfare of the inhabitants."

Finding of Fact #107 is included in Appendix C, South Dakota Final Decision and Order Tracking Table of Changes which was ordered by the PUC as part of the scope of discovery.

Finding of Fact #107 is listed under the heading "Socio-Economic Factors".

HP09-001, Finding of Fact #107, as directly copied from that document:

Socio-Economic Factors

107. Socio-economic evidence offered by both Keystone and Staff demonstrates that the welfare of the citizens of South Dakota will not be impaired by the Project. Staff expert Dr. Michael Madden conducted a socio-economic analysis of the Keystone Pipeline, and concluded that the positive economic benefits of the project were unambiguous, while most if not all of the social impacts were positive or neutral. S-2, Madden Assessment at 21. The Project, subject to compliance with the Special Permit and the Conditions herein, would not, from a socioeconomic standpoint: (i) pose a threat of serious injury to the socioeconomic conditions in the project area; (ii) substantially impair the health, safety, or welfare of the inhabitants in the project area; or (iii) unduly interfere with the orderly development of the region.

I agree with Mr. Kearney that Dr. Madden's testimony does not include information concerning how the project would impact the health, safety, or welfare of the inhabitants, but finding of fact #107, as written, concludes that Dr. Madden's testimony supports SDCL 49-41 B-22, including the subpart "The facility will not pose a threat of serious injury to the environment nor to the social and economic condition of inhabitants or expected inhabitants in the siting area" and also the subpart "the facility will not substantially impair the health, safety or welfare of the inhabitants"

Respectfully submitted this 29th day of April, 2015

Cindy Myers
Individual Intervener HP14-001
PO Box 104
87925 468th Ave.
Stuart, NE 68780
csmyers77@hotmail.com
402-709-2920

A copy of this letter has been electronically sent to the following:

Ms. Patricia Van Gerpen
Executive Director
South Dakota Public Utilities Commission
500 E. Capitol Ave.
Pierre, SD 57501
patty.vangerpen@state.sd.us

(605) 773-3201  (605) 773-3201 - voice

Ms. Kristen Edwards
Staff Attorney
South Dakota Public Utilities Commission
500 E. Capitol Ave.
Pierre, SD 57501
Kristen.edwards@state.sd.us

(605) 773-3201  (605) 773-3201 - voice

Mr. Brian Rounds
Staff Analyst
South Dakota Public Utilities Commission
500 E. Capitol Ave.
Pierre, SD 57501
brian.rounds@state.sd.us

(605) 773-3201  (605) 773-3201 - voice

Mr. Darren Kearney
Staff Analyst
South Dakota Public Utilities Commission
500 E. Capitol Ave.
Pierre, SD 57501
darren.kearney@state.sd.us

(605) 773-3201  (605) 773-3201 - voice

Mr. James E. Moore - Representing: TransCanada Keystone Pipeline, LP
Attorney
Woods, Fuller, Shultz and Smith P.C.
PO Box 5027
Sioux Falls, SD 57117
james.moore@woodsfuller.com

(605) 336-3890  (605) 336-3890 - voice
(605) 339-3357 - fax

Mr. Bill G. Taylor - Representing: TransCanada Keystone Pipeline, LP
Attorney
Woods, Fuller, Shultz and Smith P.C.
PO Box 5027
Sioux Falls, SD 57117
bill.taylor@woodsfuller.com

(605) 336-3890  (605) 336-3890 - voice
(605) 339-3357 - fax

Mr. Paul F. Seamans
27893 249th St.
Draper, SD 57531
jackknife@goldenwest.net

(605) 669-2777  (605) 669-2777 - voice

Mr. John H. Harter
28125 307th Ave.
Winner, SD 57580
johnharter11@yahoo.com

(605) 842-0934  (605) 842-0934 - voice

Ms. Elizabeth Lone Eagle
PO Box 160
Howes, SD 57748
bethcbest@gmail.com

(605) 538-4224  (605) 538-4224 - voice

Mr. Tony Rogers
Rosebud Sioux Tribe - Tribal Utility Commission
153 S. Main St.
Mission, SD 57555
tuc@rosebudsiouxtribe-nsn.gov

(605) 856-2727  (605) 856-2727 - voice

Ms. Viola Waln
PO Box 937
Rosebud, SD 57570
waln ranch@goldenwest.net

(605) 747-2440  (605) 747-2440 - voice

Ms. Jane Kleeb
Bold Nebraska
1010 N. Denver Ave.
Hastings, NE 68901
jane@boldnebraska.org

(402) 705-3622  (402) 705-3622 - voice

Mr. Benjamin D. Gotschall
Bold Nebraska
6505 W. Davey Rd.
Raymond, NE 68428
ben@boldnebraska.org

(402) 783-0377  (402) 783-0377 - voice

Mr. Byron T. Steskal & Ms. Diana L. Steskal
707 E. 2nd St.
Stuart NE 68780
prairierose@nntc.net

(402) 924-3186  (402) 924-3186 - voice

Ms. Cindy Myers, R.N.
PO Box 104
Stuart, NE 68780
csmyers77@hotmail.com

(402) 709-2920  (402) 709-2920 - voice

Mr. Arthur R. Tanderup
52343 857th Rd.
Neligh, NE 68756
atanderu@gmail.com

(402) 278-0942  (402) 278-0942 - voice

Mr. Lewis GrassRope
PO Box 61
Lower Brule, SD 57548
wisestar8@msn.com

(605) 208-0606  (605) 208-0606 - voice

Ms. Carolyn P. Smith
305 N. 3rd St.
Plainview, NE 68769
peachie_1234@yahoo.com

(402) 582-4708  (402) 582-4708 - voice

Mr. Robert G. Allpress
46165 Badger Rd.
Naper, NE 68755
bobandnan2008@hotmail.com

(402) 832-5298  (402) 832-5298 - voice

Mr. Louis T. Genung
902 E. 7th St.
Hastings, NE 68901
tg64152@windstream.net

(402) 984-7548  (402) 984-7548 - voice

Mr. Peter Capossela, P.C. - Representing: Standing Rock Sioux Tribe
Attorney at Law
PO Box 10643
Eugene, OR 97440
pcapossela@nu-world.com

(541) 505-4883  (541) 505-4883 - voice

Ms. Nancy Hilding
6300 W. Elm
Black Hawk, SD 57718
nhilshat@rapidnet.com

(605) 787-6779  (605) 787-6779 - voice

Mr. Gary F. Dorr
27853 292nd
Winner, SD 57580
gfdorr@gmail.com


(605) 828-8391  (605) 828-8391 - voice


Mr. Bruce & Ms. RoxAnn Boettcher
Boettcher Organics
86061 Edgewater Ave.
Bassett, NE 68714
boettcherann@abbnebraska.com


(402) 244-5348  (402) 244-5348 - voice


Ms. Wrexie Lainson Bardaglio
9748 Arden Rd.
Trumansburg, NY 14886
wrexie.bardaglio@gmail.com

(607) 229-8819  (607) 229-8819 - voice

Mr. Cyril Scott
President
Rosebud Sioux Tribe
PO Box 430
Rosebud, SD 57570
cscott@gwtc.net
ejantoine@hotmail.com
(605) 747-2381  (605) 747-2381 - voice

Mr. Eric Antoine
Attorney
Rosebud Sioux Tribe
PO Box 430
Rosebud, SD 57570
ejantoine@hotmail.com
(605) 747-2381  (605) 747-2381 - voice

Ms. Paula Antoine
Sicangu Oyate Land Office Coordinator
Rosebud Sioux Tribe
PO Box 658
Rosebud, SD 57570
wopila@gwtc.net
paula.antoine@rosebudsiouxtribe-nsn.gov
(605) 747-4225  (605) 747-4225 - voice

Mr. Harold C. Frazier
Chairman
Cheyenne River Sioux Tribe
PO Box 590
Eagle Butte, SD 57625
haroldcfrazier@yahoo.com
(605) 964-4155  (605) 964-4155 - voice

Mr. Cody Jones
21648 US HWY 14/63
Midland, SD 57552
(605) 843-2827  (605) 843-2827 - voice

Ms. Amy Schaffer
PO Box 114
Louisville, NE 68037
amyannschafter@gmail.com

(402) 234-2590  (402) 234-2590

Mr. Jerry Jones
22584 US HWY 14
Midland SD 57552

(605) 843-2264  (605) 843-2264

Ms. Debbie J. Trapp
24952 US HWY 14
Midland, SD 57552
mtdt@goldenwest.net

Ms. Gena M. Parkhurst
2825 Minnewasta Place
Rapid City, SD 57702
gmp66@hotmail.com

(605) 716-5147  (605) 716-5147 - voice


Ms. Joye Braun
PO Box 484
Eagle Butte, SD 57625
jmbraun57625@gmail.com

(605) 964-3813  (605) 964-3813

Mr. Robert Flying Hawk
Chairman
Yankton Sioux Tribe
PO Box 1153
Wagner, SD 57380
Robertflyinghawk@gmail.com

(605) 384-3804  (605) 384-3804 - voice

Ms. Thomasina Real Bird - Representing - Yankton Sioux Tribe
Attorney
Fredericks Peebles & Morgan LLP
1900 Plaza Dr.
Louisville, CO 80027
trealbird@ndnlaw.com

(303) 673-9600  (303) 673-9600 - voice
(303) 673-9155 - fax

Ms. Chastity Jewett
1321 Woodridge Dr.
Rapid City, SD 57701
chasjewett@gmail.com

(605) 431-3594  (605) 431-3594 - voice

Mr. Duncan Meisel
350.org
20 Jay St. #1010
Brooklyn, NY 11201
duncan@350.org

(518) 635-0350  (518) 635-0350 - voice

Ms. Sabrina King
Dakota Rural Action
518 Sixth Street, #6
Rapid City, SD 57701
sabrina@dakotarural.org

(605) 716-2200  (605) 716-2200 - voice

Mr. Frank James
Dakota Rural Action
PO Box 549
Brookings, SD 57006
fejames@dakotarural.org

(605) 697-5204  (605) 697-5204 - voice
(605) 697-6230 - fax

Mr. Bruce Ellison
Attorney
Dakota Rural Action
518 Sixth St. #6
Rapid City, SD 57701
belli4law@aol.com

(605) 716-2200  (605) 716-2200 - voice

(605) 348-1117  (605) 348-1117 - voice

Mr. Tom BK Goldtooth
Indigenous Environmental Network (IEN)
PO Box 485
Bemidji, MN 56619
ien@igc.org

(218) 760-0442  (218) 760-0442 - voice

Mr. Dallas Goldtooth
38371 Res. HWY 1
Morton, MN 56270
goldtoothdallas@gmail.com

(507) 412-7609  (507) 412-7609

Mr. Ronald Fees
17401 Fox Ridge Rd.
Opal, SD 57758

(605) 748-2422  (605) 748-2422 - voice

Ms. Bonny Kilmurry
47798 888 Rd.
Atkinson, NE 68713
bjkilmurry@gmail.com

(402) 925-5538  (402) 925-5538 - voice

Mr. Robert P. Gough
Secretary
Intertribal Council on Utility Policy
PO Box 25
Rosebud, SD 57570
bobgough@intertribalCOUP.org

(605) 441-8316  (605) 441-8316 - voice

Mr. Terry & Cheryl Frisch
47591 875th Rd.
Atkinson, NE 68713
tcfrisch@q.com


(402) 925-2656  (402) 925-2656 - voice


Ms. Tracey Zephier - Representing: Cheyenne River Sioux Tribe
Fredericks Peebles & Morgan LLP
Ste. 104
910 5th St.
Rapid City, SD 57701
tzephier@ndnlaw.com

(605) 791-1515  (605) 791-1515 - voice


Mr. Robin S. Martinez - Representing: Dakota Rural Action
Martinez Madrigal & Machicao, LLC
616 W. 26th St.


Kansas City, MO 64108
robin.martinez@martinezlawn.net

Ms. Mary Turgeon Wynne, Esq.
Rosebud Sioux Tribe - Tribal Utility Commission
153 S. Main St
Mission, SD 57555
tuc@rosebudsiouxtribe-nsn.gov
(605) 856-2727  (605) 856-2727 - voice

Mr. Matthew L. Rappold - Representing: Rosebud Sioux Tribe
Rappold Law Office
816 Sixth St.
PO Box 873
Rapid City, SD 57709
Matt.rappold01@gmail.com
(605) 828-1680  (605) 828-1680 - voice

Ms. April D. McCart - Representing: Dakota Rural Action
Certified Paralegal
Martinez Madrigal & Machicao, LLC
616 W. 26th St.
Kansas City, MO 64108
april.mccart@martinezlawn.net
(816) 415-9503  (816) 415-9503 - voice

Mr. Paul C. Blackburn - Representing: Bold Nebraska
Attorney
4145 20th Ave. South
Minneapolis, MN 55407
paul@paulblackburn.net
(612) 599-5568  (612) 599-5568 - voice

Ms. Kimberly E. Craven - Representing: Indigenous Environmental Network (IEN)
Attorney
3560 Catalpa Way
Boulder, CO 80304
kimecraven@gmail.com
(303) 494-1974  (303) 494-1974 - voice

Carol Moyer, Public Water Contact for Colome, SD
Colome City Finance Officer

Information and quotes from phone and email conversations with Carol on 05-13-15
Permission granted by Carol to use this information in my testimony.

- The first route crossed through the 10 acres where Colome's two wells are located.
- The route was moved approximately 200 yards from the well acreage.
- "I do have concerns"
- "I don't think safety was a concern at all"
- "Moved it just far enough to get an easement"

Kevin Schlosser, Emergency Management Coordinator, Avera McKenna
(Assists Avera St. Mary's in Pierre, SD)

Quotes/thoughts from Kevin per phone visit and email on 04-01-15 and 04-02-15
Permission granted by Kevin to use this information in my testimony.

- **“What are we dealing with? Give me an SDS, to know the chemicals involved.”**
- **“Time-frame, how fast is it moving, when will it reach water intakes”**
- **“Would want to know how to slow it down, contain it. I would like to ask industry experts how soon will it reach us. I have not seen any of that.”**
- **“If they would provide SDS, it would be kept in the Emergency Department to have readily available.**
- **“Have not been given any information specific to tar sands oil product.”**
- **“I would rely on the County Emergency Manager, the Sheriff's Dept., and also would rely on a SDS for treatments.”**
- **Not aware of training to instruct health facilities how to respond to tar sands emergencies/disasters.**
- **For decontamination, would rely on the Safety Data Sheet for review and instructions.**
- **“I've checked w/ the person that does Emergency Preparedness for Avera St. Mary's and they have not seen SDS to this point” (email message on 04-02-15)**

**Phone visits by Cindy Myers with 3 SD Water treatment plants
April/May 2015**

- **I visited with three SD water treatment plants using water from the Missouri River. Two water treatment plants were unaware of response planning to an oil spill affecting the Missouri River, the third did say a spill kit (for water analysis) is available for emergencies.**
- **“DNR usually sends out information, but “haven’t heard a word from them” when asked what he knew about tar sands spillage into water.**
- **The Bureau of Reclamation would notify them if an oil spill threatened the water supply.**
- **One plant thought benzene analysis was done quarterly and another plant thought benzene analysis was done yearly.**