BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

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HP 14-001

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 PROJECT

REBUTTAL TESTIMONY OF COREY GOULET

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Pursuant to the Commission's Order Granting Motion to Define Issues and Setting Procedural Schedule, Petitioner TransCanada Keystone Pipeline, LP, offers the following rebuttal testimony of Corey Goulet.

1. Please state your name and address for the record.

Answer: My name is Corey Goulet. My business address is 450 1st Street S.W., Calgary, AB Canada T2P 5H1.

2. Please state your position with Keystone and provide a description of your areas of responsibility with respect to the Keystone XL Project.

Answer: I am President, Keystone Projects, with overall accountability for the implementation and development of the Keystone Pipeline system, including the Keystone XL Project (Project). In that capacity, I am responsible for overall leadership and direction of the Project.

3. Have you provided direct testimony in this proceeding?

Answer: Yes, I have.

4. Which witnesses' direct testimony are you responding to in your rebuttal testimony?

Answer: I am responding to portions of the direct testimony of Cindy Myers, Sue Sibson, Diana Steskal, and Paul Seamans.

5. Cindy Myers testified that the Materials Safety Data Sheets (MDSD) provided in the State Department's Final Supplemental Environmental Impact Statement do not reflect the actual product that would flow through the proposed pipeline. Can you comment on that point?

Answer: The MSDS's provided in the Final Supplemental EIS represent the range of the different types of crude oil that would be transported through the proposed pipeline. Importantly, in the event of a release from the pipeline, the MSDS for the particular product or products involved in the release would be provided to responders and state and local officials within minutes.

6. Has TransCanada tested its ability to provide the applicable MSDS to responders and officials in the event of a release?

Answer: Yes we have. During its evaluation of the proposed pipeline reroute in Nebraska, the Nebraska Department of Environmental Quality (NDEQ) required TransCanada to demonstrate that ability. Accordingly, the NDEQ required TransCanada to conduct a test that is reported in its January 2013 Final Evaluation Report.

This emergency response exercise was conducted on the existing Keystone pipeline. Representatives of NDEQ and the Nebraska Emergency Management Agency (NEMA) attended the exercise at the TransCanada Regional Emergency Operations Center (EOC) in Omaha, Nebraska. The scenario chosen for the exercise was a landowner performing excavation work without first calling 811 to determine the location of any utilities on the property. The hypothetical landowner struck the pipeline, smelled and saw oil flowing into the trench, and called TransCanada's toll-free emergency line to report the incident. NDEQ randomly selected the simulated spill location and provided it at the start of the exercise.

The exercise facilitator, playing the role of the toll-free emergency line operator, began the exercise by calling the TransCanada Operations Control Centre (OCC) in Calgary and reporting the third-party excavation damage to the pipeline. The controller at the OCC stated that he had observed indications of a product release and that he was shutting down the line and contacting the nearest TransCanada on-scene responder to drive to the location of the spill. The Regional EOC in Omaha was activated, along with the Corporate EOC in Calgary. The Regional EOC Manager requested that the OCC email an MSDS for the batch of crude oil in the pipeline at the point of the third-party strike. The OCC controller stated that the location of the strike was near the interface of two batches of oil and sent an MSDS for each batch to the Regional EOC Manager, the Regional EOC Logistics Manager, and the TransCanada on-scene responder.

NDEQ and the other exercise observers reviewed the two MSDSs. Seventeen minutes after the exercise began, the Regional EOC Logistics Manager emailed the two safety data sheets to NEMA, the Wayne County Sheriff, the Wayne County Local Emergency Planning Committee (LEPC), and the PSAP (public safety answering point, or 911), successfully completing the

exercise. According to the NDEQ's Final Evaluation report, "the exercise demonstrated that Keystone could provide an MSDS for the exact material being transported in the pipeline at the time of a hypothetical spill in a reasonable length of time."

7. Have you reviewed the direct testimony of Sue Sibson and Diana Steskal?

Answer: Yes I have. They both raise concerns with respect to our reclamation efforts on the Sibson property after the construction of the first Keystone Pipeline.

8. Can you comment on the concerns that they raise?

Answer: I have not personally viewed the property in question but I have reviewed the photos provided in Ms. Sibson's testimony. I understand the stated concerns that our reclamation efforts to date have not been to the Sibsons' satisfaction. I reiterate our commitment to continue working with the Sibsons to address these concerns and to achieve reclamation success equivalent to similar off-right-of-way property. In addition, I reiterate our commitment to compensate landowners for demonstrated damages to property that result from our construction activities.

9. Mr. Seamans testified that TransCanada overstated the estimated tax benefits to the counties along the route of the proposed pipeline. Can you comment on that testimony?

Answer: Yes. At the time of its 2009 application, and again at the 2009 hearing, TransCanada estimated the tax impacts of the KXL project in good faith, employing estimated construction costs. TransCanada does not control the assessed valuation determined by the Department of Revenue or the methodology the Department employs. To date, the actual taxes levied on the first Keystone Pipeline have been less than our estimates. Nonetheless, the taxes paid by Keystone, and the taxes expected on the Keystone XL Pipeline, are substantial, and

represent a significant benefit to the counties and school districts that host the pipeline. For 2014, Keystone will pay real property taxes totaling slightly more than $4,300,000 in the ten counties transited by the first Keystone Pipeline. The 2014 taxes paid on the first Keystone Pipeline will represent about 3.4% of the total real property taxes collected in the ten counties crossed by the pipeline.

10. Does this conclude your prepared rebuttal testimony?

Answer: Yes.

Dated this 24 day of June, 2015.

Corey Goulet

CERTIFICATE OF SERVICE

I hereby certify that on the 26th day of June, 2015, I sent by United States first-class mail, postage prepaid, or e-mail transmission, a true and correct copy of the foregoing Rebuttal Testimony of Corey Goulet, to the following:

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BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

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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 PROJECT	:	DOCKET NUMBER HP14-001
	:	REBUTTAL TESTIMONY OF DAN KING

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1. State your name and occupation.

Answer: My name is Dan King. My role at TransCanada is Vice-President of Engineering, Asset Reliability and Chief Engineer. I am responsible for ensuring the safety and reliability of TransCanada's pipeline assets.

2. Please state your professional qualifications and experience.

Answer: I have been with TransCanada for 32 years. During that time, I have participated in the design, construction, operation and maintenance of TransCanada's natural gas and oil facilities in Canada, the United States, Mexico and overseas. I lead a team of approximately 600 engineering and other professionals whose job it is to meet or exceed regulatory requirements in the design, construction and safe operation of TransCanada's pipeline assets. I hold a Bachelor of Science degree in electrical engineering from the University of Calgary. I am a member of the Association of Professional Engineers and Geoscientists of Alberta, the American Society of Mechanical Engineers, and the Institute of Electrical and

Electronics Engineers. I sit on the board of the Common Ground Alliance, which is a U.S.-based non-profit organization that promotes the importance of safe excavation around utilities. My resume is attached as Exhibit A.

3. Did you provide direct testimony in this proceeding?

Answer: No.

4. To whose testimony are you responding to in your rebuttal?

Answer: I am responding to the direct testimony of Evan Vokes. During the entirety of his employment with TransCanada, Mr. Vokes worked in an engineering group which I led.

5. Mr. Vokes states his opinion that the current management of TransCanada is a very significant technical threat to the safety of pipelines, including the proposed KXL pipeline. Please comment on the focus of TransCanada's management on pipeline safety, with respect to the operations and engineering function.

Answer: TransCanada's management is fully focused on pipeline safety as our highest priority. We are a recognized leader in the industry in developing and implementing safe construction and operations practices. Management review of the suitability, adequacy, and effectiveness of our pipeline integrity and protection programs occurs at every level of oversight at TransCanada. The senior governance structures for each of the management systems provide the highest level of management governance, overseeing the strategic aspects of management review and direction setting.

TransCanada builds safety and compliance into every aspect of our operations - starting with design and continuing through construction and operation of our pipelines. Not only is this the right thing to do, but there is no benefit to TransCanada, financial or otherwise, of cutting

corners on safety or compliance. TransCanada's success, from a business perspective, depends on building safe, reliable pipelines that service North America's energy needs on a long-term basis. TransCanada will not compromise safety - period.

Contrary to Mr. Vokes' comments, TransCanada does not profit from cutting prudently incurred safety-related expenses. From a business standpoint, we are paid to safely move products on behalf of our customers. If our systems are not designed properly or do not work reliably, that impacts our bottom line. It just makes good business sense to do things right from the beginning. We deliver critical energy products that we all rely on every day and the public, our regulators, and our shareholders expect us to do our jobs as safely as possible.

One of the primary tools for ensuring safety and compliance is the implementation of robust and rigorous quality management systems (QMS) for pipeline design and construction. The quality management system includes various checks and balances to ensure all pipelines are constructed in compliance with regulatory requirements, codes, and internal company specifications.

Pipeline projects are complex undertakings and there are many factors that may lead to issues during the lifecycle of a pipeline, but the quality management system operates to identify issues or non-conformances. Non-conformances are situations where code or internal specifications are not met in the initial construction. Should non-conformances occur, they are identified and corrective actions are developed and implemented prior to a pipeline being placed into service. The quality management system is comprised of a series of processes that apply to engineering design, procurement, and construction of pipelines. These processes include:

- Engineering design reviews;
- Specifications for materials, welding, and non-destructive examination (NDE);
- Qualification of suppliers and services;
- Inspection requirements and training for manufacturing, fabrication, and construction;
- Engineering reviews and audits of construction; and,
- Lessons learned and continuous improvement.

The quality, safety and inspection standards that TransCanada adheres to during construction are among the best in the world. Prior to putting a pipeline into service, non-destructive examination is carried out on all welds. Hydrostatic pressure testing is conducted at pressures well in excess of design operating pressures to prove the integrity of the pipeline. In-line inspection tools, known as smart pigs, are then used to measure and test for any defects in the pipe. Any anomalies that do not meet acceptance criteria are cut out and replaced prior to operations.

This department was fully and adequately staffed during Mr. Vokes' tenure with TransCanada. Moreover, since Mr. Vokes' departure in 2012, over 1,500 new employees have been hired into the TransCanada Operations and Engineering department, which is reflective of the Company's growth. Specifically, 241 net new permanent hires have been made in the Engineering and Asset Reliability team. The Materials Engineering department (which Mr. Vokes refers to as the Engineering Specialist department) currently employs 31 employees whose primary purpose is to support projects and ensure our standards are followed.

6. Can you discuss Mr. Vokes' position and responsibilities while at TransCanada?

Answer: In 2007, Mr. Vokes was hired on as an Engineer-in-Training (EIT). He worked in the welding team along with senior engineers and technologists. In the Province of Alberta, an engineer must have four years of suitable work experience under the supervision of a professional engineer before being eligible for professional engineering status (P.Eng.). As an EIT, Mr. Vokes worked under the guidance and supervision of a senior professional engineer. In July, 2009, Mr. Vokes received his P.Eng. He was then promoted to a junior engineer position. As a P.Eng., Mr. Vokes was moved into the Non-Destructive Examination (NDE) area. He worked under the guidance of a senior NDE technologist. In both the welding area and the non-destructive examination area, Mr. Vokes was responsible for identifying issues and addressing non-conforming work as a standard part of the quality control process.

7. **Mr. Vokes alleges that a rupture on the North Central Corridor Buffalo West pipeline was the result of cost/schedule decisions made by project managers, and specifically that the materials involved were understrength. Can you comment on that allegation?**

Answer: The failure was not caused by cost and schedule decision or by understrength materials. To the best of my knowledge and based on a good faith inquiry, TransCanada did not falsify any documents in this regard. TransCanada's finding is that the cause of this natural gas pipeline failure was a set of issues unique to this pipeline, its design, and operating temperature. These conditions are not directly relevant to the Keystone XL Project, but we do incorporate the learnings from all failures and quality issues into future projects and operations.

8. **Mr. Vokes alleges that substandard fittings are in service in the US and an equal number in Canada on the Keystone system. Can you comment on that allegation?**

Answer: All fittings in service on the Keystone system in Canada and the US are safe for continued operation of the pipeline. Every fitting in service has successfully undergone a hydrostatic pressure test to a pressure significantly higher than the maximum operating pressure.

Fittings were ordered stronger than required to meet the intended design. Because certain fittings came with less strength than ordered, TransCanada conducted an extensive engineering assessment to ensure the fittings were acceptable for design and operations, which included mechanical testing, stress analysis, and proof testing. TransCanada also applied composite reinforcement to specific fittings in consultation with PHMSA.

Both the National Energy Board and PHMSA have been heavily involved and engaged throughout this process. PHMSA initiated an independent third party engineering review of TransCanada's engineering assessment and the review confirmed the fittings within the pump stations meet burst pressure requirements, stress analysis requirements, and the design requirements for the maximum operating pressure (MOP) of the Pipeline. TransCanada would not be operating the system if we could not prove it was safe for operation.

9. **Mr. Vokes alleges that on the Keystone Phase II or Cushing Extension project, TransCanada engineers were forced into allowing the project to permit substandard inspection techniques on girth welds. Can you comment on that allegation?**

Answer: Keystone engineers specified industry-accepted non-destructive examination practices in accordance with federal code requirements, Company specifications,

and industry standards. Full time third-party auditors also were employed during construction activities to verify the inspection techniques being applied and the results of those inspections.

10. **Mr. Vokes alleges that there was a problem with the original design of the Keystone pump stations and that inspectors were penalized for a practice of "contractor self-inspection." Can you comment on that allegation?**

Answer: Keystone has safely transported almost one billion barrels of crude oil since 2010, thus validating the original design of the pump stations. I am not aware that TransCanada has penalized any inspectors for a practice of "contractor self-inspection." In fact, TransCanada requires Contractors to implement a quality management plan because we believe it is imperative that contractors take responsibility for the quality of their work. Requiring the contractor to implement a quality management plan, however, is just one of part of TransCanada's larger, multi-layer quality management program, which also includes inspection by TransCanada.

11. Mr. Vokes alleges a "salt induced microcracking" problem with pipe ordered for the Keystone XL pipeline. Can you comment on that allegation?

Answer: There is no phenomenon known as "salt induced microcracking" in the pipeline industry. Salt on the surface of the bare pipe can cause disbondment of the coating during the application process. Because of this, the pipe is cleaned prior to coating application, both in the mill and in the field, in order to remove any contaminants. Furthermore, the pipe is inspected through the use of a "holiday" detector, which identifies any gaps in the coating, both in the mill upon completion of coating application, and prior to the pipe being placed into the

ground, to verify that no coating disbondment has occurred. An above-ground close interval cathodic protection survey is performed on the pipeline after it has been lowered into the trench and backfilled to determine if there are any areas of coating disbondment as required by PHMSA special condition requirements.

12. **Mr. Vokes alleges that certain anomalies on the Gulf Coast section of the Keystone pipeline were the result of construction contractors not following the code of construction and inspectors not enforcing the rules. Can you comment on those allegations?**

Answer: TransCanada conducts various inspections throughout a project, including inspections after hydrostatic pressure testing. These inspections were effective in finding anomalies on the Keystone Gulf Coast pipeline. Coating damage and pipe body dents were all identified and repaired prior to any oil product being introduced into the pipeline and at no time posed a threat to the safety of the pipeline or to the environment. .

13. **Mr. Vokes alleges that on the Gulf Coast project there were extensive problems including pipe falling or ready to fall off skids, heavy equipment marks consistent with collisions with pipe, serious coating damage from pipe being mishandled, repair coatings not correctly applied, and pipe on top of large rocks. Can you comment on those allegations?**

Answer: As I have indicated, the purpose of TransCanada's multi-layer inspection system is to identify and remediate events or occurrences that do not meet our stringent construction standards. If there were instances of the issues cited by Mr. Vokes, they would have been identified and addressed by these inspections. Indeed, as I have testified, the Keystone

pipeline system has safely transported almost one billion barrels of crude oil since 2010, thus demonstrating the efficacy of our quality management system.

14. **Mr. Vokes alleges numerous quality failings on the Bison Pipeline project. Can you comment on those allegations?**

Answer: The Bison pipeline experienced a failure six months after being placed in service. The failure was caused by a back-hoe strike that was unreported. PHMSA had extensive involvement during the failure investigation and repair program. TransCanada conducted high resolution in-line inspections of the Bison pipeline, pipeline excavations, and an above ground close interval cathodic protection survey, and addressed all indications found to PHMSA's satisfaction. The Bison pipeline is in full operation. Other than at this one location, TransCanada did not find any other indications of external damage or other issues with the safe operation of the pipeline. As a result of this failure, increased numbers of inspectors and enhanced inspector training have been instituted on future projects.

15. **Mr. Vokes alleges that managers at TransCanada sanction unsafe construction practices to the benefit of cost and schedule. Can you comment on that allegation?**

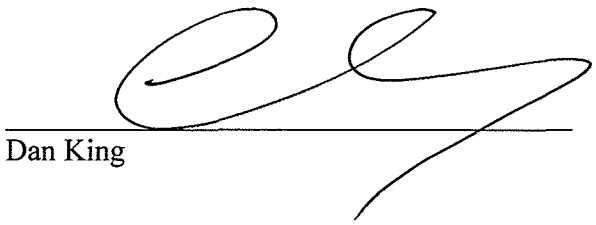
Answer: As I have described, TransCanada employs a project management system based on industry best practices for quality management and project management to deliver large-scale construction projects. TransCanada is a leader in the use of advanced construction practices. This is demonstrated by our voluntary commitment to adopt special conditions related to the design, construction and operations of the Keystone XL project that are above the requirements in the applicable federal regulations and industry standards. In view of the

extensive internal and external checks on construction practices, cost and schedule concerns do not override adherence to safe construction practices. Contrary to Mr. Vokes assertion, TransCanada's business does not benefit from unsafe pipeline construction or operations. Pipelines that are unsafe cannot be operated and shippers will not move products through pipelines that are not reliable.

16. **Does this conclude your testimony?**

Answer: Yes it does.

Dated this 15 day of June, 2014.



Dan King

RESUME FOR DAN KING

EDUCATION: Bachelor of Science in Electrical Engineering, Minor in Computer Engineering, University of Calgary, 1983
Ivey Executive Program, Ivey School of Business, University of Western Ontario, 1997

EXPERIENCE SUMMARY: Over thirty years of experience in the design, construction, maintenance, project and program management of pipeline and energy facilities in Canada and overseas. Experience includes:
- leadership of TransCanada's central engineering group
- leadership of Pipe Integrity planning for 42,000k pipeline system
- front line and senior level management of several different multi-disciplinary teams.
- program management of the implementation of a receipt point specific pricing system for the NGTL pipeline system.
- wide variety of project and program management activities
- Development, design and commissioning work on the instrumentation and control systems for pipeline facilities.

EXPERIENCE: **TransCanada & Predecesor Companies**

2009 to Present **Vice President – Engineering & Asset Reliability**
Leadership of engineering and asset reliability for O&E operations as well as broader engineering, operations and major project support services including engineering governance, risk management and specialized core technical support

2005 to 2009 **Director – Engineering**
Management of the Engineering department. Accountable for the reliability of all TransCanada's operated physical assets including pipeline, power and other energy assets. Provide engineering standards, owner engineering functions and engineering expertise to the corporation. Leadership for 12 managers, strategy and goal setting for the department, reorganization and other change initiatives.

2003 to 2005 **Director – Pipe Engineering**
Management of the Pipe Engineering department. Accountable for the development, implementation, standards and technical support for the pipeline integrity program at TransCanada. Leadership for 3 managers, strategy and goal setting for the department, reorganization and outsourcing of certain activities.

2000 to 2003 **Manager – Program Development – Pipe Engineering**
Management of a multidisciplinary group accountable for the development of the pipe integrity program for TransCanada. The group uses extensive quantitative risk management techniques to develop a $65 to $100 million per year program to ensure the safety of the pipeline system. Includes the management and planning activities for a staff of approximately 25 engineers and technologists, dealing extensively with regulators and other third parties.

1999 to 2000 **Manager – Materials, Standards and Technology**
Management of a services group accountable for: materials testing and failure analysis, Engineering Standards and Procedures management, Technology Program Management (R&D). Includes the management and planning activities for a staff of approximately 25 engineers and technologists executing a program of approximately $10 Million annually.

1998 to 1999 **Program Manager - Products & Pricing Implementation**
Customer Interface - Rates and Revenues
Responsible for developing and managing the program to implement the business process and computer system changes necessary to support the major change in Nova Gas Transmission's service and pricing offerings to customers. This change involves moving from the "Postage Stamp" toll to receipt point specific tolls.

1983 to 1998 **Various Positions**
Various line and leadership roles of increasing responsibility in the design, construction, commissioning and operations of natural gas and liquid pipeline facilities in Canada and overseas.

PROFESSIONAL ASSOCIATIONS:

- Association of Professional Engineers and Geoscientists of Alberta
- Institute of Electrical and Electronic Engineers
- ASME International

CERTIFICATE OF SERVICE

I hereby certify that on the 26th day of June, 2015, I sent by United States first-class mail, postage prepaid, or e-mail transmission, a true and correct copy of the foregoing Rebuttal Testimony of Dan King, to the following:

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BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

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HP 14-001

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

REBUTTAL TESTIMONY OF
F. J. (RICK) PERKINS

o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o

Pursuant to the Commission's Order Granting Motion to Define Issues and Setting Procedural Schedule, Petitioner TransCanada Keystone Pipeline, LP, offers the following rebuttal testimony of F. J. (Rick) Perkins.

1. Please state your name and occupation.

Answer: Rick Perkins. I am the Project Manager-Logistics and Services for the TransCanada Keystone XL Pipeline project. I am employed by TransCanada.

2. Whose testimony are you rebutting?

Answer: Faith Spotted Eagle.

3. Are construction workforce camps to be utilized during the construction of the KXL pipeline part of your area of responsibility?

Answer: Yes.

4. Will there be any workforce camps in South Dakota during the construction of the Keystone XL pipeline?

Answer: Yes, three camps, one located near Buffalo in Harding County, one near Howes in northern Meade County, and one near Colome in Tripp County.

5. Will Keystone operate the camps?

Answer: No, the camps will be operated by Target Logistics, a company that specializes in the development and in the operation of workforce camps worldwide.

6. Tell the Commission about Target Logistics' experience in operating workforce camps.

Answer: Target Logistics is highly experienced in operating workforce camps, both civilian and military. It has operated workforce camps throughout the nation and internationally for years.

7. Describe the camps for the Commission.

Answer: The workforce camps are constructed on property that is leased for that purpose. Keystone has leased sites for the three South Dakota workforce camps. Each camp is constructed employing purpose built modular units. The modular living units contain rooms much like small motel rooms, each occupied by a project employee. Other modular support units contain a commissary style store that sells a wide range of necessities, a kitchen and dining complex, medical facilities, recreational facilities, laundry facilities, administrative offices; other modular units contain support facilities. The camp will be entirely removed at the conclusion of camp operation. Target Logistics supplies the modular units, custom built to Keystone's specifications.

8. What is the capacity of the camps?

Answer: Typically the camps will be constructed to accommodate a peak capacity of 1,200 persons. During the run up to the peak of construction, occupancy will ramp up over

time. We expect occupancy during the height of construction to peak at about 1,200 and to ramp down as construction activities are completed.

9. How long do you expect the camps to remain open?

Answer: Approximately 18 months from the beginning of camp construction until the camp is closed and all facilities removed.

10. Describe the typical employee who will live in the camps.

Answer: The camps will be populated by pipeline construction workers and construction support personal. Pipeline construction workers, often called "pipeliners," are typically union employees, hired by our construction contractors. Most are career pipeliners, who make their living constructing cross-country pipelines. Skill sets run from common laborers to equipment operators through highly skilled specialty welders, inspectors, and a wide variety of specialist technicians and support personnel. Typically, a superintendent for one of our contractors has a core group of key employees that he hires for each project; usually all are acquainted, and work on projects as they develop. Pipeliners as a group are hard-working, used to long work hours, highly responsible, and well compensated. Many have college degrees and years of experience in the business of constructing pipelines. The average age of camp occupants will be in the early 40s.

In addition, Target Logistics employees who operate the workforce camps will live in the camps.

11. How do construction workers get from the camp to the job site?

Answer: Pipeline construction is accomplished in construction "spreads". A "spread" is considered the labor and equipment required to construct the pipeline in a given geographic area, typically a distance of from fifty to one-hundred miles long. Many of the

pipeline construction workers are transported to and from the pipeline construction location each day in work buses provided by the pipeline construction contractor. This is done to reduce highway traffic congestion.

12. Are there behavior codes imposed on occupants of the camps?

Answer: Target Logistics will have strict behavior codes that apply to all persons living in the camp. If a resident violates the terms of the behavior code, their residency in the camp could be terminated. Because camp lodging will be provided to all camp residents at Keystone's expense; the loss of camp residency privileges is a major cost benefit to the worker and a major good behavior motivator. Therefore, we anticipate no discipline problems in the camps.

13. How are the behavior codes enforced?

Answer: Each camp will have a security team provided by Target Logistics. The security team enforces the rules of conduct that govern the camps. There is very little occasion to enforce the behavior codes in the camps. Most workers put in 10 hour days, plus travel time from the camp to the construction and return, and accordingly have little extra time or energy to involve themselves in behavior that is in violation of the occupancy rules.

14. Is local law enforcement engaged for the camps?

Answer: Target Logistics will provide 24-7 camp security using its own security officers. Local law enforcement will be engaged if needed within the camps; however, that is not anticipated. Keystone has already conducted preliminary discussions with local law enforcement agencies and has indicated that when necessary, it will augment the cost of additional law enforcement personnel required as a result of the workforce camp.

15. Have you obtained local government approval for the camps?

Answer: Keystone has obtained a conditional use permit from Harding County for the construction and operation of the camp near Buffalo. A conditional use permit for operation of the camp to be constructed in Meade County is not required; however an occupancy permit for work force camp will be obtained prior to operation of the camp. Tripp County does not have a zoning ordinance or a conditional use permit requirement for the camp planned for near Colome.

16. Is your professional resume attached and marked Exhibit A?

Answer: Yes.

Dated this 25th day of June, 2015.

F. J. (Rick) Perkins

F.J. (Rick) Perkins

5401 Rampart #275, Houston, TX 77081 Work: (832) 320-5915 Cell: (402) 350-1281

email: Rick_Perkins@TransCanada.com

CAREER EXPERIENCE OVERVIEW

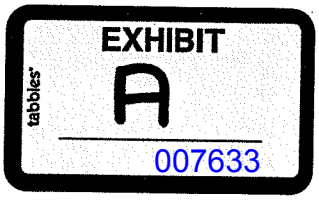
- 25 Years - Service contract development for onshore and offshore pipeline, process plant, and compressor station engineering, construction, and other project support activities
- 6 Years - International Offshore Project Materials Management (Purchasing and Logistics)
- 7 Years - Onshore exploration and production administrative budgeting and forecasting, office and fleet management
- 3 Years – Project Management

SIGNIFICANT CAREER ACCOMPLISHMENTS

- As a Buyer, Purchasing Manager, and Contracts Manager, I have participated in the development and installation of 5 major offshore platforms in the Java Sea in Indonesia, the development and installation of over 3,000 miles of large diameter pipeline and over 500,000 horsepower of pipeline compression in the United States.

WORK HISTORY

May/2012 - Present	**TransCanada/Keystone XL Project – Houston, TX – responsible for project workforce camp development, project pipe logistics and pipe preservation activities, project aviation requirements, and project field office development.** **Title – Project Manager – Services & Logistics**
2010–May/2012	**TransCanada USA Operations, Inc. – Houston, TX - currently manage the service contracting requirements in the U.S. for all of TransCanada operating pipeline entities** **Title – Supply Chain Management - Manager – U.S. Services**
2007 to Sept 2010	**TransCanada USA Operations, Inc. – Omaha, NE - supported various TransCanada pipelines with the purchasing and contract requirements for major pipeline and compression projects in the United States** **Title - Sr. Contract Analyst**
2005 to 2007	**ONEOK Partners GP, LLC - supported Northern Border Pipeline Company, Viking Gas Transmission Co, Guardian Pipeline LLC, and Midwestern Gas Transmission Co with their contract requirements for major pipeline and compression projects in the United States** **Title - Sr. Contract Analyst**
2002- 2005	**EL PASO CORPORATION - supported ANR Pipeline Co. and Tennessee Gas Transmission Co. with the contract requirements for major pipeline and compressor projects, both onshore and offshore** **Title – Principal Procurement Specialist**
1989 – 2002	**Enron Engineering and Construction Co. (supported all Enron pipeline entities with the contract requirements for all major pipeline and compression projects in the U.S.)** **Title: Contracts Manager – Major Projects**
1987 – 1989	**Enron Gas Processing Company** **Title: Sr. Administrative Specialist**
1980 – 1987	**Lear Petroleum Corp** **Title: Division Administrative Manager**



1975 – 1980	**Natomas International Corp.** (parent company of "Independent Indonesian American Petroleum Company") **Title: Buyer/Purchasing Manager**
1973 – 1975	**Ingersoll Rand Corp.** **Title: Regional Corporate Expediter**
1971 – 1973	**Missouri Pacific Railroad** (now part of Union Pacific Railroad) **Assistant Terminal Manager**

EDUCATION

BBA, University of Houston, 1971
CM, American Society of Transportation & Logistics
Airline Transport Pilot, Flight Instructor

HEALTH

Excellent, non-smoker.

REFERENCES – Personal and Professional

Furnished upon request.

CERTIFICATE OF SERVICE

I hereby certify that on the 26th day of June, 2015, I sent by United States first-class mail, postage prepaid, or e-mail transmission, a true and correct copy of the foregoing Direct Testimony of F. J. (Rick) Perkins, to the following:

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BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

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HP 14-001

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

REBUTTAL TESTIMONY OF MEERA KOTHARI

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Pursuant to the Commission's Order Granting Motion to Define Issues and Setting Procedural Schedule, Petitioner TransCanada Keystone Pipeline, LP, offers the following rebuttal testimony of Meera Kothari.

1. Please state your name and occupation.

Answer: Meera Kothari

2. Did you provide direct testimony in this proceeding?

Answer: Yes.

3. To whose direct testimony are you responding in your rebuttal testimony?

Answer: I am responding to the direct testimonies of Richard Kuprewicz, Ian Goodman, and Dr. Arden Davis.

4. Mr. Kuprewicz's testimony states "The proposed routing in South Dakota is in areas of steep elevation changes." Do you agree with this statement?

Answer: No. The alignment through South Dakota totals approximately 315 miles in length. The vast majority of this alignment has generally flat (i.e., low sloping) to moderate topographic relief, with some buttes and badlands. The State Department's Final Supplemental January 2014 Environmental Impact Statement defines areas of incline greater than 20% as "steep." A desktop review was performed at my direction by independent engineering experts in this field using aerial photographs, video documentation of the alignment, publicly available topographic information, and LiDAR data, based on the most conservative assumptions. The review concluded that a maximum of approximately 18 miles or 5% of the alignment could traverse terrain with slopes greater than 20%.

Percent Slope	Approximate Distance (miles)
20-25%	13
25-30%	3
30-35%	1
>35%	1

Areas of steep slopes are located in isolated areas along the entire alignment and are generally more prevalent in the vicinity of the larger river crossings. I would note that a 20% slope does not present significant construction challenges in light of the mitigation measures and techniques discussed in the response to Question 7.

5. Can you comment on the USGS map that is attached as Exhibit 4 to Ian Goodman's testimony?

Answer: The USGS Landslide Overview Map of the Conterminous United States was published in 1982 at a scale of 1:7,500,000 in the USGS Professional Paper 1183 (USGS 1982), and then subsequently updated in digital format in 1997 in the USGS Open-File Report 97-289 (USGS 1997). The map depicts potential landslide hazard areas across a wide area of South Dakota. This map is intended for geographic display and analysis at the national level and for reviewing possible hazards at large regional scales. This map was used initially as publicly available data in the early phases of planning and design for the KXL project. Subsequent project routing review, design work and field visits were completed to refine and optimize the alignment, in particular at targeted, steeper topographic areas and at larger river crossings, such as the Cheyenne River (MP 430), the Bad River (MP 486), and the White River (MP 541).

6. Is that map appropriate for identification of landslide risk on a site specific basis?

Answer: No, it is not appropriate given the scale of the map (1:7,000,000). As cited on the USGS website for the landslide map (http://landslides.usgs.gov/hazards/nationalmap/) "because the map is highly generalized, owing to the small scale and the scarcity of precise landslide information for much of the country, it is unsuitable for local planning or actual site selection."

7. Mr. Kuprewicz's testifies that "geo-hazard risk cannot be appropriately mitigated by pipeline design or construction techniques." Do you agree with that statement?

Answer: No, this statement is not accurate. Pipelines are routinely constructed and operated in challenging terrain throughout North America, as well as internationally in similar terrain and geologic conditions. In particular, the standard of practice for pipeline construction and the practice of geotechnical engineering and geologic hazards assessment and mitigation specifically addressing landslide hazards are well understood and applicable to the kinds of

terrain, topography, and geologic conditions encountered along the KXL alignment through South Dakota.

Geo-hazard risk is addressed through routing, pipeline design and mitigative construction techniques. To the extent necessary and practicable during the routing process, Keystone avoided areas of potential geo-hazard risk. Beyond that, mitigation addressing landslide hazards may include one or more design and construction measures including, but not limited to, the following, many of which are included in the Project's construction plans and Construction and Mitigation Reclamation Plan (CMRP):

- Installing the pipeline beneath landslide (deep burial)
- Engineering of the backfill around or within landslide areas
- Installation of engineered structures to protect the pipeline
- Installation of strain gauges on the pipeline to monitor and track potential strain accumulation in the pipeline
- Installation of geodetic monitoring stations to track potential changes in ground movement
- Installation of other below ground monitoring to track potential changes in ground conditions
- Removal of the landslide through excavation
- Targeted site management and diversion of surface water around landslide sites
- Mitigation of surface erosion by armoring or otherwise stabilizing surface soils
- Targeted site management of sources of water along the trench excavation
- Targeted mitigation of seeps, springs, or other subsurface water encountered along the disturbed ROW
- Reduction in surcharge on landslide areas
- Installation of deformable backfill around the pipeline
- Special in-line monitoring of pipeline parameters
- Completion of regular visual monitoring of site to observe and identify potential changes.

8. Mr. Kuprewicz testifies that Keystone should have determined worst case discharge based on a capacity of 922,000 B/SD. Can you comment on that assertion?

Answer: As required by federal regulation at 49 CFR 194.105, operators must use the maximum capacity to complete worst case discharge calculations. Keystone used the

maximum pipeline throughput capacity of 1,000,000 barrels per day in determining worst case discharge.

9. Mr. Kuprewicz's testifies that "(r)eliability can be improved only if proper transient dynamics have been incorporated into a rupture detection alarming system, and procedures are in place that require shutdown and isolation of pipeline segments along the system where a rupture may be suspected." Has a transient analysis been performed and incorporated into the procedures required to shut down and isolate the pipeline?

Answer: Yes, a transient analysis has been performed and incorporated in the design of the pipeline and Computational Pipeline Monitoring (CPM) leak detection system in accordance with PHMSA Special Condition 27 and API 1130.

10. Mr. Kuprewicz's testifies that "further information is warranted to clarify how much of this terrain identified as High Landslide Hazard Area is really at risk to such massive abnormal loading forces." What is the total mileage of high risk landslide hazard along the pipeline route in South Dakota?

Answer: Based on Keystone's detailed engineering analysis approximately 0.5% of the alignment intersects potential landslide hazards. This number may further decrease with site reconnaissance to finalize the Project's construction plans. Taking a more conservative perspective, and looking for potential landslide hazards that may occur within approximately 200 feet (to either side) of the alignment but that do not actually intersect the alignment, the area of additional potential landslide risk only increases by approximately an additional 1.5%. These additional areas of potential landslides identified along the alignment may or may not pose a hazard to the pipeline (e.g., depending on direction of movement, activity level, depth of landslide, etc.); thus, this additional approximately 1.5% is a conservative estimate intended to

capture the full potential landslide hazard, and will likely decrease in actual number once the Project's construction plans are finalized. The combined potential of landslide hazards that intersect, or are within approximately 200 feet of, the alignment through South Dakota that were identified did not appear to have the potential to generate "massive abnormal loading" conditions, and can be mitigated through standard pipeline design and construction practices or through the use of targeted mitigation measures.

11. Kuprewicz (p. 6) claims that the proposed Keystone "valving is seriously inadequate…in a location of considerable elevation changes." Please comment on this assertion.

Answer: A two-year independent review of Keystone XL's design and the 2009 Keystone XL Risk Assessment was conducted by Battelle Memorial Institute (Battelle) and E^{x}ponent Inc. (E^{x}ponent) under the direction of the US Department of State (DOS), Pipeline and Hazardous Materials Safety Administration (PHMSA), and the US Environmental Protection Agency (USEPA) to address concerns raised by the USEPA in the NEPA review of the Project. With respect to Keystone's valve placement, Battelle concluded that "*[t]he model and the process that were used to ensure that valves are placed to minimize the total outflow from a break appear to be correct and should be continued to be used*" (Battelle 2013).

12. Dr. Davis' testimony (p. 4) discusses concerns involving the stability of steep slopes where Pierre Shale or other expansive clays, such as bentonite, can "absorb large amounts of water during wet periods, leading to instability and potential failure," and subsequent surface water contamination. How will Keystone address these concerns?

Answer: Ground movement, including landslides, seismic events and subsidence, and heavy rains and flooding, account for a very small percentage (1.08%) of pipeline incidents

(PHMSA 2008). To prevent pipeline damage, Keystone considered slope stability during the routing and design process. Once the pipeline is operating, Keystone will conduct aerial patrols to monitor the pipeline right-of-way for signs of slope instability as well as other threats to pipeline integrity. This surveillance is required by Federal Regulation at 49 CFR 195.412. Keystone continually evaluates slope stability over the life of the pipeline. If Keystone suspected damage to the pipeline's integrity, Keystone would inspect the pipeline as required by PHMSA Special Condition 53c.

Dated this 25 day of June, 2015.

Meera Kothari

CERTIFICATE OF SERVICE

I hereby certify that on the 26th day of June, 2015, I sent by United States first-class mail, postage prepaid, or e-mail transmission, a true and correct copy of the foregoing Rebuttal Testimony of Meera Kothari, to the following:

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BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

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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 PROJECT	:	DOCKET NUMBER HP 14-001 REBUTTAL TESTIMONY OF JON SCHMIDT

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Pursuant to the Commission's Order Granting Motion to Define Issues and Setting Procedural Schedule, Petitioner TransCanada Keystone Pipeline, LP, offers the following rebuttal testimony of Jon Schmidt.

1. State your name and occupation.

Answer: My name is Jon Schmidt. I am employed as Vice President, Environmental and Regulatory Services, Energy Services, by exp Energy Services, a consultant for the Keystone XL Project.

2. Did you provide direct testimony in this proceeding?

Answer: Yes.

3. To whose testimony are you responding in rebuttal?

Answer: I am responding to the direct testimony of Doug Crow Ghost and Carlyle Ducheneaux.

4. On pages 2-4 of his testimony, Crow Ghost discusses the Winters Doctrine. Will construction of the Keystone Pipeline affect the water rights of the Tribe under this doctrine?

Answer: Keystone has not applied yet for temporary water use permits. Current South Dakota administrative code (ARSD 46:5:40:1) indicates that "no temporary permit may be issued if the permit interferes with or adversely affects prior appropriations or vested rights." Thus, there are administrative protections for the Tribe's claimed water rights. The proposed temporary water uses will not interfere with long-standing water rights in any of the rivers proposed for withdrawal.

5. On page 5 of his testimony, Crow Ghost states that the Little Missouri River, the Cheyenne River, the North Fork of the Morean River, the Bad River, and the White River have been potentially impacted by long-term drought. If Keystone withdraws water from these river systems, is it possible that downstream water users, including Tribal water users and non-Indian farmers and ranchers, will not have adequate water supplies?

Answer: As discussed above, the permitting process will address that issue. In addition, Keystone's primary use of water during construction is for hydrostatic testing. Water used in hydrostatic testing is returned to the water source.

6. On page 6 of his testimony, Crow Ghost discusses the effect of construction on water quality. Will construction of the Keystone Pipeline affect water quality, specifically referencing the North Fork of the Grand River and the Little Missouri River?

Answer: The Project will not cross the North Fork of the Grand River, and therefore will not release any sediment contamination in the river through handling or construction. The Project will also cross the Little Missouri River using the HDD construction method, thereby avoiding any impacts to the river sediments, and thereby avoiding release of potential contaminants in the river.

7. If drought conditions exist during the period of time when Keystone requires water for dust control or hydrostatic testing, how will Keystone obtain adequate water supplies?

Answer: If drought conditions were to exist such that insufficient unappropriated water was available in quantities required by Keystone, Keystone would seek alternate sources of water, which could include use of existing water wells, drilling new water wells, reuse of water from upstream tested sections as appropriate, or use of municipal supply. Additionally, Keystone could use alternate dust abatement methods

such as magnesium chloride to reduce the amount of water needed. Lastly, if no alternate solutions were feasible Keystone would delay its testing program.

8. In question 8 of his testimony, Carlyle Ducheneaux states that the soils in and around the Cheyenne River and its tributaries are contaminated by previous polluters. Will construction of the Keystone XL Pipeline disrupt these contaminated sediments?

Answer: The Cheyenne River will be crossed using HDD construction techniques, which do not result in the disturbance or release of potential contaminants from existing river bed sediments or cause significant disturbance of soils in the area of the river.

9. In questions 12 and 13 of his direct testimony, Ducheneaux addresses the likelihood of pipeline failure due to sloughing of river banks and the fact that the banks of the Cheyenne River are highly susceptible to collapse. Will the construction of the Keystone XL Pipeline cause sloughing, erosion, or collapse of these river banks?

Answer: The Cheyenne River will be crossed using HDD construction techniques. There will be no impact to the river banks and bluffs that could lead to sloughing of the banks into the river. With respect to tributaries that are crossed using the open cut construction technique, Keystone will mitigate bank and bluff sloughing by

various stabilization means such as installation of rip-rap, geotextile material or re-sloping of the banks, all of which are addressed in the CMR Plan.

Dated this 4 day of June, 2015.

Jon Schmidt

CERTIFICATE OF SERVICE

I hereby certify that on the 26th day of June, 2015, I sent by United States first-class mail, postage prepaid, or e-mail transmission, a true and correct copy of the foregoing Rebuttal Testimony of Jon Schmidt, to the following:

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BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

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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 PROJECT	HP 14-001 REBUTTAL TESTIMONY OF HEIDI TILLQUIST

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Pursuant to the Commission's Order Granting Motion to Define Issues and Setting Procedural Schedule, Petitioner TransCanada Keystone Pipeline, LP, offers the following rebuttal testimony of Heidi Tillquist.

1. Please state your name and occupation.

Answer: Heidi Tillquist, Director of Oil and Gas Risk Management, Stantec Consulting Services Inc., Fort Collins, CO.

2. Did you provide direct testimony in this proceeding?

Answer: Yes.

3. To whose direct testimony are you responding in your rebuttal testimony?

Answer: I am responding to the direct testimonies of Richard Kuprewicz of Accufacts Inc., Ian Goodman and Brigid Rowan of The Goodman Group, Ltd., and Arden Davis, Ph.D., P.E.

4. Kuprewicz (p. 4) and Goodman and Rowan (p. 22, 23, 24, 25, 34, 35, and 50) question the use of historical incident databases to conduct the 2009 Keystone XL Risk Assessment included as part of the Department of State Final Supplemental Environmental Impact Statement (FSEIS). Can you comment on the use of historical incident databases, such as the PHMSA database, as industry practice? Additionally, please explain how the PHMSA database was used to determine risk as part of the permitting process for the Keystone XL pipeline.

Answer: During the environmental permitting process, Keystone elected to provide an estimate of failure frequencies and range of probable spill volumes based on historical data since no operational data is available for the proposed project. These statistics are then combined with environmental data to assess the reasonable range of environmental impacts that may occur in the event of a release.

The PHMSA database was used in the development of the 2009 Keystone XL Risk Assessment. While future events cannot be known with absolute certainty, historic incident frequencies are an appropriate basis on which to estimate the number of events that might occur over a period of time. The 2009 Keystone XL Risk Assessment was developed as a part of the State Department's environmental review under the National Environmental Policy Act (NEPA) during its permitting process. The purpose of this Risk Assessment is to provide a conservative range of anticipated effects from the operation of the Project that is sufficient for the purposes of federal permitting requirements. Additionally, the 2009 Keystone XL Risk Assessment provides a preliminary evaluation of potential risk during the pipeline's design phase and provides an initial basis for emergency response planning.

A two-year independent review of Keystone XL's design and the 2009 Keystone XL Risk Assessment was conducted by Battelle Memorial Institute (Battelle) and E^{x}ponent Inc. (E^{x}ponent) under the direction of the US Department of State (DOS), Pipeline and Hazardous Materials Safety Administration (PHMSA), and the US Environmental Protection Agency (USEPA) to address concerns raised by the USEPA in the NEPA review of the proposed project. Battelle (2013) concluded that "*because historic data provide a sound basis to assess risk from a historic perspective, it is customary to do such analysis based on the historic record. As stated in the [2009] Keystone [XL] Risk Assessment, the Project is being weighed relative to the US portion of the system; therefore, their assessment focused exclusively on the US database, which is maintained by the PHMSA…As has been noted by Keystone, all data available were used with the exception of information involving terminals and tanks, with a rationale noted for that decision. As needed, gaps were bridged or adjustments were made in the context of judgment, which has been a usual practice since risk analysis emerged in the early 1990s as a viable assessment under the auspices of a joint industry-government task force…Much of what has been done is usual and consistent with industry practices as part of the procedure for obtaining PHMSA approval to commission a pipeline.* ***However, the Risk Assessment presented does go beyond the process typically followed for the National Environmental Policy Act (NEPA) stage of the Federal process*** [emphasis added]" (Battelle 2013).

5. Kuprewicz (p. 4) and Goodman and Rowan (p. 23, 25, 50, and 52) suggest that PHMSA data have significantly changed since the 2009 Keystone XL Risk Assessment due to the "recent growth in North America crude oil production, the accompanying increase in terrestrial transport of more hazardous non-conventional crudes, as well as the unfortunate advent of very large spills." Based on your analysis, has the PHMSA incident

database significantly changed such that the findings and conclusions of the 2009 Keystone XL Risk Assessment are no longer valid?

Answer: No. For consistency, the values presented in this testimony are based on the same database used for the 2009 Keystone XL Risk Assessment. Nonetheless, the risk statistics presented in the 2009 Keystone XL Risk Assessment are highly comparable with current PHMSA data. Recent high profile spill events remain extremely uncommon and are not representative of the majority of spills. Spill volume data continue to reflect a highly skewed distribution, with the spill distribution for very large spills decreasing by one tenth of one percent (i.e., spills greater than 10,000 barrels now account for 0.4% of all spills, as compared to 0.5% of all spills as reported in 2009 Keystone XL Risk Assessment).

6. Goodman (p. 23) states "[m]ost of the data is provided by industry, which tends to underreport spills, particularly the serious ones, which are of greatest concern." Please comment on this assertion.

Answer: Goodman's assertion that operators do not comply is contrary to federal regulations is unsupported by data. Since 2002, pipeline operators are required by federal regulations (49 CFR Sections 195.50 and 195.54) to file accident reports for a release of 5 gallons or more. Failure to report incidents constitutes a noncompliance violation and PHMSA can impose fines and other punitive measures. PHMSA regularly audits pipeline operators for compliance. Questions regarding compliance with incident reporting are identified on two separate auditing forms provided by PHMSA. These forms allow operators to conduct internal audits to ensure compliance and provide companies with the minimum documentation that they will be required to produce during an audit.

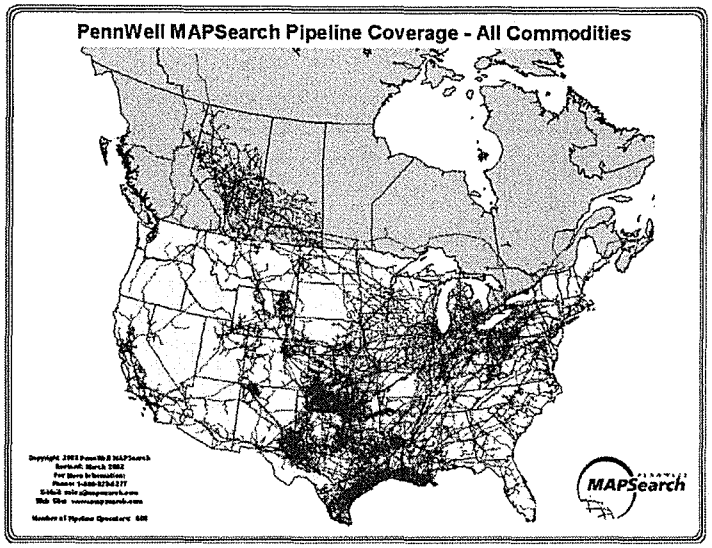
7. Kuprewicz (p. 5) suggests that a "true risk assessment" should be conducted using "specific pipeline" information. Goodman and Rowan (p. 22, 23, 24, and 25) also suggest that a similar site-specific risk assessment using "the elevation profile and other key information" be conducted. Can you comment on these suggestions?

Answer: As described above, the 2009 Keystone XL Risk Assessment was prepared as part of the environmental permitting process and evaluated all "specific pipeline" information identified by Kuprewicz and Goodman and Rowan.

8. Can you comment on the appropriateness of the PHMSA database for determining risk in areas that are "unique" (e.g., areas of reported high landslide risk as mentioned in testimonies of Kuprewicz [p. 2 and 4] and Goodman and Rowan [p. 22])?

Answer: The PHMSA incident database contains historical incident data for approximately 200,000 miles of liquid pipelines. The extent of US liquid pipelines is shown on Figure 1. These pipelines routinely cross discrete areas of high landslide risk, slope instability, soils with high clay content, and other landscape features. Thus, it is reasonable to use the PHMSA database to estimate incident frequencies for a pipeline that crosses several states for permitting purposes.

Figure 1. Pipelines in North America



While geological hazards are addressed at a macro-scale in the 2009 Keystone XL Risk Assessment, actual routing, design, engineering, and operations incorporate site-specific information and analyses to account for terrain, including slope stability issues.

9. Kuprewicz (p. 6) states, "[l]andslides are most likely to be associated with high water/rain events (e.g., flash floods) where rivers and streams will be at higher flow." Can you comment on that assertion?

Answer: While landslides may be associated with high water/rain events, pipeline failures caused by flooding are not associated with landslides. Instead, pipeline failures caused by flooding are almost always due to the loss of cover caused by either vertical scour or lateral stream migration.

While flooding only causes a small fraction of pipeline failures (0.52%) with a median spill volume of 97.0 barrels (PHMSA 2008), under federal regulations (49 CFR Section 195),

Keystone's Integrity Management Program is required to monitor and reduce risks from a number of threats, including outside forces due to flooding.

Pipeline failures at river crossings are highly uncommon and almost always are associated with loss of depth of cover. According to the PHMSA Report to US Congress (2012), during the 21-year span between 1991 and 2012, only 20 accidents involving water crossings occurred. "*A depletion of cover, sometimes in the waterway and other times in new channels cut by floodwaters, was a factor in 16 accidents. The dynamic and unique nature of rivers and flood plains was a factor in each accident. These 16 accidents are 0.3 percent of all reported hazardous liquid accidents and 0.5 percent of the hazardous liquid significant incidents*" (PHMSA 2012). A "significant release" is defined by PHMSA as a release of 50 barrels or more, fire, explosion, injury resulting in hospitalization, fatality, or damages of $50,000 or more of cost incurred by operator (PHMSA 2015). PHMSA promulgated 49 CFR Section 195 to establish minimum pipeline safety standards for hazardous liquid pipeline systems. Regulations relevant to depth of cover are found in two subparts: Construction, and Operation and Maintenance.

As part of the 59 Special Conditions developed by PHMSA and set forth in Appendix Z to the State Department's FSEIS, Keystone has committed to a depth of cover of 48 inches in most locations, which exceeds federal regulatory standards. Additionally, as part of the 59 PHMSA Special Conditions, Keystone is required to maintain that depth of cover for the life of the Project.

10. Kuprewicz (p. 6) states that landslides are the "most likely event that could cause rupture" for the Keystone XL pipeline in South Dakota. Goodman and Rowan (p. 28) state that the worst case scenario for the Keystone XL pipeline is "a full bore rupture…caused by a breakaway landslide in areas of steep elevation change." Is the risk of

landslides/ground movement expected to be a leading cause of pipeline failure along the route in South Dakota?

Answer: No. The relevant historical data indicate that the overall probability of an incident related to landslides is very low and unlikely to be the leading cause of pipeline incidents for Keystone XL. Earth movement accounts for approximately 0.56% of pipeline incidents (PHMSA 2008). This is corroborated by Goodman and Rowan on page 27 of their testimony. The majority of earth movement incidents result in relatively small releases, with 50% resulting in releases of 43.5 barrels or less (PHMSA 2008).

11. Kuprewicz (p. 2) and Goodman and Rowan (p. 10 and 36) claim that a rupture would result in substantial volumes of oil being released along terrain in South Dakota. Please comment on the probability of a large volume spill occurring along the route.

Answer: Based on the PHMSA dataset, the probability of a 10,000 barrel spill at any 1-mile segment along the Keystone XL pipeline in South Dakota is equivalent to 1 spill every 1.5 million years. The occurrence intervals for a range of spill volumes, including greater than 10,000 barrels, are shown in Table 1.

Table 1 Occurrence Intervals by Spill Volume

	Occurrence Interval (years) by Spill Volume				
Crossing Distance	**All spills**	**3 bbl**	**100 bbl**	**1,000 bbl**	**10,000 bbl**
1 mile	7,407	14,599	48,662	145,985	1,459,854

Source: PHMSA 2008.

Based on the PHMSA pipeline incident database (2002 to 2009), only 3.8% and 3.2% of spills affected surface water or groundwater resources, respectively, and most of those water resources were not drinking water resources. Only 0.16% of spills actually affect drinking water resources. Consequently, the possibility of a spill occurring and affecting drinking water is very remote.

12. Kuprewicz (p. 2) claims that there would be a "remarkably low amount of released oil that will actually be recovered in the event of a spill." Please comment on the fate of released crude oil in the environment in the event of a spill.

Answer: Crude oil released into the environment undergoes weathering (i.e., the loss and degradation of petroleum products). Using ADIOS2, an environmental fate model for crude oil spills, approximately 20 to 60% of the crude oil evaporates within the first 12 hours following a spill. For Western Canadian Select, approximately 20% evaporates in the first 12 hours, consistent with other heavy conventional crude oils. In addition, according to the PHMSA database, approximately 50% of crude oil released is recovered. Therefore, the vast majority of crude oil either evaporates or is recovered following an incident.

13. Goodman and Rowan (p. 28 and 29) claim that "[i]n light the Line 6B spill, there is now substantial evidence that dilbit can sink in water making a dilbit spill to water significantly more difficult to clean up." Please comment on this assertion.

Answer: On July 25, 2012, Enbridge's 6B pipeline failed near Marshall, Michigan, and released over 20,000 barrels of oil into Talmadge Creek. At the time of the accident, Enbridge's 6B pipeline was transporting Cold Lake diluted bitumen. An API of 10 is equivalent to water, which means any oil with an API above 10 will float on water while any with an API below 10 will sink (Petroleum 2015). Keystone's diluted bitumen has an API gravity of 16. In comparison, the API gravities of Western Canadian Select and Bakken crude are 20.6 and 52.9, respectively (Crude Monitor 2013, Shafizadeh 2010). Cold Lake's API value is lower than most diluted bitumen crude oils but is greater than 10 and, therefore, it was expected to float on the water's surface. According to the US Environmental Protection Agency (DOS 2014, USFWS et

al. 2015) and PHMSA's on-site coordinator (J. Hess, personal communication, January 2013), the oil did float initially, as expected.

It has been suggested that the type of oil contributed to the severity of the spill and its impacts. Recent evaluations of diluted bitumen (Battelle 2012, Been 2011, National Academy of Sciences [NAS] 2013) found no significant differences in the physical or chemical properties of diluted bitumen and other heavy crude oils. Copies of these reports have been attached as Exhibits 1 through 3 of my testimony.

The behavior of the crude oil in the Kalamazoo spill was similar to that expected for other heavy crude oils; it was not unique. Extenuating factors (flood conditions and emergency response times) allowed time for the crude to weather prior to cleanup. As the oil weathered with time (i.e., light end hydrocarbons evaporated), the remaining oil became heavier until the API gravity was less than 10 and portions of the oil slick became submerged. This process was exacerbated by heavy turbulence caused when the oil passed over an overflow dam and flooding that caused sediment, rocks, debris, and water to become incorporated into the crude oil, forming a heavier-than-water emulsion. The resulting submerged oil formed globules that were transported downstream.

References:

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Petroleum. 2015. API Gravity. Internet website: http://www.petroleum.co.uk/api. Accessed on May 27, 2015.

Shafizadeh, A. (2010, June 10). Bakken [Powerpoint slides]. Retrieved from Crude Oil Quality Association website: http://www.coqa-inc.org/06102010_Shafizadeh.pdf

US Fish and Wildlife Service (USFWS), Nottawaseppi Huron Band of the Potawatomi Tribe, Match-E-Be-Nash-She-Wish Band of the Pottawatomi Indians. 2015. Draft Damage Assessment and Restoration Plan/Environmental Assessment for the July 25-26, 2010 Enbridge Line 6B Oil Discharges near Marshall, MI. May 2015.

14. Following up on Goodman and Rowan's discussion of the Kalamazoo spill (p. 23), can you discuss key differences between Enbridge Line 6B and the proposed Keystone XL pipeline that affect the risk posed by each pipeline.

Answer: A major failure comparable to Enbridge's 6B failure at Kalamazoo is highly unlikely for the Keystone XL pipeline for the following key reasons: i) the quality of the pipe and longitudinal seam welding procedures; ii) corrosion protection systems; iii) the use of in-line inspection tools; and iv) other key materials and construction procedures.

Pipeline manufacturing processes and regulatory standards have evolved and improving technologies have resulted in demonstrable improvements in pipeline safety performance. The Enbridge Line 6B pipeline was constructed in 1969 when there were different pipe materials and manufacturing processes than today. The Keystone XL pipeline will be manufactured with much

higher quality and stronger steel that helps reduce the impacts of external forces, such as excavation and flooding damage.

Federal pipeline regulations have evolved over time and pipeline operators are now required to manage their pipelines actively to reduce the possibility of incidents. Keystone has agreed to implement an additional 59 PHMSA Special Conditions identified in the FSEIS. The State Department, in consultation with PHMSA, has determined that incorporation of the 59 PHMSA Special Conditions "*would result in a Project that would have a degree of safety over any other typically constructed domestic oil pipeline system under current code and a degree of safety along the entire length of the pipeline system similar to that which is required in HCAs, as defined in 49 CFR 195.450*" (DOS 2014).

15. Goodman and Rowan (p. 38 and 52) state, "a slow and undiscovered leak is likely to be the more serious threat to the Ogallala Aquifer and RST water resources." Kuprewicz (p. 7 and 8, respectively) states, "leaks are probably the most likely risk of concern to the water wells" and that leaks "could migrate underground possibly delaying discovery." Please comment on the subsurface movement of groundwater plumes and the potential impacts on these specific groundwater resources.

Answer: The proposition that a leak could go undetected for a long period of time that could release thousands of barrels is not realistic. The independent Battelle review (2013) concurred with the conclusions in the 2009 Keystone XL Risk Assessment that a small leak going undetected indefinitely is unlikely. Battelle (2013) estimated that crude oil from a small "pin hole" leak (28 bbl/day) would theoretically reach the ground surface in no more than a few months.

Data from actual pipeline spills demonstrate that substantial leaks do not go undetected for long periods of time. Further, those spills that are not detected within the first 48 hours almost always are small. The data used in the 2009 Risk Assessment indicate that the majority of spills are 3 barrels or less, regardless of detection time. These data also indicate that the majority of spills are detected within 2 hours, with 99 percent of spills detected within 7 days. Of those spills not detected within the first 48 hours, the majority of spills were 15 barrels or less. These data demonstrate that the theory of a leak going undetected for months to years resulting in a release of tens of thousands of barrels is not reasonable or realistic.

In the event of a release, crude oil would spread through the interstitial spaces between soil particles. Often the oil will remain in the trench where soils are less consolidated compared to the adjacent soils as well as move to the soil's surface. Crude oil adheres to soil particles and has very limited mobility. If crude oil was not removed from the environment and crude oil came into contact with groundwater, soluble constituents could begin to form a groundwater plume. Plume formation takes months to years to occur due to the limited subsurface movement of petroleum hydrocarbons. Newell and Connor (1998) summarized the results of four nationwide studies looking at groundwater plumes from petroleum hydrocarbon contamination. The results show that the subsurface movement of petroleum hydrocarbons is very limited, moving 312 feet or less in 90 percent of the cases. Additional studies support this plume transport distance. Copies of these reports have been attached as Exhibits 4 through 9 of my testimony.

Petroleum hydrocarbon plumes do not sink within groundwater as observed with chlorinated solvent plumes (e.g., trichloroethylene [TCE], perchloroethylene [PCE]); instead, they form along the uppermost layer of groundwater. Therefore, contamination of groundwater would be limited to the uppermost volume associated with the groundwater surface. Petroleum

hydrocarbons are naturally degraded by microbial communities naturally found within soils. As a result, petroleum hydrocarbon plumes would be expected to result in highly localized effects. Removal of the source oil and remediation actions would help to further minimize groundwater impacts. Kuprewicz reaches the same conclusion (p. 7), specifically stating that impacts to RST groundwater wells are not anticipated due to the slow-moving nature of the groundwater plumes.

16. Goodman and Rowan (p. 32, 37, and 52) also identify groundwater resources associated with the Ogallala Aquifer in Tripp County as being a high value resource. How is Keystone addressing groundwater vulnerability in this region?

Answer: The High Plains Aquifer area in southern Tripp County has been identified as a hydrological sensitive area, as defined by the Public Utilities Commission's June 2010 Amended Final Order in Docket HP09-001. Keystone has elected to treat "hydrologically sensitive areas" as operator-defined HCAs based on a number of factors, including those identified by the Public Utilities Commission Amended Final Order Condition 35.

17. Kuprewicz (p. 3 and 6) states, "[i]t is my understanding that much of the state gets its water from the Missouri River so the impact on the state's overall water supply should the pipeline rupture and threaten this resource needs to be properly evaluated." Please comment on this as it relates to spill distance to this resource and possible impacts.

Answer: The Missouri River is not crossed by the Keystone XL pipeline and is located at least 82 river miles downstream from the Keystone XL pipeline at the closest point. The White River represents the shortest downstream flow path from the pipeline to the Missouri River. The 82-mile distance far exceeds the maximum transport distance observed in even catastrophic pipeline failures during flood conditions. Three major rivers that are tributaries to the Missouri River will be crossed using HDD, thereby reducing the possibility of i) stream scour

resulting in pipeline failure and ii) a pipeline release entering the waterbody due to the amount of overburden. All water crossings were evaluated using a vertical and horizontal scour analysis based on a 100-year flood event and the depth of crossings adjusted accordingly.

Most historic spill incidents are relatively small, are contained in close proximity to the origin of the spill, are cleaned up immediately, and never reach flowing surface water. Most spills would not move significant distances downstream and still be detectable. Under exceptional circumstances, there have been cases where large volume spills have resulted in crude oil being detected miles downstream. Examination of exceptional spill events (e.g., spills into the Coffeyville and Kalamazoo rivers) illustrate that contamination typically does not travel more than 20 miles downstream, with the maximum observed distance of 30 miles. Following a 10,000 barrel release in 2007 from the Coffeyville Refinery in Kansas into the Verdigris River, the USEPA found no detectable concentrations of petroleum products 20 miles downstream at the closest municipal water intake. USEPA samples reported concentration of petroleum hydrocarbons to be below threshold limits at the first sampling point, located 12 downstream miles of the spill. In 2010, an Enbridge 30-inch pipeline ruptured, spilling 19,500 barrels of oil into the Kalamazoo River system. While the majority of contamination occurred in close proximity to the source, USEPA reports that contamination has been documented in localized areas within 30 miles of the spill's origin. I concur with Kuprewicz's conclusion on p. 3 and reiterated on p. 7 that the risks to the two RST water supply line crossings and the Cheyenne River are not significant.

18. Kuprewicz (p. 6) states, "[t]he steepness of the terrain also indicates that a rupture release will result in considerable surface migration, either over the ground surface or via

river transport should a rupture release reach a river that crosses the pipeline." Please comment on river and overland ground transport distances of diluted bitumen.

Answer: Refer to my response to Question 17 for case studies regarding downstream transport distances following large spills. Maximum overland transport distances were calculated using a GIS-based analysis and pipeline product parameters (e.g., transport temperature, dynamic viscosity, and 25,000-barrel spill). Overland transport distances for diluted bitumen are summarized in Table 2.

Table 2 Overland Transport Distances

Slope (%)	Miles of Route	Transport Distance (feet)
Herbaceous Land		
0-20	297	35-218
20-25	13	244
25-30	3	267
30-35	1	289
>35	1	345
Barren Land		
0-20	297	103-655
20-25	13	732
25-30	3	802
30-35	1	866
>35	1	1,035

19. Goodman and Rowan (p. 22 and 24) raise concerns as to whether sufficient attention is being given to these sensitive areas in terms of pipeline safety and oil spill response planning. Please comment on protection of High Consequence Areas.

Answer: Keystone's evaluation of potential impacts to HCAs has been quantified in a confidential appendix for federal agencies. This preliminary analysis is not required by regulation, but assists regulators with understanding the possibility of an incident and its potential impacts. The 2009 Keystone XL Risk Assessment is not intended to replace the more detailed Engineering Assessment required by federal pipeline safety regulations as identified in

49 CFR Section 195.452 and Section 195 Appendix C. That analysis is subject to audit and review by PHMSA, which has regulatory authority over interstate pipelines, including the Keystone XL pipeline.

20. Kuprewicz (p. 7) claims that, in his experience, pipeline incidents are often due to a failure "to incorporate some degree of challenge or reality check to assure spill risk was really low." Please comment on this assertion.

Answer: Key features of Keystone's operational program, where applicable, include the incorporation of industry best practices and participation in industry conferences and forums to exchange ideas and information, as well as involvement with industry research and development programs. Keystone had adopted many of the PHMSA Special Conditions into the Keystone XL pipeline long before they were mandated by regulators. It has been my personal experience that Keystone strives to meet or exceed pipeline safety requirements and often leads the industry in adopting more stringent safety requirements.

The types of errors Kuprewicz refers to can be minimized by independent third-party review of Keystone's policies and practices. In addition to the regulator auditing conducted by PHMSA, the design basis and risk assessment process were reviewed by independent, third-party contractors (Battelle and E^{x}ponent) during a two-year review process that was conducted on behalf of the DOS to address similar concerns expressed by the USEPA. Battelle concluded that the 2009 Keystone XL Risk Assessment was appropriate for the permitting process and that the design of the Project meets or exceeds current regulatory requirements. If approved, the Keystone XL pipeline will be required to meet more stringent requirements than any other pipeline built to date. Thus, the review recommended by Kuprewicz has already been conducted.

21. Dr. Davis' testimony (p.1) states that "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." Will the pipeline adversely affect these areas?

Answer: Adverse impacts to these areas are highly unlikely. The Keystone XL pipeline crosses a number of formations in western South Dakota that outcrop in hills, stream cuts, and along mesas. Many of these formations are covered by shallow soil. In Tripp County, the pipeline crosses the Tertiary Ogallala Formation of the High Plains Aquifer system. South of the town of Buffalo, in Harding County, the pipeline crosses a section of wind-blown sand mapped as Qe (Quaternary eolian). As discussed in the State Department's January 2014 Final Supplemental Environmental Impact Statement (FSEIS) for the Keystone XL pipeline project, *"typical recharge rates to the Ogallala Formation and associated alluvial aquifers range from 0.5 to 5 inches per year along the proposed route, with the highest recharge rates in the areas of the aquifer associated with the Sand Hills Unit"* (US Department of State [DOS] 2014). The 50-foot permanent right-of-way for the Keystone XL pipeline will occupy less than 0.1% of the total recharge area associated with the Fox Hills, Hell Creek, and Ogallala formations, as well as areas of wind-blown deposits (Qe), within counties crossed by the pipeline.

22. Dr. Davis' testimony (p. 2) states "the proposed pipeline also would have major stream crossings at water courses…These drainages have associated alluvial aquifers." Will the pipeline adversely affect these areas?

Answer: Adverse impacts to these areas are highly unlikely. The Keystone XL pipeline will cross major drainages with alluvial aquifers in South Dakota. Spills at individual river crossings are rare with occurrence intervals of no more than once in 22,000 years to

830,000 years based on representative stream crossing distances (Appendix P of the FSEIS; DOS 2014). Most spills are less than 3 barrels.

The Keystone XL pipeline is designed with a minimum depth of cover of 5 feet below the bottom of waterbodies and that depth is maintained over a distance of 15 feet on each side of the waterbody, measured from the ordinary high water mark. Depth of cover is an important factor to reduce the threat of outside force damage and stream scour.

The Project's depth of cover meets or exceeds the federal requirements noted in 49 CFR Section 195.248 of 48 inches for inland bodies of water with a width of at least 100 feet from high water mark to high water mark (for normal excavation, 18 inches for rock excavation) and PHMSA Special Condition 19 regarding depth of cover.

23. Dr. Davis' testimony (p. 2) states "in Harding County, the proposed route would cross permeable wind-blown deposits shown as Qe on Figure 4. These wind-blown deposits of silt and sand recharge from rainfall and snowmelt, they are capable of supplying water to shallow wells in the area." Will the pipeline adversely affect these areas?

Answer: Adverse impacts to these areas are highly unlikely. The wind-blown sand south of Buffalo in Harding County has been mapped by Erickson (1956) and Petsch (1956). The deposits are mostly sand overlying the Cretaceous Hell Creek Formation. Erickson (1956) interprets these deposits to be derived from the underlying Hell Creek Formation. Rainfall falling on these sand deposits would infiltrate and form a local, temporary water-bearing zone near the base of the deposits. Because the deposits are found on bluffs and the underlying Hell Creek has a much lower permeability, it is likely that water entering the sand may form temporary springs and seeps at the base of the sand deposits, rather than migrating downward into the Hell Creek Formation.

The Keystone XL pipeline crosses these sand deposits near their eastern edge, where the deposits are thin. Examination of well logs for wells within the 1-mile buffer zone around the pipeline indicates that none of the wells are screened in the wind-blown sands. In the area of the pipeline ROW, the wind-blown deposits are thin and not likely to be water-bearing most of the year. Based on this, along the ROW in areas of wind-blown deposits, a potential release from the pipeline would most likely not encounter permanent groundwater.

References:

Erickson, H.D., 1956. GQ 62K-045. Areal geology of the Buffalo quadrangle, scale 1:62,500 (22 x 17 in. map).

Petsch, B.C., 1956. GQ 62K-052. Areal geology of the Mouth of Bull Creek quadrangle, scale 1:62,500 (22 x 17 in. map).

24. Dr. Davis' testimony (p. 3) states "South of the Cheyenne River in Haakon County, the proposed route would cross permeable Quaternary terrace gravels (Qt on Figure 6) and wind-blown deposits (Qe on Figure 6)...The terrace gravels and wind-blown deposits are permeable and are recharged by precipitation" and in places "are capable of supplying water to wells." Will the pipeline adversely affect these areas?

Answer: Adverse impacts to these areas are highly unlikely. The wind-blown deposits crossed in Haakon County south of the Cheyenne River are relatively thin and not likely to form a major aquifer. Wells within 1 mile of the pipeline ROW are not screened in wind-blown material. The Cheyenne River will be crossed employing the HDD method, whereby the pipe is installed at a depth of 50 feet below the river bottom, thereby eliminating the potential for key threats including excavation damage and outside force associated with potential stream scour.

25. Dr. Davis' testimony (p. 3) states "In Jones and Lyman counties, the proposed pipeline route would cross permeable wind-blown deposits (Qe on Figure 8) and also would cross Quaternary terrace deposits north of the White River (Qt on Figure 8)." The terrace deposits have a shallow water table, are recharged by rainfall, and provide water to springs. Will the pipeline adversely affect these areas?

Answer: Adverse impacts to these areas are highly unlikely. The wind-blown deposits crossed in Jones and Lyman counties associated with the White River are relatively thin and not likely to form a major aquifer. Wells within 1 mile of the pipeline ROW are not screened in wind-blown material. The White River will be crossed employing the HDD method, whereby the pipe is installed at a depth of 70 feet below the river bottom, thereby eliminating the potential for key threats including excavation damage and outside force associated with potential stream scour.

26. Dr. Davis' testimony (p. 3) states "In Tripp County...the route would cross the Ogallala aquifer (To on Figure 9)" and "wind-blown Sand Hills type material (Qe on Figure 9)...The hydrologic situation is similar to the Sand Hills of Nebraska...and therefore deserves consideration for special protection as a high consequence area. As noted by Stansbury (2011), areas with shallow groundwater that are overlain by permeable soils...pose risks of special concern because leaks could go undetected for long periods of time." Please comment on this assertion.

Answer: "The High Plains Aquifer area in southern Tripp County" has been identified as a hydrologically sensitive area, as defined by the Public Utilities Commission's June 2010 Amended Final Order in Docket HP09-001. Keystone has elected to treat "hydrologically sensitive areas" as operator-defined HCAs based on a number of factors,

including those identified by the Public Utilities Commission Amended Final Order Condition 35.

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. Keystone has attempted to identify vulnerable aquifers through consultation with State agencies and rural water districts, as well as through the use of data provided by 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. The SD DENR website provides well logs for wells near the pipeline ROW. It is possible that, during construction and through discussion with landowners crossed by the Project, Keystone may identify shallow wells located in unconfined aquifers.

There are multiple leak detection processes that help identify small leaks, as stated in the Public Utilities Commission Amended Final Order Finding of Fact 94. While detection of a smaller leak may require additional confirmation time, examination of historical incident data confirms that small leaks do not remain undetected for long periods of time. PHMSA records (2001 through 2009) indicate that the majority of spills are 3 barrels or less, regardless of detection time. These data also indicate that the majority of spills are detected within 2 hours, with 99 percent of spills detected within 7 days. Of those spills not detected within the first 48 hours, the majority of spills were 15 barrels or less. These data do not support the contention that small leaks remain undetected for long periods of time.

27. Dr. Davis' testimony (p. 3) states that diluted bitumen is "more corrosive than conventional crude oil transported in existing pipelines." Do you agree with this statement?

Answer: No. A number of recent studies have investigated the claim that diluted bitumen is more corrosive to pipelines than conventional crude oil, but none found evidence of corrosion that is unique to the transportation of diluted bitumen. Although some diluted bitumen contains higher concentrations of naphthenic acids than conventional crude oils, these compounds are only corrosive at temperatures above 200 degrees Celsius (392 degrees Fahrenheit). These temperatures do not occur in pipelines (Been 2011). The Keystone XL pipeline will not exceed temperatures of 150 degrees Fahrenheit per PHMSA Special Condition 15. Other compounds within diluted bitumen that are capable of causing corrosion, including water and sediments, occur at very low levels that are consistent with or lower than levels found in other crude oils (NAS 2013). Copies of these reports have been attached as Exhibits 2 and 3 of my testimony.

References:

Been, J. 2011. Comparison of the Corrosivity of Dilbit and Conventional Crude. Corrosion Engineering, Advanced Materials, Alberta Innovates Technology Futures. 29 pp. Internet website: http://www.ai-ees.ca/media/6860/1919_corrosivity_of_dilbit_vs_conventional_crude-nov28-11_rev1.pdf

National Academy of Sciences (NAS). 2013. Special Report 311: Effect of Diluted Bitumen on Crude Oil Transmission Pipelines. 110 pp.

28. Dr. Davis' testimony (p. 3) states benzene is "known to produce leukemia in humans." Please comment on this assertion.

Answer: While benzene is a known human carcinogen, cancer formation is associated with long-term chronic exposure, not the short-term exposure that could occur

following an oil spill. For instance, a cohort study of 79 individuals exposed to benzene through their work in the Australian petroleum industry found an increased risk of leukemia following cumulative exposures above 2 ppm-years (Glass et al. 2003). This is equivalent to being exposed to 1 ppm of benzene for 8-hours per day for two working years (500 days). Exposures such as these would not be expected to occur following a crude oil spill due to the low persistence of benzene and preventative actions such as localized evacuations. Further, emergency response personnel would evacuate the area if there were concerns for human health effects. A copy of this report has been attached as Exhibit 10 of my testimony.

Reference:

Glass, Deborah C.; Gray, Christopher N.; Jolley, Damien J.; Gibbons, Carl; Sim, Malcolm R.; Fritschi, Lin; Adams, Geoffrey G.; Bisby, John A.; Manuell, Richard. 2003. Leukemia Risk Associated with Low-Level Benzene Exposure. Epidemiology. 2003;14: 569-577.

29. Dr. Davis's testimony (p. 3 and 4) discusses concerns with benzene being "transported downgradient toward receptors, such as public water-supply wells, private wells, and springs or seeps" as well as pipeline releases that have occurred in the past that have threatened groundwater supplies. How will Keystone address these concerns?

Answer: With regard to surface water intakes, Keystone's Emergency Response Plan would identify downstream public water intakes and associated contact information. In the event of a release, Keystone would immediately notify downstream water users so that the intakes can be proactively shut down. With regard to groundwater, municipal and residential intake users would be notified through the implementation of Keystone's Emergency Response Plan. Potential impacts would take months to years to occur.

In terms of the potential effects from a release to groundwater, the following points demonstrate why a release would not threaten groundwater sources:

- The subsurface movement of petroleum hydrocarbons is very limited, moving 312 feet or less in 90 percent of the cases (Newell and Connor 1998, as presented in Exhibit 4 of my testimony). Additional studies support this plume transport distance, as presented in Exhibits 4 through 9 of my testimony.
- A plume of dissolved petroleum hydrocarbons could begin to develop if crude oil reached groundwater and was allowed to remain in contact with the groundwater for a period of months.
- The plume would then move in the direction of the groundwater; however, plume movement would be slower than for groundwater.
- The plume would form along the uppermost surface of groundwater; they do not sink within groundwater as observed with solvent plumes. As such, contamination of groundwater would be limited to the volume associated with the groundwater surface.
- Petroleum hydrocarbons are degraded by microbial communities naturally found within soils, and as a result, only highly localized effects would be expected.
- Removal of the source oil and remediation actions would help to minimize groundwater impacts further.

Based on the PHMSA pipeline incident database (2002 to 2009), only 3.8% and 3.2% of spills affected surface water or groundwater resources; however, only 0.16% of spills actually affect drinking water resources. Consequently, the possibility of a spill occurring and affecting drinking water is very remote.

Data from actual pipeline spills demonstrate that substantial leaks do not go undetected for long periods of time. Further, those spills that are not detected within the first 48 hours are typically relatively small. PHMSA records (2001 through 2009) indicate that the majority of spills are 3 barrels or less, regardless of detection time. These data also indicate that the majority of spills are detected within 2 hours, with 99 percent of spills detected within 7 days. Of those spills not detected within the first 48 hours, the majority of spills were 15 barrels or less. In summary, large spills do not remain undetected for substantial periods of time.

Keystone will utilize an integrated leak detection system as stated in the Public Utilities Commission Amended Final Order Finding of Fact 94. Keystone also will have an Emergency Response Plan (ERP) in place to respond to incidents. The ERP contains comprehensive manuals, detailed training plans, equipment requirements, resource plans, and auditing, change management and continuous improvement processes. The Integrity Management Program (IMP) (49 CFR Section 195) and ERP will ensure Keystone will operate the pipeline in an environmentally responsible manner.

Reference:

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.

30. Dr. Davis' testimony (p. 5) restates Stansbury (2011) concerns regarding questionable assumptions and calculations by TransCanada of expected frequency of spills. Do you agree with that analysis?

Answer: No. The majority of pipeline infrastructure in North America was constructed many decades ago at a time when the materials, coating systems, and ongoing

inspection capabilities that will be used for Keystone XL were not available. Studies show the benefits of these technologies in reducing pipeline incidents. Approximately two thirds of the pipelines in the US were constructed prior to 1970. It is therefore entirely appropriate to use an incident frequency for Keystone XL that is derived from pipelines of its class. This is corroborated by observations included in the FSEIS, "*[i]t is reasonable to conclude that modern and larger-diameter pipelines would experience a lower spill rate than older pipelines. Modern pipelines have built-in measures to reduce the likelihood of a spill (e.g., modern protective coatings, SCADA monitoring)...with the application of the Special Conditions and various studies that indicate more modern pipelines are less likely to leak, it is reasonable to expect a sizable reduction in spills when compared to the historic spill record*" (DOS 2014).

31. Dr. Davis' testimony (p. 5) restates the Stansbury (2011) argument that "worst-case spill volumes from the proposed Keystone XL pipeline are likely to be significantly larger than those estimated by TransCanada." Do you agree with that analysis?

Answer: No. Stansbury's estimate of worst case discharge was based on incorrect assumptions. Keystone has calculated the worst case discharge for the Keystone XL pipeline in accordance with 49 CFR Section 194.105. The Stansbury document suggests that, because shutdown on another pipeline took longer, that increased time should be used as the shut down time assumption for the Keystone XL pipeline. The referenced Enbridge pipeline was constructed in 1969, while the Keystone XL pipeline would be constructed to meet or exceed current regulatory standards. Stansbury does not take into account that the Keystone XL pipeline is instrumented at every mainline valve, which enhances the leak detection system, and that Keystone has incorporated API's recommended practices for computational pipeline monitoring as well as ASME's Pipeline Personnel Qualification standards per Special Conditions 27 and 30.

This makes it unlikely that Keystone operators would experience difficulty detecting a leak. Nor does he address industry information sharing or the workings of the regulatory regime, both of which serve to make it unlikely that alleged operational errors on one system are repeated on another system. For example, TransCanada requires the pipeline be shut down if an operator cannot definitively determine the cause of an alarm within a 10-minute validation period.

In addition, Stansbury does not take into account the fact that worst case discharge is determined using a large leak that would be instantaneously detected by the leak detection system resulting in immediate initiation of shutdown procedures. Nonetheless, in determining its worst case discharge, Keystone conservatively assumed a 10-minute leak confirmation period, plus 9 minutes for pump shut down, plus a 3-minute valve closure time, for a total of 22 minutes. While detection of a smaller leak may require additional confirmation time, the small volumes released would not approach worst case discharge amounts. As discussed in my response to Question 26, it is incorrect to assume that there could be a small leak that remained undetected for an extended period of time, as suggested by the Stansbury document. A copy of this report has been attached as Exhibit 11 of my testimony.

32. Dr. Davis' testimony (p. 5) states concerns regarding transport distance (e.g., up to 120 miles downstream) of petroleum contaminants if a release were to occur at a major water course. What is your response to these concerns?

Answer: Dr. Davis' testimony does not account for containment and cleanup efforts by the operator that limit downstream movement. As discussed in my response to Question 29, most spills do not affect water resources. Exceptional spills that occur during flood conditions represent the worst case for downstream transport, but these do not support a 120-mile downstream transport distance. For example, following a 10,000 barrel release in 2007 from the

Coffeeville Refinery in Kansas into the Verdigris River, the USEPA found no detectable concentrations of petroleum products 20 miles downstream at the closest municipal water intake. USEPA samples reported concentration of petroleum hydrocarbons to be below threshold limits at the first sampling point, located 12 downstream miles of the spill. In 2010, an Enbridge 30-inch pipeline ruptured, spilling 19,500 barrels of oil into the Kalamazoo River system. While the majority of contamination occurred in close proximity to the source, USEPA reported that contamination had been documented in localized areas within 30 miles of the spill's origin. The material downstream was sedimented oil, which lost most of its BTEX compounds through weathering and consisted primarily of asphaltenes and other heavy molecular weight petroleum hydrocarbons. As a group, these compounds tend to have low environmental toxicity, adhere to sediments, have low bioavailability, and do not biomagnify in food chains. The BTEX values at these locations did not exceed EPA human heath exposure thresholds. Sedimented oil was removed by dredging due to their environmental persistence.

As part of its Integrity Management Program and consistent with Federal pipeline safety regulations (49 CFR Section 195), Keystone has evaluated the downstream transport of a spill to identify those pipeline segments with the potential to affect High Consequence Areas.

Dated this 25 day of June, 2015.

Heidi Tillquist

Exhibit 1: Diluted Bitumen-Derived Crude Oil: Relative Pipeline Impacts (Battelle 2012)

Exhibit 2: Comparison of the Corrosivity to Dilbit and Conventional Crude (Been 2011)

Exhibit 3: Effects of Diluted Bitumen on Crude Oil Pipelines (National Academy of Sciences 2013)

Exhibit 4: Crude Oil at the Bemidji site: 25 Years of Monitoring, Modeling, and Understanding (Essaid et al. 2011)

Exhibit 5: Use of long-term monitoring data to evaluate benzene, MTBE and TBA plume behavior in groundwater at retail gasoline sites (Kamath et al. 2012)

Exhibit 6: Review of Quantitative Surveys of the Length and Stability of MTBE. TBA, and Benzene Plumes in Groundwater at UST Sites (Connor et al. 2015).

Exhibit 7: Characteristics of Dissolved Petroleum Hydrocarbon Plumes: Results from Four Studies (Newell and Connor 1998)

Exhibit 8: A comparison of benzene and toluene plume lengths for sites contaminated with regular vs. ethanol-amended gasoline (Ruiz-Aguilar et al. 2003)

Exhibit 9: Evaluation of the impact of fuel hydrocarbons and oxygenates on groundwater resources (Shih et al. 2004)

Exhibit 10: Leukemia Risk Associated With Low-Level Benzene Exposure (Glass et al. 2003)

Exhibit 11: United States Department of State 12.1: Keystone XL Project, Risk Analysis (Kothari, Bajnok, Tillquist)

Battelle
The Business of Innovation

Final Report

Diluted Bitumen-Derived Crude Oil: Relative Pipeline Impacts

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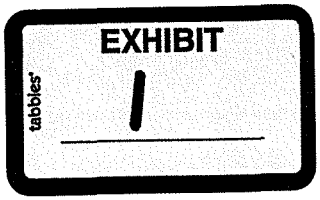
July 20, 2012



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Executive Summary

This report evaluated the claim made that dilbit is more corrosive than other crudes. This evaluation was benchmarked against conventional and/or sour crude, and was based on the existing literature on crude and dilbit properties and characteristics, data on pipeline integrity and results of engineering assays of pipe that has been transporting dilbit, with such outcomes supplemented by interviews of industry engineering experts from operators with pipelines transporting dilbit.

It was found that the literature on this topic concludes that "the characteristics of dilbit are not unique and are comparable to conventional crude oils." The relative measure of similarity developed in this project did not indicate that crude oil derived from diluted bitumen is significantly more corrosive than any other oil, and that the dilbit oils likely have corrosivities close to the heavy sour conventional oils. In addition to this relative outcome, the experience of operators transporting dilbit does not indicate it behaves differently from typical crudes. That view can be supported with images of the inside of such pipelines, which appear no different after many years of service than those shipping conventional crude and data reported to PHMSA that no releases from pipelines transporting Canadian crudes and caused by internal corrosion occurred from 2002 to early 2011.

Similarity of Dilbit Relative to Conventional Crude Oils

Introduction

Following a brief discussion of factors that affect internal corrosion independent of the type of crude involved, this section evaluates the first of the above-noted claims that dilbit is more corrosive as compared to conventional crude oil. This evaluation is based on available data and a review of published literature: no laboratory experiments were conducted as part of this evaluation. This section draws extensively from one of the most comprehensive yet concise reviews of the corrosivity of dilbit as compared to conventional crude oil, which was developed by Alberta Innovates Energy and Environmental Solutions.[iii] [1] Use is also made of the references cited in that report, with the related analysis developed as part of this project founded on basic corrosion science and electrochemistry.

Some Generic Factors that Affect Internal Corrosion

While the focus of this section is to evaluate dilbit relative to other crudes transported by pipeline, for the sake of completeness it is appropriate to briefly note that other factors more strongly influence if and where internal corrosion can occur, and its rate. Among some of the more important factors are the presence of solids like sand, and the design of the line as it influences the flow regime, which depends on the speed of flow and the "dropout" of liquid-phase water and its transport in the line along with solids. The presence of abrasive solids like sand in crude depends on the source of the crude and any prior processing, with sand being found in many sources of crude. As such solids are not unique to dilbit, they are not addressed as part of this comparison. Moreover, existing tariffs include limits on the water and solids content, where the combined total is usually limited to 0.5 weight percent. In regard to factors that are controlled by pipeline design it is important to note that pipelines transporting products that have the potential to cause internal corrosion are designed for turbulent flow, which limits liquid water and its dropout from the product stream. Because this and related aspects are design issues, and common to transported crudes rather than unique to dilbit, these and other such aspects that are not unique to dilbit are not addressed in the comparison that follows.

Approach to Compare and Contrast Crude Types

The approach used to compare the corrosivity of dilbit to conventional crude oil was to examine the factors that would most affect the corrosivity of oil in pipelines. These factors, based on fundamental electrochemical considerations, include oxygen content, water content, effect of Microbiologically Influenced Corrosion (MIC), underdeposit corrosion, and temperature. In addition to the relative outcomes of this analytical approach, input from operators that transport dilbit was assessed to determine an absolute metric of corrosion susceptibility.

Regarding the analytical assessment, other pipeline oil parameters such as total sulfur, sediment, and salt contents were used to derive a relative index of oil similarity. The "average" similarity of conventional oil was defined as a value of 1.0. Based on a consideration of how the common factors varied for dilbit and other oils compared to a conventional crude oil, a similarity index was defined as the ratio of the similarity of dilbit to a conventional Canadian heavy sour crude. A similarity index greater than 1.0 indicated that the oil was may be more corrosive than conventional crude, whereas an index value less than 1.0 indicated that the oil was likely less

[1] Superscript Roman numerals refer to the list of references compiled at the end of this report.

corrosive than conventional crude. The properties of the Canadian oils that were used for comparison were obtained from the on-line data available from Crude Quality Inc. (CQI)[iv] and Enbridge 2010 Crude Characteristics.[v] Data from crude oils from Colombia[vi] and Mexico[vii] were also included.

Results

Almost all corrosion processes in metals are electrochemical in nature. When electrochemical processes occur, there is only one anodic reaction that occurs on metals, namely

$$M \rightarrow M^{+n} + ne \quad [1]$$

where M stands for a metal and n is the number of valence electrons. In the case of pipeline steel, the predominant metal in the steel alloy is iron. For most anodic reactions in steel exposed to an aqueous phase at ambient temperature, Eqn. 1 becomes,

$$Fe \rightarrow Fe^{+2} + 2e \quad [2]$$

For every anodic reaction there must be at least one cathodic reaction, otherwise the corrosion process cannot proceed. Corrosion inhibitors are used to interfere with either the anodic or cathodic reaction or both in the attempt to minimize the corrosion reaction rate.

The following paragraphs review the role that water content, oxygen content, temperature, MIC, sulfur, underdeposit corrosion, total acid number (TAN), and salt concentration have on the interior corrosion of pipelines.

Water Content

For corrosion to occur, an electrolyte needs to be present. In oil pipelines, in the presence of sludge, the predominant electrolyte is water. While pure water is not a good electrolyte, the water in oil pipelines is sufficiently contaminated with dissolved solids and salts that it will serve as a good electrolyte. The amount of water that is typically present in any transmission oil pipeline will be quite low, as required by the basic sediment and water (BS&W) limitation of 0.5 volume percent[iii]. Moreover, this value is significantly less than what is considered the critical water concentration of greater than 10 percent,[viii] and water that is present must be the continuous phase of any water and oil emulsion.

The necessary condition for water to participate in the corrosion of the interior steel wall of a pipe is that water exists in the oil-in-water (O/W) condition rather than the non-corrosive water-in-oil (W/O) condition[ix]. The water layer on the surface of the pipe wall will be very thin. Unfortunately specific information on water-dropout for the examined crude oils was not available. Moreover, the pH of the water phase, which is an important parameter for determining the corrosivity of the water phase to steel, was also not available in the examined data.

Oxygen and other Gas Content

Oxygen content plays a major role in the corrosion reaction of steel. In neutral and alkaline pH solutions the predominant cathodic reaction involving reduction of oxygen is given by

$$O_2 + 2H_2O + 4e \rightarrow 4OH^- \quad [3]$$

Combining the anodic reaction for iron given in Eqn. 2 with the cathodic reaction in Eqn. 3, yields,

$$Fe^{+2} + 2OH^- \rightarrow Fe(OH)_2\downarrow \quad [4a]$$

The reaction product in this case is the relatively insoluble ferrous hydroxide. Ferrous hydroxide can also occur from the reaction of ferrous sulfate with hydroxide ions yielding sulfate ions.

$$FeSO_4 + 2OH^- \rightarrow Fe(OH)_2 + SO_4^{2-} \quad [4b]$$

Sulfate ions, however, were experimentally found to not have an effect on pitting corrosion rate on steel.[ix]

In the absence of oxygen, ferrous hydroxide can be further oxidized by the hydrogen ions in water to form magnetite (Fe_3O_4), which is more stable than many other iron oxides and provides a protective coating to the underlying steel surface.

$$3\ Fe(OH)_2 \rightarrow Fe_3O_4 + H_2 + 2\ H_2O \quad [5]$$

The corrosion of iron can also occur in acid solutions (pH below 7) in the absence of oxygen.

Other gases such as hydrogen sulfide (sour gas) can directly react with steel to form iron sulfide without the presence of oxygen and carbon dioxide (sweet gas) can also play a role in some corrosion reactions with pipeline steel. However, these presence or absence of these gases have not been reported in the evaluated crude oils and are therefore were not considered.

Temperature

It is not clear what the typical operating temperatures of the dilbit pipelines are compared to the conventional crude oil pipelines operating temperatures below 180 F are not expected to contribute to corrosivity of the oil. In addition, there are several factors that would temper the expected increase in corrosion rate as temperature increases. The major mitigating factor is the decrease in oxygen solubility in the water phase of the oil with increasing temperature. When additional constituents are in the water such as salts, the solubility will decrease further. On the other hand, the oxygen solubility increases with pressure. A higher pressure pipeline can have higher oxygen solubility in its water phase than a lower pressure pipeline.

Microbiologically Influenced Corrosion and Underdeposit Corrosion

MIC is most often associated with the presence of sludge, which plays a dominant role in underdeposit corrosion. Bacteria responsible for MIC in pipelines include sulfate reducing bacteria (SRB), heterotrophic aerobic bacteria (HAB), and acid producing bacteria (APB).[x] These bacteria are found in a wide variety of oil pipelines including those carrying conventional crude oil and dilbit.

Sulfur Content

The organic sulfur content of the oils at ambient temperature were found to either have no effect or actually decreased the corrosion rate of steel.[xi] The reported values for sulfur in oil, however, are the total sulfur concentrations that include both organic and inorganic forms of sulfur such as sulfates and sulfides. The presence of sulfate reducing bacteria can lead to pitting attack of the interior pipeline wall. Consequently, the sulfur parameter was included in the similarity index.

Sediment and Sludge

While the amount of sediment and sludge present in the oil may or may not be related to the amount of underdeposit corrosion, there are several variables associated with these parameters that need to be considered. These include the particulate size and distribution of sludge particles, the waxiness or oiliness of the deposits, and the velocity and turbulence of the deposits[xii]. The

presence of MIC is also associated with sediments. For these reasons, the concentration of sediment was included in the similarity index.

Total Acid Number

The total acid numbers (TAN) for pipeline oils are associated with the presence of naphthenic acids. This parameter is important in determining the crude oils corrosivity at high temperatures encountered in crude oil distillation columns in refineries but not at ambient temperatures of 35 F to 75 F of oil transport in pipelines. The temperature range where the TAN is important is from 430 F to 750 F[xiii]. Because TAN is "not necessarily reflective of the corrosivity of crude oil,"[iii] it was excluded from the similarity index.

Salt Concentration

Chlorides and other halides are usually associated with the corrosive species in most salts but "it has been shown that high salinity brines in contact with oil did not affect the corrosion rate."[iii] However, this parameter was included in the similarity index because the ubiquitous nature of these constituents in the oils.

Nickel and Vanadium Content

The low-concentration presence of these metals in the pipeline oil will not play any role in the corrosion of steel pipelines and therefore was not included in the similarity index.

Pipeline Oil Similarity Index

There have been several attempts to arrive at a corrosivity index for pipelines with the most extensive one being based on a scoring method using points and a parameter weighting scheme.[xiv] However, because the common properties reported for pipeline oil have not been shown to be directly related to the interior corrosion of the pipeline steel, a similarity index scheme is used in this report that is based solely on published properties of the oil rather than the entire pipeline infrastructure and simply uses equal weighting for three oil parameters. These parameters include the sulfur content, sediment concentration, and the salt concentration. The selection of these parameters does not imply that they are responsible for any corrosion in the pipeline but are simply being used as a basis for comparison of one oil to another. The rationale for this approach is that if similar properties are found for dilbit oils compared to conventional crude that have not exhibited corrosivity, then the dilbit would also be expected to be equally non-corrosive. As a basis for comparison, the heavy sour conventional crude oil designated Western Canadian Blend (WCB) was chosen.

The pipeline oil similarity index (POSI) is calculated as follows:

$$POSI = \frac{\frac{Sulfur\ (wt\%)}{3.16} + \frac{Sediment\ (ppmw)}{294} + \frac{Salt\ (ptb)}{71.5}}{} \quad [6]$$

where the values in the denominator for each factor is for WCB; the POSI for WCB, therefore would be 1.0.

Table 1 shows the POSI values calculated for a variety of heavy sour conventional, heavy sour dilbit, heavy sour synbit, heavy sour dilsynbit, medium sour, and light sour crude oils.

Table 1. List of Crude Oil Types and Their Associated Pipeline Similarity Index Based on Eqn. 6.

Country	Crude Type	Crude Name	Crude Code	POSI
Canada	Heavy Sour - Conventional	Bow River North	CAN A	0.82
		Bow River South	CAN B	0.62
		Fosterton	CAN C	0.63
		Lloyd Blend	CAN D	1.02
		Lloyd Kerrobert	CAN E	0.92
		Smiley-Coleville	CAN F	0.66
		Western Canadian Blend	Control (WCB)	1.00
	Heavy Sour - Dilbit	Access Western Blend	Dilbit A	0.69
		Cold Lake	Dilbit B	0.65
		Peace River Heavy	Dilbit C	0.81
		Seal Heavy	Dilbit D	0.79
		Statoil Cheecham Blend	Dilbit E	0.64
		Wabasca Heavy	Dilbit F	0.70
		Western Canadian Select	Dilbit G	1.01
	Heavy Sour - Synbit	Long Lake Heavy	Synbit A	0.59
		Surmount Heavy Blend	Synbit B	0.53
	Heavy Sour - Dilsynbit	Albian Heavy Synthetic	Dilsynbit	1.21
	Medium Sour	Midale	CAN Med Sour A	0.89
		Mixed Sour Blend	CAN Med Sour B	0.63
		Sour High Edmonton	CAN Med Sour C	0.55
	Light Sour	Light Sour Blend	Light Sour	1.09
Mexico	Heavy Sour	Maya	Maya	2.60
Mexico	Medium Sour	Isthmus	Isthmus	0.69
Colombia	Heavy Sour	Rubiales Oil Field	Rubiales	1.26

Figures 1 to 4 are bar charts of the data listed in Table 1. The red horizontal line in the charts at a POSI of 1.0 represents the similarity of the control oil, namely, the Western Canadian Blend conventional crude.

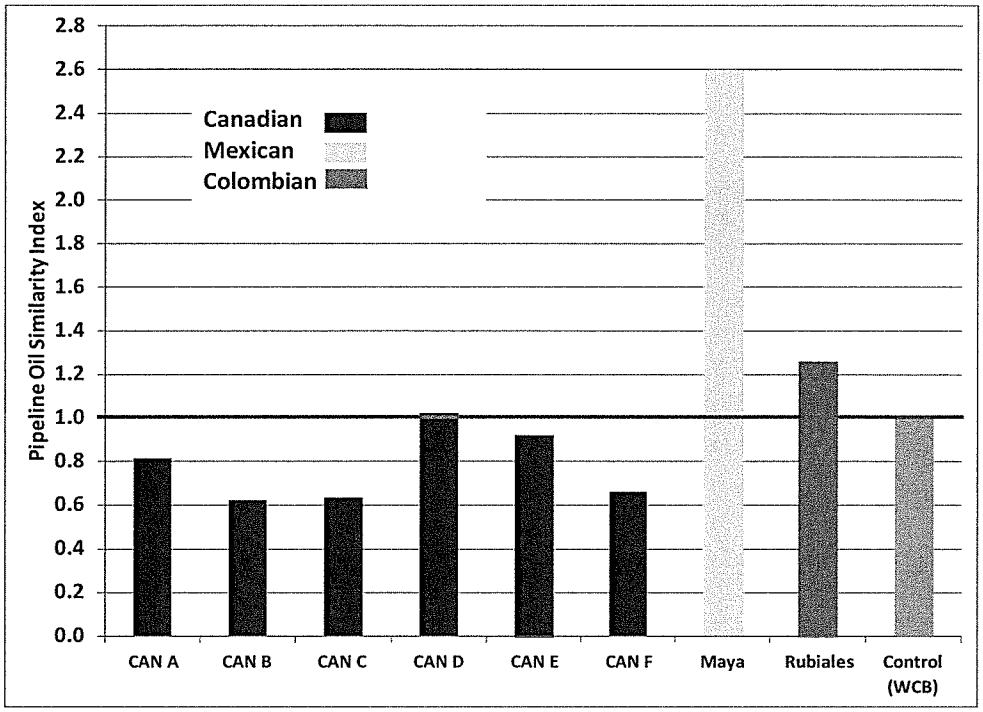

Figure 1. Pipeline oil similarity indices for heavy sour conventional crude oils.

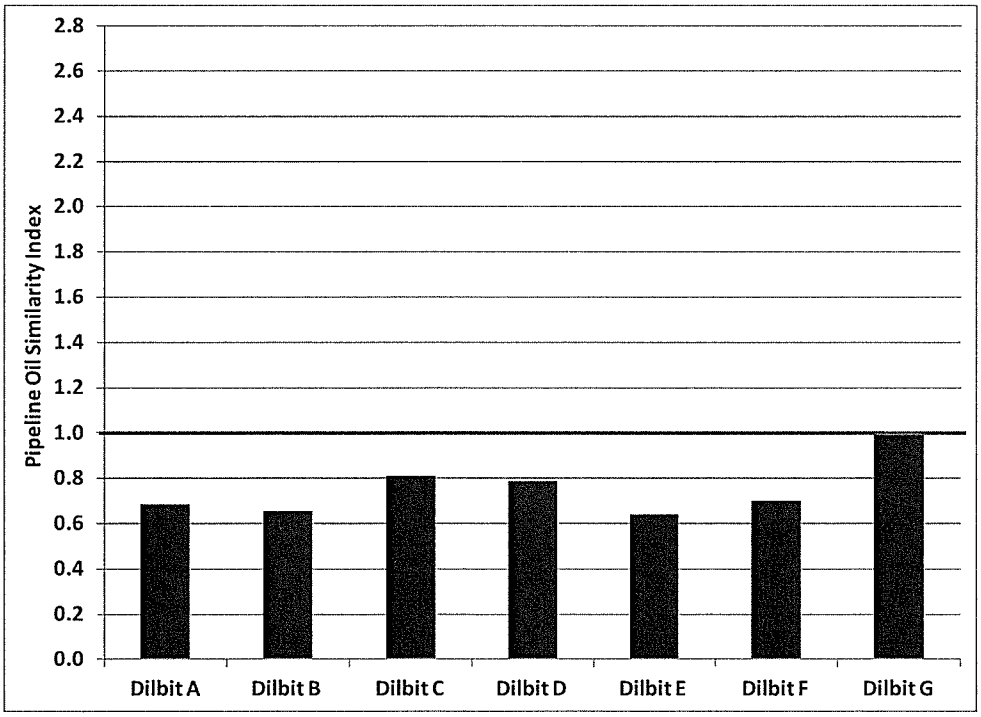

Figure 2. Pipeline oil similarity indices for Canadian heavy sour dilbit crude oils.

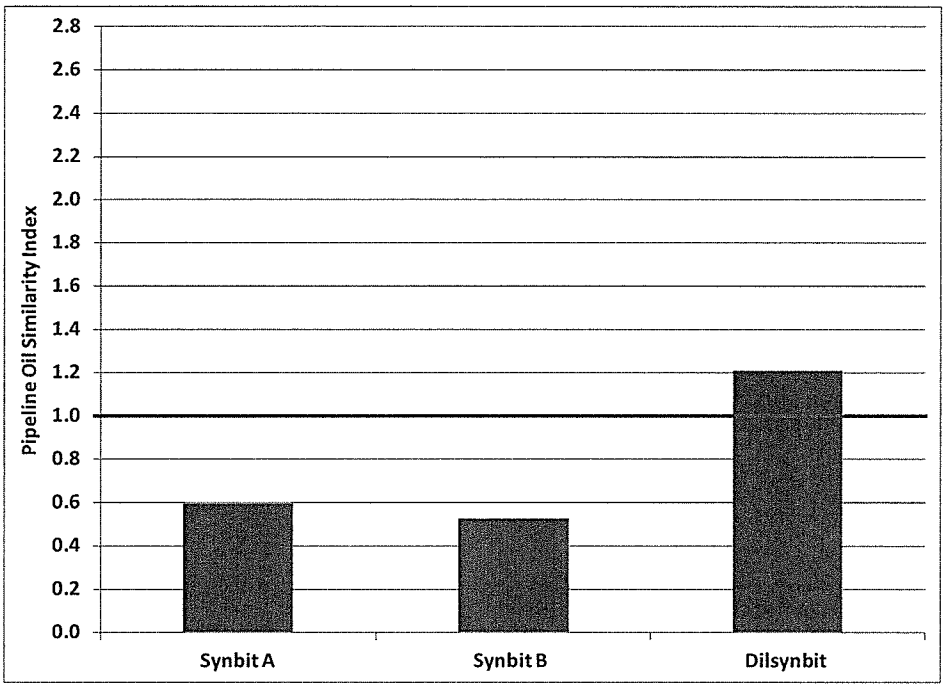

Figure 3. Pipeline oil similarity indices for Canadian heavy sour synbit and dilsynbit crude oils.

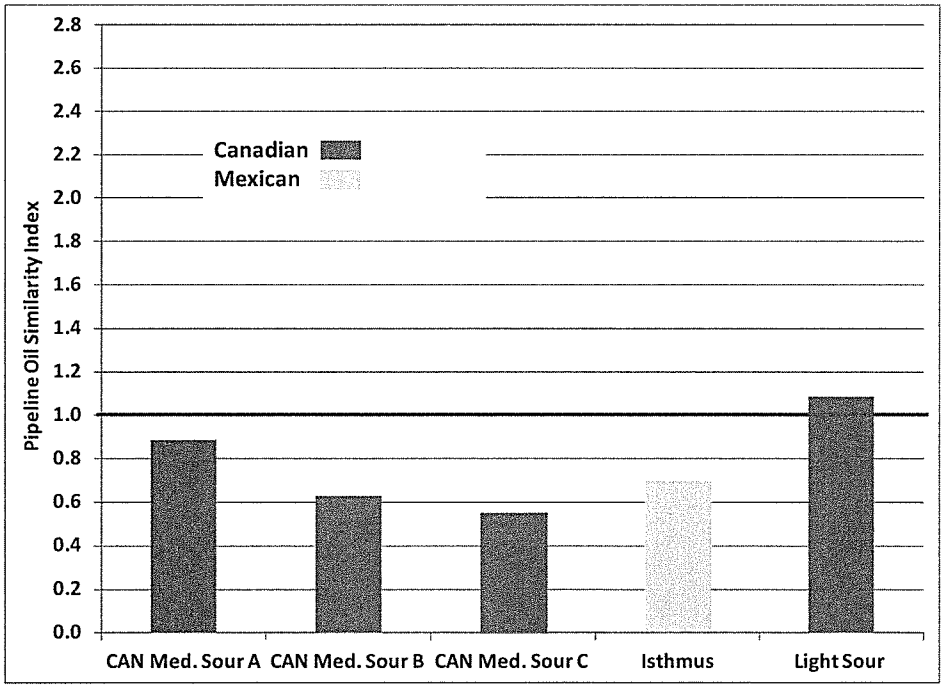

Figure 4. Pipeline oil similarity indices for medium and light sour crude oils.

In Figure 1, the POSI of the Mexican heavy sour conventional crude oil is significantly greater than the Canadian and Colombian crude oils, and the POSI values of all Canadian heavy sours are also less than the Colombian crude oil. Six of the seven heavy sour dilbit crude oils had POSI values less than the control and the seventh dilbit crude oil had the same value as the control (Figure 2). The POSI for the heavy sour synbit and dilsynbit crude oils were either slightly greater or less than the control (Figure 3). All of the medium sour crude oils had POSI values less than the control and the light sour Canadian oil was only slightly greater than the control (Figure 4).

Conclusions and Recommendations

The selection of a Pipeline Oil Similarity Index (POSI) to compare the similarities of various crude oils to one another revealed that the heavy sour dilbit crude oils were either less than or had the same similarity than a typical North American heavy sour conventional crude oil. More striking was the relatively high POSI value of the selected Mexican heavy sour crude, which was greater than any of the other oils randomly chosen for comparison. The key question that is left unanswered is what significance are the POSI values in terms of actual pipeline corrosion.

While choosing a different conventional crude oil as a control will yield different POSI values, the general approach is reasonable from a corrosion engineering consideration for calculating the relative corrosiveness of pipeline oils. While it is clear that the POSI approach does not indicate that crude oil derived by diluted bitumen is more corrosive than any other oil it also shows that the dilbit oils in particular likely have corrosivities close to or less than other heavy sour conventional oils commonly used in North America. In other words, based on the information available, diluted bitumen poses no more of a corrosion risk to pipelines than conventional crudes.

Further insight into similarity follows from absolute metrics of the extent of metal loss due to corrosion for pipelines that transport dilbit as well as conventional crudes. Dialog with operators clearly indicates operational experience with dilbit shows that it does not behave any differently than typical crudes. That dialog is supported by images of the inside of pipelines transporting dilbit, which appear no different than shipping conventional crude after many years of service. This observation is consistent with literature on this topic[i], which concludes that "the characteristics of dilbit are not unique and are comparable to conventional crude oils."

Should there be interest in corrosivity as quantified by the POSI approach, it is recommended that it be further refined to perhaps introduce additional weighting factors to capture the fact that some parameters are anticipated to have a greater affect on pipeline oil's corrosivity than others. Such refinement will likely require collection of additional field data specifically relevant to similarity of pipeline oil, and possibly also benchmark experiments.

Summary and Conclusions

This report evaluated the claim that dilbit is more corrosive than currently transported crudes. This evaluation was made benchmarked against conventional and/or sour crude, and based on the existing literature on crude and dilbit properties and characteristics, data on pipeline integrity and results of engineering assays of pipe that has been transporting dilbit, with such outcomes supplemented to a limited extent by interviews of industry engineering experts from operators with pipelines transporting dilbit.

Major conclusions at a high-level follow:

- Literature on this topic concludes that "the characteristics of dilbit are not unique and are comparable to conventional crude oils."
- The relative measure of similarity developed in this project did not indicate that one oil is significantly more corrosive than any other oil, and that the dilbit oils likely have corrosivities close to the heavy sour conventional oils.
- In addition to this relative outcome, the experience of operators transporting dilbit does not indicate it behaves differently from typical crudes. This view can be supported with images of the inside of such pipelines, which appear no different after many years of service than those shipping conventional crude.

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