Risk Assessments – Do they educate the public? Do they improve decisions?
The Case of the Independent Risk Analysis for the Straits Pipelines

Dr. Adam Wellstead, Michigan Tech

2018 Pipeline Safety Trust Conference
New Orleans, LA October 19, 2018
Background
What? Where?
Strong Public Opposition

Public good issue
Focus of my presentation (Questions posed by Carl)

• What was the public engagement?***
• Why you couldn’t get information/data from the companies or regulators?*
• How your efforts may have changed the discussion of pipelines in your areas?***
• Why people should believe such a community-led effort would produce more than pipeline companies?**
• Whether your efforts weren’t biased and/or just trying to drive to an anti-pipeline conclusion?**
• People also sometimes want to know if you addressed both the consequence of a pipeline failures equally with the probability of one?*
What was the public engagement?***

- A multi-university effort led by the Great Lakes Research Center at Michigan Tech (a public university)
- A well publicized assessment
- Engagement of stakeholders was part of the assessment (Task “X”)
- Overlooked public good derived from this assessment
Why Michigan Tech?

• Originally the risk assessment of a **worst case scenario** was conducted by consulting company.
• Conflict of interest with Embridge one week before release of assessment.
• Assessment had to be redone and FAST!
• State approached Dr. Guy Meadows (Director of Great Lakes Research Center and a member of Pipeline Safety Advisory Board) to submit a proposal.
Most importantly...

Capacity

Competency

Commitment
Project Organization

Team Structure

I. Public & Private Costs
- SL-Lalita Gupta (MTU)
- CS-Frank Lupi (MSU)
- SA-Yongli Zhang (WSU)
- SA-Carson Rouling (WMU)
- SA-Max Melstrom (LUC)
- SA-Steve Miller (MTU)

H. Governmental Costs
- SL-Adam Wellstead (MTU)
- CS-John Bratton (LinnTech)
- SA-David Shonnard (MTU)
- SA-Amlan Mukherjee (MTU)

G. Nat. Resource Damage
- SL-Lalita Gupta (MTU)
- CS-Frank Lupi (MSU)
- SA-Yongli Zhang (WSU)
- SA-Carson Rouling (WMU)
- SA-Max Melstrom (LUC)
- SA-Steve Miller (MTU)

F. Restoration
- SL-Stephen Tuchmann (MTU)
- CS-Avery Demond (UM)
- SA-Aline Cotel (UM)
- SA-Timothy Scarlett (MTU)
- SA-Jill Olin (MTU)

E. Ecological Impacts
- SL-Jill Olin (MTU)
- CS-Charles Ide (WMU)
- SA-Scott Powell (PASS)

D. Public Health
- SL-Kelly Hamm (MTU)
- CS-Richard Olwosoyin (OU)
- SA-Charles Ide (WMU)
- SA-Gerd Paterson (MTU)

X. Broader Impacts
- SL-Roman Sidortsov (MTU)
- SA-Nancy Langston (MTU), Mark Rouleau (MTU)
- and Chelsea Schelly (MTU); Alice Lippert (DoE retired) and Joanne Shore (AFPM retired)

Guy Meadows (PI & CS)
SL-Amanda Grimm
SA-Sarah Green
SA-Sarah Green
SA-Steven Miller
SA-Guy Meadows
Project Organization

PI: Guy Meadows  Project Coordinator: Amanda Grimm

Sub-Section Teams

Section Leads A, B and C  Section Leads D, E and F  Section Leads G, H and I

Section Teams


Broader Impacts Team

X. Broader Impacts Team (cross-cutting)

Final Report

J. Final Report

Title of document here
Many moving parts

- $765,000 may sound like a lot. But...
- Ten task groups
  - Chief Scientist, Section leads, Authors
  - Majority were Michigan Tech faculty members
  - Chief Scientists outside experts (except Task B)
  - Other faculty members from other universities and other organizations
  - Research assistants (graduate students)
- Weekly Section Leader conference calls
- Bi-Weekly Technical Team conference calls
- Regular contact with the State and Enbridge
For many, a balancing act
The final report

- Estimated length = 100 pages
- Final length = 384 pages
  - Feb 1 - Project start
  - July 15 - Delivery of Draft Risk Analysis
  - July/Aug - Public presentation of Draft Report
  - July/Aug - Public comment period 30 days
  - Aug - Respond to public and State input
  - Sept 15 - Delivery of Final Report
- What happened between February & July?**
What we found

- A worst-case spill would release 58,000 barrels of oil into the Straits
- Water and shoreline in either or both lakes would be impacted
- Up to 40% of oil could be recovered from the water surface
- Shoreline clean-up would take 12-24 months
- Sensitive and threatened habitats and species would be harmed
- For the spring scenario expected to result in the highest total damages, liability is estimated as $1.3B in economic losses and $500M in restoration
- In addition to total liability, approx. $200M in net tax revenues would be lost.
- Intangible costs would also be very high
Did We Make a difference?

Final Report Released
September 15th, 2018

October 3rd, 2018

Agreement paves way for Enbridge to permanently shut down, replace Line 5 in Straits of Mackinac

Final Report Released
September 15th, 2018
Media Coverage of the Assessment
Life after the assessment?

- Graduate student training
- Special journal issue
- Follow up research
Section X - Broader Impacts

• Overall approach: if risk cannot be quantified, it does not mean that it does not exist. → perceived risk

• Data sources: 44,966 comments in response to the DR analysis, semi-structured interviews, tribal consultation

• Main concept: Social License to Operate (SLO)

Section Team:
Section Scientists and Authors: Alice Lippert (DoE retired), Joanne Shore (DoE former), Mark Rouleau (MTU), Chelsea Schelly (MTU), John Baetan (MTU), Roman Sidortsov (MTU)
Section Lead: Roman Sidortsov (MTU)
Section X - Quantitative analysis

- Respondents = stakeholders
- Institutional respondents tend to comment on the DR reports, individual respondents tend to focus on risks posed by the Straits Pipelines
- Questionable comments
  - 4 subsets totaling 1,136 comments
  - 884 CEAM comments
- Overwhelming sentiment against the Straits Pipelines
- High organizational influence regarding SLO
Section X – Qualitative analysis

Two main themes: risk identification and risk tolerance/acceptance

• Risk identification:
  • No worst case scenario for supporters, severity of a worst case is very high for opponents
  • Additional risks: sudden service interruption, climate change, lack of trust in the industry and government, not just the Straits, future generations, Michigan’s image and reputation (Pure Michigan, tourism)

• Tolerance/acceptance
  • Split on the ability to manage risk - preparedness, safety record
  • Proponents focus on the benefits, very little risk v. benefit analysis
  • Opponents focus on low benefits compared to the risks and emphasize risk v. benefit analysis: Michigan v. Canada, industry v. people
  • Water is of utmost importance, acceptance of additional costs

• Institutional support by those who directly benefit
Section X – Tribal concerns

• Strong opposition from Michigan’s 12 federally recognized Tribal Nations

• Legal rights, economic dependence, cultural & religious identity, thus, *highly* vulnerable

• Traditionally used flora and fauna for subsistence and cultural purposes, burial and other sacred sites = intergenerational relationship

• Strong basis for litigation, litigation against Enbridge and potentially against the state is near certain
Section X - Summary

• Overwhelming opposition, direct interest generally leads to support
• Opposition’s concerns are generally well-reasoned and well-supported
• Not just the Straits
• Recreancy effect - SLO all but does not exist according to the stakeholders that grant it
• Unanimous and strong opposition by the Tribal Nations and near certain litigation in the case of a petroleum release
• Calculated impacts can only get worse, likely much worse
Thank You
Task A: Identifying and analyzing the duration and magnitude of a “worst-case” spill or release

- US 40 CFR 194.5 defines a worst-case discharge volume as “the largest foreseeable discharge of oil, including a discharge from fire or explosion, in adverse weather conditions”, consider the maximum plausible potential release.

- We found several “worst-case” scenarios for an oil spill.
  - Most shoreline oiled in each lake
  - Most surface covered with floating oil
  - Fastest spread of oil to shorelines

Section Team:
Chief Scientist: Ying Huang (NDSU)
Section Authors: Guy Meadows (MTU), Mir Sadri-Sabet (MTU), Samuel Ariaratnam
Section Lead: Amanda Grimm (MTU)
## Task A: Worst case spill or release

<table>
<thead>
<tr>
<th>Threats</th>
<th>Mode</th>
<th>Pipes Affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrosion</td>
<td>Pinhole leak</td>
<td>One</td>
</tr>
<tr>
<td>Cracking (defects)</td>
<td>Larger area hole</td>
<td>One</td>
</tr>
<tr>
<td>Spanning-related stress</td>
<td>Guillotine rupture</td>
<td>One</td>
</tr>
<tr>
<td>3rd Party damage</td>
<td>Any hole size</td>
<td>One or Both</td>
</tr>
<tr>
<td>Incorrect Operation</td>
<td>Guillotine rupture</td>
<td>One or Both</td>
</tr>
</tbody>
</table>

**Section Team:**
Chief Scientist: Ying Huang (NDSU)
Section Authors: Guy Meadows (MTU), Mir Sadri-Sabet (MTU), Samuel Ariaratnam
Section Lead: Amanda Grimm (MTU)
Task A: Worst case discharge for different tiers of failure

3” pinhole leak, one pipe

**Tier 1:** Shutdown in 3.5 minutes: Spill 4,400 barrels.

**Tier 2:** Shutdown in 13.5 minutes: Spill 8,600 barrels.

3” pinhole leak, both pipes

**Tier 3:** Both pipes. 8,300 barrels (3.5 min shutdown) or 16,800 barrels (13.5 min shutdown).

Full rupture, one pipe

**Tier 4:** Manual shutdown in (1) to 2 hours. Spill: (16,200) 29,000 barrels.

Full rupture, both pipes

**Tier 5:** Manual shutdown in (1) to 2 hours. Spill: (32,400) 58,000 barrels - carried through remaining tasks.

Section Team:
Chief Scientist: Ying Huang (NDSU)
Section Authors: Guy Meadows (MTU), Mir Sadri-Sabet (MTU), Samuel Ariaratnam
Section Lead: Amanda Grimm (MTU)
Task B: Fate & Transport

Predicting where spilled oil would go

- Model used weather conditions such as wind speed, currents, temperatures, and ice cover as well as oil weathering/evaporation to simulate how spilled oil would move.

- It used the conditions from Jan through Dec in 2016.

- The simulations show oil dispersal on the water and in the air, and when and where it would reach the shore.

- 4,380 simulations were run.
Task B: Fate & Transport

Summary:

- Movement of spilled oil depends on the weather in the hours and days after a spill.
- Oil could move into one or both lakes.
- Maximum shorelines impacted:
  - 1,021 km in Lake Michigan
  - 2,006 km in Lake Huron
- VOCs would mostly dissipate over water, limited effects on population centers
Task C: Time to contain and clean up released oil

Case study: longest stretch of shoreline impacted in the shortest time

- Estimate the time to contain and recover oil from water
- Estimate clean-up time for beached oil

Consider:
- Emergency response process
- Resources available
- Weather conditions
### Task C: Estimated time to clean shoreline oil

**Comparison shoreline spills**

<table>
<thead>
<tr>
<th></th>
<th>Deep Water Horizon</th>
<th>Marshall, MI</th>
<th>Refugio, CA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spill volume (Barrels)</strong></td>
<td>4.9 Million</td>
<td>20,082</td>
<td>2500</td>
</tr>
<tr>
<td><strong>Oiled shoreline (miles)</strong></td>
<td>1100</td>
<td>70</td>
<td>24</td>
</tr>
</tbody>
</table>

**Recovery Times**

<table>
<thead>
<tr>
<th></th>
<th>Deep Water Horizon</th>
<th>Marshall, MI</th>
<th>Refugio, CA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Responsible Party engagement period</strong></td>
<td>48 months</td>
<td>51 months</td>
<td>22 months</td>
</tr>
<tr>
<td><strong>Beach closure duration</strong></td>
<td>14 months</td>
<td>23 months</td>
<td>2 months</td>
</tr>
<tr>
<td><strong>Fishing closure duration</strong></td>
<td>5 months</td>
<td>24 months</td>
<td>41 days</td>
</tr>
</tbody>
</table>

**Estimate for Straits: 12-24 months of active beach clean-up.**
## Task D: Public health & safety impacts

<table>
<thead>
<tr>
<th>Drinking water contamination</th>
<th>Fire and explosion</th>
<th>Mental stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Municipal intakes</td>
<td>• Heat/fire from release occurs over water</td>
<td>• Communities with ties to lakes may experience psychological stresses</td>
</tr>
<tr>
<td>→ 12 could be contaminated</td>
<td>• Minimal risk to public</td>
<td></td>
</tr>
<tr>
<td>• Alternative water sources may be needed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Private wells:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>→ low risk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Water testing advised</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Task E: Ecological impacts

Long-term effects

- Oil on the shore can persist for years

- Oil contains toxic PAHs
  - PAHs disrupt endocrine and metabolic systems.
  - Cause cancer, compromised immunity, poor growth and reproduction.

- Juvenile and adult fish, birds, other animals that feed or live in contaminated sediments are at risk
Task E: Ecological impacts

Habitats and Species at Risk

● Habitats:
  ○ Fish spawning grounds
  ○ ≈60,000 acres of rare and unique habitats: open dunes, wooded dune and swale, and marsh

● Key species:
  ○ 47 Threatened or endangered species
  ○ Shoreline mammals: raccoon, muskrat, river otter, beaver, mink, northern long-eared bat
  ○ Migrating birds, nesting shorebirds such as piping plover and terns
Task F: Potential Restoration & Mitigation Measures

Goals
• Methods to restore damaged natural and cultural resources.
• Costs and effectiveness of restoration methods.

• Guided by:
  ○ Natural Resource Damage Assessment (NRDA)
  ○ Damage Assessment and Restoration Plan (DARP)
  ○ defined in the Oil Pollution Act (OPA).

• Restoration types
  ○ Primary - return injured resources and services to baseline
  ○ Compensatory - reimburse the public for losses ← Not included

Only Primary restoration costs were assessed.
Task F: Ecological Resources (Habitats)

Habitats:
Wetlands, Shorelines and Uplands, Open Water, Critical/Sensitive Habitat

Approaches for Restoration
• Removal of contaminated substrate
• Plantings to restore vegetation
• Bioremediation – using natural microbes for oil breakdown

Monitoring
• Monitor habitat structure, the progress of vegetation, and use by animals
• Restoration approaches must not further harm the environment
• Bioremediation can be slow
→ We don’t know much about oil biodegradation in the Great Lakes.
Task F: Ecological Resources (Organisms)

Organisms:
Vegetation, Macrobenthos, Mussels, Clams, Snails, Reptiles, Amphibians, Fish, Birds, Terrestrial Mammals

Approaches for Restoration
• Habitat restoration and creation of new habitat
• Limit human interactions through signage, closures of fisheries, beach closures.

Monitoring
• Existing monitoring programs: Great Lakes Aquatic Habitat Framework, and Michigan DNR.
• Sampling of organisms to monitor populations and species in restored habitats.
Task F: Cultural Resources

Some cultural resources **cannot** be “restored”
   → archaeological sites, shipwrecks
   • Avoid damage during clean-up and restoration.
   • Recover scientific and historical information before
     Damage occurs.
   • **Costs are included** in clean-up and primary restoration projects

Other resources **can** be physically restored
   → historic buildings, lighthouses, monuments, significant
     landscapes
   • **Costs are not included** in this study. Would be calculated as part of compensatory
     restoration.

*Shipwreck at Thunder Bay National Marine Sanctuary*
*Photo Courtesy of NOAA*
Task F: Cost of Restoration

- No comparable spills have occurred in the Great Lakes.

- Estimates were based on Line 6B (Kalamazoo River) and Deepwater Horizon oil spills.

- Costs were estimated per km of shoreline oiled.

- Restoration costs would be between $165M and $1.3B. For the spring worst-case scenario, restoration costs are approx. $500M.
  - Overlap with Task H-estimated gov costs

- Costs will be higher with the addition of cultural resources restoration, compensatory restoration, and litigation costs.
Tasks G/I: Estimating public & private economic damages

Economic damages = lost economic values from worst-case release

Recreation and tourism
- Lost value to recreational users (beaches, fishing, boating, and parks)
- Lost incomes for tourism and recreation-related businesses

Other private costs and losses
- Water supplies
- Energy supplies
- Property values
- Commercial shipping & fishing
Tasks G/I: Economic damages

Tourism income losses

Impact scenarios run through regional economic models for MI & WI to estimate losses to wages and business incomes.

$679.7 Million

High (green) and low (yellow) tourism impact areas: Economic worst case spill

Section Team:
Chief Scientist: Frank Lupi (MSU)
Section Authors: Yongli Zhang (WSU), Carson Reeling (WMU), Richard (Max) Melstrom (LUC), Steve Miller (MSU)
Section Lead: Latika Gupta (MTU)
Tasks G/I: Economic damages

Water supplies

Costs for municipal water intakes for time alternative supplies are needed

Costs for testing for private wells within 200 feet of oiled shorelines

$3.6 Million

Water intakes (green) and private wells (black dots) within 200 ft of oiled shore (red line): Economic worst case spill

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Section Lead: Latika Gupta (MTU)
Tasks G/I: Economic damages

Energy supplies

Pipeline closure affects energy supplies (crude production) and increases prices for propane and gasoline.

$181 Million
Tasks G/I: Economic damages

Property values
Diminished value of property along coasts.

Commercial fishing
Lost tribal and state-licensed harvests during potential closures

Commercial shipping
Costs for waiting and holding until shipping lanes are passable

$45.9 Million
Tasks G/I: Economic damages: total public and private

Lost value to recreation users  $ 459.8
Lost tourism incomes    $ 679.7
Other losses     $ 230.5

=========

Total

$1,370 Million
Task H: Estimating governmental costs of a worst-case release - approach

- Partial estimate of total losses:
  Beach tourism tax ($75M) + cleanup oversight ($123M-$535M) + loss deduction ($263M) = $461-$873 million

- Partial gains: cleanup worker income tax up to $131M

- Net government cost: $330-$742 million
  (does not include excluded costs mentioned previously)
Additional slides for reference during Q/A
Task A: Straits Safety Valve locations

Locations of Safety Valves
Task C: Overview of Spill Response

[Diagram showing the structure of a spill response plan with roles and responsibilities, including State Officials and Emergency Operations Center, Local Officials and Emergency Operations Center, Joint Field Office, Unified Coordination Group, Joint Operations Center, Joint Task Force, External Affairs, Liaisons, Defense Coordinating Element, Chief of Staff, Safety Officer, Operations, Planning, Logistics, Finance/Admin, Emergency Support Functions, and coordination with Private-Sector and Nongovernmental Organizations.]
Task C - Including in situ burning with no wind for 24-hour operations
Recoverable oil over the first five days of a spill using average conditions for each month.
<table>
<thead>
<tr>
<th>Strategy</th>
<th>Description and limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Booming for collection or deflection</td>
<td>Boom is deployed on water toward the approaching current to divert oil in a controlled way to recover oil. Boom can also be used to divert oil away from sensitive shoreline. Boom is used at currents greater than 1 knot (Fingas, 2012). High winds and high waves restrict the use of boom (Al-Majed et al., 2012).</td>
</tr>
<tr>
<td>Exclusionary booming</td>
<td>Use of boom to exclude oil from a sensitive shoreline. Current should not exceed 0.75 knots and breaking waves should not exceed 0.5 feet (US EPA, 2013 )</td>
</tr>
<tr>
<td>Current buster</td>
<td>A system designed to be towed behind a vessel for capture and storage of oil as part of containment strategy.</td>
</tr>
<tr>
<td>In-situ burning</td>
<td>A method for efficient removal of oil from water surfaces by corraling oil and then igniting the oil. Approval and environmental assessment are required.</td>
</tr>
<tr>
<td>Skimming</td>
<td>A method for recovery of oil after it has been collected through booming or current buster technology.</td>
</tr>
</tbody>
</table>
Old versions of slides...

Slides below were replaced by edited (slimmed down) versions
Additions to SOW

• **Team II-X Broader Impacts:** Engage in a qualitative risk identification to provide overview of risks that various affected communities perceive to arise in connections with the Straights Pipelines including Indigenous communities; state, U.S. and Canadian local government officials; environmental and historic preservation groups; as well as tourism, fishing, and recreation industries.

• **Michigan Tech High Performance Computing Cluster:** 256 cores plus 63 standby cores and 5TB memory. This will allow very high spatial resolution of the combined Lakes Michigan-Huron hydrodynamic model (FVCOM).

• **Multi-layer Web Based GIS Portal:** Will be developed as part of this effort, serve to accumulate output from each team, and will be made available to the State upon completion to serve as a rapid response resource inventory.

• **NOAA/GLERL:** Providing two lead numerical hydrodynamic modelers to assist in this effort, at no cost to the project.
Project Organization

PI: Guy Meadows  Project Coordinator: Amanda Grimm

Section Leads
A, B and C

Section Leads
D, E and F

Section Leads
G, H and I

GIS Tool

A. Worst Case Scenario
B. Fails & Transport
C. Clean-up Timeline
D. Public Health
E. Ecological Impacts
F. Restoration
G. Nat. Resource Damage
H. Governmental Costs
I. Economic Outcomes

X. Broader Impacts Team (cross-cutting)

J. Final Report

Title of document here
Task A: Worst case discharge for different tiers of failure

Tier 1: The worst Tier 1 discharge would result from a 3” pinhole leak in the west line near Mackinaw Station with shutdown occurring in 3.5 minutes; the discharge amount would be 4,400 bbl.

Tier 2: The worst Tier 2 discharge would result from a 3” pinhole leak at Location 5 near Mackinaw Station, with shutdown occurring in 13.5 minutes; the discharge amount would be 8,600 bbl.

Tier 3: In Tier 3, both segments are ruptured at approximately the same location. The rupture discharge amounts of the West and East Segments are added together. If this occurs using the response time assumed for Tier 1, (3.5 minutes), the estimated release is 8,300 bbl. If this occurs using the response time assumed for Tier 2 (13.5 minutes), the response time is 13.5 minutes, resulting in a total discharge amount of 16,800 bbl.

Tier 4: In Tier 4, the rupture location associated with the largest release volume is near Mackinaw Station, and the manual shut down time is assumed to be 2 hours. During the 2 hours, the pipeline is assumed to still be carrying crude oil at the full flow rate, and all of the crude oil within this 2 hours is discharged. For one 20" pipe, the discharge amount is 25,600 bbl. After manual shutdown, the drawdown volume on the west line is 3,400 bbl for a total discharge amount of 29,000 bbl.

Tier 5: In Tier 5, the rupture is also assumed to be near Mackinaw Station, and the manual shutdown time is assumed to be 2 hours. During this 2 hours, both pipelines are still carrying crude oil at the full assumed flow rate, 25,600 bbl./h, and all of the crude oil within this 2 hours is discharged. The discharge amount is 51,200 barrels. This is added to the combined post-shutdown drawdown volume of 6,800 bbl from both 20" lines for a total release volume of 58,000 bbl.
Task B: Fate & Transport

- Predicting the likely environmental fate and transport of oil or other products released from the Straits Pipeline under a worst-case release scenario.

- Used hydrodynamic and atmospheric dispersion modeling to predict possible at risk areas for open water and shoreline oiling and also airborne dispersal of pipeline products.

- Comprehensive environmental conditions included: Wind speed and direction, water current strength and direction, water and air temperatures, ice-cover.

- Spill simulations were conducted for the period 01/01/2016 - 12/31/2016 at 6 hr intervals and from 3 release locations (4380 simulations).

Section Team:
Chief Scientist: Pengfei Xue (MTU)
Section Authors: David Shonnard (MTU), David Schwab (UM), Philip Chu (NOAA), Eric Anderson (NOAA)
Section Lead: Gordon Paterson (MTU)
Task B: Fate & Transport

- Of the 4380 cases examined, the one which resulted in the maximum length of impacted shoreline (711 km) began on 2/28 and mainly affected Lake Michigan shorelines.

- The case which resulted in the largest size of the spill in open water (1745 km²) began on 4/24 and also primarily affected Lake Michigan waters.

- Although both of these extreme cases primarily affected Lake Michigan, the majority of cases impacted mainly Lake Huron waters and shorelines, or a combination of the two lakes.

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Task B: Fate & Transport

- Atmospheric dispersal modeling predicted a minimal increase in airborne concentrations of pipeline constituents for Mackinaw City.

- Highest airborne concentrations predicted to be present over the water prior to plume reaching population.

**Summary:**

1. Meteorological conditions are main factors determining transport and fate of potentially spilled Line 5 products.

2. No single ‘worst-case’ scenario.
Task C: Estimation of time to contain and recover oil on water

- Response Options Calculator (ROC) - ‘a publicly available oil spill planning and response model that simulates oil weathering, spreading, and recovery by advanced skimming systems, treatment by dispersant application, and removal by in-situ burning’. It does not include beached oil.

- Effect of wind and wave height included

- Equipment used in simulation (Enbridge + MPC + T&T owned located at the Straits):

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Number</th>
<th>Location and owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Buster IV</td>
<td>8</td>
<td>Straits by Enbridge</td>
</tr>
<tr>
<td>Current Buster II</td>
<td>8</td>
<td>Straits by Enbridge</td>
</tr>
<tr>
<td>Foilex TDS 150</td>
<td>8</td>
<td>Straits by Enbridge</td>
</tr>
<tr>
<td>Lamor Bucket recovery systems</td>
<td>2</td>
<td>Straits by Enbridge</td>
</tr>
<tr>
<td>Medium Drum Skimmer</td>
<td>2</td>
<td>MPC</td>
</tr>
<tr>
<td>Medium Brush Skimmer</td>
<td>1</td>
<td>MPC</td>
</tr>
<tr>
<td>Medium Weir Skimmer</td>
<td>1</td>
<td>T&amp;T</td>
</tr>
</tbody>
</table>
Task C: Results from ROC

Oil recovered as a function of time from ROC simulations with no wind for 24 hour operations.

Oil recovered as a function of time from ROC simulations with the wind conditions for storm (Dec. 27 - 31st 2016).
Task C: Estimated time to clean shoreline oil

• Analysis of three spills that cover a range of oil releases spanning three orders of magnitude from 24 miles to 1,101 miles of shoreline.

• Clean-up operations for a spill in the Straits somewhere between the Marshall MI spill and the Deepwater Horizon spill.

• Active shoreline clean-up from 12 months to 24 months, with the responsible party’s involvement lasting for longer time during the monitoring phases.
Task C: Estimated time to clean up oils on shorelines

• Analysis of three spills that cover a range of oil releases spanning three orders of magnitude from 24 miles to 1,101 miles of shoreline.

• Clean-up operations for a spill in the Straits somewhere between the Marshall MI spill and the Deepwater Horizon spill.

• Active shoreline clean-up from 12 months to 24 months, with the responsible party’s involvement lasting for longer time during the monitoring phases.

Section Team:
Chief Scientist: Aline Cotel (UM)
Section Authors: Stephen Techtmann (MTU), Amlan Mukherjee (MTU)
Section Lead: Daisuke Minakata (MTU)
Task D: Public health & safety impacts

• Assess the scope and magnitude of impacts to public health and safety that could potentially occur in the event of a worst-case Line 5 spill, including
  • contact or airborne exposure to waterborne and atmospheric contaminants,
  • effects on drinking water sources, and
  • fire or explosion hazards
Task E: Ecological impacts

- Identify and produce expert-informed estimates of the magnitude and duration of impacts on potentially affected natural resources, including effects on air and water quality, on fish and wildlife, and on aquatic, benthic, and coastal habitats.
- Evaluate the ecological impacts to natural resources that may result from proposed mitigation and restoration alternatives identified in Task F.
- Identify gaps in data, knowledge or any uncertainties.

Section Team:
Chief Scientist: Charles Ide (WMU)
Section Authors: Marla Fisher (WMU), Robert Powell (PASS), Kevin B. Strychar (GVSU), David Flaspohler (MTU)
Section Lead: Jill Olin (MTU)
Task E: Ecological impacts

Organisms at Risk from Exposure to Oil

Short-term effects

• As the oil spreads in the lakes, animals, plants, and microorganisms that cannot move away from the oil will die
  – Surface organisms, including birds, swimming mammals, amphibians, and reptiles
  – Organisms in the lake bottom sediments and the water column, including primary producers, invertebrates, fish eggs and larvae
  – Plants and submerged vegetation at the shoreline

• Mortality results from coating with oil and exposure to toxic compounds
Task E: Ecological impacts

Organisms at Risk from Exposure to Oil

Long-term effects

• Toxic PAHs will be present in the oil
  – Exposure through contact and ingestion causes disruption of endocrine and metabolic processes including
  – Impaired reproduction, cancer, compromised immunity, decreased growth

• Oil on the shore will be absorbed into sediments and can remain toxic for years
  – Juvenile and adult fish, birds, other animals that eat organisms in contaminated sediments will be at risk

The oil on the shoreline exceeds NOAA Standards for clean-up and remediation
SEC > 1g/m², EF > 100g/m², black
Task E: Ecological impacts

Habitats and Organisms at Risk

• Fish spawning grounds
• Approximately 60,000 acres of rare and unique habitats, including open dunes, wooded dune and swale, and marsh
• 47 state and federally listed species of conservation status
• Shoreline mammals: raccoon, muskrat, river otter, beaver, mink, northern long-eared bat
• Primary producers: plants, phytoplankton
• Migrating birds, nesting shorebirds, i.e., piping plover and tern species
Task F: Potential Restoration & Mitigation Measures

- Identify the potential measures that could be applied to restore the systems affected by the potential worst case spills identified in earlier tasks.
- Identify and assess alternative options for restoring natural and cultural resources and/or mitigating the ecological damages quantified in Task E in terms of the availability, effectiveness, requirements, and costs of each countermeasure.
Task F: Overview

- Restoration of oil spills follows the Natural Resource Damage Assessment (NRDA) and Damage Assessment and Restoration Plan (DARP) process as outlined in the Oil Pollution Act (OPA).
- Restoration takes two forms:
  - Primary - any action that helps return injured resources and services to baseline, or the condition that would have existed had the incident not occurred.
  - Compensatory - any action taken to reimburse the public for interim losses during the period between the oil spill and the return to the baseline condition.
- Primary restoration approaches were the focus of this section as compensatory restoration can only occur after all losses are inventoried and primary restoration complete.
Task F: Ecological Resources (Organisms)

Organisms (Vegetation, Macrobenthos, Mussels, clams, snails, Reptiles and Amphibians, Fish, Birds, Terrestrial mammals)

- **Approaches for Restoration**
  - Habitat restoration and creation of new habitat
  - Limit human interactions through signage, closures of fisheries, beach closures during nesting season

- **Monitoring**
  - GLAHF (Great Lakes Aquatic Habitat Framework) as baseline plus Michigan DNR monitoring system ([https://www.miherpatlas.org/](https://www.miherpatlas.org/)) for reptiles and amphibians, specifically.
  - Sampling of organisms to take place on an agreed upon schedule to monitor the population and distribution of species in the various restored habitats.
Task F: Cost of Restoration

- No comparable spills have occurred in the Great Lakes.
- The costs associated with restoring the Line 6B in Marshall MI and the Deepwater Horizon oil spills were used for comparison.
- Costs per km of shoreline oiled was used to determine costs of a potential spill in the Straits based on modeling from task B (assuming no clean up efforts, which would limit the extent of shoreline oiling).
- Cost to restore a potential spill would be between the costs for Marshall and the Deepwater Horizon spill, a likely range of $165 million to $1,372 million, when containment and recovery is taken into account. Cultural resources restoration, compensatory restoration, and litigation costs would increase this estimate.
Section X - Overview

• Overall approach: if risk cannot be quantified, it does not mean that it does not exist. → perceived risk

• Data sources: 44,966 comments in response to the DR analysis, semi-structured interviews, tribal consultation

• Methodology: mixed-method, largely qualitative discourse analysis premised on grounded theory

• Main concept: Social License to Operate (SLO)
Section X – Qualitative analysis

• Separate analysis of institutional and individual comments
• Multiple rounds of analysis (combination of axial and open coding)
• Two main themes: risk identification and risk tolerance/acceptance
• Risk identification:
  • No worst case scenario for supporters, severity is very high for opponents
  • Additional risks: risk of a sudden service interruption, climate change, lack of trust in the industry and government, not just the Straits, future generations, Michigan’s image and reputation (Pure Michigan, tourism)
• Tolerance/acceptance
  • Split on the ability to manage risk - preparedness, safety record
  • Proponents focus on the benefits, very little risk v. benefit analysis
  • Opponents focus on low benefits compared to the risks and emphasize risk v. benefit analysis: Michigan v. Canada, industry v. people
  • Water is of outmost importance, acceptance of additional costs
• Institutional support by those who directly benefit
  • The Kalamazoo spill is a major factor
Section X – Tribal concerns

• Strong opposition from Michigan’s 12 federally recognized Tribal Nations

• Similar analysis + consultation

• Legal rights, economic dependence, cultural & religious identity, thus, *highly* vulnerable

• Traditionally used flora and fauna for subsistence and cultural purposes, burial and other sacred sites = intergenerational relationship

• Strong basis for litigation, litigation against Enbridge and potentially against the state is near certain
Section X - Summary

• Overwhelming opposition, generally interest-motivated support
• Opposition’s concerns are generally well-reasoned and well-supported
• Not just the Straits
• Recreancy effect - SLO all but does not exist according to the stakeholders that grant it
• Unanimous and strong opposition by the Tribal Nations and near certain litigation in the case of a petroleum release
• A quantitatively described worst case scenario can only get worse, likely much worse