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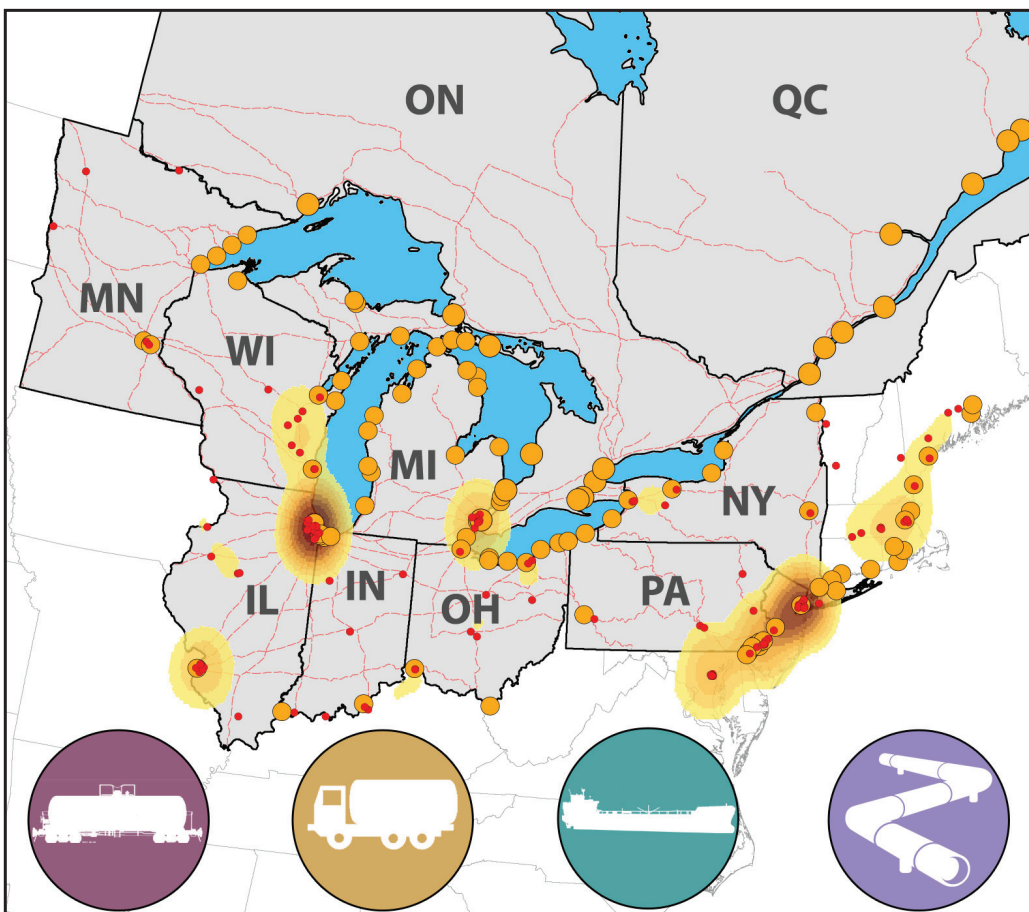
# CaRDI Reports

ISSUE NUMBER 15/NOVEMBER 2014

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## A New Era of Crude Oil Transport: Risks and Impacts in the Great Lakes Basin

by Susan Christopherson and Kushan Dave



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## **A New Era of Crude Oil Transport: Risks and Impacts in the Great Lakes Basin**

**by Susan Christopherson and Kushan Dave<sup>a</sup>**

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<sup>a</sup> Susan Christopherson is Chair of The Department of City and Regional Planning, Cornell University. ([smc23@cornell.edu](mailto:smc23@cornell.edu)),  
Kushan Dave is a Master of Regional Planning candidate at Department of City and Regional Planning, Cornell University. ([kbd47@cornell.edu](mailto:kbd47@cornell.edu))

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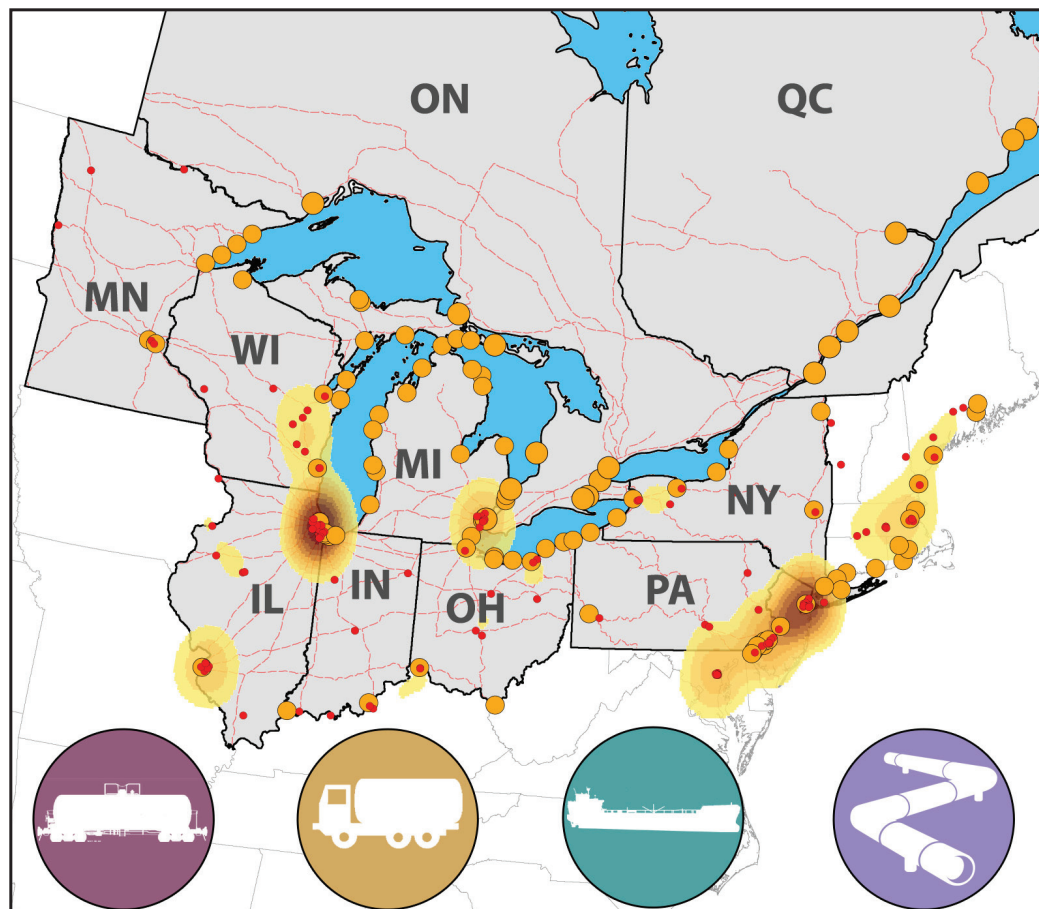
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## Abstract

High global oil prices have encouraged new methods of extraction and distribution within North America. The resulting footprint of unconventional oil extraction is rapidly evolving beyond the extraction locations and extends to the networks used to transport and distribute oil products to refineries and international markets. Questions related to crude oil transportation from newly developed oil fields in the Western US and Canada have been identified as critical to public safety and environmental health by regulatory agencies, such as The US National Transportation Safety Board and in recent assessments by the Great Lakes Commission. Addressing these concerns requires a comprehensive approach that looks at oil extraction, transportation and distribution as integrated processes.

The Great Lakes region is strategic to the connection between key US and Canadian extraction sites and refineries and ports on the East, West and

Gulf Coasts. The increase in oil production has resulted in a dramatic surge in the movement of oil through the Great Lakes basin, which has further increased environmental, public health and safety concerns among regulatory bodies. This report examines the potential risks and impacts associated with the use of land and water crude oil transport networks in the Great Lakes. All the modes of crude oil transport - pipelines, rail, barge and trucks - as well as the transshipment locations where oil is moved from one mode of transport to another, pose potential risks to the environment, public health, and safety. This report describes the range of risks and impacts associated with each mode of transport and at transshipment points. Our goal is to provide a comprehensive literature review of what is known about the range of transport risks and associated impacts so that they can become more visible in analyses of the costs and benefits of unconventional fossil fuel extraction.



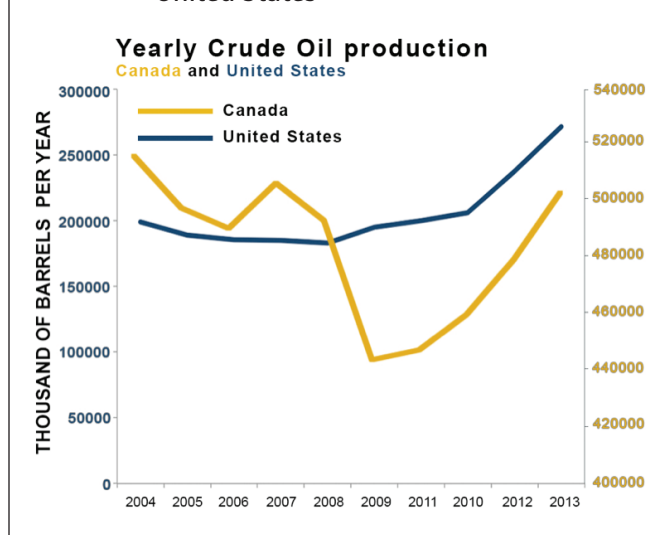
With an increase in oil transportation, ports, transportation routes and intermodal sites are at risk and will require new infrastructure to mitigate impacts.

## What is the Issue?

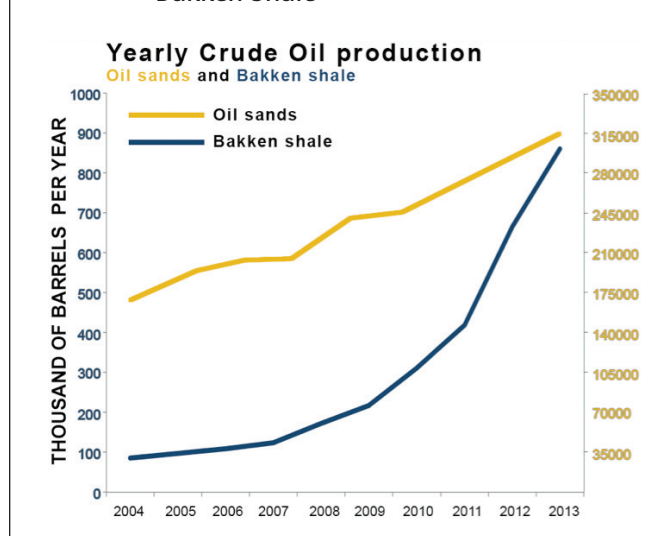
The surge in crude oil shipments in the U.S poses environmental and public safety risks from accidents that may occur on pipeline systems, on railroad lines, on waterways and at transshipment sites. While some risks of oil transport in the Great Lakes region could be mitigated by construction of West-to-East and North-to-South pipelines, oil pipelines are long-term projects, expensive to construct, and with fixed routes. Railroads, barges and trucks provide the transportation flexibility that oil industry shippers require to respond to changing trends in productivity at the resource extraction site and in demand from coastal refineries. So, although pipeline transport may be safer under some conditions, more flexible transport

options are preferred for economic reasons.<sup>1,2</sup> For example, while transport by rail is more expensive than by pipeline, transport time from extraction sites to coastal refineries is reduced from weeks to days.<sup>3</sup> In addition to being economical, shortened transit time also reduces the risk of a catastrophic event since the shipped commodity spends less time in storage. However, each transport system has distinctive risks and impacts. In addition, the regulatory framework within which each transport network operates further complicates the problem of choice since it affects the way risks and impacts of a particular system are mitigated or addressed. Only a small literature deals with the impact of regulatory oversight and liability on choices among transport systems because the focus is generally on the more quantifiable aspects such as commodity weight, perishability, and distance.<sup>4</sup>

**Figure 1: Yearly Crude Oil Production: Canada & United States<sup>5</sup>**



**Figure 2: Yearly Crude Oil Production: Oil Sands & Bakken Shale<sup>6</sup>**



## Freight Transportation Externalities and Assessment of Costs and Benefits

Although analysis of freight transportation choices is carried out to assess their relative costs and benefits, little attention is paid to the externalities, such as environmental risks, created by the transport choices. The absence of evidence on externalities further complicates the analysis of total costs and benefits (including externalities) and their implications for the transportation choice process.

Because transportation is a necessity, consideration of costs without consideration of benefits creates an unrealistic assessment of choices. This is why assessment of costs and externalities associated with particular transportation choices often produces the question: Compared to what? It is in this realm that strategic choices by shippers and carriers enter the picture. Transportation decisions are not solely determined by technology. They are driven by the cost and profit options open to shippers and by politically constructed regulatory systems that provide a framework within which strategic transport decisions are made. For these reasons, the “compared to what?” question is more complex than those who pose it may acknowledge.

In addition, models of transportation costs and benefits frequently assume benefits to non-users because efficient transportation may lower the

cost of the commodity to the non-user. Lower transportation costs do not necessarily reduce the prices paid by non-users, however. They may be taken as profits. And, subsidies (for example in the form of lax regulation) that increase risks to non-users may outweigh lower commodity transport cost benefits.

From a methodological perspective, the taken-for-granted boundaries around cost-benefit analysis of transportation choices make it difficult to comprehensively assess the social and economic costs and benefits of transportation choices and, more broadly, of resource development choices. Assessment is also limited by the absence of place-specific data that allows researchers to analyze the distribution of costs and benefits across places in a transportation network. In the case we look at – that of crude oil transport in the Great Lakes Basin—the absence of place-specific data to enable analysis of risk distribution is particularly in evidence.

The cost-benefit problem may become particularly “wicked” when unintended and unanticipated costs or externalities are considered. For example, how do you weigh the cost of a catastrophic accident, such as that which occurred in July 2013 in Lac Megantic Quebec, killing 47 people? That this question is not easily amenable to cost-benefit analysis is demonstrated by the absence of commercial insurance to cover the costs of such accidents. While it might be theoretically possible to provide insurance against the human and property damage associated with a low probability, high impact accident, that insurance is expensive and unlikely to be purchased. As a result there is probable market failure, with the public forced to assume the costs of low probability, high-risk accidents.

Accepting the risk of such accidents necessarily engages ethical as well as economic considerations. As Greene and Jones noted in describing theories about how to assess the full costs of transportation choices:

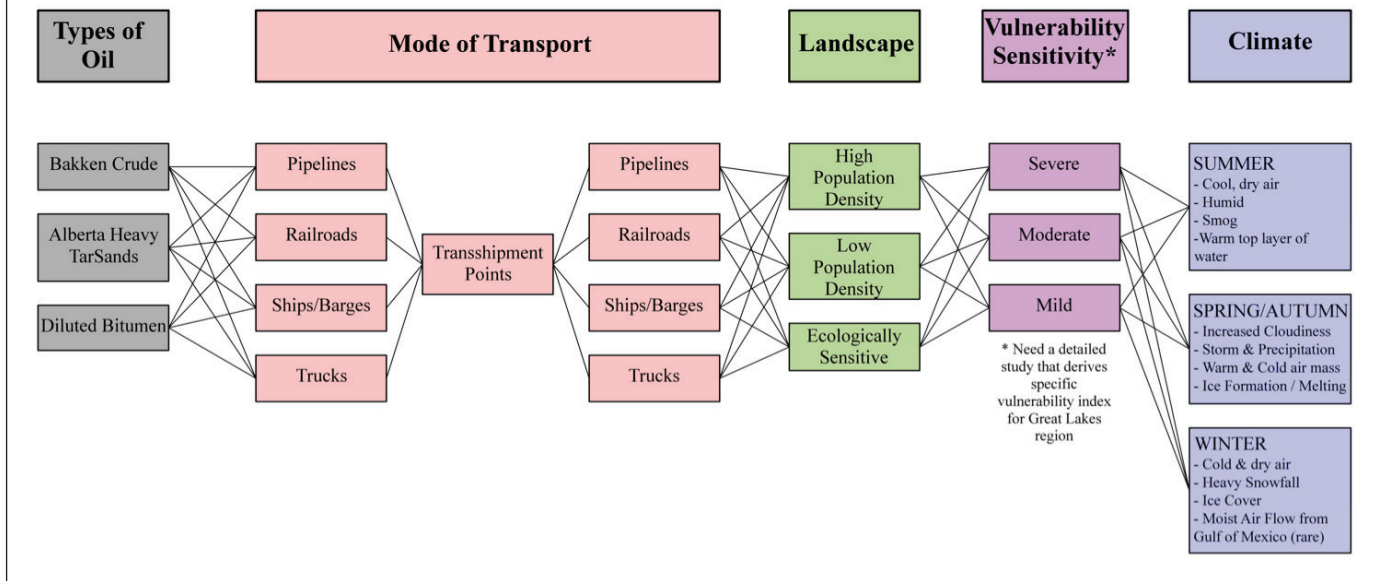
“The conflict of rational economic action and ethical beliefs drives us to continuously search for better ways: better technology, better planning, better operations. Specifying and counting up costs can be an important aid to focusing efforts... Furthermore, the issue of who pays and who benefits will continue to be of interest even in a Pareto-efficient economy.”<sup>7</sup>

The following assessment of risks and impacts from increased crude oil transport in the Great Lakes basin is intended as a step toward effectively weighing costs and benefits, including externalities. This assessment is intended to inform policy development, both in the affected region and at a national scale.

## How Do We Define Risks and Impacts?

Risk is typically defined in relative terms, as a ratio describing the probability of an event with negative consequences. In the case of oil transport in the Great Lakes basin, risk assessment is complicated by: the variety of landscapes potentially affected by an oil spill-related incident; the vulnerability of those landscapes to damaging impacts, and the type and extent of the incident (see Figure 3). An “incident” may range from a minor spill of light “sweet” crude oil on isolated rural land in the winter (limiting ground contamination) to a major catastrophic spill of tar sands crude oil in one of the Great Lakes or a derailment-produced spill and fire in a major urban area. Moreover, the risks can be further complicated based on the properties of oil being transported – for instance, research shows that dilbit from Canada has corrosive properties and weathers quickly while Bakken crude oil is volatile with a low flashpoint and may be more explosive than conventional crude oil.<sup>8,9</sup>

Because of the diverse nature of oil spills, it is difficult to predict the duration of impacts on the ecosystem, human health and the regional economy. As the Deepwater Horizon oil spill demonstrated, impacts on fisheries, local businesses and tourism may persist until the oil has been completely removed, and in some cases, long after the oil has been removed.<sup>10, 11</sup> In the Great Lakes region, key industries, such as agriculture and sport and commercial fishing are at risk. Agricultural land, (67,000 square miles as of 2012) and the commercial fishing catch (approximately 110 million pounds annually as of 2012), could be impacted under a worst-case scenario.<sup>12, 13</sup> In addition to resource-based industries, manufacturing industries in the Great Lakes region include steel, paper, chemicals and automobiles. As these industries rely on use of the Great Lakes basin water for industrial processes, they could also be impacted by oil spills.<sup>14</sup> Moreover,

**Figure 3: Conditions Affecting Oil Spill and Risk Severity**

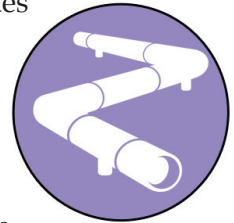
the Great Lakes region is home to some of the most pristine and ecologically sensitive areas in the world and is considered central to the physical and cultural heritage of North America. A spill in such an important and sensitive region can have far reaching consequences. Finally, in addition to the impacts caused by a spill itself, clean-up techniques can compound the environmental impacts in ecologically sensitive areas.

As has already been indicated, transport of two types of crude oil is predicted to increase dramatically across the Great Lakes states and provinces and through the waterways: 1) light crude shale oil, particularly from North Dakota's Bakken Shale; and 2) exceptionally heavy "tar sands" crude from Northern Alberta region, sometimes as diluted bitumen (dilbit). It is expected that light crude from U.S. shale and heavy crude from Canadian tar sands will play a prominent role in commodity transport in the Great Lakes states and provinces into the 2020s.<sup>15</sup> In the next sections we examine what is known about risks and impacts associated with different crude oil transport options.

## Modes of Crude Oil Transport in the Great Lakes Basin - Associated Risks and Impacts

### Pipelines

The Canadian and United States pipeline infrastructure has been responsible for domestic and international transportation of oil for over a century. The 44,117 miles of Canadian crude oil pipeline infrastructure, regulated by National Energy Board, stretches from Vancouver, BC to Montreal, QC in the Great Lakes region.<sup>16</sup> The Canadian pipelines are highly integrated with the United States crude oil pipeline infrastructure, which spans over 57,348 miles including in eight of the Great Lakes states.<sup>17</sup> Within the Great Lakes region, active crude oil pipelines extend over 9,122 miles.<sup>18,19</sup> Although studies show that, by comparison with other modes of transport, pipelines have a lower incident and fatality rate per billion ton-miles of oil transported, a pipeline oil spill can have severe and long lasting impacts on the environment and regional economy.<sup>20</sup>



The quality of pipeline infrastructure is an important contributor to oil spill risk in the Great Lakes region. According to the Office of Pipeline Safety, much of the pipeline infrastructure has

been in place for decades.<sup>21</sup> In the U.S Great Lakes States, 55% of the pipelines were installed prior to 1970.<sup>22</sup> While it is difficult to deduce the age of pipeline infrastructure in the Great Lakes Canadian provinces, the National Energy Board's statistics from July 2011 show that approximately 48% of Canadian pipelines carrying hazardous liquids were installed more than 30 years ago.<sup>23</sup> Additionally, incident data collected by PHMSA (Pipeline and Hazardous Material Safety Administration, U.S Department of Transportation) show that the most common cause of spill incidents is pipeline infrastructure failure.<sup>24</sup>

### Associated Risks:

**a) Pipeline Quality:** Over time the quality of pipeline performance declines due to material deterioration, cracks from corrosion, erosion and defective welding. Notable examples are the two Enbridge pipelines that lie below water to the west of Mackinac Bridge in Northern Michigan. These pipelines were installed in 1953, over 60 years ago, and have never been replaced.<sup>25</sup> As noted by a PHMSA report, old pipelines are prone to corrosion and material and weld failure. This deterioration accounts for 60% of pipeline failure and rupture incidents resulting in an oil spill.<sup>26</sup> Similarly, Enbridge Line 9, installed in 1975 and made of carbon steel with wall thickness varying between 6.35 – 9.5 mm, was found to have multiple external cracks on January, 2014.<sup>27</sup> Moreover, studies from North Dakota, Minnesota, Wisconsin, and Michigan show that the corrosive effect of dilbit oil caused spills of 38,220 barrels of crude, or 30.3% of the total crude oil spill in the United States between 2007 and 2010.<sup>28, 29</sup>

**b) Natural Hazards and Extreme Weather Conditions:** Pipelines in the Great Lakes region traverse areas subject to damage from ice, currents, floods and lakebed erosion leading to landslides, which can have detrimental effects on the pipeline infrastructure.<sup>30</sup> Furthermore, the flood maps and information provided by FEMA's Flood Insurance Rate Maps date back to the 1970's.<sup>31</sup> The outdated information can lead to increased risk. The lack of contemporary information and data create uncertainties regarding the effects of proposed pipeline infrastructural expansion, particularly the risks associated with extreme weather conditions.

Long-term data from an effective monitoring program are, for example, critical to assessing the risks associated with the proposed expansion of Enbridge pipeline 6B, which crosses over four rivers at points within 20 miles of Lake Michigan.<sup>32</sup> To cite only one instance, the extreme weather conditions, resulting from ice in winters and deep surface currents in opposite directions can create massive clean-up challenges in the event of an oil spill.<sup>33</sup>

- c) Monitoring:** Pipelines require constant monitoring and accidents may result from undetected failures due to insufficient or delayed monitoring. For instance, the National Wildlife Federation's underwater dive in 2013 highlighted some of the structural defects of Line 5 that were previously unnoticed.<sup>34</sup> In future, if Line 5 starts to transport DilBit, a lapse in monitoring defects could lead to catastrophic accidents. For example, during the Enbridge Kalamazoo river spill, the pipelines spilled for more than twelve hours before the pipeline was finally shut down.<sup>35</sup>
- d) Out-dated Regulatory Regime:** Studies show that more efficient external sensors could improve on the performance of current sensors, which have detected only five percent of pipeline spills in the U.S.<sup>36</sup> However, the existing regulatory framework has failed to effectively enforce improved monitoring standards. Moreover U.S. pipeline regulations do not require pipeline companies to make public if they are transporting bitumen, which may create greater spill risks.<sup>37</sup> Such disclosure might aid state and provincial officials in preparing for spills. The inability to provide up-to-date data and sporadic monitoring lapses may exacerbate the risks from pipeline spills. While studies show that upgrading pipeline infrastructure with the automatic shut-off valve can reduce potential risks, the current regulations do not enforce such upgrades.<sup>38, 39</sup> Pipeline companies may discourage the installation of remote shut-off systems due to heavy installation costs.<sup>40</sup>
- e) Physical Environment:** In the Great Lakes, pipelines traverse diverse ecological areas including many locations that are pristine, protected areas that are sensitive to environmental degradation, and remote areas that are isolated – where there is a risk of delayed emergency response. Both these conditions contribute to the



potential risks of pipeline spills.

The pipeline safety statistics from 2000-2009 reported 411 spill incidents in Canadian pipelines and 3,318 spill incidents in the U.S. pipelines.<sup>41</sup> Within the eight U.S. Great Lakes states, 559 hazardous liquid spill incidents between 2004-2010, resulted in property damages of over \$1.1 billion.<sup>42</sup> Although data from Canada's National Energy Board (NEB) and U.S. Department of Transportation (DOT) show that pipelines result in fewer oil spill incidents and personal injuries than road and rail, the cumulative impact of a spill on the environment, economy and human health of the affected region remains to be examined.

### Impacts:

Across the bi-national Great Lakes region, oil pipelines are often located in close proximity to dense urban as well as ecologically sensitive areas. As mentioned below, a spill can jeopardize surrounding neighborhoods, commercial industries, including agriculture, and waterways, resulting in severe immediate and long-term potential impacts as the released product spreads over or penetrates deep into soil or waterways. In addition to the existing pipelines, new infrastructural proposals may impact the Great Lakes region, which supports recreational activities that are vital to the regional economy and nurture an ecosystem that is home to rare plants and animals. Cases in particular are the Enbridge Line 6B and Line 9 that create risks for Lake Michigan and the Ottawa river in Ontario respectively – both provide important drinking water supplies.<sup>43, 44</sup>

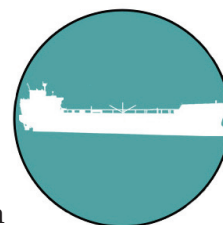
- **Ecological:** Research indicates that floating oil spills cause death from oil ingestion in aquatic and semi aquatic mammals, and that submerged oil causes abnormalities, including spinal deformation, eye defects etc., in the newly born aquatic species.<sup>45</sup> A land spill can degrade the top-soil or penetrate deep into a local aquifer, impacting the health and economic well being of the near-by communities.
- **Human Health:** The diluent in the DilBit evaporates-rapidly in the air and can lead to high airborne levels of toxic components. This impacts the health and safety of the emergency responders as well as the surrounding communities.<sup>46</sup>

Moreover, the proximity of pipelines to groundwater sources within the Great Lakes Region can cause serious contamination that can have a detrimental impact on communities.<sup>47</sup>

- **Economic:** In addition to the costs incurred in clean-up activities, an oil spill may negatively impact the regional economy. After the Enbridge pipeline Kalamazoo river spill in 2010, some homeowners in surrounding communities sold their homes, fearing a fall in market prices. In 2014 local businesses continue to be affected by loss of clientele. Either a water or land spill can result in significant economic and employment costs by putting existing jobs at risk.<sup>48</sup>

## Ships and Barges

About 70 per cent of the tar sands crude recently extracted in Alberta, Canada was sent to refineries in the Midwestern U.S.<sup>49</sup> However, the surge in Alberta tar sands has increased the total quantity of oil transported to refineries in the U.S. by 53 per cent between 2011 and 2012.<sup>50</sup> Although large quantities of crude oil are not being transported over the Great Lakes currently, the interconnecting channels of the Great Lakes do provide favorable conditions for oil shipments in future. In places such as Hennepin, IL and Albany, NY, barges are used to transport small quantities of crude oil as an alternative to rail transport.<sup>51</sup> In the absence of crude oil shipments through the Great lakes, an analysis of recent hazardous liquid spill data from commercial vessel shipping on the Great Lakes can point to some of the associated risks. Studies show that ships and barges pose fewer risks in transporting hazardous liquids than trains and trucks, and have economic advantages over other modes of transport.<sup>52, 53, 54</sup> However the possibility of an oil spill, particularly of tar sands crude oil, in open waters or inland-restricted waters poses risks with potential long lasting impacts on the environment and the economy.<sup>55</sup>



### Associated Risks:

- Collisions:** A barge or tanker ship hull containing crude oil can suffer severe structural damage as the result of a collision with another ship, resulting in an oil spill. The latest regulations by

Transport Canada require all tankers, small and large, to be double-hulled by 2015.<sup>56</sup> Similarly, in the United States, under the Oil Pollution Act (OPA) of 1990, double-hulled tankers will replace the double bottom and double side vessels by 2015.<sup>57</sup> According to Coast Guard data, there are currently 10 domestic ships transporting oil and finished petroleum over the Great Lakes and most of these have met the OPA requirements.<sup>58</sup> The Galveston Bay (Texas) oil spill shows that, while structurally safer, the double-hulled ships and barges do not provide complete protection in the event of high impact collisions.<sup>59</sup> Moreover, depending on the type of oil in the vessel, the impact resulting from collision may cause fire and explosion.<sup>60</sup>

- b) **Spill Spreading in Connecting Channels:** Many of the refineries, oil storage facilities and ports lie along the connecting channels and tributaries of the Great Lakes.<sup>61</sup> Water currents and climatic conditions pose a risk of spreading the spill into the adjacent watershed, which can complicate a comprehensive response.
- c) **Regulatory Risks and Human Error:** A special risk arises from the nature of ship and barge operations, which might not be addressed by existing regulatory measures. For instance, ship and barge traffic does not have set routes and intersections as compared to railroads or trucks. The seaway traffic needs to be controlled partly by remote dispatchers, which increases the risk of human error leading to an accident – an important risk in the advent of increasing oil shipments over the Great Lakes. In addition, the current regulations may compound the risks since they rarely require the vessel operators or harbor personnel to be aware of up-to-date emergency procedures in the event of a spill.<sup>62</sup>

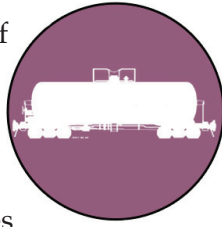
#### Impacts:

Spilled oil weathers quickly, breaking down and changing its physical and chemical properties. In this process, the oil can have impacts on flora and fauna of the Great Lakes depending on their sensitivity to oil contamination. Such impacts are difficult to measure and can complicate the response process. In addition, depending on the type of oil, the impacts can have different repercussions for the environment, health and economy.

- **In Open Water:** In tar sands crude spills, the diluent hydrocarbon (eg. Benzene) floats on the surface of the water. The ingestion and inhalation of the resulting toxic fumes can endanger seabirds and mammals. Furthermore, since tar sands crude oil is heavier than water, it can sink to bottom of the lake or river bed making the extraction process resource intensive and, in a few cases, impossible.<sup>63</sup> Similarly, the Bakken light crude oil has a high proportion of hydrocarbons that make it viscous and explosive at the same time. Owing to its high volatility, a Bakken oil spill could result in a fire or explosion. More importantly, a spill in open water (and shoreline) can affect the approximately 26 million people living in the Great Lakes basin who depend on the Great Lakes for their drinking water.<sup>64</sup>
- **At Shoreline:** Apart from impacting the flora and fauna, the arrival of oil at the shoreline can be detrimental to the environment as well as to human coastal activities. The washed away oil that reaches coastal wetlands and beaches can severely impact commercial and sport fishing activity - an important industry of the Great Lakes – and other commercial industries dependent on Great Lakes water usage for industrial purposes.<sup>65</sup>
- **Economic:** The commercial fishing industry, including fishermen and suppliers of marine-related produce, can be damaged in an event of an oil spill. Simultaneously, small and medium businesses (especially tourism businesses) incur heavy losses due to cordoned off waterways. After the clean up, these industries incur additional expenses to retrieve lost clientele.<sup>66</sup> The Great Lakes waterway system is a critical trade and industry corridor. The increased use of ships and barges to transport Alberta tar sands crude may also “crowd out” existing commercial cargo such as coal, limestone, grain, newsprint, and cement, raising prices in the industries they supply.<sup>67</sup> Shipments of crude oil via trains have already begun to crowd out commodity shipments to North-West ports, and ship and barge transport could potentially follow a similar path.<sup>68</sup>

## Railroad Transport

According to the Association of American Railroads, 434,000 carloads of crude oil moved by rail across United States in 2013, roughly 45 times the amount shipped in 2008, and the volumes continue to rise.<sup>69</sup> The reason that oil shipping by rail has expanded is the ability of rail to quickly respond to increasing resource extraction. In addition, railroads are willing to enter into shorter-term contracts with shippers (oil companies), which further adds to their flexibility in a constantly changing oil market.<sup>70</sup> However, the increased volume of transport has also led to a surge in oil spill incidents. Over the period of 1996-2007, railroads consistently spilled less crude oil per ton-mile than either trucks or pipes. However, in 2013 alone, the total gallons of oil spilled by rail were more than the combined total from 1975-2012.<sup>71, 72</sup> The recent disastrous events – Lac-Mégantic QC, Casselton ND, Aliceville AL, Lynchburg VA. – and the growth in projections in volume of oil transport by rail have raised serious safety and environmental concerns about the transport of crude oil by rail.<sup>73</sup> Owing to these increasing incidents, rail transportation of crude oil has received more public and regulatory scrutiny in the U.S. and Canada.



### Associated Risks:

- a) Infrastructure:** Studies of Federal Railroad Administration data show that 60% of the freight-train accidents are caused by derailments.<sup>74</sup> Research also shows that the major causes of derailment are broken rails or welds, buckled track, obstruction and main-line brake operation – one of the reasons for the Lac Mégantic derailment incident that resulted in a catastrophic fire and explosion was the failure of brakes.<sup>75</sup> Other similar derailment incidents, such as that in Aliceville Alabama point to failure of trestles, which are antiquated and have not been adequately maintained – It should be noted that this accident remains under investigation –an official NTSB report on the incident was not produced when this policy brief was written.<sup>76</sup> In addition, factors like abnormal train speed, weather conditions and human-error can contribute to oil spill incidents.
- b) Tank Car Design:** The DOT-111/Class 111 tank car is most frequently used to ship crude oil in the US and Canada. Several problems have been identified with this tank car model. These tank cars are prone to structural failure and rupture upon impact. Studies from TSB and NTSB show that the DOT-111/Class 111 car's wall thickness (7/16 inch) might not be sufficient to withstand impact during an accident.<sup>77</sup> The top-fittings, used for loading and unloading of content, may burst open in a derailment or rollover. The head shields, at the front of the cars, are prone to puncture in a collision. The three bottom valves, facilitating quick unloading at the terminals, break easily on impact, thus releasing the oil. Out of the 63 oil-filled tanker cars that derailed in Lac-Mégantic, 60 (95%) cars spilled oil due to tank car damage – puncture of shell and front/rear heads were identified as the major causes.<sup>78</sup>
- c) Crossings:** Unmonitored crossing points are special risk zones where accidents with automobiles, vans, trucks and buses can increase the risk of oil spill or explosion. With the advent of unit trains, which are frequently over a mile in length, drivers may be tempted to run through closed crossings. Monitoring of crossings, including illegal trespassing, and installation of proper infrastructure are the responsibility of local law enforcement officials who do not have the manpower to monitor crossings in densely trafficked urban areas. For example, the recent accident between a truck and an empty oil tanker in West Nyack, NY that led to fire and explosion, points to lack of infrastructure (safety gate system) and lack of monitoring.<sup>79</sup>
- d) Mixed and Unit Trains:** Unit or block trains carry one commodity in multiple tank cars. Unit trains may contain between 120 and 140 tank cars and are typically over a mile long. The volume of oil carried in unit trains poses particular risks because a derailment may result in fire and explosion that can spread to non-derailed tank cars. While volume carried is less concern in mixed trains, the lack of complete information about commodity contained in the tanker can increase risks since operators may change the sequencing of cars during the rail journey.<sup>80</sup> The risks are further heightened if the emergency procedures being adopted in the US and Canada focus exclusively on unit trains. Mixed trains

carrying crude oil are not adequately studied in risk analysis and emergency preparedness programs that address crude oil transport.

- e) **Train Assembly:** Research shows that improperly assembled trains are more susceptible to derailment.<sup>81</sup> The distribution of cars that are empty or loaded and short or long affects the train's ability to negotiate track routes while subjected to 'stretching' and 'compressive' forces that may result in derailment. In addition to train assembly, other factors like track grades and turning radius affect train maneuverability, and may result in derailment.
- f) **Regulatory Regime:** In the U.S., regulations require that railroads have either a 'basic' response plan or a more 'comprehensive' response plan, depending on the volume capacity of the rail car transporting the oil. In 1996 the Federal Railroad Administration (FRA) set the threshold differentiating the response plans at 1,000 barrels, thus deterring the applicability of a comprehensive response to incidents caused by new DOT-111 cars that carry around 700 barrels.<sup>82</sup> Proper classification of trains hauling crude oil is critical because it ensures that hazardous materials are placed in the appropriate tank cars and that emergency responders will know the right protocols to follow in the event of an accident.<sup>83</sup> However such regulations do not ensure the safety of a manifest train, where cargo gets loaded and unloaded at different transshipment sites.
- g) **Human Capital Planning:** In the quickly changing scenario of oil transportation, local agencies might find it difficult to recruit, train and allocate new employees to meet dramatically increased volumes of crude oil transport and associated risks. The FRA (Federal Railroad Administration) is facing strategic human capital planning challenges to cope with increase traffic flow, new technologies and new regulations – a risk that is applicable to all the modes of transport.<sup>84</sup>

An important issue that remains to be investigated is train speeds and corresponding dwell time – the amount of time a train spends between its destinations. Data from the Association of American Railroads (AAR) show that between 2013-2014 the dwell times remained 25% above the previous

average time, while the average train speeds were 12% slower than during the same period in 2013.<sup>85</sup> Reducing dwell time and increasing train speed would reduce the total time that oil trains spend in populated areas. However, whether changing this ratio will reduce the probability of accidents, requires further research.

### Impacts:

The US Federal Railroad Administration-approved tracks that carry crude oil shipments often run in close proximity to dense urban areas, environmentally sensitive areas and important bodies of water, including the Great Lakes. With a potential risk of fire and explosion, an oil spill could have a severe and long lasting impact on a regional economy.

- **Environment:** An oil spill into bodies of water and on land surfaces can have detrimental effects on the environment as well as human activities. The most dangerous impact, specific to railway incidents, is the release of hydrocarbons and other toxic materials during an explosion that can contaminate the air.
- **Human Health:** Apart from air contamination causing respiratory disorders in surrounding communities, the biggest threat is that to human life if a fire and blast occurs.<sup>86</sup>
- **Economic:** In the event of a catastrophe, the railroad companies have insufficient insurance coverage to pay for accident damages. Damages may require public investment to rebuild lives, fund soil or water remediation and reconstruct the local economy.<sup>87</sup> Furthermore, an explosion can inflict severe property damage that can disrupt communities and neighborhoods.

### Tanker Trucks

Tanker trucks provide flexibility, linking extraction sites and refineries to pipelines and rail terminals. As compared to other modes of transport, trucks are primarily used to transport oil for relatively short distances because long distance transport by truck is not an economical option.<sup>88</sup> Although trucks transport only a small percentage of the total oil being moved in the U.S. and Canada, and an even smaller percentage in the Great Lakes region, the increase in truck oil shipments can be a



cause of concern. The truck oil shipment from shale formations in North Dakota and tar sands in Canada to U.S. refineries increased by 38% between 2011 and 2012.<sup>89</sup> The existing studies on truck transport indicate that trucks are not a favored mode of transport due to high incident rates per billion ton-mile when compared to rail, ships/barge and pipeline.<sup>90, 91</sup> However the surge in production can change the transportation trends. In the absence of studies on tanker trucks carrying crude oil, studies of trucks hauling hazardous liquids can point to some of the associated risks and impacts.

### Associated Risks:

- a) **En route collision:** As compared to other modes of transport, tanker trucks operate in close proximity to the general public and share the same infrastructure – highways, roads, neighborhoods etc. This increases the risk of accidents, including collisions and accidents at crossings, during the course of their journey. Since a collision can involve vehicles traveling at high speed, the chances of fire and explosion are higher.<sup>92</sup>
- b) **Inadequate Infrastructure:** Since trucks are often used to transport oil to and from railway transshipment sites and pipelines, poorly maintained and monitored infrastructure at delivery points and fuel loading terminals could contribute to accidents, including fire and explosion.<sup>93</sup>
- c) **Truck Design:** While loading the oil through the bottom lines of the tanker trucks, the lines do not drain completely into the main tanks because they are at the lowest point. The structurally fragile bottom lines can contain more than 50 gallons of the hazardous liquid, referred to as ‘wetlines’, and may contribute to an event leading to fire and explosion.<sup>94</sup>
- d) **Regulatory Regime:** A significant risk emerges from lack of information – for example, the U.S. Department of Transportation does not track the total number of cargo tank trucks operating within United States.<sup>95</sup>

### Impacts:

Although tanker trucks account for only 4 percent of the total crude oil and petroleum transport, the high incident and fatality rates in comparison with other modes of transport, create a higher probability

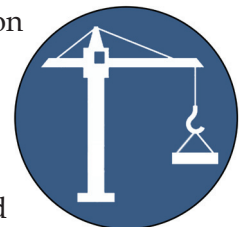
for a catastrophic event every time a tanker truck is on the road.<sup>96</sup>

- **Environment:** Previous experiences with truck-related oil spills indicate that the biggest threat to the environment is the contamination of active water streams whose water is used for household and industrial purposes.<sup>97</sup> Additionally, similar to aforementioned land and water spill impacts, the after effects of a spill can be felt on flora and fauna and on human activities.
- **Human Health:** Apart from the threat of air contamination, an oil spill can cause fire and explosion resulting in serious injuries and/or fatalities and loss of property.<sup>98</sup>
- **Economic:** An oil spill causing fire and explosion can inflict property damages that can have a long lasting impact on the housing prices of the area. Moreover, a cordoned off highway and/or closure to important business routes can affect businesses in the area.

### Transshipment Sites

The surge in crude oil production from the Western US and Canada is changing the ways in which oil is moved in both countries and the geography of oil transport lines, networks, and nodes. Transshipment sites are being expanded in some instances and new ones created. These include truck transfer sites at the point of extraction to connect with pipelines; loading and off-loading sites at rail spurs and in rail yards; and transfer and storage sites at refineries and ports. One example of this industrial transformation is at the Port of Duluth-Superior at the border of Minnesota and Wisconsin. A corporation that owns a refinery at the port is repairing a shipping dock and has proposed to build an oil terminal at the port. These new facilities and the risks they pose are based on estimates of 35,000 barrels of crude oil from Canada being shipped across the Great Lakes as soon as 2015.<sup>99</sup>

While some Great Lakes transshipment sites are becoming more important because of their proximity to booming oil fields or other geographic advantages, some transshipment sites and their facilities are less economically viable because they are linked to older and now declining sources of resource extraction. This is an inherent feature



of the boom-bust cycle of resource extraction-based economies. To cope with uncertainties, oil companies use multiple modes of transport to link key production sites and refineries. They also utilize make-shift facilities, as has happened in North Dakota, to provide immediate services. These temporary facilities are likely to create more risks than those that have been planned carefully and vetted by regulators.<sup>100</sup>

As the Bakken shale oil production and Alberta tar sands oil production intensify, so will the transshipment and trans-loading infrastructure in the Great Lakes states and provinces. The Bakken Oil Express rail terminal in North Dakota, constructed in 2011, receives oil from two pipelines with 22 truck loading bays and 55,000 feet of rail loading.<sup>101</sup> In the US Great Lakes states, recent information suggests that Canadian Pacific railway has five and the BNSF railway has nine crude oil trans-loading facilities that can potentially increase their operating capacity to meet the rising demand of crude oil transportation.<sup>102, 103</sup> To add to these are the 15 major ports and 50 smaller regional ports along the Great Lakes-St. Lawrence Seaway region that are at risk from oil spills and 75 active ports on U.S side and 29 on the Canadian side.<sup>104, 105</sup> Smaller inland ports may also pose indirect risks to the Great Lakes, should they choose to ship oil as a commodity. The Wood River, Illinois port, for example, off-loads 40,000 barrels per day of heavy Canadian crude from pipelines onto barges, which creates the risk of a spill incident.<sup>106</sup>

The anticipated growth of crude oil shipping will require more and more efficient transfer facilities that can handle the increased flow of traffic. Both the design and monitoring of these facilities to reduce risks remain open questions.

#### Associated Risks:

**a) Human Error:** The most common risks associated with transshipment points are the technical failure and defects of equipment such as an oil loader at a barge and truck-loading terminal that can cause oil to spill.<sup>107</sup> Past studies attribute the majority of failures to human errors while operating loading equipment at a terminal, however an updated study of the Great Lakes region is required that points to more precise risks.<sup>108</sup> In addition, as mentioned earlier, ships and barges have limited fixed routes and are

maneuvered by local dispatchers. This increases the chance of human error that can result in industrial accidents, causing fire and explosion during docking, or collision between incoming and outgoing tankers.

**b) Storage and Maintenance:** Cargo shipments may stay docked for days at transshipment points before being transferred to other modes of transport and they may not be monitored for leakage and/or accidental damages. – a case in particular is the incident at the Port of Albany where 100 gallons of oil was spilled from a stored rail car because of a pressure release valve.<sup>109</sup> To respond to the increasing supply of oil, transshipment sites have begun to increase their oil storage capacity, which further increases the risk.<sup>110</sup>

**c) Regulatory Regime:** The vast majority of Great Lakes ports are not managed by a single entity. On the U.S side, the majority of the docks are privately owned and located around federally-maintained navigation channels. The control of property and operations lies with the private entity. In rare cases, especially major cities, ports are managed by local public agencies while the docks are privately owned. In these instances, the control of docks lies with private entities, and in part with local public agencies. Similarly, federal port authorities, provincial governments and municipal governments manage the ports, while private companies own the docks in Canadian provinces.<sup>111</sup> The ambiguous issue of control and ownership can complicate the risk governance process. As with other transport risks “arenas”, transshipment sites are affected by the absence of current information on the potential risks they face; risks that may be exacerbated by an increase in the volume of oil they are handling. For example, outdated coastal flood maps may underestimate a variety of dangers to Great Lakes carriers. The Great Lakes region experiences lake level changes, coastal flooding, long and short time soil erosion and storm surges among other hazards.<sup>112</sup> These hazards can potentially cause physical damage to the port infrastructure that can then lead to a catastrophic event.

The existing literature on crude oil transportation focuses almost exclusively on the modes of transportation and overlooks the substantial risks

of transshipment points in the U.S. and Canada. A comprehensive understanding of risks and impacts of transshipment ports can help to manage these critical points and reduce the possibility of catastrophic accidents.

### Impacts:

The impacts of an incident at a transshipment point are similar to the aforementioned shoreline, land and open water spill. Similar to these risks, the most distinctive impact at a transshipment point comes from unmonitored docked cargos that can turn from a small oil spill into a catastrophic event. Furthermore, unclear accountability for the docked cargo, between docking and unloading, can complicate or delay an oil spill response.

- **Economic:** A spill or a catastrophic event at transshipment point renders it dysfunctional for days. The impact can be felt by commercial freight as well as the tourism industry, which can affect the regional and national economy.<sup>113</sup>
- **Proximity to population:** A transshipment site, such as a port, rail yard, or refinery may be adjacent to a residential neighborhood. In the event of an accident, this residential area may be at serious risk from fire or explosion.

## What are the Gaps in Our Knowledge of Risks and Impacts?

This report provides evidence that all the modes of crude oil transport through the bi-national Great Lakes basin pose risks that depend on a number of factors – the type of crude oil being transported, population density, ecological vulnerability, emergency preparedness in the region, and climate and weather conditions. The resulting impacts may have complex consequences for the environment, human health and economy of the region. Both complex risks and impacts make it difficult to formulate a comprehensive oil spill response. Our understanding of risks and impacts is limited by what we know from the accidents that have happened thus far. Although some of the literature reviewed in this report recommends one mode of transport over the other, the conclusions are based on partial data and evidence and rarely reflect the rapidly changing physical, regulatory, and economic environment of crude oil transport in

the Great Lakes region. With the surge in crude oil transportation, there are important issues that need to be addressed to develop a more comprehensive response to reduce the risks of spills

- **Relative Risk Analysis:** The most important step is to develop a more complete analysis of relative risks and impacts that systematically considers all the factors for each mode of transport – economic consequences, incident rates, fatality rates, potential long-run environmental damages, etc. Such scenario-based research could focus on the distinctive risks and impacts for each mode of transport.
- **Regulatory Gaps and Risk Governance:** Governance can affect the way that risks are managed and impacts are mitigated. This report points to some of the obvious gaps in the existing regulatory regimes. However, there are other gaps that have not yet been fully addressed. For instance, the issue of liability is not fully addressed by the market or by regulators. In the case of rail transport, the shipping and carrying companies are often under-insured and the costs of accident remediation clearly exceed the insurance coverage available in the commercial market.<sup>114</sup> Although shared liability, where the government bears the costs over and above the cap established by commercial insurance, seems a possible solution, using public money to cover risks created by transport of a highly profitable commodity necessarily attracts public scrutiny. The issue is further complicated by the ambiguity of liability when the oil is in transit. An approach such as diverting severance tax from general state revenues to a dedicated environment and community restoration fund for future compensation, may be a more effective way to mitigate potential impacts.<sup>115, 116</sup>
- **Emergency Capacity:** Some local governments lack professional emergency responders and must rely on volunteer fire fighting teams during a catastrophic incident. Reliance on volunteers to address major industrial accidents jeopardizes the lives of citizens and precludes an effective risk mitigation strategy. To meet the challenges of crude oil transportation, the Great Lakes states and provinces and their respective national governments should update the information that underpins their regulatory regimes. Already

accepted regulatory regimes, such as that governing airline safety, can provide effective working models that can be used to evaluate the safety and response mechanisms for the various modes of transport that ship crude oil.

- **Emergency Preparedness for Major Accidents:** Emergency preparedness for minor incidents, although useful, may not provide adequate preparation for major incidents with catastrophic consequences – low probability high impact incidents. Preparedness has been complicated by lack of communication between shippers, carriers, and local emergency responders.<sup>117</sup> Studies of risk management and emergency preparedness indicate that there is a general tendency to under prepare for catastrophic accidents. This preparation is costly and may alarm the public. The alternative course to approach risk and uncertainty is to build a risk management system that reduces risks of high-cost incidents.<sup>118</sup> The regulatory practices by the U.S. Federal Aviation Administration and U.S. Coast Guard can be useful case studies in this process – for example, the Coast Guard already has 29 planned oil-spill response exercises in the Great Lakes region.<sup>119</sup>
- **The Impact of Different Types of Oil:** One contentious topic that emerges out of the current discussion concerns oil characteristics and its implications for transportation infrastructure. For instance, while research indicates that raw tar sands products have higher sulfur content than medium and light crude oils and can contribute to corrosiveness, other research suggests that tar sands products in their transported state are no more corrosive than standard crude oil.<sup>120</sup> Similarly, there has been research arguing for and against the explosive characteristics of Bakken crude oil and its impact on transportation modes and vessels.<sup>121</sup> Studies of oil characteristics, particular to the mode of transport currently used, can help inform the decision process.
- **Land Use Planning in the Great Lakes Region:** The Great Lakes land use planning happens at a local level of government – town, city etc. – so the federal government cannot effectively control this aspect of development.<sup>122</sup> Local land use plans often do not consider the broader impact of oil transport on the surrounding area and nearby communities. In the wake of increasing

oil infrastructure, and with little or no regional analysis in local land use plans, there is a risk of unplanned development that could negatively affect the environment of the Great Lakes region.

This report summarizes some of the key risks and impacts for the Great Lakes states and provinces emerging from a dramatic increase in demand for the transport of crude oil. With rapid expansion of crude oil production in Canada and the US, oil shippers are utilizing the Great Lakes transportation infrastructure to get their product to East coast refineries and into global markets. All segments of this critical transport infrastructure, including rail, tanker ships, and pipelines, are affected along with the ports and sites where the oil is moved from one type of transport to another. The rising demand for crude oil transportation has challenged the response mechanisms and governance frameworks of public and private institutions that provide monitoring, safety regulations and emergency preparedness. The ability to address the risks created by crude oil transport in the Great Lakes has also been affected by fragmented responsibility and limited capacity. The risk and impact information in this initial report is intended to contribute to evolving discussions about how monitoring, safety regulation and emergency preparedness can be brought up-to-speed to insure public safety and the protection of critical environmental resources in the Great Lakes region.



## End Notes

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- <sup>3</sup> Frittelli et al., *US Rail Transportation of Crude Oil*, 7. Moving oil by train from North Dakota to the Gulf Coast or Atlantic Coast requires about 5 to 7 days' transit, versus about 40 days for oil moving by pipeline, reducing producers' need for working capital to cover the cost of oil in transit.
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- <sup>5</sup> Annual growth projection data for United States and Canada retrieved from Energy Information Administration and Canadian Association Of Petroleum Producers (CAPP) respectively.
- <sup>6</sup> North Dakota Field Production data retrieved from Energy Information Administration and Alberta Oil Sands data retrieved from Canadian Association Of Petroleum Producers (CAPP).
- <sup>7</sup> David Green and Donal Jones, "The Full Costs and Benefits of Transportation: Conceptual and Theoretical Issues", in *The Full Cost and Benefits of Transportation* (Berlin: Springer-Verlag, 2007), 1-26
- <sup>8</sup> Anthony Swift et al., *Tar Sands Pipelines Safety Risks* (Natural Resource Defense Council, National Wildlife Federation, Pipeline Safety Trust, Sierra Club, 2011),3.
- <sup>9</sup> *Operation Safe Delivery Update* (PHMSA, 2014), 16.
- <sup>10</sup> America's Gulf Coast: A Long Term Recovery Plan after the Deepwater Horizon Oil Spill (Restore Gulf Coast, 2010), 1.
- <sup>11</sup> Assessing the Long-term Effects of the BP Deepwater Horizon Oil Spill on Marine Mammals in Gulf of Mexico (Maritime Mammal Commission, 2011), 10. The report states that Exxon Valdez oil spill's (1989) long-term effects were felt 15 years or more after the spill.
- <sup>12</sup> Great Lakes Monitoring, U.S Environmental Protection Agency, accessed July 24, 2014, [http://www.epa.gov/glnpo/monitoring/great\\_minds\\_great\\_lakes/social\\_studies/without.html](http://www.epa.gov/glnpo/monitoring/great_minds_great_lakes/social_studies/without.html)
- <sup>13</sup> Land and Shoreline Uses, U.S Environmental Protection Agency, accessed July 24, 2014, <http://www.epa.gov/greatlakes/atlas/gl-fact2.html>
- <sup>14</sup> Consumptive Water Use in the Great Lakes Basin, U.S. Geology Survey 2008, accessed July 24, 2014, <http://pubs.usgs.gov/fs/2008/3032/pdf/fs2008-3032.pdf>
- <sup>15</sup> Welch, et al., *Oil and Water*,1-3.
- <sup>16</sup> "How extensive is Canada's pipeline system?", National Resource Canada, 2013, accessed July 21, 2014, <http://www.nrcan.gc.ca/energy/infrastructure/5893#h-1-3>.
- <sup>17</sup> "Annual Report Mileage For Hazardous Liquid or Carbon Dioxide System 2014", Pipeline and Hazard Materials Safety Administration, accessed July 21, 2014, <http://www.phmsa.dot.gov/portal/site/PHMSA/menuitem-m.6f23687cf7b00b0f22e4c6962d9c8789?vgnextoid=d731f5448a359310VgnVCM1000001ecb7898RCRD&vgnextchannel=3430fb649a2dc110VgnVCM1000009ed07898RCRD&vgnextfmt=print>.
- <sup>18</sup> EIA GIS database, accessed July 20, 2014, <http://www.eia.gov/state/notes-sources.cfm>.
- <sup>19</sup> Data and Statistics for each individual U.S. states can be found at Pipeline and Hazard Materials Safety Administration, accessed July 21, 2014, [http://primis.phmsa.dot.gov/comm/reports/safety/WI\\_detail1.html?nocache=2566#\\_OuterPanel\\_tab\\_5](http://primis.phmsa.dot.gov/comm/reports/safety/WI_detail1.html?nocache=2566#_OuterPanel_tab_5).
- <sup>20</sup> Diana Furchtgott-Roth and Kenneth Green, *Intermodal Safety in the Transport of Oil*. *Studies In Energy Transportation*. (Fraser Institute, 2013).
- <sup>21</sup> Office of Pipeline Safety, *Building Safe Communities: Pipeline Risk and its Application to Local Development Decisions* (U.S. Department of Transportation, 2010), 5. The article states that at least 55% of currently operating hazardous liquid pipelines in the U.S were installed before 1970 and at least 71% were installed before 1980.
- <sup>22</sup> Data on age of pipelines for U.S. states can be found at Pipeline and Hazard Materials Safety Administration database, accessed July 21, 2014, [http://opsweb.phmsa.dot.gov/pipeline\\_replacement/by\\_decade\\_installation.asp](http://opsweb.phmsa.dot.gov/pipeline_replacement/by_decade_installation.asp)
- <sup>23</sup> *2011 December Report of the Commissioner and the Environment and Sustainable Development* (Officer of Auditor General of Canada, 2011), Exhibit 1.5, accessed August 15, 2014, [http://www.oag-bvg.gc.ca/internet/English/par\\_cesd\\_201112\\_01\\_e\\_36029.html#ex5](http://www.oag-bvg.gc.ca/internet/English/par_cesd_201112_01_e_36029.html#ex5).
- <sup>24</sup> *The State of The National Pipeline Infrastructure*, Secretary's Infrastructure Report (U.S. Department of Transportation, 2011), 3.
- <sup>25</sup> Jess Alexander and Beth Wallace, *Sunken Hazard: Aging Oil Pipelines Beneath The Straits of Mackinac An Ever-Present Threat To The Great Lakes*, (National Wildlife Federation, 2012), 2-5.
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- <sup>28</sup> Lara Skinner and Sean Sweeney, *The Impact of Tar Sands Pipeline Spills On Employment and The Economy* (Global Labor Institute, Cornell University, 2010), 4.

- <sup>29</sup> Swift et al., *Tar Sands Pipelines*, 6.
- <sup>30</sup> "Great Lakes Coastal Resilience Planning Guide", Great Lakes Coastal Resilience, accessed July 23, 2014, <http://www.greatlakesresilience.org/climate-environment/climate-natural-processes#bluff-erosion>.
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- <sup>34</sup> "Concerns Mount About 61-year Old Enbridge Pipeline in the Great Lakes", DESMOG CANADA 2014, accessed July 21, 2014, <http://desmog.ca/2014/03/06/concerns-mount-about-61-year-old-enbridge-pipeline-great-lakes>.
- <sup>35</sup> Swift et al., *Tar Sands Pipelines*, 7.
- <sup>36</sup> "Little Oversight for Enbridge Pipeline Route that Skirts Lake Michigan", Inside Climate News 2014, accessed July 23, 2014, <http://insideclimatenews.org/news/20121227/indiana-enbridge-pipeline-6b-lake-michigan-rivers-dilbit-oil-spill-wetlands>.
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- <sup>38</sup> Paul Parfomak, *Keeping America's Pipelines Safe and Secure: Key Issues for Congress* (Congressional Research Service, 2013), 21. Although the report points at natural gas transmission pipelines, similar technology can also be installed for oil pipelines that can reduce the risks.
- <sup>39</sup> *Studies for the Requirements of Automatic and Remotely Controlled Shutoff Valves on Hazardous Liquids and Natural Gas Pipelines with Respect to Public and Environmental Safety* (Oak Ridge National Laboratory, 2012), 182-185.
- <sup>40</sup> "Safety Valve Was Skipped", The Wall Street Journal, accessed August 16, 2014, <http://online.wsj.com/news/articles/SB10001424052748704506004576174322210513228>
- <sup>41</sup> Focus on Safety and Environment: A Comparative Analysis of Pipeline Performance – 2000-2009 (Nation Energy Board, 2011), accessed July 24, 2014, [http://www.neb-one.gc.ca/clf-nsi/rsftyndthnvrnmnt/sfty/sftyprfrnmncndctr/fcsnsfty/2011/fcsnsfty2000\\_2009-eng.html#s2\\_5](http://www.neb-one.gc.ca/clf-nsi/rsftyndthnvrnmnt/sfty/sftyprfrnmncndctr/fcsnsfty/2011/fcsnsfty2000_2009-eng.html#s2_5)
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- <sup>43</sup> Alexander and Wallace, *Sunken Hazard*, 6-10.
- <sup>44</sup> *Economics of Transporting and Processing Tar Sands Crudes in Quebec* (Goodman Group, LTD 2014), 8.
- <sup>45</sup> Shanese Crosby et al., *Transporting Alberta Oil Sands Products: Defining the Issues and Assessing the Risks*, NOAA Technical Memorandum NOS OR&R43 (Seattle, WA: Emergency Response Division, 2013), 63-65. The report uses the example of Athabasca River. Although not directly oil spill related, the study investigates the impacts of toxic materials in the oil sands on aquatic and semi aquatic species.
- <sup>46</sup> Jessica Winter and Robert Haddad, "Ecological Impacts of Dilbit Spills: Consideration for Natural Resource Damage Assessment" (paper presented at 37th AMOP Technical Seminar on Environmental Contamination and Response, Alberta, Canada, June 3-5, 2014), 5. The authors state that due to high evaporation rate of diluents of DilBits in the 2010 Kalamazoo River spill, respirators were required for all personnel in the area of the pipeline break, and residents of nearby homes were evacuated. The NOAA 2013 report (op cit.) also claims that the responders reported elevated levels of benzene in the air relative to those recorded at spills of standard crude oils and that 11 responders and many residents reported having headaches, nausea, and respiratory issues.
- <sup>47</sup> Skinner and Sweeney, *Impact of Tar Sands*, 7. The report states a claim by Dr. Stansbury (University of Nebraska) that a worst-case spill of the proposed Keystone XL pipeline that crosses 1,748 bodies of water, can pose serious health risks to people using that groundwater for drinking water and irrigation.
- <sup>48</sup> Skinner and Sweeney, *Impact of Tar Sands*, 5-10.
- <sup>49</sup> Welch, et al., *Oil and Water*, 2.
- <sup>50</sup> Maude Barlow, *Liquid Pipeline: Extreme energy's threat to the Great lakes and the St. Lawrence River* (The council of Canadians, 2014), 10.
- <sup>51</sup> Frittelli et al., *US Rail Transportation of Crude Oil*, 7.
- <sup>52</sup> Welch, et al., *Oil and Water*, 7-8. According to Coast Guard data, the average annual spill for commercial vessels from 2003-07 was approximately 3,157 gallons (60 events), and the average annual spill from 2008-12 was approximately 10 gallons (50 events).
- <sup>53</sup> "With Production on the rise, oil by barge traffic sets off greater safety concerns", Alberta Oil Magazine 2014, accessed July 25, 2014, <http://www.albertaoilmagazine.com/2014/06/athabasca-mississippi-oil-by-barge/>. The cost of transporting crude oil through barge is \$0.72 per ton-mile, as compared to \$2.24 per ton-mile for equivalent rail capacity. Truck transportation, for the same capacity, is 37 times more expensive
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- <sup>55</sup> Welch, et al., *Oil and Water*, 7-8. According to Coast Guard data, the average annual spill for commercial vessels from 2003-07 was approximately 3,157 gallons (60 events), and the average annual spill from 2008-12 was approximately 10 gallons (50 events).
- <sup>56</sup> *Moving Energy Safely: A Study of the Safe Transport of Hydrocarbons by Pipelines, Tankers and Railcars in Canada* (Standing Senate Committee on Energy, the Environment and Natural Resource, 2013), 24.
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- <sup>58</sup> Welch, et al., *Oil and Water*, 6.
- <sup>59</sup> "Galveston Bay Oil Spill Leaves Hundreds of Birds Oiled", The Texas Tribune, accessed July 5, 2014, <http://www.texastribune.org/2014/04/04/shorebirds-devastated-galveston-oil-spill/>. Miss Susan, a barge, carrying almost a million gallons of heavy oil collided with a commercial ship. The barge is now partially sunk in the channel. One of four tanks on the barge was damaged and started leaking. The oil is now moving from Galveston Bay into the Gulf of Mexico.
- <sup>60</sup> Welch, et al., *Oil and Water*, 7-8. In January 2005, a large explosion aboard Egan Marine Corporation's tank barge, EMC-423, discharged about 84,000 gallons of crude oil into the Chicago Sanitary and Ship canal.
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- <sup>62</sup> *Challenges and Priorities For The Great Lakes – St. Lawrence River*, 19.
- <sup>63</sup> Welch, et al., *Oil and Water*, 4. Based on the lessons learnt from Kalamazoo River spill in 2010, the authors claim that extracting of one barrel of tar sands oil removes four tons of sand and soil and three barrels of water in the process.
- <sup>64</sup> Great Lakes Monitoring, U.S Environmental Protection Agency, accessed July 29, 2014, [http://www.epa.gov/glnpo/monitoring/great\\_minds\\_great\\_lakes/social\\_studies/without.html](http://www.epa.gov/glnpo/monitoring/great_minds_great_lakes/social_studies/without.html).
- <sup>65</sup> Consumptive Water Use in the Great Lakes Basin, U.S. Geology Survey 2008, accessed July 24, 2014, <http://pubs.usgs.gov/fs/2008/3032/pdf/fs2008-3032.pdf>
- <sup>66</sup> "Discussion on Oil Spill Impact", Planete-Energies, accessed June 14, 2014, [http://www.black-tides.com/index.php?chapitre=chap\\_3&menu=c2](http://www.black-tides.com/index.php?chapitre=chap_3&menu=c2)
- <sup>67</sup> Great Lakes Monitoring, U.S Environmental Protection Agency, accessed July 29, 2014, [http://www.epa.gov/glnpo/monitoring/great\\_minds\\_great\\_lakes/social\\_studies/without.html](http://www.epa.gov/glnpo/monitoring/great_minds_great_lakes/social_studies/without.html). The article outlines the major industries shipping cargo across the Great Lakes.
- <sup>68</sup> "Oil trains crowd out grain shipments to NW ports", Seattle Times, accessed Aug 15, 2014, [http://seattletimes.com/html/business/technology/2024172633\\_columbiatrainsxml.html](http://seattletimes.com/html/business/technology/2024172633_columbiatrainsxml.html)
- <sup>69</sup> Frittelli et al., *US Rail Transportation of Crude Oil*, 1.
- <sup>70</sup> Frittelli et al., *US Rail Transportation of Crude Oil*, 5-7.
- <sup>71</sup> "More oil spilled from trains in 2013 than in previous 4 decades, federal data show", McClatchy Washington Bureau, accessed July 4, 2014, <http://www.mcclatchydc.com/2014/01/20/215143/more-oil-spilled-from-trains-in.html>. Oil spilled in 2013 was 1.1 million gallon as opposed to 792,600 gallons between 1975-2012.
- <sup>72</sup> Frittelli et al., *US Rail Transportation of Crude Oil*, 14.
- <sup>73</sup> Furchtgott-Roth and Green, *Intermodal Safety*, 2. The study states that while Canada shipped 20,000 barrels per day (bbl/d) by rail in 2011, the United States ships 115,000 barrels of oil per day, as of 2013 with a projected trend showing an increase to 300,000 barrels shipped per day by rail by 2015.
- <sup>74</sup> Xiang Liu, et al., "Analysis of causes of major train derailment and their effect on accident rates", Journal of Transportation Research Board, No. 2289 (Transportation Research Board of the National Academies: Washington, 2012)
- <sup>75</sup> Frittelli et al., *US Rail Transportation of Crude Oil*, 12.
- <sup>76</sup> "Alabama Oil-Train Derailment", Huffington Post 2013, accessed July 31, 2014, [http://www.huffingtonpost.com/2013/11/11/alabama-oil-train-derailment\\_n\\_4252887.html](http://www.huffingtonpost.com/2013/11/11/alabama-oil-train-derailment_n_4252887.html)
- <sup>77</sup> Presentation on "DOT-111 Tank Car Design", Office of Railroad, Pipeline and Hazardous Materials Safety, National Transportation Safety Board, 2012, accessed July 5, 2014, [http://www.nts.gov/news/events/2012/cherry\\_valley/presentations/hazardous%20materials%20board%20presentation%20508%20completed.pdf](http://www.nts.gov/news/events/2012/cherry_valley/presentations/hazardous%20materials%20board%20presentation%20508%20completed.pdf).
- <sup>78</sup> Rail Safety Recommendations - 23 January 2014, Transportation Safety Board of Canada, 4, accessed August 15, 2014, <http://www.tsb.gc.ca/eng/recommendations-recommendations/rail/2014/rec-r1401-r1403.pdf>.
- <sup>79</sup> Bill Demarest, "Train Accident in West Nyack", Nyack Free Press, December 6, 2013, accessed Aug 16, 2014, <http://nyackfreepress.blogspot.com/2013/12/train-accident-in-west-nyack.html>
- <sup>80</sup> Frittelli et al., *US Rail Transportation of Crude Oil*, 22.
- <sup>81</sup> *Safe Placement of Train Cars: A Report* (U.S. Department of Transportation and Federal Railroad Administration, 2005), 5-10.
- <sup>82</sup> Frittelli et al., *US Rail Transportation of Crude Oil*, 16.
- <sup>83</sup> David Pumphrey, et al., *Safety of Crude Oil by Rail* (Center for Strategic and International Studies, 2014), 3.
- <sup>84</sup> Rail Safety: Improved Human Capital Planing Could Address Emerging Safety Oversight Challenges (U.S Government Accountability Office, 2013), 24.

- <sup>85</sup> See [http://www.stb.dot.gov/filings/all.nsf/ba7f93537688b8e5852573210004b318/ce390a014c57664785257cb7006eb630/\\$FILE/235863.pdf](http://www.stb.dot.gov/filings/all.nsf/ba7f93537688b8e5852573210004b318/ce390a014c57664785257cb7006eb630/$FILE/235863.pdf)
- <sup>86</sup> "Rail Safety Staff Activities: Federal rulemaking follow-up to the Lac Megantic crude oil train tragedy", California Public Utilities Commission Safety and Enforcement Divisions, accessed June 15, 2014, <http://www.cpuc.ca.gov/NR/rdonlyres/A51DD641-447D-4C07-9B68-C8928618B2B0/0/9513CommissionMeetingAgenda3321.pdf>. The report states that there were 47 casualties from explosion and fire and the effects of the blast were felt to about 1 mile radius.
- <sup>87</sup> Marry-Jane Bennett, M, "*Lessons from Lac Megantic – Risk in Transportation of Dangerous Goods*", Frontier Center For Public Policy, Backgrounder No. 113, 2013, 3-4. The pricing of railways is structured to increase traffic and to decrease operational cost/expenses. Moreover, with market prices of TIH (toxic inhalation hazards) and other dangerous goods remaining relatively low, the transportation price remains relatively low in relation to risk as well. Not only is the pricing low, federal laws in both Canada and United States limit the extent to which railways can raise rates in an attempt to cover the risks in the transportation of these goods. Following this, in the Lac Mégantic incident in 2010, the railroad company sought bankruptcy and eventually the government used the taxpayer's money to rebuild the local economy.
- <sup>88</sup> Refer footnote 39 in this article.
- <sup>89</sup> "Oil Shipment by rail, truck, and barge up substantially", Institute For Energy Research, accessed June 24, 2014, <http://instituteforenergyresearch.org/analysis/oil-shipments-by-rail-truck-and-barge-up-substantially/>
- <sup>90</sup> U.S. Rail Transportation of Crude Oil: Background and Issues for Congress, (Congressional Research Service, 2014), Figure 3, 4.
- <sup>91</sup> CSX Transportation claims that "For every billion ton-miles of hazardous materials transported, trucks are involved in more than 10 times as many accidents as the railroads." Union Pacific Railroad claims that trucks are "16 times more likely than train to have hazmat incident."
- <sup>92</sup> "Portion of I-69 remains closed due to tanker explosion", ABC12 News, accessed July 6, 2014, <http://www.abc12.com/story/24347559/portion-of-i-69-remains-closed-following-tanker-explosion>. In Genesee County, Michigan, a tanker carrying crude oil slipped, crashed and exploded on January 2, 2014. Hydro carbons were released in the air and there was a temporary evacuation.
- <sup>93</sup> *Cargo Tank Trucks* (U.S. Government Accountability Office, 2013), 6. Figure 2A points out the possible risks associated during loading-unloading process at delivery points and fuel loading terminals.
- <sup>94</sup> *Cargo Tank Trucks* (U.S. Government Accountability Office, 2013), 1-7.
- <sup>95</sup> *Cargo Tank Trucks: Improved Incident Data and Regulatory Analysis Would Better Inform Decisions about Safety Risks*, (U.S Government Accountability Office, 2013), 3.
- <sup>96</sup> Furchtgott-Roth and Green, *Intermodal Safety*, 11. The authors use Hazmat incident database for incidents between 2005-2009 to conclude that road transportation have the highest incidents per billion ton-miles in the U.S. Moreover, road transportation also has the highest fatality rate amongst the different modes of crude oil transport.
- <sup>97</sup> "Tanker spills, pipelines raise questions about crude oil transport", Desert News, accessed June 24, 2014, <http://www.deseretnews.com/article/865602091/Health-department-concerned-about-culinary-water-after-semi-accident.html?pg=all>. On April 30, 2014, a tanker crashed and spilled 4,800 gallons of oil in Parleys Canyon, Utah. Salt Lake City Department of Public Utility said about 100 feet of active stream was affected by the spill.
- <sup>98</sup> "Tanker truck spill oil, explodes on Long Island", FoxTwelve News. accessed June 24, 2014, from: <http://www.myfoxny.com/story/24248525/tanker-truck-overturns-on-nys-long-island-2-hurt>. Twelve vehicles and three homes were damaged while the driver suffered minor injuries in the incident.
- <sup>99</sup> Yadullah Hussain. Are The Great Lakes the New Transport Lane for Alberta Crude Oil? Financial Post, December 16, 2013. From: [http://business.financialpost.com/2013/12/12/are-the-great-lakes-the-next-pipeline-for-alberta-crude-oil/?\\_\\_lsa=cb87-b7c1](http://business.financialpost.com/2013/12/12/are-the-great-lakes-the-next-pipeline-for-alberta-crude-oil/?__lsa=cb87-b7c1) Accessed July 31, 2014.
- <sup>100</sup> New Town, North Dakota has a make shift facility where trucks transfer the Bakken oil from well heads to Central Pacific rail cars . he Central Pacific Rail branch line terminates at New Town, ND. The Google image shows the make shift facility where tank trucks load oil onto railcars. At the bottom of the image, a more permanent loop track construction can be seen. <http://goo.gl/maps/uBRR5>
- <sup>101</sup> For more information, see <http://www.boemidstream.com/our-facilities/>.
- <sup>102</sup> For details on BNSF Crude Oil trans-load facilities, see <https://www.bnsf.com/customers/oil-gas/interactive-map/pdfs/BNSF-OG-Overview-Map.pdf>.
- <sup>103</sup> For details on Canadian Pacific intermodal terminals, see <http://www.cpr.ca/en/our-network-and-facilities/Pages/default.aspx>
- <sup>104</sup> For more information on Great Lakes Ports, see [http://www.great-lakes.net/teach/business/ship/ship\\_4.html](http://www.great-lakes.net/teach/business/ship/ship_4.html)
- <sup>105</sup> "Manual of Best Management Practices for Port Operations And Model Environmental Management System", Great Lakes Maritime Research Institute, accessed July 30, 2014, <http://greatlakesports.org/pp/uploads/CorsonStudyFinal.pdf>.
- <sup>106</sup> Barlow, *Liquid Pipeline*, 10.
- <sup>107</sup> For a detailed understanding of associated risks during loading and unloading processes that can cause a catastrophic accident, please see <http://www2.uwstout.edu/content/lib/thesis/2000/2000trianag.pdf>
- <sup>108</sup> Curt Hart and John Bernhardt, Department of Ecology Spill Management Program: Prevention and Response Activities: 1994 Annual Report (Washing State Department of Ecology, 1994).

- <sup>109</sup> "100 gallons of oil spiked from rail car at Port of Albany", Times Union, accessed July 3, 2014, <http://www.timesunion.com/local/article/100-gallons-of-oil-spills-from-Port-of-Albany-5588442.php>.
- <sup>110</sup> "Crude Loves Rock 'n' Rail – Bakken Oil Express, Dakota Plains, Bakken Link, & Savage", RBN Energy 2013, accessed July 30, 2014, <https://rbnenergy.com/bakken-oil-express-dakota-plains-bakken-link-and-trenton-railport>. The article says that both the transshipment points, Bakken Oil Express and Dakota Plains have increased their infrastructure and oil storing capacity since 2011.
- <sup>111</sup> "Manual of Best Management Practices for Port Operations And Model Environmental Management System", Great Lakes Maritime Research Institute, accessed July 30, 2014, <http://greatlakesports.org/pp/uploads/CorsonStudyFinal.pdf>.
- <sup>112</sup> For more information on Great Lakes natural hazards, see <http://www.greatlakesresilience.org/climate-environment/coastal-hazards-risks>. For more information on Great Lakes Coastal Analysis and Mapping, see <http://www.greatlakescoast.org/great-lakes-coastal-analysis-and-mapping/>.
- <sup>113</sup> "Oil Spill Cleanup Operation Continues At Texas City Dike After Barge and Tanker Collide", ABC13 News, accessed June 15, 2014, <http://abc13.com/archive/9476801/>. The Houston Ship Channel was blocked for 2 days following a collision of a barge with an oil tanker at the Texas City Dike on March 22, 2014. As many as 60 vessels, most of them petrochemicals, were restricted to get out and get in the port.
- <sup>114</sup> "Risk Assessment for Railroads", Sightline Daily, accessed July 3, 2014, <http://daily.sightline.org/2014/05/19/risk-assessment-for-railroads/>. James Beardly, as quoted in Eric De Place's article, "The maximum possible coverage is \$1.5 billion in liability insurance for Class 1 railroads. Considering that the Lac Megantic impact alone was more than \$2 billion, the coverage seems insufficient especially when the impacts can be severe in a more dense urban area."
- <sup>115</sup> Stephen Breyer, *Breaking The Vicious Circle: Towards Effective Risk Regulation* (Cambridge: Harvard University Press, 1993), 56.
- <sup>116</sup> Susan Christopherson, et al., Risks and Risk Governance in Unconventional Shale Gas Development (Environmental Science & Technology, 2014, accessed October 9, 2014, <http://pubs.acs.org/doi/pdf/10.1021/es502111u>
- <sup>117</sup> On May 7, 2014, Anthony Foxx (Secretary of Transportation, U.S. DOT) signed an order that requires all operating trains containing 1,000,000 gallons or larger amount of crude oil to provide the appropriate SERC – State Emergency Response Commission – with notification regarding their movement through the state's counties. However, such a step is yet to be amended and requires huge logistical planning of the current human capital with the FRA.
- <sup>118</sup> Patrick Roberts, Review of *Catastrophe: Risk and Response* by Richard Poser (Oxford University Press, 2004).
- <sup>119</sup> Welch, et al., Oil and Water, 12. The details of these programs can be found under PREP (Preparedness for Response Exercise Program) guidelines.
- <sup>120</sup> Shanese Crosby et al., *Transporting Alberta Oil Sands Products*, 6.
- <sup>121</sup> *A Survey of Bakken Crude Oil Characteristics Assembled For the U.S. Department of Transportation*, Submitted by American Fuel & Petrochemical Manufacturers (Dangerous Goods Transport Consulting, 2014), 4.
- <sup>122</sup> For more information on land use planning in Great Lakes, see [http://www.great-lakes.net/teach/pollution/sprawl/sprawl\\_2.html](http://www.great-lakes.net/teach/pollution/sprawl/sprawl_2.html)





