Dirty Drilling

The Threat of Oil and Gas Drilling in Michigan's Great Lakes

Bryan M. Clark
Tony Dutzik

Edited by Brad Heavner, Rose Garr, Brian Imus, Margaux Shields and Amy Simpson

PIRGIM Education Fund
February 2002

ACKNOWLEDGEMENTS

PIRGIM Education Fund wishes to acknowledge the Beldon Fund, which provided financial support for this project, and all those who provided editorial and technical support.

The authors alone bear responsibility for any factual errors. The recommendations are those of PIRGIM Education Fund. The views expressed in this report are those of the authors and do not necessarily reflect the views of our funders.

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EXECUTIVE SUMMARY

With recent attempts to reopen the Great Lakes to oil and gas drilling, Michigan faces a significant new threat to its economy, environment, and health. Both offshore drilling – currently banned in Michigan – and directional drilling in the Great Lakes pose unacceptable risks and hazards. Drilling in Michigan's Great Lakes would have significant long-term and short-term negative impacts on the lake's watershed, regardless of the drilling method employed.

Environmental Impacts

Natural gas and oil leaks and spills can have extremely negative effects on the natural environment, both on and off shore. Past safety records from drilling sites across the country indicate that such accidents will take place – it is a matter of when it will happen, not if it will happen. The potential for accidental or routine release of drilling wastes into the environment is alarming. Releases can occur through containment failure, run-off, pipeline accidents, and direct discharge.

Routine drilling wastes, such as drilling muds, cuttings, and produced waters, contain both profuse and varied toxic chemicals that pose significant risks to the environment. These risks to wildlife include developmental defects, shortened lifespan, and physiological changes. Many of the toxic chemicals associated with oil and gas drilling can accumulate and magnify in the food chain. This poses a risk to aquatic organisms higher in the food chain, such as fish and birds. Furthermore, many of these chemicals tend to persist in the environment, leading to long-term, chronic exposure for aquatic organisms.

Economic Impacts

An expansion of oil and gas drilling would likely have a net negative effect on the economy of the Great Lakes region. The annual value of all oil and gas drilling in Michigan – including the small portion that currently takes place under the Great Lakes – is $2 billion, compared to the $11.5 billion spent by tourists traveling 100 miles or more to Michigan locations in 1999.

Oil and gas drilling under the Great Lakes can adversely affect the lake economy in several ways. Oil and gas drilling could lower water quality, both through routine operations and accidental leaks and spills, and would lead to direct conflicts with nearby water-related recreational uses. These impacts could negatively affect the boating and recreational fishing industries, which pump a combined $2.5 billion in consumer spending into the state's economy annually – about a third of which is directly attributable to activities on the Great Lakes.

Moreover, Michigan's water resources are the most frequently cited positive impression created by the state with Midwestern tourists. Thus, real or perceived declines in Great Lakes water quality caused by drilling could reduce the state's appeal to outside visitors, whether or not they partake in water-related recreational activities.

Expanded oil and gas drilling under the Great Lakes would also not bring significant additional revenue to the state. State officials estimate that expanded drilling would bring a *total* of $100 million in additional revenue to the Michigan Natural Resources Trust Fund, compared to *annual* state general fund-general purpose revenues of $9.1 billion.

Human Health Impacts

While the human health impacts of leaks and spills are primarily local in nature, placement of wells onshore puts human health at greater risk from accidents, as well as from routine pollution and discharges. People can also be exposed to toxic chemicals from routine drilling wastes, such as drilling muds and cuttings. As pollutants from oil and gas drilling build up in the food chain, people who consume fish from the Great Lakes will be at serious risk of health problems such as genetic defects and cancer. Routine discharge or accidental release of these materials could be devastating in the densely populated areas of the Great Lakes watershed.

Northern Michigan residents have already experienced negative impacts from the release of poisonous hydrogen sulfide gas from onshore and directional natural gas wells. At least 24 people, five of them children, have been seriously injured due to hydrogen sulfide releases in northern Michigan.

Routine discharges and accidental spills of toxic chemicals from drilling sites can also contaminate the water of the Great Lakes, thus contaminating a primary drinking water source for millions of Michigan residents. Some of these discharges, such as air emissions and runoff, are an unavailable

consequence of oil and gas drilling. Discharge need not occur in the water to impact the water quality. In fact, discharges in the Great Lakes drainage basin can be as significant as discharges directly into the lake.

Regulatory Oversight of Drilling in Michigan

Michigan's history of regulation of oil and gas drilling activities gives little assurance that such activity could take place safely under the Great Lakes. A 1999 audit by the Michigan Auditor General's office found that the Department of Environmental Quality, which is responsible for regulating drilling activities, failed to inspect oil and gas wells as frequently as required, handled citizen complaints inefficiently, and experienced long delays in following up on violations of drilling regulations.

Even with an effective watchdog of the drilling process, present regulations do not adequately protect the Great Lakes. The state's failure to fully implement Michigan Environmental Science Board recommendations for extensive environmental assessment of coastal areas and greater public participation in leasing decisions are especially troubling.

Canadian Drilling in the Great Lakes

The Canadian experience of drilling for natural gas and oil on the Canadian side of Lake Erie serves as a cautionary example for Michigan. Spills associated with the petroleum industry are both widespread and highly significant environmental threats to the Canadian Great Lakes. Fifty-one natural gas spills directly associated with gas drilling in Canada's portion of Lake Erie were documented between 1997 and 2001 – an average of almost one spill a month. The volume of natural gas released and the full duration of the leaks were not reported to or by the Canadian government.

The Canadian side of Lake Erie was also impacted by 83 petroleum spills from all sectors between 1990 and 1995 (the last year for which data was made available for this report). The volume spilled was not known for at least one-third of the spills. In addition, only 45% of the contaminants were cleaned up, on average.

The routine, long-term discharge of drilling wastes from drilling in Canada's portion of Lake Erie represents a significant environmental hazard. These direct discharges into Lake Erie have subjected aquatic organisms to immediate and long-term health risks, ranging from localized fish kills to aquatic organism developmental impairment. These risks are exacerbated by the routine usage of toxic chemicals during oil and gas drilling.

Canadian regulations that track the usage and disposal of toxic chemicals (the National Pollutant Release Inventory) expressly exclude oil and gas drilling operations from reporting. As a result, there is no publicly available data regarding the quantity or extent of toxic chemical usage in the natural gas drilling operations in Canada's portion of Lake Erie. This both restricts research into the safety of the drilling and hampers oversight of that industry.

The Ontario Ministry of Natural Resources, which is charged with regulatory oversight of oil and gas drilling, has shown a historic trend towards a lack of environmental consideration in its permitting. For example, the ministry was severely criticized for its failure to implement the Ontario Environmental Bill of Rights, effectively thwarting citizen access to and involvement in environmental decision-making.

Finally, there is a significant lack of data about the systemic impacts of the Canadian oil and gas drilling operations in the Great Lakes. Neither Canadian nor American governmental agencies have investigated the impacts of existing drilling operations over the past 20 years. Despite this lack of readily accessible data, information pieced together from the Canadian Coast Guard, the Ontario Ministry of Natural Resources, and the Ontario Ministry of Environment demonstrates severe impacts.

Policy Recommendations

Based on the findings of this report, oil and gas drilling in or under the Great Lakes would pose unacceptably high environmental, economic, and public health risks. Many of these risks are inherent to the oil and gas drilling process and, as such, cannot be mitigated by regulatory changes or management practices. As a result, PIRGIM Education Fund recommends that Michigan enact a permanent ban directional drilling under the Great Lakes and maintain its ban on offshore drilling.

Rather than relying on dirty drilling to meet Michigan's energy demands, the state should invest in a cleaner, smarter energy future by promoting energy efficiency and renewable energy. This can be

undertaken with the following: tax rebates and incentives for the purchase of energy efficiency appliances; updated energy efficiency requirements in Michigan's building codes; tax rebates and incentives for the installation of small-scale renewable energy generation equipment; and passage of a Renewable Portfolio Standard that requires 10% of the electricity sold in Michigan come from renewable sources by 2010 and 20% by 2020. By investing in energy efficiency and renewable energy, Michigan can permanently protect the Great Lakes, further protect our other environmental resources, and save Michigan residents money.

AN INTRODUCTION TO MICHIGAN'S GREATEST NATURAL RESOURCE

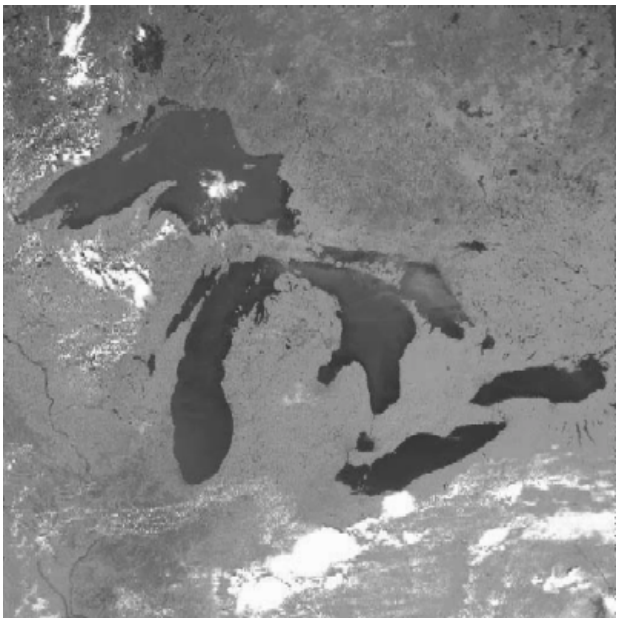
The Great Lakes are arguably Michigan's greatest natural resource. They represent the largest source of surface freshwater on earth, containing 18 percent of the world's supply.[1] Virtually the entire state sits within the Great Lakes basin, which includes 10 percent of the population of the United States and a quarter of the population of Canada. The four Great Lakes that border the state – Superior, Huron, Michigan and Erie – as well as smaller waterways in the Great Lakes system such as the St. Clair River, Lake St. Clair and the Detroit River, define Michigan both geographically and culturally in the minds of residents and visitors.

For years, Michiganders have recognized the unique challenges associated with Great Lakes protection and restoration. Since the mid-1960s, Great Lakes restoration efforts have led to significant improvements in water quality and reductions in industrial emissions to the lakes.

Despite these enormous restoration efforts, the Great Lakes are still in transition into healthy, stable ecosystems. The International Joint Commission has established 43 "areas of concern" under the U.S.-Canada Great Lakes Water Quality Agreement, with those areas defined as "geographic areas that fail to meet the general or specific objectives of the agreement where such failure has caused or is likely to cause impairment of beneficial use of the area's ability to support aquatic life."[2] Thirteen of those areas are entirely or partially within the state of Michigan.[3]

Great Lakes Drilling in Michigan

One threat that most of Michigan's Great Lakes have not had to face is that of offshore oil and gas drilling. For over 16 years, Michiganders have enjoyed the benefits of a moratorium, or non-binding compact, on offshore oil and gas drilling in the Great Lakes. Signed by the Great Lakes governors (Michigan, Wisconsin, Pennsylvania, Minnesota, Indiana, Ohio, Illinois, and New York) the "Statement of Principle Against Oil Drilling in the Great Lakes" stated, in part, that "this precious resource [the Great Lakes] should not be vulnerable to oil drilling and its attendant dangers . . . [T]his action will protect our shared resource from an unwise risk."[4]



Satellite image of the Great Lakes.[5]

Michigan has also enacted a ban on offshore oil and gas drilling in its Great Lakes waters. State law prohibits drilling operations from lake bottomlands or connected bays, harbors or waterways that originate from below the waterways' ordinary high-water mark.[6]

However, Michigan is the only Great Lakes state to allow "directional drilling," in which on-shore facilities tap oil and gas stored beneath the lakes. Beginning in 1979, the state has permitted the operation of 13 directional drilling wells, of which seven, in Manistee and Bay counties, remain active.[7] During this period, leases and permits for directional drilling were typically issued with little public fanfare or involvement, and, as a result, attracted little attention outside of the communities in which drilling was occurring.

The proposal of a particularly controversial drilling operation in 1997, however, brought the issue to wide public attention and created political pressure in support of greater limits on drilling.

Responding to that pressure, the Department of Natural Resources stopped issuing Great Lakes leases in 1997 and Gov. Engler charged the Michigan Environmental Science Board with undertaking a

study of the issue. Gov. Engler charged the board with evaluating the potential for contamination of the Great Lakes by directional drilling, the potential impact on competing uses of Great Lakes shorelines, and the adequacy of existing permits in protecting the shoreline environment.[8] The board's charge was limited and did not include such issues as pipeline safety and air pollution.

While the board found that releases from directly beneath the lakes posed "little to no risk of contamination to the Great Lakes bottom or waters," the board further concluded that there was a "small risk" of contamination at the well head, or the location on land where the drill is inserted. Further, the board found that directional drilling could harm coastal ecosystems due to construction impacts and accidents and that it could create conflicts with nearby land and water uses, including recreation and tourism.[9] The board made a series of recommendations designed to protect shoreline habitat and communities from the impacts of oil and gas drilling, including:

- Drilling operations should be set back at least 1,500 feet from the shoreline.
- Oil and gas drilling should be prohibited in sensitive natural locations.
- Environmental and land use impacts should be considered during the leasing process, and not just during the permitting process.
- Comprehensive coastal zone environmental inventories should be compiled for Lake Michigan and Lake Huron to identify areas that are already impacted by oil and gas development, areas where environmental concerns would preclude oil and gas leasing, and areas where directional drilling could be undertaken if it could be shown to cause only minimal impact.
- Lease sales should prohibit the construction of new infrastructure (such as roads and pipelines) and limit oil and gas development to areas where infrastructure already exists.
- Drilling residuals, such as muds and brines, should not be stored above ground for any length of time without thorough precautions. Drilling muds should not be buried on-site.

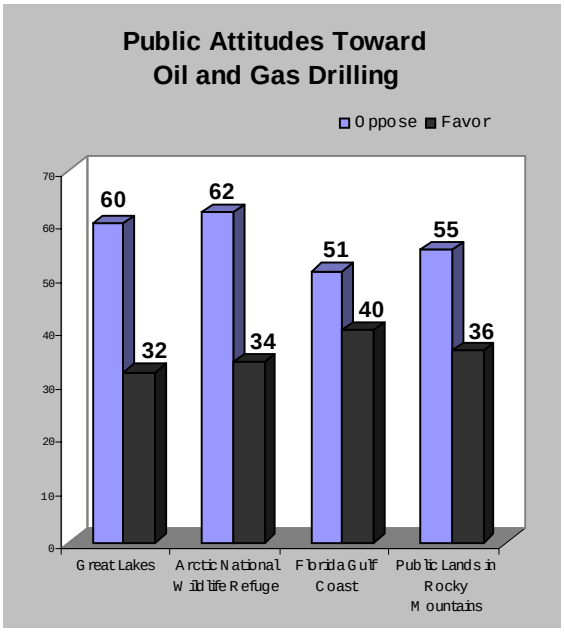
The Department of Environmental Quality adopted several of the board's recommendations, including the 1,500-foot setback and the ban on on-site burial of drilling muds. But other recommendations – such as thorough coastal-zone planning – have not yet been implemented.

As DEQ and other state officials were considering the board's recommendations, the moratorium on Great Lakes oil and gas leasing remained in effect. However, oil and gas companies continued to press for the resumption of drilling. Their efforts received two major political boosts with the spike in natural gas prices experienced during the 2000-01 home heating season and the elevation of George W. Bush to the presidency.

The price spike came about due to a unique confluence of four factors: a lull in the natural gas market due to recent warm winters; restricted cash flow for natural gas producers due to low prices from January 1998 to March 1999; unusually high and unpredictable oil prices in 2000; and a very cold winter in 2000-01.[10] This clearly indicates a temporary price spike, rather than a long-term trend in natural gas prices, as can be seen in the rapid decrease in prices during the second half of 2001.

In response to the 2000-01 natural gas price spike, energy companies and the Bush administration's National Energy Policy laid a course towards ever-greater reliance on new drilling for oil and natural gas. In Michigan, concern over energy prices and availability added new momentum to efforts to lift the temporary moratorium on directional drilling imposed by Gov. Engler. In September 2001, the moratorium was lifted, allowing the state to once again grant leases for drilling. The Michigan Legislature, however, has considered measures to re-impose the moratorium, and similar efforts have taken place in Congress as well.

Michiganders have viewed the debate over the resumption of directional drilling and the push for new oil and gas drilling in the Great Lakes with alarm. A 2001 poll of Michigan residents showed that opponents of increased drilling for oil and gas in the Great Lakes outnumbered supporters by two-to-one. More than 50 percent of those polled supported continuation of the moratorium on directional drilling.[11]



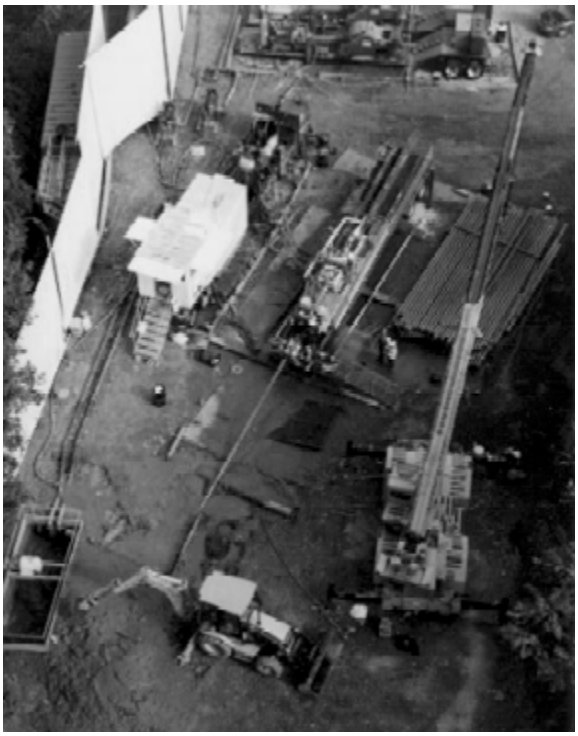
Michiganders are not alone in their commitment to a clean environment and a healthy economy. A recent national poll demonstrates that Americans strongly support increased protection of our environment in general and our precious natural treasures in particular.[12] Americans indicated by an almost two-to-one margin their opposition to oil or gas drilling in the Great Lakes. Americans also clearly indicated their belief that stronger environmental laws are necessary for, rather than an impediment to, a healthy, productive economy.[13]

The recent battle over directional drilling in Michigan has shown the grave concerns held by many Michiganders over the exploitation of the Great Lakes' minimal oil and gas deposits. They have also shown the weakness of temporary moratoriums on drilling that can be altered or lifted based on changing political or economic circumstances. While Michigan may now be protected from offshore drilling in the Great Lakes – and while it has been protected for several years from new directional drilling as well – there is no guarantee that those protections will continue indefinitely. The remainder of this report will detail the potential threats posed by both offshore and directional drilling to the Great Lakes and the health, economy and well-being of Michiganders.

How Much Natural Gas is Under Michigan's Great Lakes?

There is wide disagreement over the amount of oil and gas stored beneath Michigan's Great Lakes. But Michigan's history with directional drilling shows that drilling is not likely to be the solution to the state's future energy needs. Of the 13 wells that have been drilled in Lake Michigan and Lake Huron since 1979, six have come up dry. The seven existing wells have cumulatively produced 439,000 barrels of oil and 17.9 billion cubic feet of natural gas.[14] That amount of energy is enough to supply Michigan with oil for 18.5 hours and gas for 7.1 days, at 1999 rates of consumption.[15] Royalties on those oil and gas sales have resulted in approximately $17 million of revenue for the state.[16] Directional drilling, therefore, has been only a marginal contributor to Michigan's energy supply and the public coffers, and even a dramatic expansion of drilling activity would be unlikely to play a large role in powering the state in years to come.

OIL AND GAS DRILLING TECHNOLOGIES



Aerial overview of a typical directional drilling site. [17]

The oil and gas industry relies on a variety of tools and methods for the exploration, production, and transmission of oil and gas. Two broad categories of drilling – offshore and directional – have the potential to access oil and gas resources under the beds of the lakes. Both processes produce roughly the same types of drilling wastes, but other impacts are quite different.

Offshore drilling is currently banned by state law in Michigan waters, but its potential impacts are worth noting – both to establish a comparison with directional drilling and to deepen understanding of how offshore drilling in Canadian waters and those of other states could affect water quality in Michigan's portion of the Great Lakes.

Offshore drilling is a process that uses a rig, or large drilling platform, to drill from the surface of a water body into underground oil or gas reserves. Offshore drilling places the wellhead, or top of the well, on the bottom of a water body. This places the wellhead in contact with the water. Directional drilling, on the other hand, uses land-based drilling equipment to drill from an onshore well under a water body. This process places the wellhead on land within the watershed of, or area that drains into, the water body.

Offshore Oil and Gas Drilling

Offshore oil and gas drilling begins after the discovery of potential oil or gas reserves through the use of seismic testing or other surveys. A mobile drilling platform is moved into place and an exploratory well is drilled into the area of potential resource reserves. This exploratory well is used to determine the location and accessibility of potential reserves. Once the best location is determined, a production well is drilled. Any number of drilling technologies can be utilized during this process, each with varying levels of direct environmental impacts. During the drilling process, support vessels ferry to and from the drilling rig, delivering pipe, chemicals, fuel, drilling fluids, and other materials.

In all cases, significant impacts to bottomlands may occur in the area of an offshore natural gas well operation, because the wellhead is the primary point for initial contamination. Not only does the actual drilling of the well require up to nine months of operation, the drilling itself is only one of many potential impacts to the bottomlands. Upon completion of the drilling activities, the drilling platform and support vessels move to the next drilling site. The wellhead and associated pipelines and infrastructure remain at the site.

Directional Oil and Gas Drilling

Also referred to as slant or horizontal drilling, directional drilling begins onshore as a traditional vertical well. The well is then angled under a formation such as a lakebed, allowing access to oil and gas held in deep geologic formations. Because the wellhead is located on land and the drilling apparatus does not need to be in the water, this drilling method does offer environmental advantages over offshore drilling. However, directional drilling still poses unacceptable levels of risk -- including the threat of water contamination from leaks, spills and the discharge of drilling residuals and air pollution from drilling equipment.

Given the proximity of drilling sites to the human environment, noise pollution is also an area of concern for directional drilling activities. As with any other natural resource extraction, the pumps, drills,

generators, and support apparatuses of directional drilling all produce a significant level of noise pollution.[18] Given the potential intersection of oil or gas drilling and communities, noise pollution would be a serious concern for neighbors in the drilling area.

ENVIRONMENTAL RISKS

The Great Lakes ecosystem is a fragile web of wetlands, beaches, aquatic environments, and human developments. Despite industry claims to the contrary, oil and gas drilling is still a dirty, dangerous business. At every stage of the drilling process – from exploration to production to transportation – the environment around the drilling site is bombarded by toxic chemicals and threatened by accidental leaks and spills. The primary environmental concerns associated with drilling are: drilling wastes, such as muds and cuttings; drilling fluids, such as produced waters; accidental leaks; blowouts; and accidental or intentional spills.

Summary of Findings

- Drilling wastes, such as drilling muds, cuttings, and produced waters, contain both abundant and diverse toxic chemicals that pose significant risks to the environment. These risks include wildlife developmental defects, shortened lifespan, and physiological changes.

- The potential for accidental or routine release of drilling wastes into the environment is alarming. Releases can occur though containment failure, run-off, and direct discharge.

- Many of the toxic chemicals associated with oil and gas drilling are known to accumulate and magnify in the food chain. This poses a risk to aquatic organisms higher in the food chain, such as fish and birds.

- Many of the toxic chemicals used or produced during oil and gas drilling tend to persist in the environment, leading to long-term, chronic exposure for aquatic and terrestrial organisms.

- Natural gas and oil leaks and spills can have extremely negative effects on the natural environment, both on and off shore. Past safety records indicate that such accidents will take place – it is a matter of when it will happen, not if it will happen.

Drilling waste pit.

Drilling Muds and Cuttings: Unavoidable Toxic By-products

Drilling muds and cuttings are the soil, rocks, and lubrication chemicals removed from an oil or gas well. These products are toxic chemicals that can contaminate the environment, cause environmental problems as diverse as fish and wildlife contamination, causing developmental abnormalities, or even death. During the course of both directional and offshore drilling, oil, water, or synthetic oil is combined with other chemicals to form a toxic drilling mixture that is circulated through the well hole. These mixtures frequently contain toxic materials such as oil and grease, suspended solids, phenol, arsenic, chromium, cadmium, lead, mercury, naturally occurring radioactive materials, and barium.[19] The composition of drilling muds varies widely depending on the location of the well, the depth of the well, and the type of drilling fluid used.[20]

The exact chemical composition of drilling muds is generally not known to anyone other than the oil or gas rig operator or company, as specific materials used may vary according to the demands of each drilling site.[21] Appendix One lists the types and kinds of chemicals routinely used in the exploration and production of oil and gas wells. While the precise contents of drilling fluids may differ, one thing is certain: all chemicals used in drilling fluids will eventually become drilling waste.

Three Types of Drilling Muds

Three types of drilling muds can be encountered in oil and gas drilling operations – water-based, oil-based, and synthetic oil-based. Water based muds are the least toxic, with toxicity increasing from synthetic to oil-based muds.[22] Drilling muds enter the environment

by: being directly discharged into a body of water; seeping into groundwater or other surface water from a land-based impoundment; accidental release from on or offshore holding facilities; absorbing to soils or sediments; and vaporization of volatile components from on or offshore.

Disposal and Transportation of Drilling Mud

The type and location of drilling process determines the fate and transport of drilling muds and cuttings. In the case of directional drilling, drilling muds are frequently placed in a holding pond or receptacle at the drilling site. Drilling muds with chemical concentrations that exceed levels determined by the U.S. EPA must be disposed in a certified hazardous waste disposal facility or injected into a deep aquifer that cannot be used for drinking water (a Class II injection well). However, wastes that do not exceed those thresholds may be disposed in a standard landfill. Waste from offshore drilling platforms is either discharged directly into the body of water or transported to an onshore disposal facility, depending on the toxicity of the wastes. Again, the type of disposal utilized depends upon the chemical characteristics of the muds.

Total drilling wastes produced at a natural gas well can be very substantial. Based on information in *Estimating Externalities of Natural Gas Fuel Cycles*,[23] the average oil or gas well requires 487 acres of land per year for waste disposal during initial drilling and 400 acres per year for final drilling and production.[24] Not only does this represent a significant amount of toxic waste, it also presents an extremely large land-based disposal problem for Michigan.

Wildlife Impacts of Drilling Muds and Cuttings

Environmental impacts from drilling muds range from disruption of wildlife reproduction and accumulation of toxic materials to wildlife habitat destruction and significant wildlife population mortality rates. U.S. EPA studies show that the routine discharge of any drilling mud can adversely impact bottom-dwelling species. These impacts range from burial of species to disruption of basic life functions, such as reproduction, eating patterns, and life span.[25] Toxic discharges from drilling muds may also lead to acute, or immediately evident, effects in some representative marine species, such as scallop, lobster, and a variety of fish.[26] Because freshwater species are more sensitive to these chemicals than similar saltwater organisms, the impact on Great Lakes species would be even greater.

Tumor on Great Lakes long-nose sucker[27]

It is important to note that Great Lakes fish are already contaminated. The entire Great Lakes system is rated unsafe for wildlife due to extensive toxic pollution. Additional pollutant loading from oil and gas drilling activities could exacerbate existing sport fish contamination, as well as general ecosystem contamination. Furthermore, the stressed or transitional nature of the Great Lakes ecosystem would intensify effects from drilling wastes discharged into the watershed.

Coastal land and wetlands could also be negatively impacted by onshore drilling mud storage and disposal. Absent stringent regulatory oversight and inspection, accidental release into ground or surface waters at the drilling sites would pose a major risk to coastal areas. In the case of oil-based drilling fluids, accidental release into a coastal marsh or wetland would have significant impacts on fish eggs and larvae known to be sensitive to oil and oil-based chemicals.[28]

- Water based drilling muds have, at a low level or greater, the following potential effects: pollution accumulation in wildlife; magnification of pollution moving up the food chain; contamination of the water column; damage to bottom-dwelling species; risk of human and wildlife ingestion; occupational exposure; emission of pollution into the air through evaporation; and landfill impact.[29] While most pathways of risk are rated low, the widespread usage of water-based drilling muds greatly increases the chances of a water based mud release.

- Oil-based drilling muds have, at a low level or higher, the following potential affects: threat of occupational exposure; emission of pollution into the air through evaporation;

risk of occupational accidents; groundwater contamination; and landfill impact.[30] When released into the environment, oil-based muds have been shown to inhibit the number and diversity of bottom-dwelling species up to 500 meters from the point of discharge. This effect can last for several years.[31]

- Synthetic based drilling muds have, at a low level or higher, the following potential affects: pollution accumulation in wildlife; magnification of pollution moving up the food chain; contamination of the water column; damage to bottom-dwelling species; risk of human and wildlife ingestion; threat of occupational exposure; emission of pollution into the air through evaporation; and landfill impact.[32]

Drilling muds and cuttings pose a real threat to the environment, either through accidental, intentional, or permitted release. Because the exact composition of different drilling muds is rarely known, the potential risks associated with a given well can only be estimated. The above paragraphs provide an overview of the most common environmental impacts related to these wastes. What is known about drilling muds provides ample evidence of the real threat oil and gas drilling would pose to an ecosystem such as the Great Lakes.

Produced Waters

In oil and gas drilling operations, brines, or salt water, can be encountered and, when this occurs, create produced waters. These wastewaters have high levels of dissolved organic compounds (primarily hydrocarbons, such as oil and propane), saline compounds, numerous heavy metals (including lead, cadmium, and chromium), and radionuclides (from naturally occurring radioactive materials).[33] Like drilling muds and cuttings, the exact composition and volume of produced waters will vary from region to region and from well to well.[34]

Produced waters may impact the surface water or groundwater of the Great Lakes watershed through a variety of routes. Although produced waters are typically disposed of in a deep aquifer (a Class II injection well), there is still the threat of accidental release from temporary storage.

The following table provides an overview of produced water characteristics from a natural gas well in Pennsylvania. The table indicates that a broad range of toxic chemicals exist in produced water from natural gas wells and these chemicals exist in quantities that can pose risk to the health of the environment. The effects of these chemicals on a given ecosystem vary based on the level of pollution in the produced waters. However, there is potential for significant cumulative impacts to Great Lakes organisms if they were to be exposed to these discharges over the long term.

Sample Characteristics of Produced Waters[35]

Parameter	Range	Number of Samples
pH	3.1 - 6.47	16
Specific Conductance	136,000 - 586,000	12
Pollutants(mg/L)		
Alkalinity	0 - 285	13
Bromide	150 - 1149	5
Chloride	81,500 - 167,448	22
Sulfate	<1.0 - 47	13
Surfactants	0.08 - 1200	13
Total dissolved solids	139,000 - 360,000	15
Total suspended solids	8 - 5484	5
Aluminum	<0.50 - 83	19
Arsenic	<0.005 - 1.51	5
Barium	9.65 - 1740	28
Cadmium	<0.02 - 1.21	19
Calcium	9400 - 51,300	19
Copper	<0.02 - 5.0	14
Iron	39.0 - 680	21
Lead	<0.20 - 10.2	18
Lithium	18.6 - 235	18
Magnesium	1300 - 3900	18
Manganese	3.59 - 65	21
Nickel	<0.08 - 9.2	18
Potassium	149 - 3870	16
Silver	0.047 - 7.0	4
Sodium	37,500 - 120,000	21
Zinc	<0.02 - 5.0	20

The American Petroleum Institute, an organization funded by the oil and gas industry, has reported low toxicity assessments of produced waters. The U.S. EPA, however, has reported very high toxicity in its objective investigation of produced water effects on ecosystems.[36] While numerous factors, such as sample source, methodology, and inherent bias, could influence the outcomes of produced water toxicity tests, the uncertainty surrounding potential environmental impacts should be cause for concern in the Great Lakes watershed.

Existing data indicate conditions that may result in the bioavailability of heavy metals associated with produced waters. Bioavailability refers to the concentration of, exposure to, and final level of a pollutant in given species. The toxic chemicals associated with produced waters remain bioavailable long after discharges stop.[37] Because wildlife effects from toxic chemicals rely on the ability of species to take up the pollutant(s), an increase in the duration and concentration of produced waters' toxic components would increase the negative effect on the Great Lakes ecosystem.

Other conditions, such as lack of oxygen at the area of produced water discharge, can make heavy metals more likely to become bioavailable.[38] Such conditions can occur in areas where high levels of organic nutrients, such as water draining from lawns or farmland, lead to a significant increase in algae growth. These algal blooms use all the available oxygen in the water, creating an oxygen-poor environment. Wildlife effects of heavy metals and other toxic chemicals found in produced water included cancer-causing effects such as mutagenicity, or damage to genetic material, and genotoxicity, or alteration of DNA.

Studies of long-term impacts from produced water discharge indicate a significant increase in the abundance and diversity of species from two years post-discharge to nine years post.[39] This is indicative of an ecosystem rebounding from the adverse environmental affects of produced water pollution. The data indicate that the toxic chemicals frequently found in produced waters have been absorbed into the food chain and the pollutant's concentrations and impacts increase as they move up the ecosystem.

In essentially closed freshwater ecosystems such as those of the Great Lakes, the impact of such bioavailable toxins becomes especially threatening. It is also important to note that the high saline content of produced waters has been shown to be quite toxic to freshwater species used as biological monitors of produced water's impacts. These adverse impacts occur regardless of the conditions of the freshwater system.[40]

Toxic chemicals such as heavy metals settling to the lake bottom will exert a sustained, long-term, and concentrated level of exposure for bottom-dwelling organisms. This can be expected because a bottom-based lake ecosystem finds the primary constituents of the ecosystem in and around the bottom of the lake, rather than in the middle or upper regions. Should this occur, the cumulative effect of heavy metals would become much greater at higher levels of the food chain. Unfortunately, the sublethal or chronic impacts of produced water-related bioaccumulation are not known for ecosystems such as the Great Lakes.

Leaks, Blowouts, and Spills

In addition to routine pollution, drilling sites also pose a danger of accidental leaks, spills, and blowouts. An accidental leak or spill can occur from the rupture or containment failure from a drilling mud pit or a pipeline rupture. A blowout takes place when drilling activities encounter a geologic formation with abnormally high pressure, leading to the rapid discharge of the well's contents. The environmental threats associated with leaks and spills are the same as those for routine discharge of drilling wastes and produced waters. Blowouts and pipeline leaks, however, pose a special risk to the environment because of the hazardous nature of methane, the primary ingredient of natural gas.[41]

If a blowout occurs underwater, fish and other aquatic organisms will come in direct contact with a very hazardous chemical – methane. Experience with previous natural gas blowouts indicates the following effects to fish: difficulty in controlling movement, decreased muscle tone and control, organ and tissue damage, cellular damage, and altered cellular formation and regeneration.[42]

During a land-based blowout, methane will quickly disperse in the atmosphere. However, a prolonged leak can produce both acute (immediate) and chronic (long-term) poisoning of birds and other wildlife that come into contact with the leak. Tests on the health effects of methane exposure have produced abnormalities of the animal's fetal brain, including brain hernia (extreme pressure inside the skull) and

hydrocephalus (excessive fluid in the brain).[43] Asphyxiation, or death due to a lack of oxygen, is also a by-product of significant methane exposure.

Other Environmental Impacts

Directional drilling poses other, less obvious, environmental impacts as well. Directional drilling sites frequently use up to two acres for the drilling rig, well, and support infrastructure.[44] As a result, directional drilling causes significant soil erosion, soil loss, and sediment contamination of surface waters during the preparation and development of the drilling site. In addition, directional drilling techniques also require extensive use of gas or oil powered drilling equipment on the lakeshore area. In fact, the potential for air quality degradation is higher for directional drilling than for conventional drilling activities.[45] Air quality impacts result from drilling machinery, injection and production pumps, and processing machinery. Fugitive emissions (dust and other small particles) from the wellhead and support infrastructure can also be anticipated. As such, directional drilling has a significant impact on local air quality during the drilling process.

ECONOMIC IMPACTS

While oil and gas drilling is frequently viewed in terms of environmental or public health impacts, the economic impact of Great Lakes drilling is also important. In general, the effect of oil and gas drilling arises from its conflict with alternative uses of the lakes. The tourism and recreation opportunities in the Great Lakes are chief among these competing uses. At present, the geographical spread of directional drilling in Michigan is limited. But further expansion of drilling would jeopardize the recreational fishing and boating industries as well as Michigan's tourism industry generally, with the impacts being most severe in localities near drilling sites. As such, oil and gas drilling is an either/or issue – either Michigan protects the lakes from oil and gas drilling or existing economic uses of the lakes will suffer significant, long-term losses.

Summary of Findings

- Expanded oil and gas drilling in the Great Lakes would be only a minor contributor to the state's economy. All oil and natural gas production in Michigan – including the small portion of which currently occurs under the Great Lakes – is estimated to be a $2 billion industry in Michigan within a $294 billion overall state economy. State officials estimate that resumed Great Lakes directional drilling would bring a *total* additional $100 million in revenue to the state, compared to *annual* state general fund-general purpose revenues of $9.1 billion.

- The economic impact of oil and gas drilling is dwarfed by the impact of the tourism industry on the state's economy. Michigan State University researchers have estimated that tourists traveling 100 miles or more spent $11.5 billion in the state in 1999, contributed to a tourism payroll of $3.5 billion, and were responsible for $2.2 billion in tax receipts.

- The success of Michigan's tourism economy is inexorably linked to water quality and scenic values in the Great Lakes. The state's water-related resources, scenery and natural attractions rank as the top three most frequently mentioned positive impressions of tourists visiting the state.

Economic Value of Michigan's Great Lakes

The Great Lakes play a major role in Michigan's economy. As a source of drinking water for 4.5 million Michigan residents and freshwater for recreational and industrial use – as well as a home for many species of wildlife – the lakes provide almost incalculable economic benefits to the state.[46]

Of the benefits that can be calculated, one of the most important is tourism. Tourism is a vital cog in Michigan's economy. Michigan State University researchers estimate that tourists traveling 100 miles or more to Michigan locations spent $11.5 billion in the state in 1999, contributed to a tourism payroll of $3.5 billion, and were responsible for $2.2 billion in tax receipts.[47] This analysis does not count the many shorter day trips made by Michigan residents and residents of nearby states.

While the above figures represent all tourism in Michigan, there is evidence that the Great Lakes themselves are a major reason – perhaps the preeminent reason – for the state's appeal to visitors. A survey of Midwestern households found that Michigan's water-related resources far and away represent the most frequently mentioned "positive impression" of the state, followed by scenery and natural attractions. "These results highlight the vital importance of natural resources to the sustainability of Michigan's tourism industry," according to the survey researchers.[48]

There is also more direct evidence of the economic impact of the Great Lakes.

- Boating – Recreational boaters were estimated to have spent approximately $1 billion in Michigan in 1998.[49] More than one-third of all recreational boating days in the state take place on the Great Lakes.[50]

- Fishing – Anglers spent $1.5 billion in the state in 1996, of which more than a third was spent on Great Lakes fishing. One of every five of those anglers is from out of state.[51]

These two sectors alone represent nearly $1 billion in approximate recreational economic impact attributable directly to the Great Lakes. They do not

include the millions more spent by those who hike, camp or swim at or near Great Lakes beaches, National Parks and state parks.

Drilling – Economic Costs and Benefits

The primary economic question posed by Great Lakes drilling is whether the risks posed to water quality, the shoreline and wildlife are outweighed by the economic benefits of oil and gas extraction.

Oil and gas development on the Great Lakes is unlikely to provide significant economic benefits to Michigan. All oil and natural gas production in Michigan – including the small portion that currently occurs under the Great Lakes – is estimated to be a $2 billion industry in Michigan within a $294 billion overall state economy.[52] In 2000, Great Lakes drilling produced approximately 26,000 barrels of oil and 1.9 billion cubic feet of gas, compared to estimated annual statewide production of 10 million barrels of oil and 300 billion cubic feet of gas. Prorating the estimated economic impact of the entire industry based on the percentage of gas produced from the Great Lakes leads to the conclusion that Michigan's seven Great Lakes wells contribute only about $13 million to the state's economy annually.[53]

Supporters of drilling frequently note the additional revenue that would be brought to the state via royalties from leasing of Great Lakes bottomlands. These revenues are dedicated toward the purchase and protection of natural lands. However, the total amount of revenue from leasing is expected to be small – a total of $100 million compared to annual state general fund-general purpose revenues of $9.1 billion.[54]

If the benefits of Great Lakes drilling are small, then what are the risks?

According to testimony by Dr. Jeffrey M. Reutter, director of Ohio Sea Grant, fish stocks on the Canadian side of Lake Erie – where drilling is widespread – are, on average, lower than stocks on the American side. While the causative agents have not been completely identified, long-term oil and gas drilling on the Canadian side of Lake Erie are considered a possible cause.[55]

In its 1997 report to Governor Engler, the Michigan Environmental Science Board warned that drilling was potentially inconsistent with local social and aesthetic concerns, including impacts on recreation and tourism. The panel recommended the completion of comprehensive planning for the Lake Michigan and Lake Huron coastlines to identify areas incompatible with drilling as a prerequisite for leasing Great Lakes bottomlands.[56]

Oil and gas drilling under the Great Lakes has already provoked conflicts with neighboring recreational uses. Filer Township Supervisor Dana Schindler, in his research on releases of poisonous hydrogen sulfide gas from natural gas operations in northern Michigan, documented several instances in which hydrogen sulfide releases forced the evacuation of resort and residential areas in the township.[57]

Further, as noted above, people throughout the Midwest and the nation identify with Michigan as a tourist destination most positively through their association of the state with its water resources. As a result, even a *perceived* decline in water quality posed by drilling could have a negative impact on the flow of tourism dollars to the state – a tragedy given the billions spent in recent decades to reduce industrial pollution and promote the Great Lakes as a clean and safe attraction for visitors.

In sum, additional oil and gas drilling in the Great Lakes would bring only minimal revenues to the state and its economy, at the possible expense of the state's thriving tourism industry. Risks run the gamut from ecosystem impacts due to chronic or sublethal pollution levels to decreased recreational activity due to inherently conflicting lake uses. Given the vast revenue from recreational boating and fishing in the lakes, a significant impact on local economies would take place should these drilling risks materialize.

HUMAN HEALTH IMPACTS

Threats to human health do not take place in a vacuum. Even permitted emissions of pollution, while within legal parameters, can produce cumulative pollution concentrations that pose a risk to human health. Such is the case with the Great Lakes. Contaminated sediments in the lakes continue to release chemicals over time, and these additional pollutant inputs pose a threat to at-risk populations, such as children, the elderly, and young women, who rely on the Great Lakes for drinking water or food sources. The introduction of a significant new pollution source – oil and gas drilling – would further exacerbate existing pollution problems.

Ingestion of contaminated sport fish or drinking water has historically served as the primary exposure route for Great Lakes populations. While data for criteria pollutants such as dioxin, methyl mercury, or PCBs have received a great deal of attention from government sources, we do not know with certainty the possible effects of additional pollutant loading of the type associated with oil and gas drilling. We can know, however, the likely risk associated with these hazards.

Summary of Findings

- Accumulation of toxic chemicals in the Great Lakes ecosystem represents one primary threat to human health. As pollutants from oil and gas drilling build up in the food chain, people who consume fish from the lakes will be at serious risk of health problems.

- Routine discharges and accidental spills from drilling sites can contaminate the water of the Great Lakes, thus contaminating a primary drinking water source for millions of Michigan residents. Some of these discharges, such as air emissions and runoff, cannot be avoided.

- While the human health impacts of leaks and spills are primarily local in nature, placement of wells on shore puts human health at greater risk from accidents, as well as from routine pollution and discharges.

- Routine drilling wastes, such as drilling muds and cuttings, contain a host of toxic chemicals that are known to be hazardous to human health. Routine discharge or accidental release of these materials could be devastating to the Great Lakes area.

Dirty Drilling Wastes and the Threat to Human Health

Because the discharge of drilling muds and produced waters impart a primarily local, rather than ecosystem-wide, effect in the short term, it can be anticipated that the bulk of adverse human health effects would take place in those areas nearest to the site of discharge. Over time, however, it can be anticipated that sustained drilling activities could exert a more widespread influence on regional Great Lakes health.

Drilling muds, cuttings, and produced waters could impact human health via several routes of exposure. While inhalation is an occupational concern for drilling workers, ingestion of contaminated food or water remain the primary threats to the general population. These routes could become contaminated through accidental release into the lake or its immediate watershed; intentional release, either permitted or not permitted, into the lake or its immediate watershed; or seepage from onshore storage areas into groundwater.

Once released into the environment, drilling muds, cuttings, and produced waters could be expected to exert a localized impact on the water column and bottom-dwelling ecosystems. Once in the food chain, toxics from the waste could accumulate in the organisms and increase in concentration as they move up the food chain, essentially growing in toxicity. Bacteria and plankton can ingest methyl mercury, the form of mercury associated with fish contamination. The organisms then transmit the toxic chemical to small fish or minnows. As predatory fish, such as walleye, continually feed on the contaminated fish, methyl mercury can accumulate over time. Human ingestion of the contaminated species would result in exposure to extremely high levels of methyl mercury. As this example illustrates, ingestion of contaminated fish remains a primary route of exposure for humans.

Health Impacts of Chemicals Used in Exploration and Production of Natural Gas[59]

Acetaldehyde— Causes severe eye irritation. Harmful if swallowed or inhaled. Affects central nervous system, liver and kidneys. Causes irritation to skin and respiratory tract. Possible cancer hazard.
Acetic acid—Liquid and mist cause severe burns to all body tissue. May be fatal if swallowed. Harmful if inhaled. Inhalation may cause lung and tooth damage.
Ammonium bisulfite—May be fatal if swallowed or inhaled. Harmful if absorbed through skin. Causes burns to any area of contact. Causes respiratory tract irritation. Can liberate poisonous and flammable hydrogen sulfide gas.
Ammonium chloride—May cause irritation. May be harmful if swallowed. Avoid contact with eyes, skin, clothing.
Crotonaldehyde—Harmful if swallowed, inhaled or absorbed through the skin. Eye contact may cause severe irritation or burns. Respiratory, eye and skin irritant.
Dodecylbenzene sulfonic acid--Contact can irritate and burn the eyes and skin. Can irritate the nose and throat.
Hydrochloric acid— Liquid and mist cause severe burns to all body tissue. May be fatal if swallowed or inhaled.
Hydrofluoric acid— Extremely hazardous liquid and vapor. Causes severe burns which may not be immediately painful or visible. May be fatal if swallowed or inhaled. Liquid and vapor can burn skin, eyes and respiratory tract. Causes bone damage.
Potassium hydroxide—Causes severe eye irritation. Harmful if swallowed or inhaled. Affects central nervous system, liver and kidneys. Causes irritation to skin and respiratory tract.
Sodium hydroxide—Corrosive. May be fatal if swallowed. Harmful if inhaled. Causes burns to any area of contact.
Zinc bromide—Harmful if swallowed or inhaled. Causes severe irritation or burns to every area of contact. Affects central nervous system, brain and eyes.

Drinking water contamination could also result from the accidental or intentional release of drilling wastes. While direct impacts to the Great Lakes through offshore dumping would serve as the greatest short-term threat, the long-term threat of leakage into the groundwater within the lake's watershed is equally troubling. Seepage of drilling wastes from onshore impoundments into area groundwater could have an immediate contaminating effect on local drinking water wells. In addition, any LNAPL (light nonaqueous phase liquid) introduced into groundwater can contaminate Great Lakes water quality through transport from the affected aquifer to the lake's waters. DNAPLs (dense nonaqueous phase liquids) would be expected to exert an aquifer-specific impact, but must be considered equally troubling due to the extreme difficulty of cleanup and the long-term impact of such pollution. For example, trichloroethylene (TCE), a common degreaser used to clean machine parts, has produced groundwater contamination that can never been fully remediated.

The hazardous chemicals in the box above, as defined in 40 CFR, Part 116, have been identified as additives in the exploration and production of natural gas wells in the Gulf of Mexico and can be considered a relative guide to the toxic chemicals that could arise from Great Lakes drilling.[58]

These chemicals are the tip of the iceberg. Drilling muds can often contain over 1,000 different chemicals in varying volumes and forms. As noted in the section on environmental risks, drilling muds frequently contain heavy metals (lead, arsenic, mercury, cadmium, and chromium) hydrocarbons (oil, diesel fuel, and polyaromatic hydrocarbons), and naturally occurring radioactive materials. At differing levels, each of these chemicals is a known threat to human health and the environment.

Once introduced into the drilling process, these chemicals become an inextricable part of the resulting drilling wastes. If chemical concentration in the muds reaches threshold limits (the legal level at which the mixture must be treated as a hazardous waste or material), the mixture is considered hazardous and must be handled as such. Such designation does not, however, protect from accidental or intentional releases of drilling muds and cuttings into the environment.

Some Chemicals of Concern

Localized impacts of drilling mud and produced water discharge could lead to the contamination of drinking water or sport fish sources by a host of toxic chemicals. Furthermore, accumulation of the chemicals within local or regional Great Lakes food chains would occur with continuous discharge or occasional accidental release of toxic drilling muds or produced waters. Exposure via drinking water or fish consumption would adversely impact at-risk populations, even with low pollution levels in the exposure medium.

Lead, a heavy metal frequently encountered in oil and gas drilling muds, is of special concern to human health. Ingestion of lead by at risk populations, such as children, the elderly, and young women, can have significant impacts at miniscule levels. In fact, the U.S. EPA states that, "It appears that some of these [adverse health] effects, particularly changes in the levels of certain blood enzymes and in aspects of children's neurobehavioral development, may occur at blood lead levels so low as to be essentially without a threshold" (emphasis added).[60]

Methyl mercury, a by-product of mercury contamination in conjunction with high levels of organic material in soils, has been associated with central nervous system effects in humans even at the level of 0.003 mg/kg/day.[61] Mercury contamination would be part of almost any drilling waste discharge. Methyl mercury is a known human neurotoxin, or nerve-destroying, compound. The chemical has also been shown to cause mental retardation and cerebral palsy in developing fetuses.[62] Given the dangers of bioaccumulation associated with methyl mercury, as well as the difficulty associated with removing it in drinking water processing at municipal water sources, additional methyl mercury contamination would be a tremendous concern in the Great Lakes area.

Chromium, specifically chromium VI, has been given a reference dose of 0.003 mg/kg/day.[63] Exceeding the reference dose can produce noncarcinogenic effects. However, the chronic and sublethal effects of chromium VI are not well known, nor is the existing literature sufficiently developed to provide high confidence in the reference dose. Existing evidence indicates the potential impacts from chromium VI exposure are as diverse as allergic contact dermatitis (skin rash), decreased fertility, embryotoxicity (decreased birth weight and increased mortality rate), developmental defects, and cancer. Chromium VI is a known human carcinogen for inhalation exposure, but has not been assessed for carcinogenicity due to ingestion.[64]

Polycyclic aromatic hydrocarbons (PAH) include known human carcinogens such as benzene and potential human carcinogens such as naphthalene.[65] Numbering in the hundreds, PAHs are frequently found oil and gas drilling wastes. Because many toxicologists now recognize that no safe dose exists for carcinogenic materials,[66] the introduction of PAHs into the Great Lakes ecosystem will always pose a serious threat to human health.

Normally occurring radioactive materials in produced waters are further cause for concern. These materials have been identified as cancer-causing agents. Because no safe exposure level exists for cancer-causing agents, any exposure to radioactive produced waters can cause cancer in humans and wildlife. The levels of naturally occurring radionuclides can be expected to vary widely from area to area due to variation in geology. Canadian natural gas industry studies have produced evidence of human health effects from exposure to normally occurring radioactive materials.[67] This evidence arises, in part, from drilling activities in or under Lake Erie in Canada. Additional drilling in the Great Lakes could result in further exposure to these highly toxic substances.

Dirty Air and the Toxic Emissions from Drilling Sites

While water pollution typically comes to mind when considering oil and gas drilling, quite significant levels of air pollution are also generated by these operations. In fact, the oil and gas extraction industry leads all other natural resource extraction industries in the total volume of air emissions each year.[68]

During routine drilling operations, very large levels of air pollution are emitted by the large diesel engines that power the drilling equipment. These engines create significant amounts of particulate matter that can contain heavy metals, volatile organic compounds, and polycyclic organic matter. They also emit sulfur oxides, a chemical associated with acid rain, and oxides of nitrogen, which contribute to smog formation. The air pollution associated with drilling deep wells can be exacerbated by long-term, multi-site drilling operations. [69]

Air Pollution Data, by Sector in Tons per Year

Industry Sector	Carbon Monoxide	Nitrogen Dioxide	Particulate Matter	Sulfur Dioxide	Volatile Organic Compounds
Oil and Gas Extraction	132,747	389,686	4,576	238,872	114,601
Metal Mining	4,951	49,252	21,732	1,202	119,761
Non-Fuel, Non-Metal Mining	31,008	21,660	44,305	9,183	138,684
Petroleum Refining	299,546	334,795	25,271	292,167	36,421
Fossil Fuel Electric Power	399,585	5,661,468	221,787	42,726	719,644

The adverse human health effects of air pollutants such as SOx (sulfur oxides), NOx (nitrogen oxides), Hg (mercury), and particulate matter are well documented.[70] Fine particulate matter has been shown to result in difficulty breathing and to aggravate existing heart and lung disease. It may also trigger pneumonia or emphysema.[71] Ozone alert days, the result of NOx emissions on hot, humid summer days, adversely impact the respiratory health of asthma suffers, at-risk populations (children, the elderly, and individuals with lowered immune system function), and individuals with existing heart and lung diseases. Mercury has been associated with neurotoxicity (nerve destruction), developmental toxicity (damage to fetal and early childhood development), and renal toxicity (kidney damage).[72]

Strong evidence indicates that the depositing of air pollutants into the Great Lakes could further impact human and ecological health.[73] There is, for instance, a clear link between air quality conditions in the Lake Michigan area and deposition of airborne pollution in the lake area. As such, one may state with confidence that increased air pollution in or around the Great Lakes, especially from ongoing oil and gas drilling, would have a negative impact on water quality due to deposition.

Leaks, Blowouts, and Spills

Natural gas pipeline leaks significantly impact area residents. These accidents happen at an alarming rate. In 2000, there were 234 natural gas transmission and distribution incidents, leading to 37 deaths, 77 injuries, and $40 million in property damage nationwide. The charts on the next page show the primary causes of pipeline leaks in 2000.[74] Corrosion was the primary cause for transmission leaks in 2000. Damage from outside forces produced the bulk of pipeline failures for distribution lines in 2000.

Natural gas drilling operation flare-up. [75]

Office of Pipeline Safety: Transmission Pipeline Incidents by Cause, 2000

Cause	No. of Incidents	% of Total Incidents	Property Damages	% of Total Damages	Fatalities	Injuries
CONSTRUCTION/MATERIAL DEFECT	7	8.75	$591,043	3.49	0	0
CORROSION, EXTERNAL	14	17.5	$3,475,500	20.54	0	0
CORROSION, INTERNAL	16	20	$1,686,790	9.96	12	2
CORROSION, NOT SPECIFIED	1	1.25	$730,000	4.31	0	0
DAMAGE BY OUTSIDE FORCE	20	25	$3,164,161	18.7	3	7
OTHER	22	27.5	$7,272,471	42.98	0	9
TOTAL	80		$16,919,965		15	18

Office of Pipeline Safety: Distribution Pipeline Incidents by Cause, 2000

Cause	No. of Incidents	% of Total Incidents	Property Damages	% of Total Damages	Fatalities	Injuries
ACCIDENTALLY CAUSED BY OPERATOR	7	4.54	$211,608	0.9	0	6
CONSTRUCTION/OPERATING ERROR	9	5.84	$1,066,000	4.55	0	6
CORROSION, EXTERNAL	4	2.59	$255,000	1.08	0	5
CORROSION, INTERNAL	1	0.64	$50,000	0.21	0	0
DAMAGE BY OUTSIDE FORCES	82	53.24	$10,826,204	46.26	4	17
NO DATA	6	3.89	$555,000	2.37	3	3
OTHER	45	29.22	$10,435,022	44.59	15	22
TOTAL	154		$23,398,834		22	59

Natural gas leaks are extremely dangerous, regardless of the location. By its very nature, natural gas is an extremely flammable material. As such, all natural gas leaks carry the risk of fire and explosion until the leak is contained.

Hydrogen Sulfide

Hydrogen sulfide is a toxic chemical gas frequently found in natural gas deposits, and is a particular problem with drilling operations in Michigan. Hydrogen sulfide is known to be present in the Niagaran Reef, which lies under much of west Michigan and the northwest Lower Peninsula.[76]

Hydrogen sulfide has the potential to poison several systems of the body. High levels of hydrogen sulfide can cause unconsciousness or death within just a few breaths. Long-term low-level exposure can cause fatigue, loss of appetite, headaches, irritability, poor memory and dizziness.[77]

The U.S. EPA has established a "no observable effect dosage" of 30.5 parts per million (ppm) and the Michigan Occupational Safety and Health Act establishes a safety standard of 10 ppm for an 8-hour average exposure and 15 ppm for the maximum 20-minute exposure.[78] However, in one case in Oceana County, the Michigan Public Service Commission approved a "sour gas" pipeline that would pass through many populated areas that would carry gas with up to 25,000 ppm of hydrogen sulfide.

A 1997 investigation by the Michigan Land Use Institute and the Human Health and Safety Committee documented that, since 1986, at least 24 people, five of them children, were seriously injured during a series of hydrogen sulfide releases in northern Michigan. The researchers concluded that the problem was worst in Mason County and in Manistee County, which is home to five of the seven wells that have been directionally drilled under the Great Lakes. At least 262 people were forced to evacuate their homes since 1980 due to hydrogen sulfide releases in those two counties alone.[79]

Potential cancer-causing impacts from hydrogen sulfide have not been studied, leaving open the

question of cancer-causing impacts from exposure to the chemical.

Onshore blowouts present another risk of exposure to hydrogen sulfide. On average, 7 out of every 1000 exploratory wells will result in a blowout.[80] In the event of a blowout, the pressurized contents of a geologic formation literally explode out of the new well, exposing any contents to the environment. If a blowout occurs in a well that has tapped into a sour gas pocket, the uncontrolled release of hydrogen would take place. This release would occur on land, where human health effects are most likely to occur. While the risk may be somewhat low, there is a potential for loss of life associated with such a release.[81]

REGULATION OF OIL AND GAS DRILLING

As with all natural resources, the regulation of oil and gas drilling has both federal and state levels. This is more than a casual observation, because the question of who regulates what is at the heart of a heated debate surrounding the Great Lakes drilling issue. Michigan is currently embroiled in a battle with the U.S. Army Corps of Engineers over the issue of permitting oil and gas drilling along Lake Michigan. Regardless of the outcome, it is important to understand the history of oil and gas regulation in Michigan, as well as the potential ramifications of the jurisdictional debate.

U.S. EPA data concerning the regulation of oil and gas drilling at the national level reveals the level of environmental damage inflicted by oil and gas extraction. Over a five-year period, 1 in 20 oil and gas extraction industry inspections revealed an alleged violation of federal law and triggered an enforcement action by U.S. EPA. At the same time, inspections led to enforcement action at an average of 1 in 6 oil and gas extraction facilities.[82] These startling statistics clearly indicate the extent of the oil and gas industry's non-compliance with existing environmental laws, as well as the extreme burden that this industry places upon regulatory agencies.

Michigan's Regulation of Dirty Drilling

Several state agencies share responsibility for regulation of oil and gas drilling in Michigan. The Department of Environmental Quality (DEQ) is responsible for the permitting of all oil and gas drilling activities in the state, including those activities that take place under the Great Lakes. The Department of Natural Resources is responsible for leasing drilling rights to Great Lakes bottomlands. Oil and gas pipelines are regulated by both the DEQ and the Michigan Public Service Commission.

Summary of Findings

- The Michigan Department of Environmental Quality's record of inspecting oil and gas wells and following up with violators does not instill confidence that Great Lakes drilling can be performed safely. Over a three-year period, the agency failed to inspect 39% of gas wells and 30% of oil wells surveyed by the Michigan Auditor General.

- While improved regulations establishing 1,500-foot setbacks from the shoreline for directional wells will reduce the threat of impacts to the Great Lakes, such a setback is insufficient to protect the fragile web of dunes, bays and wetlands that are part of lake ecosystems.

- The increasing frequency of natural gas pipeline accidents nationwide in recent years – combined with the unwillingness of state and federal regulators to issue fines to violators of pipeline regulations – is reason for additional concern about widespread natural gas development along Michigan's Great Lakes.

Oil and Gas Well Inspection in Michigan

The Department of Environmental Quality is responsible for permitting and inspection of natural gas and oil wells in Michigan, including those under the Great Lakes. In 1997, the agency performed more than 14,000 inspections on 11,000 wells in the state. The agency has a target of conducting two inspections of wells every three years.[83]

However, a 1999 audit by the Michigan Auditor General's office found that DEQ was not inspecting oil and gas wells as frequently as required. The audit found that DEQ had failed to carry out any inspections on 22 of 56 natural gas wells surveyed over a three-year period (39%) and three of 10 surveyed oil wells (30%).[84] In addition, the audit found that citizen complaints about oil and gas wells were "not documented and tracked effectively," that complaints in which the facility's permit number was unknown simply went unrecorded, and that the department did not conduct adequate follow-up after sending out notices of violation, taking an average of 626 days to schedule initial meetings with violators instead of the required 60 days.[85] The DEQ claimed, in its response to the audit, that the delay in follow-up of violations was due to "resource limitations and high staff turnover."[86]

Failure to adequately inspect oil and gas wells, track citizen complaints, and ensure that violations of drilling regulations are resolved could result in increased risk of mishaps that could enhance the

danger of accidental release of oil, gas, or drilling residuals into the environment. The DEQ's record in this regard is not promising for those concerned about limiting the impact of oil and gas drilling – let alone drilling near important natural resources such as the Great Lakes.

Well Placement and the Great Lakes

The threat of damage to Great Lakes waters from drilling is reduced (though not eliminated) the further wells are set back from the lakeshore. In response to the recommendations of the Michigan Environmental Science Board, new directional drilling wells must now be located more than 1,500 feet from the shoreline.

However, the board's report noted that the setback requirement alone would not be enough to protect sensitive environmental areas, particularly along Lake Huron:

> Lake Huron . . . is characterized by meandering riverine flood plains and coastal wetlands. These can extend miles inland from the shoreline. Setbacks alone will not address issues of environmental protections.[87]

The board suggested that the development of comprehensive coastal zone inventories could identify environmental and other resources with which oil and gas drilling could pose a conflict. Yet the state of Michigan has not yet fully complied with the board's recommendation.[88] Such detailed planning would be absolutely necessary to ensure that not just the waters of the Great Lakes, but the entire interconnected ecosystem in which they reside, are protected from potential hazards of drilling.

Collecting and Disposing of Drilling By-Products

Michigan regulations bar the storage or disposal of drilling by-products – such as brines and muds – in ways that cause, or can lead to, pollution.[89] Brines may be used for other purposes, such as ice and dust control, provided that they comply with limits on concentrations of hydrogen sulfide and aromatic hydrocarbons.[90] These wastewaters, along with standard well treatment fluids, may also be injected into injection wells.

With regard to muds, if the composition of drilling wastes does not trigger hazardous waste handling levels, the wastes can be disposed of as a simple solid waste. Based on operations in other navigable waters of the United States, these materials can be dumped into water bodies with the presence of a NPDES (National Pollution Discharge Elimination System) permit, regardless of the drilling method employed. EPA regulations governing the disposal of drilling muds rely on the Best Available Technology standard.[91] In addition, the EPA has required the following of all drilling mud disposal:[92]

- No release of muds or cuttings containing free oil, as determined by the static sheen test.
- No release of muds or cuttings that contain diesel fuel.
- 30,000 ppm 96 hour LC50 toxicity limit for any suspended particulate matter.
- No release of muds or cuttings within three miles of the shoreline.
- Stronger regulation of cadmium and mercury content of barite added to drilling fluid.

Of significant concern, however, is the storage of brines, muds and bulk fuels at or near drilling sites. The Michigan Environmental Science Board noted in its report on directional drilling that, under then-current state regulations, drilling muds could be stored and eventually buried in plastic-lined pits. The panel recommended that no drilling residue be stored in the ground and that above-ground storage at drilling sites be only short-term.[93]

Yet, with the storage and disposal of brines and muds, the possibility of accidental release into the environment is a major concern. Michigan may be able to reduce those risks, but it cannot eliminate them entirely.

Natural Gas Pipeline Safety

The federal Office of Pipeline Safety (OPS) is primarily responsible for ensuring the safety of the nation's pipeline system. Federal administration of pipeline safety was sharply criticized by a Government Accounting Office report issued in 2000. The report, *The Office of Pipeline Safety is Changing How it Oversees*

the Pipeline Industry, states that pipeline accidents have steadily increased from 1984 to 1998. At the same time, the OPS has significantly decreased total fines, while also failing to provide adequate implementation and enforcement of existing regulations.

The report indicates that the increase in major accidents could result from the following: a 10 percent overall increase in pipeline mileage; growth in the volume of products transported by pipelines (due to an increase in the nation's energy consumption); and population growth near pipelines.[94]

In Michigan, OPS has delegated much of the authority to regulate interstate pipelines to the Michigan Public Service Commission and the Geological Survey Division of DEQ.[95] OPS's database of natural gas transmission incidents notes 25 significant incidents that have taken place in Michigan since 1984, 16 of them pipeline ruptures or leaks. The incidents resulted in seven injuries and more than $6 million in property damage.[96] These accidents represent only those that were actually reported to the agency. The Michigan Public Service Commission notes that it investigated 15 natural gas incidents in Michigan in 2000, conducted 760 inspections of natural gas transmission and distribution systems and issued 45 notices of probable noncompliance.[97]

Yet, as at the federal level, fines against violators have not been a major part of Michigan's enforcement strategy. In 1998, Michigan imposed no fines for pipeline violations, and in 1999, it imposed three fines of about $1,000 each.[98]

Public Participation

The public has traditionally had little role in decisions related to directional drilling under the Great Lakes. DNR and DEQ have rarely held public hearings on proposals to issue drilling permits and lease Great Lakes bottomlands.[99] In its report, the Michigan Environmental Science Board recommended that lease agreements include "an aggressive environmental impact assessment and stakeholder participation prior to the lease sale."[100] In response, DNR and DEQ moved to include a 30-day public notice and comment period prior to the issuance of bottomland leases.[101] This provision is far from the kind of inclusive public participation that would be needed to protect Great Lakes communities and ecosystems from negative impacts caused by drilling.

Summary of Michigan's Regulations

Michigan's existing regulations and the history of implementation of those regulations do not generate confidence that the state can adequately protect the Great Lakes from the negative impacts of directional drilling. The state's record of inadequate inspection of well sites and its lack of aggressiveness with regard to citizen complaints and permit violations contribute to the potential for accidental environmental impacts. The increasing frequency of pipeline accidents nationwide, and the reluctance of state and federal officials to issue fines to violators of pipeline regulations are also troubling. Perhaps most distressing is the failure of state officials to thoroughly implement the recommendations of the Michigan Environmental Science Board and to create an open and inclusive process of public participation for the leasing of Great Lakes bottomlands and issuance of drilling permits.

Federal vs. State Jurisdiction

As with so many natural resources issues, the question of ultimate permitting authority for Great Lakes oil and gas drilling remains a debated issue. Extractive activities such as oil and gas drilling always require the presence of a governmental "O.K." in the form of a permit. Depending upon the location of the resources, that permit might be issued by any number of federal or state agencies.

In Michigan, as noted above, the DNR claims authority to lease Great Lakes bottomlands for drilling, with DEQ charged with issuing drilling permits and for enforcing drilling regulations. However, the matter of whether the state or the federal government has ultimate jurisdiction over drilling remains disputed.

In a letter issued to the Michigan Department of Environmental Quality, the U.S. Army Corps of Engineers has claimed federal jurisdiction over any directional drilling activities in or under the Great Lakes.[102] Specifically, the Corps made the following claim:

"Under Section 10 of the Rivers & Harbors Act of 1899, the U.S. Army Corps of Engineers has authority to require permits for construction in navigable waters of the U.S., and the Corps' Detroit District examined whether this authority could apply to the proposed drilling. It found that drilling under the Great Lakes could fall under Corps jurisdiction if work affected the

course, location, condition, or capacity of navigable waters. The determination would have to be made on a case-by-case basis and consider geologic conditions in drilling area, such as the potential for gas or oil to leak into lakes."[103]

Based on this evaluation of the Corps' regulatory authority, all directional drilling projects in or under the Great Lakes would fall under the purview of the Corps' permitting program.

In evaluating the Corps' claims, the actual text of Section 10 serves as a fruitful point of departure. The geographic jurisdiction of the Rivers and Harbors Act of 1899 includes all navigable waters of the United States which are defined in 33 CFR Part 329 as, "those waters that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible to use to transport interstate or foreign commerce." This regulation clearly applies to the Great Lakes. Furthermore, the statute clearly indicates that, but for explicit exceptions, the Corps maintains authority over any of the following actions: construction, excavation, or deposition of materials in, over, or under U.S. navigable waters; or any action which would affect the course, location, condition, or capacity of those waters.

Directional drilling in or under the Great Lakes satisfies the criteria of Section 10. The lakes are considered a navigable water of the United States and are utilized for interstate and foreign commerce. Furthermore, evidence presented under this report's section dealing with the environmental impacts of drilling clearly indicate the significant potential for effects to the condition and capacity of Great Lakes waters. As such, the Corps' claim of jurisdiction over directional drilling appears to have standing under current U.S. laws.

Only one state has actively disputed the claims of the Corps – Michigan. In reaction to Corps claims regarding directional drilling jurisdiction in Michigan, the Engler administration has routinely dismissed any assertion of Corps jurisdiction.[104] Michigan continues to assert sole authority of the permitting of directional drilling in the Great Lakes area. As such, the state relies on state laws, notably the Natural Resources and Environmental Protection Act, Act No. 451.[105]

To date, neither the U.S. Army Corps of Engineers nor the State of Michigan has sought legal remedy for the conflicting claims of authority. Until such time as a judicial ruling has been made or the statutory authority of the Corps is further explained, the question of jurisdiction will remain contested. Given the multi-state and bi-national nature reach of oil and gas drilling impacts, the United States federal government should have jurisdiction over all Great Lakes oil and gas drilling. Examination of existing statutes indicates a strong, long-standing basis for that jurisdictional claim.

THE CANADIAN DRILLING EXPERIENCE: A WARNING FOR MICHIGAN

As noted above, Michigan is the only state to allow oil and gas drilling under its portion of the Great Lakes. But that does not mean it is the only drilling activity underway.

Canadians have been actively drilling for oil and gas in their portion of the Great Lakes since the 1920s. Natural gas development has been particularly intensive on Lake Erie, where there are over 550 active wells and 1,000 miles of pipeline under the Canadian side of the lake.

The Canadian experience has often been cited by drilling proponents as evidence of the safety of oil and gas exploitation in the Great Lakes. But further research into the Canadian Lake Erie drilling experience clearly shows that the activity has not been as benign as its supporters claim.

As decision-makers and the public consider the pros and cons of drilling, the subject of the Canadian drilling experience is especially relevant for consideration of drilling on the American side of the Great Lakes. Oil and gas industry representatives constantly refer to such drilling as "safe" and claim that it has had little or no adverse impact on the Great Lakes ecosystem. However, research into the available data about drilling on the Canadian side of Lake Erie indicates that drilling has been neither safe nor risk-free. If better information were available, further risk would likely be exposed that is currently unknown.

Summary of Findings

- Between 1997 and 2001, there were 51 documented natural gas leaks directly associated with gas drilling operations in Canada's portion of Lake Erie. Lake Erie was also impacted by 83 petroleum spills between 1990 and 1995 (the last year for which data was made available for this report). The volume spilled was not known for many spills. In those spills, only 45% of the contaminants were cleaned up, on average.

- The routine, long-term discharge of drilling wastes from drilling in Canada's portion of Lake Erie represents a significant environmental hazard. These direct discharges into Lake Erie have subjected aquatic organisms to immediate and long-term health risks, ranging from localized fish kills to aquatic organism developmental impairment. These risks are exacerbated by the routine usage of toxic chemicals during oil and gas drilling.

- Spills associated with the petroleum industry are both widespread and highly significant environmental threats. While spills data includes production, transportation, storage, and usage of all petroleum products, the data clearly indicates that production field and pipeline spill events are the most significant in and around Canada's portion of Lake Erie.

- The Ontario Ministry of Natural Resources, which is charged with regulatory oversight of oil and gas drilling, has shown a historic trend towards a lack of environmental consideration in its permitting. For example, the ministry was severely criticized for its failure to implement the Ontario Environmental Bill of Rights, effectively thwarting citizen access to and involvement in environmental decision-making.

- The Canadian National Pollutant Release Inventory (NPRI), which tracks the use and disposal of toxic chemicals in Canada, expressly excludes oil and gas drilling operations from its reporting requirements. As a result, we have no publicly available information about the toxic chemicals routinely used and discharged from Canada's drilling in Lake Erie.

- There is a significant lack of data about the systemic impacts of the Canadian oil and gas drilling operations in the Great Lakes. Neither Canadian nor American governmental agencies have investigated the impacts of existing drilling operations over the past 20 years. Despite this lack of readily

accessible data, information pieced together from the Canadian Coast Guard, the Ontario Ministry of Natural Resources, and the Ontario Ministry of Environment demonstrates severe impacts.

As these findings indicate, the Canadian drilling experience has not proven to be safe and, as a result, provides no evidence that drilling in other portions of the Great Lakes would be clean or safe.

Drilling in Canada – Inadequate Enforcement and Regulations

Under the 1993 Environmental Bill of Rights (EBR), Canadians in the Ontario province obtained wide-ranging access to and intervention in ministry actions that can have an environmental impact. As a result, citizens of Ontario can exercise significant oversight of potentially harmful environmental actions. Part of that legislation required all ministries to classify their "instruments," which include the Canadian equivalent of American permits to allow actions such as petroleum or aggregate materials operations, according to their potential environmental impact.

But according to a special report from the Environmental Commissioner of Ontario, the Ministry of Natural Resources (MNR) failed to comply with the instrument reclassification requirement of the Environmental Bill of Rights. This failure is both long-standing and systemic in nature according to the Commissioner. In fact, the Commissioner concluded that, "I no longer have confidence that the ministry will carry out its legal obligation of its own accord."[106]

This has long-reaching implications for the permitting of oil and gas operations in and under Lake Erie. As a result of the Ministry of Natural Resource's failure to comply with the Environmental Bill of Rights, the ministry's instruments are still not subject to public comment, review and appeal rights as granted under the EBR. Therefore, permits for oil and gas drilling have little or no public comment and oversight.

One intention of the EBR was the provision of a tiered system through which Ontario's citizens could judge the potential environmental impacts of oil and gas drilling. Because MNR has not provided that tier, the public has no standard by which to gauge the serious environmental impacts associated with the ministry's oil and gas drilling instruments. In addition, the classification of an instrument determines the level of involvement the public can expect to exercise under the EBR.

The MNR's actions indicate a lack of commitment to full, open permitting processes or legislated environmental protections. This systematic issue extends to the permitting of oil and gas drilling in Lake Erie. As a result of the ministry's inaction, the public cannot access vital information concerning the environmental impacts of drilling. Consequently, the public cannot intervene in the permitting of drilling or seek to change or amend drilling instruments.

Toxic Chemicals and Canadian Drilling

The National Pollutant Release Inventory, the Canadian equivalent of the U.S. Toxic Release Inventory, is the only comprehensive data source for total toxic releases into the air, water, or soil of Canada. However, oil and gas well drilling activities are expressly excluded from NPRI reporting requirements.[107] As a result, oil and gas drilling operations in or under the Canadian portion of Lake Erie are not required to submit information regarding the routine release of drilling related chemicals. This means that there is no publicly available database for the levels of chemicals used and discharged by drilling companies in Lake Erie. As a result, the public and its governments do not know the types, kinds, quantities, or final fate of chemicals routinely used by drilling operations in Canada's portion of Lake Erie.

Natural Gas Drilling Accidents in Canadian Waters of Lake Erie

Great Lakes drilling proponents and the media have regularly reported that drilling in the Canadian waters of Lake Erie has been safe and largely problem free. The data about spills and leaks indicates that oil and gas operations in the Great Lakes have not been safe or clean. With over 83 reported petroleum spills during a 5-year period and 51 drilling-related natural gas spills in the last 5 years, the petroleum industry in Lake Erie has produced significant and widespread pollution through direct spills alone. Furthermore, the reported environmental cleanup and impact levels reveal oil and gas operations to be a source of unacceptable pollution.

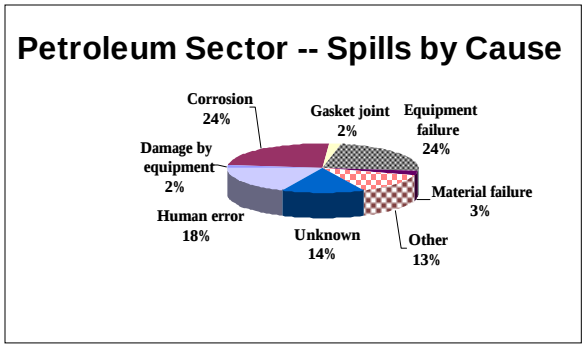
Natural Gas Leaks in Canadian Waters of Lake Erie

SUBJECT	DATE	NUMBER	SUBJECT	DATE	NUMBER
Gas Well Leak	26-Oct-01	C 2727	Gas Well Leak	20-Sep-99	C 2658
Gas Well Leak	24-Oct-01	C 2708	Gas Well Leak	22-Aug-99	C 2380
Gas Well Leak	11-Sep-01	C 2402	Gas Well Leak	15-Aug-99	C 2280
Gas Well Leak	10-Sep-01	C 2393	Gas Well Leak	26-Jun-99	C 1606
Gas Well Leak	15-Aug-01	C 2084	Gas Well Leak	5-Nov-98	C 3052
Gas Well Leak	11-Aug-01	C 2083	Gas Well Leak	29-Oct-98	C 2990
Gas Well Leak	25-Jul-01	C 1813	Gas Well Leak	11-Oct-98	C 2791
Gas Well Leak	13-Jul-01	C 1644	Gas Well Leak	21-Aug-98	C 2433
Gas Well Leak	13-Jul-01	C 1648	Gas Well Leak	2-Aug-98	C 2030
Gas Well Leak	24-Jun-01	C 1386	Gas Well Leak	18-Jul-98	C 1804
Gas Well Leak	16-May-01	C 871	Gas Well Leak	9-Jun-98	C 1269
Gas Well Leak	14-May-01	C 838	Gas Well Leak	22-Apr-98	C 596
Gas Well Leak	11-May-01	C 815	Gas Well Leak	5-Jan-98	C 12
Gas Well Leak	28-Mar-01	C 223	Gas Well Leak	1-Sep-97	C 2593
Gas Well Leak	26-Mar-01	C 181	Gas Well Leak	1-Sep-97	C 2594
Gas Well Leak	14-Dec-00	C 3366	Gas Well Leak	3-Aug-97	C 2201
Gas Leak	31-Oct-00	C 2931	Gas Well Leak	27-Jun-97	C 1698
Gas Leak	31-Oct-00	C 2932	Gas Well Leak	27-Jun-97	C 1687
Natural Gas Leak	26-Aug-00	C 2350	Gas Well Leak	3-Jun-97	C 1279
Gas Well Plugging Operation	12-Aug-00	C 2242	Gas Well Leak	28-May-97	C 1204
Natural Gas Leak	24-May-00	C 1034	Gas Well Leak	26-May-97	C 1179
Natural Gas Leak	13-Apr-00	C 380	Gas Well Leak	24-May-97	C 1157
Gas Well Leak	13-Apr-00	C 495	Gas Well Leak	18-May-97	C 1081
Gas Well Leak	13-Mar-00	C 204	Gas Well Leak	2-May-97	C 783
Gas Leak Reported	24-Jan-00	C 75	Gas Well Leak	23-Apr-97	C 585
Gas Well Leak	20-Jan-00	C 1415			

A review of Canadian spills information from 1988 to 1995 provides further cause for alarm. As can be seen in Appendices Two and Three, there were 83 documented petroleum spills in Lake Erie between 1990 and 1995. The total volume discharged was not known for 39% of the spills, due to causes as diverse as the source of the spill and lack of real-time monitoring of the spill. For the remaining spills the total volume discharged was up to 5,000 liters of petroleum products. To place this in perspective, one liter (roughly 1 quart) of crude oil can contaminate up to 2 million gallons of drinking water and produce an oil slick up to 2 acres in size.[108]

Across Canada, including the Great Lakes area, petroleum sector spills account for the largest source of reported spills in any given year (45%).[109] This sector includes exploration, production, transportation, storage, and usage of petroleum products, including crude oil and natural gas. Reasons for petroleum sector spills range from corrosion and equipment failure to human error and material failure. Causes are primarily pipeline leaks, overflow, and unknown causes. The majority of crude oil spills occur at the stage where the crude is still mixed with brines – i.e., during the exploration and production phase of drilling. This data clearly indicates that drilling is routinely and unavoidably dirty and unsafe.

Spills in the production field are one of the top sources for four of the top five reasons: equipment failure, corrosion, material failure, human error, and storm or flood. Fifty-eight percent of total reported spills involve petroleum products. Corrosion remains the most significant danger related to these spills. Pipeline spills (45%) and spills occurring in the production field [which includes both mines and wells] (42%) together account for 87% of the spills resulting from corrosion.[110]



Companies and Canadian government officials have had a difficult time cleaning up these spills. Between 1993 and 1995, only 45% of spills were fully cleaned up, with 35% not cleaned up at all – a dismal record. The impact of spills on the environment was significant. Over 40% of spills report associated property damage; over 35% report vegetation damage; and nearly 5% report a fish kill.

Drilling Fluids and Produced Waters in Canadian Drilling

Produced waters are typically highly saline fluids that result from natural gas and oil drilling. In Ontario, regulations prohibit the discharge of highly saline waters directly into any fresh water body.[111] However, offshore drilling operations in Lake Erie utilize lake water as the base for drilling fluids. If the drilling operations do not encounter brine, or salt water, during the course of well production, regulations allow the drilling fluids to be directly discharged into Lake Erie. These fluids can contain a whole array of chemical additives (see Appendix One), many of which pose risks to fish and other organisms. Canadian regulatory agencies have not studied the composition or impacts of these drilling fluids

Spawning fish in Lake Erie are already under considerable stress and drilling can increase that stress on a local and regional level. For example, a sudden change in simple physical factors such as water temperature, water oxygen level, or water pH can cause an immediate effect, such as death, or a delayed effect, such as secondary infections or shortened lifespan.[112] The continuous discharge of drilling fluids and waters can also create immediate changes in water chemistry, such as increased pH or temperature. Additionally, they can decrease the dissolved oxygen levels in the lake by contributing to nutrient loading. Nutrient loading is the introduction of very high levels of elements, such as phosphorus, which increase the growth of algae and aquatic plants. As these plants grow and decompose, they remove oxygen from the water and endanger aquatic organisms.

Existing data about toxic drilling discharges in marine environments indicates the potential for significant adverse effects as a consequence of Canadian drilling. Drilling fluid and produced water discharges tend to dissipate in the water environment and these fluids produce an immediate, localized impact at the site of discharge. This means that freshwater organisms in the direct vicinity of the discharge experience immediate and long-term toxic responses to the fluids. These responses can range from loss of muscle control to death, depending on the composition and concentration of the fluids.

Drilling Muds and Cuttings in Canadian Drilling

Drilling muds and cuttings, the toxic solid and semi-solid waste produced by drilling, pose an extreme risk to Lake Erie habitat. Canadian drilling operations utilize a closed-loop drilling system, which is designed to contain drilling muds during the drilling process. The drilling cuttings are separated from the muds and continuously discharged directly to the bottom of Lake Erie.[113] A single Canadian well may produce as much as 6,000 cubic meters of cuttings and mud discharge.[114] These discharges can endanger an environment up to 300 meters from the point of release. This practice poses extreme environmental risks for bottom-dwelling organisms. Burial of bottom-dwelling organisms often takes place over a long distance from the site of the drilling rig, depending on the strength of underwater currents at the time of discharge. This burial causes the death of aquatic species in the affected area.

Because drilling muds and cuttings contain a wide variety of toxic chemicals, direct discharge of these materials into Lake Erie is of special concern.

Evidence shows that the quantity of fish on the Canadian side of Lake Erie is noticeably smaller than on the American side. One potential cause is the presence of large-scale, long-term drilling operations. No coordinated environmental assessment of drilling effects on the aquatic environment has been undertaken in Canada. However, evidence from other drilling sites discussed in this report indicate that habitat disruption, immediate toxic effects, long-term toxic effects, and decreased wildlife number and diversity are all linked to the routine, continuous discharge of drilling muds and cuttings.

Contaminated Sediments in Canadian Waters of Lake Erie

Offshore natural gas drilling in Lake Erie directly disturbs the sediments of the lake because it places the wellhead and pipelines at the bottom of the lake. These sediments are highly contaminated with toxic chemicals and organisms. One such organism, Clostridium botulinum or Type E Botulism, is abundant in the bottom sediments of Canadian lakes, including Lake Erie.[115] This organism was responsible for massive fish and bird kills at the lake during 2000. While the reason for the kills has not been positively identified, offshore drilling can disturb the contaminated sediments and provide a greater opportunity for the organism to gain entrance to a large segment of the food chain.

Of even greater concern is the disturbance of sediments contaminated with polychlorinated biphenyls (PCBs), chlorinated pesticides, and heavy metals. The Lake Erie bottom sediments are extremely contaminated by these criteria pollutants. PCBs are suspected human carcinogens and can accumulate and magnify in the food chain. Chlorinated pesticides also accumulate and magnify in the food chain. Their negative human health impacts range from developmental disorders, nervous system damage, and, in high concentrations, death. Finally, the environmental and health effects of heavy metals are far-reaching. For example, lead is a known developmental toxin and has been associated with brain and nervous system damage. While it is difficult to quantify contaminated sediment disturbance, there are 15 to 30 new drilling sites in Canada's portion of Lake Erie each year. These sites disrupt the lake's bottomlands for up to 9 months during the drilling and production processes.

Pipeline Development and Safety in Canada

After over 80 years of continuous oil and gas drilling, the Canadian portion of Lake Erie has become a dense web of underwater pipelines. Currently, over 1,000 miles of pipeline have been laid on the bottomlands of Lake Erie in Canada. This is enough pipeline to cross the length of Lake Erie almost 4 times. These pipelines transfer natural gas from the 550 active wells in Lake Erie to processing, storage, and distribution stations on land. The process of laying pipeline disrupts contaminated sediments on the Canadian side of Lake Erie throughout the year. With 15 to 30 new offshore wells developed each year, the scale of pipeline development can be quite widespread.

Pipe leaks are the most common cause of spills in the seven sectors, representing 22% of total causes.[116] Of these leaks, over 65% were a result of the petroleum sector, which includes drilling, production, transportation, and delivery of petroleum products. These leaks include every portion of the petroleum sector, from production to final use. Given the vast length of pipeline under Lake Erie, this safety record indicates that Lake Erie drilling infrastructure poses a significant risk to the lake's environment.

Corrosion is the primary and ultimately unavoidable cause of pipeline leaks. Pipeline spills and leaks represent 6% of materials failures, 2% of human errors, 4% of equipment failure, and 45% of corrosions. Stress corrosion cracking, tiny cracks that develop on pipelines as a result of environmental conditions, has been the subject of Canadian governmental and private sector investigations since 1977. This type of corrosion is very difficult to detect, but can create significant environmental and public health hazards. For example, a 4-inch crack in a Canadian-U.S. pipeline resulted in the release of 222,000 gallons of crude oil and an undetermined amount of natural gas. The resulting natural gas leak caused the evacuation of 400 Michigan residents.[117] As this example indicates, the environmental and public health impacts of pipeline leaks are quite extensive.

While much of the impact of oil and gas drilling in Canada's portion of Lake Erie remains unknown due to the lack of available data, the impacts that are known should serve as a cautionary tale for Michigan as the state considers whether to allow directional drilling in its portion of the Great Lakes.

A Better Option: Clean Energy

Michigan residents neither need the natural gas under the Great Lakes, nor want the economic, environmental, and human health impacts that would result from drilling for that gas. As a result, Michigan needs a state-based, permanent ban on all oil and gas drilling in and under the Great Lakes. This will provide the permanent protection Michigan's greatest natural resource deserves. But Michigan should not stop there. To meet the need for clean, affordable energy, the state should pursue a smarter, cleaner energy future.

Energy efficiency improvements have provided enormous economic and environmental benefits over the past three decades. If the United States had not implemented energy conservation and efficiency measures in the 1970s, energy bills would be 40% higher today. However, Michiganders still have enormous energy saving opportunities. The state also has great potential to expand its use of renewable sources of energy, such as wind power. Reliance on these opportunities, rather than dirty drilling, will provide Ohio with sufficient energy supply levels, economic savings, and environmental benefits.

In Michigan, the potential benefits of a clean energy future are staggering. Energy efficiency investments can produce all of the following for Michigan:[118]

- Reduce net electricity costs by $968 million by 2020.
- Save 45,000 GWh of electricity – equal to about 16 large power plants – by 2020.
- Reduce electricity demand by 17 percent in 2010 and 29 percent by 2020.
- Cost less – at an average investment of 2.2¢/kWh – than generating, transmitting and distributing electricity from power plants.

Energy efficiency facts clearly indicate the desirability of a clean energy course for Michigan. Every $1 invested in energy efficiency produces a $1.81 return on investment. Homeowners and commercial and industrial energy users can actually make money on energy efficiency investments. Furthermore, these savings are, in many cases, immediate.

Renewable energy should be the second part of Ohio's clean energy equation. As a state, Michigan can rely on a Renewable Portfolio Standard that requires 10% of the electricity sold in Michigan to come from renewable sources by 2010 and 20% by 2020. Renewable energy from solar, wind, and geothermal sources holds significant opportunities for Michigan. By one estimate, 2,552 MW of electricity could be provided from wind turbine generation by 2020.[119]

Policy Solutions

- Institute a permanent ban on all oil and gas drilling in and under the Great Lakes.
- Provide consumers with rebates and tax incentives for the purchase of energy efficient appliances and the construction of energy efficient buildings.
- Increase efficiency standards for building codes in Michigan.
- Institute a Renewable Portfolio Standard that requires 10% of all electricity sold in Michigan to come from renewable energy by 2010 and 20% by 2020.
- Provide consumers with tax incentives and rebates for the installation of renewable energy generation equipment, such as photovoltaic cells.

APPENDIX ONE: DRILLING FLUID CHEMICALS

CODES, FUNCTIONAL CATEGORIES, DESCRIPTIONS, AND MATERIAL TYPES USED[120]

Code	Functional Categories	Description	Material Types Used
A	Alkalinity, pH control additives	Controls the alkalinity or acidity of a fluid. These factors are important in controlling mud properties.	Lime (CaO), caustic soda (NaOH), soda ash (Na2CO3), bicarbonate of soda (NaHCO3), other common acids and bases
B	Bactericides	Prevents bacterial degradation of organic additives.	Aldehydes and others Soda ash (Na2CO3), bicarbonate of soda (NaHCO3), caustic soda (NaOH). and certain polyphosphates
CA	Calcium reducers	Used to counteract the effects of calcium from seawater, cement contamination, anhydrites, and gypsum from the formation on mud properties.	Amine- and phosphate-based products and other specially formulated chemicals
CO	Corrosion inhibitors	Controls corrosion acids and acid gases.	Alcohol-based materials, silicone-based materials, aluminum stearate, alkyl phosphates
D	Defoamers	Used to reduce foaming action that affects mud properties.	
E	Emulsifiers	Used to create a heterogeneous mixture of two insoluble liquids. They may be anionic (-), nonionic (no charge), or cationic (+).	Detergents, soaps, organic acids, and water based surfactants are used in water-based muds
FR	Filtrate reducers	Used to decrease fluid (as opposed to whole mud) loss through the filter cake on the walls of the wellbore.	Bentonite clays, lignite, CMC (sodium carboxymethylcellulose), polyacrylate, and pregelatinized starch
FL	Flocculants	Used to increase viscosity, increase effectiveness of clay viscosifiers, or clarify or de-water low solids fluids.	Inorganic salts, hydrated lime, gypsum (calcium sulfate penta hydrate), soda ash (Na2CO3), bicarbonate of soda (NaHCO3), sodium tetraphosphate, and acrylamide-based polymers
FO	Foaming agents	Used to create foam in water to permit air or gas drilling through water-bearing formations.	See inventory for product examples (e.g., amplifoam, airfoam B)
LO	Lost circulation materials	Used to plug leaks in the wellbore and prevent the loss of whole drilling fluid to the formation.	Nut shells, natural fibrous materials, inorganic solids
LU	Lubricants	Used to reduce torque and drag on the drill string.	Oils, synthetic liquids, graphite, surfactants, glycols, and glycerin
P	Pipe-freeing agents	Spotted at a particular point in a well to prevent the drill pipe from sticking to the formation.	Detergents, soaps, oils, surfactants, and other chemicals

SH	Shale control inhibitors	Used to control shale hydration and subsequent wellbore enlargement, heaving and caving of water-sensitive shales.	Soluble calcium and potassium salts, other inorganic salts, and organic compounds
SU	Surface-active agents	Used to modify the interfacial tension between contacting surfaces. They may act as emulsifiers, de-emulsifiers, wetting agents, flocculants, or deflocculants.	See inventory for product examples (e.g., avabiowet, anco rope)
TE	Temperature stability agents	Used to increase the stability of dispersions, emulsions, and rheological properties at high temperatures.	Acrylic polymers, sulfonated polymers, copolymers, lignite, lignosulfonate, and tannin-based additives
TH	Thinners, dispersants	Used as a deflocculant to reduce the attraction (flocculation) of clay particles which causes high viscosity and gel strength. That is, they balance the effect of viscosifiers and control mud viscosity and gel strength.	Tannins, various polyphosphates, lignite, lignosulfonates
V	Viscosifiers	Used to increase viscosity in muds.	Bentonite, attapulgite clays, CMC, and other polymers
W	Weighting materials	Used to increase the density of the mud and thereby enable it to control formation pressures.	Barite (barium sulfate), lead compounds, iron oxides, calcium carbonate, and similar products

APPENDIX TWO: PETROLEUM SPILLS IN THE CANADIAN GREAT LAKES — 1990-95 (BY VOLUME) [121]

Year	Volume in liters	Total	Lake Superior	St. Marys River	Georgian Bay	Lake Huron	St. Clair River	Detroit River	Lake Erie	Niagara River	Welland Canal	Lake Ontario	St. Lawrence River
1990	0-10	29											
1990	10-100	43											
1990	100-1000	27											
1990	1000-10000	13											
1990	10000-100000	1											
1990	100000 +	0											
1991	0-10	46											
1991	10-100	34											
1991	100-1000	20											
1991	1000-10000	12											
1991	10000-100000	1											
1991	100000 +	1											
1992	Unknown	43	1	1	5	5		2	5			20	4
1992	0-10	24		2	2	11	1	1				6	1
1992	10-100	27	1	1	2	3			6		1	8	5
1992	100-1000	18	1		4	1		1		1		7	3
1992	1000-10000	8	2	1								5	
1992	10000-100000	2		1								1	
1993	Unknown	44	3		X	9	1	2	2		1	20	6
1993	0-10	25			X	7	7		3		1	6	1
1993	10-100	25	3		X	5	3	1	1			11	1
1993	100-1000	18		1	X	2	1	1	3		2	4	4
1993	1000-10000	4			X	1		1				2	
1993	10000-100000	0			X								
1994	Unknown	42	1	2	X	9	1	2	6		3	16	2
1994	0-10	22		1	X	5	5	2	4			5	
1994	10-100	17	1		X	3			3	1	2	6	1
1994	100-1000	15			X	1	1	1	1	1		8	2
1994	1000-10000	5			X		2					2	1
1994	10000-100000	0			X								
1995	Unknown	43		4	X	8	1	4	5		19	2	
1995	0-10	16			X	4	5		3	1	3		
1995	10-100	21			X	2	3		4	1	8	3	
1995	100-1000	11		1	X		2			2	4	2	
1995	1000-10000	5		1	X						3	1	
1995	10000 +	0			X								

APPENDIX THREE: PETROLEUM SPILLS IN THE CANADIAN GREAT LAKES – 1990-1995 (BY DATE) [122]

Year	Source	Lake Superior	St. Marys River	Georgian Bay	Lake Huron	St. Clair River	Detroit River	Lake Erie	Niagara River	Welland Canal	Lake Ontario	St. Lawrence River
1990	Crude											
1990	Gasoline/Jet Fuel	1	1	1	2	2	2	1			6	3
1990	Light Petroleum Oils	5	2	1	8	12	4	8	2		26	
1990	Heavy Petroleum Oils	1	1			12	1	9	2		14	
1990	Other Petroleum Oils	1	3		2	9	6	7			29	4
1990	Non-Petroleum Oils	1				2					2	
1990	Total	9	7	2	12	37	13	25	4		77	7
1991	Crude					1						
1991	Gasoline/Jet Fuel			3	3	3					8	2
1991	Light Petroleum Oils	2	1	3	6	12	2	7	2		45	3
1991	Heavy Petroleum Oils	2			5	5	1	4	1		13	
1991	Other Petroleum Oils	1				8	2	1			15	
1991	Non-Petroleum Oils											
1991	Total	5	1	6	14	29	5	12	3		81	5
1992	Petroleum Oils (Total)	5	6	13	20	1	4	11	1	1	47	13
1993	Petroleum Oils (Total)	6	1		24	12	5	9		4	43	12
1994	Petroleum Oils (Total)	2	3		18	9	5	14	2	5	37	6
1995	Petroleum Oils (Total)		6		14	11	4	12	4	*	37	8

APPENDIX FOUR: THE NATURAL GAS CYCLE

Emissions	Sources	Resource Categories
	Air Emissions	
Carbon dioxide (CO2), Carbon Monoxide (CO)	Releases from drilling equipment, processing plant, and power plant stack	All impact categories
Nitrogen oxides Sulfur dioxide	Releases from drilling equipment, processing plant, and power plant stack	Health effect; biodiversity; crop production; tree growth
Acid aerosols	Formation in atmosphere from NOx and SOx; long-range transport, acid deposition	Health effects; recreational fishing; crop production; tree growth; biodiversity
Ozone	Formation in the atmosphere from NOx and HC	Health effects; change in crop production
Hydrocarbons	Fugitive emissions at drilling site, in pipeline, at processing plant, drilling equipment, power plant stack	Biodiversity; recreational and commercial fishing
Particulate, Acid aerosols	Power plant emissions	Health effects; recreational use of parks
Peroxyacayl nitrate (PAN)	Formation in the atmosphere from NO, and HC	Biodiversity
	Water Emissions	
Offshore: Produced Water Drilling Fluids Drill Cuttings	Emissions from offshore drilling platforms	Commercial fisheries; recreational fishing; biodiversity
Onshore: Produced Water Drilling Fluids Drill Cuttings	Discharge to coastal areas, underground injection, pond or pit storage, landfill	Biodiversity; Drinking water
Wastes and wastewater	Processing plant, power plant	Biodiversity
	Land Emissions	
Drilling fluids and muds	Land or pond storage or disposal at drilling sites	Biodiversity; occupational health effects
Ash	Land disposal	Biodiversity; groundwater and soil contamination impacts
Land use	Production fields, processing plant, power plant	Biodiversity
Drilling platforms	Construction	Commercial fishing, recreational fishing
Dredging	Offshore and onshore construction of pipelines; access to onshore coastal areas	Commercial fishing, biodiversity
Navigation, pipelines	Shoreline activities associated with production	Recreational use of shoreline, biodiversity

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