THE

ONTARIO WATER RESOURCES

COMMISSION

INDUSTRIAL WASTES SURVEY

of

GAS WELL DRILLING OPERATIONS

ON LAKE ERIE

Lake Erie, Ontario

1968

A

Report On

An Industrial Wastes Survey

of

GAS WELL DRILLING OPERATIONS ON LAKE ERIE

Lake Erie, Ontario

June, 1968

Division of Industrial Wastes

ONTARIO WATER RESOURCES COMMISSION

INTRODUCTION

Well drilling on Lake Erie started as early as 1913. After the Second World War, as the demand for gas increased, the number of wells increased to a point where there are now well over 300 producing wells on the Lake. Off-shore drilling has become an established industry that accounts for a significant portion of the total gas consumption in Ontario, and has a marked effect on the economy of the Province.

Up to now, there have been no serious pollution incidents on Lake Erie resulting from the off-shore drilling operations. However, with the Torrey Canyon incident, and more recently with the oil damages resulting from off-shore drilling operations in California, there has been a mounting concern that this expanding industry could become a source of severe water pollution.

On June 6, 1968, and again on June 15, 1968, field staff from the Ontario Water Resources Commission visited two of the off-shore drilling rigs to become familiar with the drilling operations in general, and to determine whether such operations contributed significantly to the pollution of Lake Erie. The two rigs in question were the "Timesaver II", at

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the time located some twelve miles out from Port Colborne, and the "Nordrill" operating approximately seven miles off Point Pelee. This report summarizes the findings of these surveys.

DETAILS OF SURVEY

On the evening of June 5, 1968, the author accompanied by Mr. D. A. Sharp, Supervisor, Petroleum Resources, Ontario Department of Energy and Resources Management, and Mr. E. Landstrom of the Water Quality Surveys Branch, OWRC, visited the drilling rig "Timesaver II". Mr. H. Townsend, Assistant Manager of Underwater Gas Developers Limited and Assistant Superintendent of Production for The Consumers' Gas Company was the host on board who provided a tour of the rig and explained the essential operations.

On Friday evening, June 14, 1968, the same OWRC staff accompanied by Mr. G. E. Crewe, Inspector, Petroleum Resources of the Ontario Department of Energy and Resources Management, visited the "Nordrill" to inspect the fracturing operations of the Atlas Lake Erie #7 Well. During the course of this inspection, Mr. R. Bryant, Production Engineer, and Mr. D. Farrington provided a tour of the drilling rig and supplied all the

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pertinent information.

Personnel Participating

Ontario Department of Energy and Resources Management:

Mr. D. A. Sharp	-	Supervisor, Petroleum Resources Section
Mr. G. E. Crewe	-	Inspector

Consumers' Gas Company:

Mr. H. Townsend	-	Assistant Superintendent of Production

Hollis IV Limited:

Mr. R. Bryant	-	Production Engineer
Mr. D. Farrington	-	Drilling Superintendent

Ontario Water Resources Commission:

Mr. E. Landstrom	-	Water Quality Surveys Branch
Mr. N. Borodczak	-	Division of Industrial Wastes

Description of Drilling Operations

The drilling of a well is a complex operation that requires a good knowledge of the configuration and characteristics of the Lake bottom, of the various underlying strata, and the depth at which gas is expected. If, after drilling,

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the well tests show that the reserves will support a commercial operation, the casing is cemented, the pay zone fractured and the well capped for subsequent production. On the other hand, if tests are negative or show a low yield, the well is plugged and immediately abandoned and the rig is moved to a new drilling location.

During the initial drilling stages, large bits are used to bore a large diameter hole. This size of bit is used until an impervious consolidated strata is penetrated which can hold and support the casing. The casing is then set in place and cemented in position to complete the upper portion of the well.

With this done, smaller diameter bits are used to complete the drilling to the gas producing formation. Tests are carried out and if a commercially exploitable reservoir is defined, the well is completed as a producing well. In most cases, a productive well on Lake Erie will have to be fractured to stimulate flow before placing it on production.

During the drilling operations, water (at approximate rates of 250 to 300 gallons per minute) is pumped to

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the bottom of the well to cool the drill and to bring the cuttings to the surface. This water passes over a shale shaker (vibrating screen) and is discharged into the Lake along with the cuttings some fifteen feet below the water surface. This waste is principally coarse granular solid material that settles directly to the bottom. It was reported by Mr. D. A. Sharp that this disposal procedure was earlier approved by the Ontario Department of Lands and Forests. These cuttings are not discharged to the Lake, but were reported to be retained on board whenever the rig is drilling near a fish spawning bed.

It was also reported that a strict watch is maintained over the return water and, if oil is noticed, the stream is rerouted and directed to a storage tank on board. The contents of the tank are allowed to settle to let the oil float to the surface. After some time, the bottom solids are discharged to the Lake while the oil and oil-mud emulsion is taken to shore for land disposal.

In some cases, when unstable formations on high pressure gas or oil zones are drilled, drilling muds are used. This mud is added to the drilling water to obtain the desired

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fluid guidelines, such as density and viscosity and the entire mixture is recirculated during the drilling of such a formation. When brought to the surface, this mixture, bearing the coarse cuttings, is passed over a shale shaker. The coarse solids are discharged to the Lake while the drilling mud solution is returned to the mud tanks from where it is pumped down the well again. It was reported that after this formation has been drilled, the mud mixture is saved on board and taken to shore for land disposal.

When a salt formation is drilled, sodium chloride is added to the drilling solution to form a saturated brine. This prevents the dissolution of salt and prevents the formation of caverns and irregular shaped wells. This brine is similarly recirculated over the shale shaker. At the end of the drilling operation, it is taken to shore for land disposal or is discharged directly to the Lake if approval from the Inspector of the Department of Energy and Resources Management is obtained.

After the well is drilled to total depth, tests are carried out to determine whether the gas zones found will be suitable for production. If sufficient reserves are found,

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casing of lower diameter than the original well bore is lowered, the annulus between it and the formation is cemented and the well is readied for production. In most instances, this necessitates perforating and fracturing to stimulate the gas flow.

In order to fracture a well, a charge or shot is first lowered down and fired to perforate the casing at the production zone to permit the fracturing fluids to flow into the formation. Then a prepared solution of chemicals and sand is pumped down the well under pressure to break the formation and make crevices radiating out from the well bottom. This allows for a better flow of gas to the well and increases the rate of production. Sand is used to prevent the crevices from sealing after the fracturing fluid has been expelled. After the formation has been fractured, gases force the fluids to the surface where they are discharged directly to the Lake.

If the fracturing operation is successful and productivity of the well has been increased to a commercial level, the well is brought into production. A pipe-line, laid on the bottom of the Lake, connects the well to the shore install-

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ations from which the gas is eventually distributed to the consumer.

The Timesaver II

At the time of the survey, "Timesaver II" owned by Underwater Gas Developers Limited, was under the supervision of The Consumers' Gas Company.

The "Timesaver II" is a 72 foot x 90 foot x 10 foot steel barge supported above the Lake surface on six legs. The legs are made of tubular steel and rest on the Lake bottom on 15 feet hexagonal steel pads which prevent the structure from sinking into the mud. The entire platform can be raised or lowered hydraulically to compensate for weather and drilling conditions. The "Timesaver II" is a complete and compact unit that can accommodate up to 30 men and houses all equipment and materials necessary to drill and complete wells on Lake Erie. The 60-foot drilling derrick is located at the centre of the platform over the drill well (large opening) which allows free access to the Lake bottom. Once the entire rig is firmly fixed over the desired drilling spot, drilling becomes an around-the-clock operation that stops only after the gas bearing formation

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is reached.

The rig has three 400 gallons per minute submersible pumps that are used to pump water from the Lake for both industrial and sanitary purposes. All the sanitary wastes are collected in a common tank, the effluent chlorinated, and discharged to the Lake. Wastes resulting directly from the drilling operation, as previously described, were also discharged to the Lake.

On the morning of June 6, 1968, the fracturing of a well was observed. The fracturing fluid on this particular occasion consisted of 12,000 gallons of Lake Erie water with coarse sand (10/20 mesh) and HOWCO suds added. Only minor quantities of the chemical were used, approximately 1/4 gallon of the detergent per 1,000 gallons of water. The fluid was injected into the well under pressure along with nitrogen. Nitrogen was used to create turbulence in the well and to bring the fluid to the surface. Because the fluids were expelled under pressure to the Lake, they formed a spray that entered the water some 20 feet out from the rig.

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Nordrill

The "Nordrill" was originally the freighter "Simcoe" and was converted for well drilling. The rig is owned by Hollis IV Limited and was drilling for the Atlas Exploration Company Ltd. A complete anchoring and rotating mechanism had been installed to keep the rig firmly fixed over a particular drilling location and to rotate the structure to keep the bow facing the wind at all times. It was pointed out that one of the difficult features of the entire operation was to maintain a fixed position on the Lake during the drilling operation in the face of heavy winds and squalls.

Although this rig is of different shape and dimensions than the "Timesaver II", the drilling and fracturing operations are essentially the same. The entire crew is housed on board and all the drilling operations are carried out on a continuous basis.

On the morning of June 15, 1968, the fracturing of the Atlas Lake Erie #7 well was observed. On this particular occasion, the fracturing fluid had the following make-up:

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450 barrels of fluid	-	approximately 16,000 gallons
150 sacks of sand	-	100 pounds per sack
450 pounds of WAC 10	-	(carrying agent for sand)
18 gallons of MORFLOW		
30 sacks calcium chloride	-	100 pounds per sack
3/4 gallon HOWCO Suds	-	per 1000 gallons of water
10 barrels of 10% acetic acid	-	approximately 400 gallons

During the fracturing of this formation, only about one-half of the solution was used as the sand sealed the well preventing the passage of additional liquid into the formation. The material from the well along with the unused residue were all discharged to the Lake. The liquids coming from the formation were not under extreme pressure and there was a steady flow into the Lake.

Sampling and Analysis

On June 6, 1968, grab samples were collected on board the "Timesaver II" of the fracturing fluid discharged to Lake Erie. A comprehensive sampling program was carried out on the

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Lake to determine the effect of this discharge on water quality. Two sets of grab samples were taken (top and subsurface) while the fracturing fluids were being discharged and then again about two hours later, after all the operations had ceased.

On the morning of June 15, 1968, similar samples were collected of the fracturing fluids and of the Lake following the fracturing of the Atlas Lake Erie #7 well by the crew on the "Nordrill".

All the above samples were collected in 40-ounce bottles and were taken to the OWRC laboratories in Toronto for analysis. A complete description of the samples collected as well as the analytical results are appended to this report.

To assess the toxicity levels of the various compounds used to make the fracturing fluids, bioassays were performed on a number of the individual additives. These tests were carried out by the OWRC Biology Branch and a report on the findings is also appended.

DISCUSSION OF FINDINGS

Drilling Operations

During the actual drilling operation a considerable

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amount of water is pumped from the Lake down to the bit to act as a coolant and transportation medium for the coarse cuttings. As no chemicals are added to this water, the resultant discharge to the Lake contains only the granular materials brought up to the surface. The disposal of this effluent to Lake Erie was reportedly approved by the Department of Lands and Forests, providing drilling was not carried out near fish spawning beds. This aspect of the drilling operation should not result in significant pollution, since the cuttings settle to the bottom almost immediately. It is, of course, imperative that a strict watch be maintained over the return waters to ensure that no oil is brought to the surface. If an oil-bearing formation is drilled, there must be sufficient storage capacity on board to retain and/or treat the return stream. At no time should oil be discharged to Lake Erie as this is prohibited by both the regulations of the OWRC and the Department of Energy and Resources Management (ODERM) Regulation 420/68.

If certain formations are encountered, drilling muds or brine are added to the drilling water to insure satisfactory continuance of drilling. It was reported that the mud solutions are recirculated and retained on board. This practice should

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be strictly adhered to because these muds, if discharged to Lake Erie, would tend to form a colloidal suspension discolouring a considerable area of the Lake. Brine solutions on the other hand, could be discharged directly to the Lake providing they do not contain oils or chemicals other than salt and providing volumes are not excessive.

Visual Observations

On the "Timesaver II", the fracturing fluids were brought to the surface under high pressure and, therefore, the discharge to the Lake was in the form of a spray. Because of this, the detergent make-up in the fracturing fluid produced a white froth, resembling shaving cream, on the surface of the water. This foam covered an area of about 1,000 square yards and the mat persisted for about two hours. Wind and wave action soon broke up the foam sending patches out into the Lake. Within a matter of about two hours, the froth dissolved completely leaving no traces on the surface.

The sand and other solids making up the fracturing solution tended to settle to the bottom immediately upon discharge to the Lake. A slight turbidity was produced in the

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water adjacent to the rig, however, this was of a short duration disappearing completely within two hours.

On the "Nordrill" on June 15, 1968, the fracturing operation was not successful. The fluids were brought to the surface only under a slight pressure and, hence, there was insufficient agitation to produce a foam. As the fluid entered the Lake in a steady stream, some bubbles were produced, however, these lasted for only a few minutes and soon disappeared. The sand in the fracturing fluids settled immediately to the bottom producing only very slight turbidity of short duration.

From an aesthetic point of view, the fracturing operations could be considered as a source of pollution, but due to the short duration of the surface effects, they were not considered as serious.

Chemical Analysis

During the course of the survey, samples were taken at both rigs of the spent fracturing fluids discharged to the Lake. Analyses of samples taken on the "Timesaver II" on June 6, 1968, indicate high concentrations of BOD_5 (from 68 parts per million to 215 parts per million) and ionic detergents as ABS

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(from 43 parts per million to 75 parts per million). On the "Nordrill", similar samples indicated high concentrations of BOD_5, in excess of 400 parts per million. No analyses were carried out for suspended solids since these concentrations would obviously be high because of the sand make-up in the fracturing fluid.

The concentrations of BOD_5 and suspended solids (presumably) were in excess of the OWRC objectives of 15 parts per million for an effluent discharge to a natural watercourse. The detergent concentrations in the fluid discharge from "Timesaver II" were certainly high enough to produce the foam noted. To assess the effects of these spent solutions on the water quality of the Lake, samples of Lake water were collected in the vicinity of the drilling rigs as the fracturing fluids were being discharged. The analytical results of these samples were compared to the results of a control sample of Lake Erie water to learn whether there was any marked change in water quality.

On June 6, 1968, samples of Lake Erie water were collected approximately 0 feet, 50 feet, 200 feet and 1,000

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feet away from the point of discharge, first while the fluids were being discharged and again about two hours later after the fracturing operations had ceased. Two sets of samples were taken at each location, one at the surface and the other at a depth of approximately 18 feet. Similarly on June 15, 1968, one set of top and subsurface samples were collected of Lake Erie following the fracturing operation on the "Nordrill".

The fluids discharged from the "Timesaver II" increased the BOD_5 and phenol concentrations in the Lake at the point of entry from 0.6 to 8.4 parts per million and from 2 parts per billion to 4 parts per billion, respectively. Slight concentration differences were noted in the Lake about 50 feet and 200 feet away as compared to the control sample, however, no difference in the water quality could be discerned 1,000 feet away. When the second set of samples was collected two hours later, no deterioration in the water quality could be found in any of the surface samples. Concentration differences could be noted in the samples collected at the lower depth when compared to the control sample indicating that the materials were settling to the bottom.

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Samples collected on June 15, 1968, following the fracturing operation on the "Nordrill" showed similar results. Only slight concentration differences in BOD_5 could be noted, the greatest being at the point of entry of the fluid into the Lake.

Bioassay Results

There are many chemical compounds which can be used to make up a fracturing solution. The chemical composition of these fluids varies considerably depending upon the type of formation drilled. During this investigation, two entirely different fracturing solutions were used and these could by no means be considered as being typical. Therefore, rather than sampling and analyzing a variety of these solutions, it was decided to carry out a bioassay on the more common chemical additives to determine their toxicity levels.

Upon request, eight chemical compounds were obtained from the Halliburton Oil Well Cementing Company. These were submitted to the Biology Branch for analyses and the report on their findings is appended.

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The bioassays were carried out on individual compounds and not on spent fracturing fluids. These tests would not show synergistic effects and, hence, the Tl_m values determined may not be truly representative of the toxic nature of a spent fracturing fluid. Howco Suds and Morflow II may have individual Tl_m values of 38 parts per million and 37 parts per million respectively, however, the toxicity of the two compounds combined may be more acute than the case for their individual levels. The Tl_m values of the fracturing compounds noted in Table I of the appended report should therefore be considered as a rough preliminary indication only.

CONCLUSIONS AND RECOMMENDATIONS

Under normal conditions, wastes produced during the drilling operation should not impair lake waters for reasonable uses even though discharged directly to Lake Erie. The return waters from the bits bring up coarse cuttings and granular materials that settle immediately to the bottom. Drilling muds and brines are used when certain formations are encountered. The muds are recirculated and are reported to be kept on board while the brines, after being recirculated, are discharged to

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the Lake if approval of an ODERM Inspector is obtained. Although there are no apparent significant pollution problems associated with the above operations, it is recommended that the wastes be discharged to the Lake below the water level to avoid temporary unsightly conditions.

Problems could occur if oil-bearing formations were encountered during the drilling operation and traces of oil became evident in the return water. A strict watch should be maintained on the return streams, and if oil is brought to the surface, this water should be recirculated, stored on board, or treated to remove the oil prior to discharge to the Lake. The company operating the drilling rig must take all necessary precautions to insure that no oil is discharged to the Lake under any circumstances.

In most cases, spent fracturing solutions can be discharged directly into the Lake without impairing lake waters for other uses. Although the immediate biochemical oxygen demand concentration of chemical components may exceed the OWRC objectives for discharge to a watercourse, because the discharge is intermittent and of short duration, no significant

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pollution occurs. Samples of Lake Erie water collected while the fracturing fluids were being discharged, showed only slight changes in the water quality. It is recommended, however, that these spent fluids be retained on board whenever the rig is drilling near the shore especially near beaches or recreational areas. It is also recommended that the fracturing operations out in the Lake be scheduled to take place during the night or if carried out during the day, measures be taken to eliminate the temporary aesthetic pollution so as to interfere as little as possible with other users of the Lake.

The bioassays carried out on the chemical compounds used to make up the fracturing fluids showed four additives to be acutely toxic. These chemicals should be used judiciously especially if acidic fracturing solutions are to be made up as these ingredients combined could render the spent fluids acutely toxic. It is, therefore, recommended that these chemicals be used as infrequently as possible and at low concentrations.

In summary, it is concluded that the off shore gas drilling industry in Lake Erie does not constitute a source of significant water pollution. During the drilling operations,

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some oil may be brought to the surface if oil-bearing formations are encountered. Proper precautions must be taken on board, to prevent oil losses to the Lake. Although a number of the fracturing additives were found to be acutely toxic, concentrations of these additives in the Lake would be reduced to non-deleterious levels immediately after discharge. Providing there are no major changes in the fracturing operations, the discharge of spent fluids to the Lake should not impair lake waters for other reasonable uses.

Prepared by:

NB/bl

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N. Borodczak, P. Eng.,
Field Services Branch,
Division of Industrial Wastes.

Approved by:

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R. M. Gotts, P. Eng.,
District Engineer,
Division of Industrial Wastes.

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ONTARIO WATER RESOURCES COMMISSION
CHEMICAL LABORATORIES

INDUSTRIAL WASTE ANALYSIS

All analyses except pH reported in p.p.m. unless otherwise indicated

1 p.p.m. = 1 mgm. / litre
= 1 lb./100,000 Imp. Gals.

Municipality:

Report to: N. Borodczak *

c.c. Chem. Lab. *

Source: Consumers Gas Co. Ltd. -Drilling Rig
"Time-Saver II" Well No. 11956
Date Sampled: June 6/68 by: N. B.

(rj)

Lab. No.	5-Day B.O.D.	Solids			Anionic Detergents as ABS	NITROGEN AS N				PHOSPHORUS AS PO_4		Phenols in ppb
		Total	Susp.	Diss.		Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	TOT.	SOL.	
T-1279	---	---	---	---	---	---	---	---	---	---	---	---
T-1280	230	---	---	---	7.5	1.0	9.4	< 0.01	0.03	1.6	0.25	4
T-1281	115	---	---	---	42.0	5.9	12.6	< 0.01	0.08	1.5	0.15	4
T-1282	185	---	---	---	75.0	9.9	16.0	< 0.01	0.02	5.3	0.15	4
T-1283	215	---	---	---	55.0	7.6	15.6	< 0.01	0.05	2.9	0.10	4
T-1284	70	---	---	---	48.0	17	18.	< 0.01	0.02	0.7	0.05	0
T-1285	68	---	---	---	43.0	18	18.6	< 0.01	0.03	1.0	0.05	10
T-1286	0.6	---	---	---	0.0	0.45	2.6	< 0.01	0.05	1.2	0.07	2

< = less than

T-1279	(A)	Howco Suds - Grab Sample of detergent used in well fracturing
T-1280	1	Inflow to Gas Well #11956 during fracturing - Grab Sample
T-1281	2	Fracturing effluent to Lake Erie - 7.25 AM)
T-1282	3	Fracturing effluent to Lake Erie 7.30 AM)
T-1283	4	Fracturing effluent to Lake Erie 7.45 AM) GRAB SAMPLES
T-1284	5	Fracturing effluent to Lake Erie 8.30 AM)
T-1285	6	Fracturing effluent to Lake Erie 9.00 AM)
T-1286	7	Grab Sample of Lake Erie at 7:00 AM

ONTARIO WATER RESOURCES COMMISSION
CHEMICAL LABORATORIES

All analyses except pH reported in p.p.m. unless otherwise indicated

INDUSTRIAL WASTE ANALYSIS

1 p.p.m. = 1 mgm. / litre = 1 lb./100,000 Imp. Gals.

Municipality: Lake Erie

Source: Gas Well

Date Sampled June6/68 by:

Report to: E. K. Landstrom *
880 Bay Street
R. Gotts *

c.c. Chem. Lab.-*
W.Q. Surveys-*
General Manager-*

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Lab. No.	5-Day B.O.D.	Solids			Phenols (ppb)	Anionic Detergents as ABS	COD	Total Kjeldahl as N	Phosphorous as PO_4			Sulphur as S	
		Total	Susp.	Diss.					Tot.	Sol.			
R 5045	8.4				4	4.0	48	0.44	0.24	-		16	
R 5046	0.8				0	0.0	9	0.28	0.07	-		11	
R 5047	7.6				2	3.2	31	0.31	0.11	-		20	
R 5048	1.1				8	0.0	5	0.36	0.07	-		11	
R 5049	2.4				3	0.1	9	0.35	0.08	-		11	
R 5050	0.9				3	0.0	5	0.40	0.07	-		11	
R 5051	0.6				3	0.0	9	0.39	0.05	-		12	
R 5052	0.8				0	0.0	5	0.52	0.07	-		11	

R 5045	A.	Lake Erie water	0 feet top	During fracturing operation
R 5046	B.	Lake Erie water	0 feet subsurface	During fracturing operation
R 5047	C.	Lake Erie water	50 feet top	During fracturing operation
R 5048	D.	Lake Erie water	50 feet subsurface	During fracturing operation
R 5049	E.	Lake Erie water	200 feet top	During fracturing operation
R 5050	F.	Lake Erie water	200 feet subsurface	During fracturing operation
R 5051	G.	Lake Erie water	1,000 feet top	During fracturing operation
R 5052	H.	Lake Erie water	1,000 feet subsurface	During fracturing operation

Gas Well Drilling Operations on L. Erie June, 1968.

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ONTARIO WATER RESOURCES COMMISSION
CHEMICAL LABORATORIES

All analyses except pH reported in p.p.m. unless otherwise indicated

INDUSTRIAL WASTE ANALYSIS

1 p.p.m. = 1 mgm. / litre = 1 lb./100,000 Imp. Gals.

Municipality: Lake Erie Report to: c.c.

Source: Gas Well

Date Sampled: June 6/68 by:

Lab. No.	5-Day B.O.D.	Solids			Phenols (ppb)	Anionic Detergents as ABS	COD	Total Kjeldahl as N	Phosphorous as PO_4			Sulphur as S
		Total	Susp.	Diss.					Tot.	Sol.		
R 5053	0.8				4	0.0	5	0.39	0.04	-		13
R 5054	1.1				4	0.0	9	0.52	0.05	-		12
R 5055	0.5				0	0.0	5	0.53	0.03	-		11
R 5056	0.7				4	0.0	5	0.57	0.11	-		11
R 5057	1.1				4	0.0	5	0.55	0.04	-		2
R 5058	1.0				3	0.0	5	0.66	0.06	-		11
R 5059	0.5				4	0.0	20	0.44	0.11	-		10
R 5060	0.7				8	0.0	5	0.50	0.04	-		7

R 5053	I.	Lake Erie water	0 feet top	2 hours after fracturing operation
R 5054	J.	Lake Erie water	0 feet subsurface	2 hours after fracturing operation
R 5055	K.	Lake Erie water	50 feet top	2 hours after fracturing operation
R 5056	L.	Lake Erie water	50 feet subsurface	2 hours after fracturing operation
R 5057	M.	Lake Erie water	200 feet top	2 hours after fracturing operation
R 5058	N.	Lake Erie water	200 feet subsurface	2 hours after fracturing operation
R 5059	O.	Lake Erie water	1,000 feet top	2 hours after fracturing operation
R 5060	P.	Lake Erie water	1,000 feet subsurface	2 hours after fracturing operation

ONTARIO WATER RESOURCES COMMISSION
CHEMICAL LABORATORIES

INDUSTRIAL WASTE ANALYSIS

All analyses except pH reported in p.p.m. unless otherwise indicated

1 p.p.m. = 1 mgm. / litre = 1 lb./100,000 Imp. Gals.

Municipality: Wheatley **Report to:** N. Borodczak * **c.c.** Chem. Lab.*

Source: Hollis IV Ltd.

Date Sampled: June 15/68 **by:** N. Borodczak /ht

Lab. No.	5-Day B.O.D.	Solids			Phenols in ppb	Anionic Detergents as ABS
		Total	Susp.	Diss.		
T 1345	**				**	**
T 1346	300				30	0.2***
T 1347	410				50	1.4***
T 1348	520.				0*	0.6***

0* Colour interference.

** Hold samples for further analysis.

*** Interference gave lower values than expected.

T 1345	1.	Fracturing Liquid into well before sand addition - Grab 7:25 a.m.
T 1346	2.	Fracturing Liquid into well after sand addition - Grab 7:30 a.m.
T 1347	3.	Fracturing effluent to Lake Erie - Grab 7:50 a.m.
T 1348	4.	Fracturing Liquid residual to Lake Erie - Grab 8:10 a.m.

5M-60-11403-65

ONTARIO WATER RESOURCES COMMISSION
CHEMICAL LABORATORIES

All analyses except pH reported in p.p.m. unless otherwise indicated

INDUSTRIAL WASTE ANALYSIS

1 p.p.m. = 1 mgm. / litre = 1 lb./100,000 Imp. Gals.

Municipality: Lake Erie

Source: Gas Well

Date Sampled: June 15/68 by:

Report to: E. D. Landstrom *
W. Q. Surveys Branch

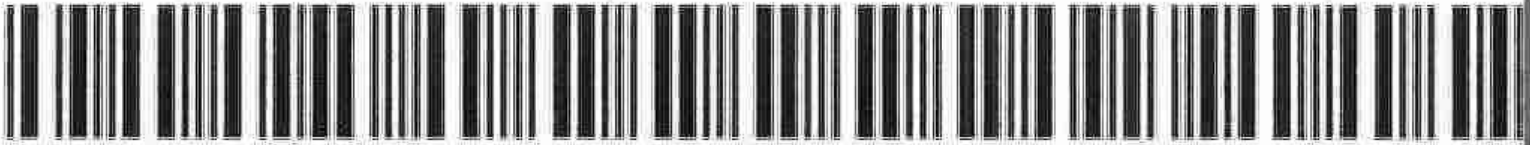
c.c. Chem.Lab.*
W.Q. Surveys *
General Manager*

Lab. No.	5-Day B.O.D.	Solids			Phenols as ppb	Total Kjeldahl as N	Anionic Detergents as ABS	Phosphorous as PO_4		pH at Lab.		
		Total	Susp.	Diss.								
R 5460	3.6				2	0.40	0.0		0.13	**		
R 5461	0.9				2	0.56	0.0		0.11	7.2		
R 5462	1.4				0	0.34	0.0		0.13	7.7		
R 5463	0.9				2	0.48	0.0		0.09	7.6		
R 5464	1.1				8	0.58	0.0		0.13	*		

* Sample broken in Lab. accident

** Sample exhausted - test could not be performed

R 5460	A.	Lake Erie following fracturing operation - 0 feet top
R 5461	B.	Lake Erie following fracturing operation - 0 feet subsurface
R 5462	C.	Lake Erie following fracturing operation - 50 feet top
R 5463	D.	Lake Erie following fracturing operation - 50 feet subsurface
R 5464	E.	Lake Erie following fracturing operation - 100 feet top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