FLOW
FOR LOVE OF WATER

Protecting the Common Waters of the Great Lakes Basin
Through Public Trust Solutions

August 25, 2016

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VIA ELECTRONIC SUBMISSION

RE: SUPPLEMENTAL PUBLIC COMMENTS AND TECHNICAL NOTE ON THE JOINT APPLICATION OF ENBRIDGE ENERGY TO OCCUPY GREAT LAKES BOTTOMLANDS FOR ANCHORING SUPPORTS TO TRANSPORT CRUDE OIL IN LINE 5 PIPELINES IN THE STRAITS OF MACKINAC AND LAKE MICHIGAN [NO. 2HB-VGKO-35JE]

Dear Michigan Department of Environmental Quality Director Grether, Officials, and Staff:

For Love of Water ("FLOW") is submitting this supplemental public comment and technical note related to Enbridge Energy's joint application to Michigan Department of Environmental Quality ("MDEQ") and the U.S. Army Corps of Engineers ("Corps") that requests authorization for additional anchoring supports to transport crude oil in Line 5 pipelines in the Straits of Mackinac and Lake Michigan.

As indicated in our initial public comments, this case presents a high risk of substantial likely impairment and safety concerns about the integrity of Enbridge's Line 5 twin underwater pipelines, as well as the mandatory state legal duties to protect health, safety, and welfare of the Great Lakes. The attached Technical Note prepared by Dr. Edward Timm – ***"Regarding Enbridge Line 5 Non-Compliance with 1953 Easement Requirements, A Mechanistic Analysis of Straits Pipeline Washout Phenomena"*** – reinforces this conclusion and raises grave and inherent structural stability questions resulting from the pipeline design error by Bechtel, Inc. in 1953. Specifically, this technical note concludes that Enbridge cannot safely comply with the easement's 75-foot support requirement using biennial underwater inspection methods, because no predictive current model exists to reliably predict future erosion or "washouts" along the pipeline following extreme weather events in the Straits of Mackinac.

Given Enbridge's history of repeated span violations coupled with the unpredictable Straits currents, it is impossible for Enbridge to prevent future violations. As a result, Enbridge's continued transport of crude oil in Line 5 in the Straits poses an unacceptable level of harm to the Great Lakes waters and aquatic resources as protected by the Great Lakes Submerged Lands Act ("GLSLA"), public trust, and the Michigan Environmental Protection Act ("MEPA"). This is especially the case because feasible and prudent alternatives currently exist to allow the continued transport of crude oil *around* the Great Lakes, not *in* the Great Lakes.

Based on this critical technical information about the safety of the Straits section and our prior submission on legal requirements, we recommend that the MDEQ exercise heightened scrutiny and take immediate steps to minimize the risk Line 5 poses to protect the health, safety, and welfare of the public. To this end, we urge the MDEQ to take either course of action:

1. immediately terminate the transport of crude oil in Line 5 at the Straits pending a comprehensive agency review of impacts, risks, and alternatives;

   or

2. issue an emergency "conditional permit" under section MCL 324.32514(2) of the GLSLA to install the four identified anchors to address the violation of the 1953 easement, subject to specific conditions that impose interim measures "to protect property or public health, safety, or welfare" and public trust in the Great Lakes. The MDEQ should consider including the recommendations of Dr. Timm in the attached Technical Note referenced above:

   (a) Clean pipelines of all marine growth (biofouling) and conduct full external inspection to evaluate the extent of external corrosion and condition of the protective coating.
   (b) Calculate the weight, drag, and curvature of pipelines due to the biofouling from mussels, algae and silt that were not anticipated as part of the original engineering design.

(c) Install multiple current profilers on the twin pipelines to measure the maximum current velocities and compare this data to the original current design calculations in the Straits (2.26 mph maximum)
(d) Hire an independent third-party contractor to recalculate the safety margins of the pipelines' unsupported length requirements given unanticipated powerful underwater currents, historic events, and biofouling stresses.
(e) Install a continuous weather and current monitoring system that shuts down oil transport in Line 5 during extreme weather events in the Straits of Mackinac.

In addition, it is emphasized that any emergency conditional permit issued pending full review (as required by the GLSLA, the MEPA, and public trust law) must inform Enbridge that this temporary authorization (1) requires immediate action to protect the public health, safety, and general welfare, and the air, water, and natural resources and public trust in those resources; (2) does not constitute satisfaction or compliance with the requirements of the GLSLA or other applicable laws and regulations; and (3) does not otherwise bind the MDEQ or state in any manner regarding the requested permits for the occupancy and activities in question. In sum, a comprehensive review is required because Enbridge cannot prevent the high risk of harm and potential impacts from a ruptured pipeline, and alternative pipeline design capacity and routes exist.

We appreciate the department's efforts to protect the public interest in the Great Lakes and to comply with these laws and the public trust duties and principles that apply. Thank you.

Sincerely yours,

James M. Olson
President

Elizabeth R. Kirkwood
Executive Director

CC: Charles Simon, Chief, Regulatory Office, Corps Detroit District
Kerrie Kuhn, Chief, Permits, Corps Detroit District
Michigan Governor Rick Snyder
Michigan Attorney General Bill Schuette
MDNR Director Keith Creagh
U.S. Senator and Hon. Gary Peters
U.S. Senator and Hon. Debbie Stabenow

Technical Note

Regarding Enbridge Line 5 Non-Compliance with 1953 Easement Requirements
A Mechanistic Analysis of Straits Pipeline Washout Phenomena

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The two legs of Enbridge's Line 5 that lie on the bottom of the Straits of Mackinac are constructed of very heavy 20" pipe and must be supported to prevent collapse due to gravitational force. A review of the original design calculations[1] conducted by famed structural engineer, Dr. Mario G. Salvadori, approved the design analysis made by Bechtel Inc. personnel and set limits on maximum unsupported span lengths. Based on both Bechtel's original design and Dr. Salvadori's calculations, the State of Michigan set a maximum unsupported span distance of 75 feet when it granted the easement[2] under the Straits. Dr. Salvadori additionally noted in his report that any unsupported span over 140 feet was dangerous and that the pipe should not be allowed to sag to a radius of curvature of less than 1750 feet during construction. These values were based on information provided to Dr. Salvatore and assumed that the maximum current under the Straits was 1.96 knots (2.26 mph). These calculations did not anticipate or include loads on the pipe due to biofouling and the mussel growth that started after the opening of the St. Lawrence Seaway in 1958. A review of these documents also reveals that the possibility that currents would erode the supporting soil under the pipe leading to 'washouts" was not considered.

When the Straits sections of Line 5 were designed by Bechtel engineers, the engineering science of underwater pipeline design was in its infancy. Many design efforts involving short river crossings where the pipe is buried in the river bottom had proven successful but there was little experience with longer crossings where the pipe was placed on the bottom of a body of water without burial. As the offshore oil industry developed in the 1960's the need for such pipelines drove engineering understanding and the problem with currents washing away the bottomlands that support an underwater pipeline was recognized. In retrospect, the mis-estimation of the magnitude of currents under the Straits coupled with the lack of understanding about the soil entrainment processes that cause washouts can be seen as a fatal flaw in the design of the Line 5 Straits crossing.

Although much has been published about the problem with washouts under Line 5 with resultant lack of support and easement violations, it does not appear that the mechanism causing this problem has been previously elucidated. Washouts occur because of currents that are fast enough to entrain soil particles and move them away from beneath the pipe. Figure 1, calculated from the Levillain[3] equation, illustrates the extremely nonlinear nature of the soil entrainment process. This figure shows that at currents below the design maximum of 2.26 mph no soil particles larger than 0.5mm can be entrained. This velocity is sufficient to entrain silt and small sand particles but is not capable of moving most soil particles. Because the Levillain equation is highly nonlinear, current speeds greater than this value have a disproportional impact on the size of soil particles that can be entrained and transported. A three mph current will entrain particles with diameters on the scale of a millimeter which includes typical lake bottom sand and a six mph current can transport small rocks with diameters on the order of one half inch. This knowledge leads to the conclusion that pipeline washouts occur during events that cause extreme currents which are most likely found in turbulent eddy flows resulting from exceptional weather events across the Great Lakes Basin.

During its 63-year lifetime, the Straits sections of Line 5 have been consistently out of compliance with the easement's 75 foot maximum unsupported span requirement. Table 1, taken from copies of the "as built" drawings of the two Straits legs of Line 5 updated through the 1979 underwater inspection[4,5] shows a total of 17 spans that exceed the 75 foot maximum unsupported span distance and three spans that exceed the 140 foot structural damage threshold. Table 2, taken from another document filed by Enbridge at the request of the

Michigan Attorney General under the terms of the 1953 easement,[6] outlines the numerous campaigns undertaken from 1962 through 2012 to inspect and add support to the pipes. This information shows a lack of urgency on Enbridge's part to insure that Line 5 is both safe and complies with applicable language in the 1953 easement. In spite of all the non-compliances shown in Table 1 which was current as of January, 1980, Table 2 shows that no action was taken by Enbridge until 1987 to remedy this dangerous situation. In 1987, Enbridge began campaigns to insure adequate support under line 5, but, as can be seen from Table 2, the 1987 effort only added support to seven unsupported spans out of the seventeen noncompliant spans that were documented in the 1980 drawings. This 1987 effort certainly did not bring Line 5 into compliance with the easement.

Beginning in 2001 and continuing today, Enbridge has made efforts to add modern screw anchor supports to Line 5 to bring it into compliance with the easement and, more importantly, prevent damage to the line. As can be seen from Table 2, a total of 106 supports were added to Line 5 through 2012. A 2014 campaign by Enbridge found 40 spans that violated easement requirements. Following this campaign Enbridge stated that there were no unsupported spans over 75 feet and the average unsupported span was 50 feet. This calculates to a total supported distance of 1.38 miles out of a total exposed distance of 4.4 miles (2.3 miles West leg, 2.1 miles East leg) which means only about 31% of the pipe has discrete supports and is not subject to washout. A recent (7/2016) underwater survey of Line 5 has found four more spans that are out of compliance with the easement and eighteen spans that Enbridge plans to support proactively to prevent future non-compliance. This information is documented in a construction permit application to the State filed in August, 2016 with a planned work start date in September, 2016. The ongoing nature of washouts under Line 5 with resulting easement non-compliances demonstrates conclusively that strong currents and a shifting bottom under the Straits requires continuous vigilance to prevent excessive spans that could result in collapse of Line 5. A careful analysis of all the documentation publicly available about this issue leads to the conclusion that the Straits segments of Line 5 never met the easement support and curvature requirements as constructed in 1953 and have been consistently and sometimes dangerously out of compliance since that date. It may be that Enbridge's support efforts have brought the line into compliance with easement requirements for brief periods but it is certain that easement requirements have not been met for the great majority of its life to date.

An analysis of the current data taken in the Straits by Saylor and Miller in 1991[7] shows that the original designers of Line 5 seriously underestimated the strength of the currents impacting the structure. This data shows that 15 minute average currents near Line 5 can exceed the design basis for several hours each year and that at some times the currents exceed 4 mph. It is probable that Line 5 washouts are caused by local turbulent eddies with peak velocities over 6 mph that occur infrequently likely during seiche inducing Derecho events or other extreme weather events. Due to the limited data available about extreme currents under the Straits and the probabilistic nature of the washout process, it is very difficult to predict when and where washouts will occur. Additionally, because of both marine fouling and current loadings well beyond the design basis, it is likely that the original stress calculations that resulted in the 75 foot maximum unsupported span requirement underestimate stresses in the pipe and the 75 foot requirement no longer results in the safety margins originally contemplated in the 1953 easement agreement. These errors also affect the calculation that predicts severe consequences should an unsupported span over 140 feet develop. Given currents above the design basis and severe biofouling, the stresses predicted to occur at a 140 foot span are underestimated and severe consequences may occur at unsupported spans less than this length.

The finding that Line 5 needs more supports that resulted from Enbridge's 2016 underwater inspection and resultant construction permit application is, once again, an admission that Enbridge has consistently violated the easement allowing construction of Line 5. Apparently, after the 2014 support campaign by Enbridge, assurances were given to the State of Michigan that, in the future, no further easement non-compliances would occur. The fact that four such non-compliances were found and eighteen more supports are required to prevent potential future non-compliances has called into question Enbridge's assurances regarding their engineering competence and ability to comply. In an August 3, 2016 letter, Michigan's Attorney General, Bill Schuette[8], notified Enbridge that, under the terms of the easement, they had to provide information about their ongoing inspection and repair program. Quoting from this letter:

"First, please provide as soon as possible, and in any event within 14 days of this letter, the results of the most recent underwater inspection of the Straits Pipelines in 2016. This includes a detailed description of the methods used to conduct the inspection, as well as the findings regarding pipeline support locations, span lengths observed, and changes to the conditions reported in 2014 that have led to the current situation where the four spans now exceed 75 feet. Specifically, please explain why and how the span lengths Enbridge represented existed in 2014 are now missing in those locations.

Second, please provide, within 14 days from this letter: (a) a detailed description of the predictive maintenance model that Enbridge relied upon and referred to in its November, 2014 letter; (b) a detailed explanation of how and why that model failed; and (c) a new span monitoring and preventative maintenance plan to ensure future and continuing compliance with the Easement pipeline support requirement. That plan should include, as needed, increased inspection frequency and proactive pipeline support repair, installation and replacement to prevent any spans greater than 75 feet before they occur."

Based on my analysis of current data and knowledge of hydrodynamics, it is probable that a model to predict future washouts that does not take into account current data will not be reliable. As shown by Anderson and Schwab[9], the oscillating flows through the Straits are driven by atmospheric pressure differences and reach extreme values during severe weather events like a Derecho induced seiche. Without taking this information into account, it is likely that washouts can occur that will go undetected by Enbridge's two year underwater survey schedule. Because a truly extreme weather event could produce a washout that exceeds the 140 foot limit for structural damage to Line 5, the risk of a rupture in Line 5 in its current condition cannot be said to be negligible. This observation raises the question of what action should be taken by the State of Michigan to assure the safety of the Straits sections of Line 5 given Enbridge's continuous inability to comply with easement support requirements since before 1975.

Allowing Enbridge's current process of bi-annual underwater inspection followed by repair to continue under these circumstances guarantees that the Straits sections of Line 5 will not be in compliance with easement requirements most of the time. Indeed, there is a finite possibility that the probabilistic nature of the washout process will result in a dangerously long unsupported span that could go undetected for over a year. This approach seems neither reasonable nor prudent since a rupture and large oil spill in the Straits would be incomprehensibly damaging to Michigan's economy and ecology. If the obvious remedy of shutting down this pipeline is judged to be too extreme based on economic concerns, it would be reasonable and prudent to take an approach that incorporates the technical arguments made in this document to reduce risk.

Since routinely scheduled (2 year) underwater inspections cannot guarantee the level of reliability that may be necessary in such a critical waterway, an event triggered approach may be useful. Real time monitoring of weather events and currents in the most vulnerable areas of the pipeline in conjunction with a Straits flow model like that of Anderson and Schwab could provide the data necessary to determine when currents reach values that threaten pipeline stability. When such a condition is reached, it would be prudent to either shut down Line 5 or restrict it to non-oil cargo until an underwater inspection could be made. These event triggered inspections along with ameliorative action would provide a level of safety unobtainable through regular inspections at reasonable cost. This approach is used in many other safety critical situations with good results. For example, commercial airliners continually record flight information and any event that causes an airplane to exceed preset limits triggers a thorough inspection, review and repair/replace decision by the operator. This approach could be used to make sure the frequent, unpredicted washouts that plague the Straits sections of Line 5 would not result in rupture when pressurized with crude oil during an extreme current event.

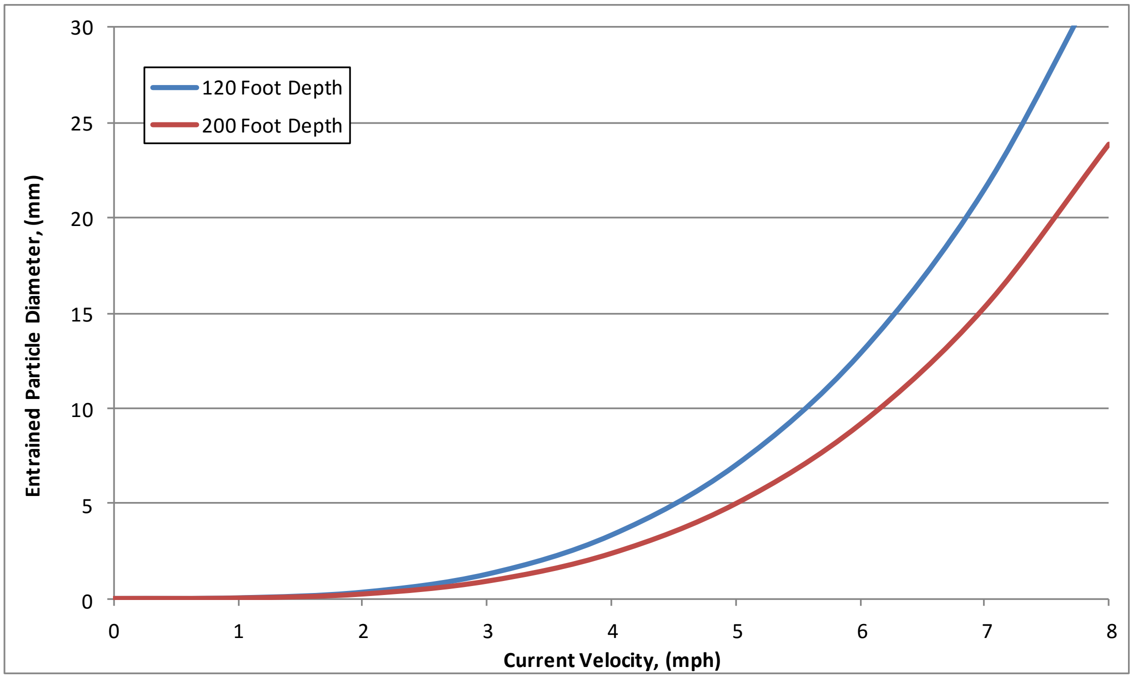

Figure 1. Soil Particle Entrainment Velocity as a Function of Underwater Current Velocity

Table 1. Summary of Spans and Supports as of the 1979 Underwater Inspection of Line 5

1. Data taken from Lakehead Pipeline Company, Inc drawings released by Michigan Attorney General
2. Drawing originally dated 4/14/64 and noted as being traced from Bechtel, Inc drawing dated 11/63
3. Drawing updated through 1980 including revisions following 1972, 1975 and 1979 underwater inspections
4. Unsupported spans over 75 feet are prohibited by 1953 easement agreement with the State of Michigan
5. Unsupported spans over 140 feet were calculated to be dangerous to line integrity by original designers at Bechtel

Summary of non-Compliant Unsupported Spans as of 1980

Location	Spans > 75 feet	Spans > 140 feet
West Leg	10	3
East Leg	7	0

West Leg Spans and Supports

Feature Description	Approximate Bechtel Chainage	Approximate Depth	Unsupported span Length (feet)	Notes
Beginning	5140	65		
Span	6800	105	60	
Span	7000	130	70	
Clay Pile	7050	135		
Span	7100	135	30	
Span	7300	165	60	
Span	7400	180	100	
Clay Pile	7500	210		Evidence of strong current action
Span	7600	240	150	Two sets of grout filled bags placed in 1978 to support span.
Note	8000			Area of many large rocks and boulders, well silted
Clay Pile	8100	240		
Span	8300	235	60	
Clay Pile	8560	242		
Span	8600	245	80	
Span	8700	245	70	
Span	8800	240	50	
Span	8900	225	85	
Span	9100	220	50	
Span	9300	205	60	
Span	9500	180	110	
Burial	9650	175		Pipe embedded 6-8 feet
Span	9800	180	80	
Span	10000	185	70	
Note	10300	170		6" triangular pieces of coating chipped off during 1978 construction
Span	10800	170	150	Two details on drawing showing pipe sideways movement and pipe unsupported in trench
Clay Pile	11200	130		
Span	11600	130	100	
Span	11800	135	160	
Clay Pile	12000	135		
Span	12250	135	70	
Clay Pile	12350	135		
Span	12450	135	40	
Span	12700	130	40	
Clay Pile	12900	130		
Clay Pile	13100	130		
Span	13200	130	60	
Note	13350	130		Cable mark on pipe, no damage
Span	13500	130	90	
Span	13900	95	35	
Clay Pile	14050	95		
Span	14300	95	50	Two small clay piles appear to have
Span	14400	95	50	been placed to create these three spans
Span	14500	95	20	from one original
Span	15200	80	40	Several small clay piles appear to have
Span	15600	75	40	been used to support pipe in area of non
Span	16400	75	10	
End	17260	65		

East Leg Spans and Supports

Feature Description	Approximate Bechtel Chainage	Approximate Depth	Unsupported span Length (feet)	Notes
Beginning	5040	65		
Span	5510	70	80	Two sets of grout bags added in 1978 to
Span	5650	70	70	suppoirt spans
Span	6000	115	70	
Note	6350	160		Large Rock
Note	6400	160		Gravel Ridge
Span	6450	160	70	
Span	7060	210	80	Evidence of strong current action
Clay Pile	7500	220		
Span	7720	220	80	
Trench	8050	225		
Span	8120	232	80	
Clay Pile	8160	232		
Span	8200	232	90	
Span	8510	190	90	
Span	8740	165	60	
Span	8880	140	70	
Span	8950	130	60	
Trench	9000	130		
Clay Pile	9210	130		
Trench	9270	130		
Clay Pile	9590	140		
Span	9600	140	50	
Trench	9800	140		
Clay Pile	9990	140		
Span	10450	120	70	
Span	10740	110	60	
Clay Pile	10950	105		
Span	11400	95	70	
Span	11930	100	90	Span well anchored
Clay Pile	12150	95		
Span	12400	105	80	
Clay Pile	12500	105		
Span	13300	90	80	
Span	13600	80	70	
Clay Pile	14100	70		
Span	14480	75	50	Pipe is 5 to 6 feet off bottom in this area
Span	14800	80	50	
Clay Pile	15300	75		
Span	15720	70	60	
End	17200	50		

Table 2 ROV Inspection and Span Support Installation History of Line 5 Straits of Mackinac

Year of ROV Inspection	Follow up Actions (Anchor Support Installation)	Type of Support Installed
1963	None	
1972	None	
1975	3	Grout Bags
1979	None	
1982	None	
1987	7	Grout Bags
1989	None	
1990	None	
1992	6	Grout Bags
1997	None	
2001	8	Grout Bags and mechanical support
2003	16	Mechanical Screw Anchors
2004	16	Mechanical Screw Anchors
2005	14	Mechanical Screw Anchors
2006	12	Mechanical Screw Anchors
2007	None	
2010	7	Mechanical Screw Anchors
2012	17	Mechanical Screw Anchors

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[1] "Report on the Structural Analysis of the Subaqueous Crossing of the Mackinac Straits", Salvadori, Mario G., PE, Department of Civil Engineering, Columbia University, New York 27, NY, January 19, 1953.
Also released by the State of Michigan as: "Engineering and Construction Considerations for the Mackinac Pipeline Company's Crossing of the Straits of Mackinac" and "Report on the Structural Analysis of the Subaqueous Crossing of the Mackinac Straits," submitted by Mackinac Pipeline Company/Lakehead Pipeline Company to the Michigan Department of Conservation, January, 1953 http://www.michigan.gov/documents/deq/Appendix_A.2_493980_7.pdf

[2] "Straits of Mackinac Pipeline Easement", Conservation Commission of the State of Michigan, April 23, 1953.

[3] "Critical Soil Particle Entrainment Velocity", Stability and Operation of Jackups, Chapter 4.5.1.2, pages 222-223, Pierre Le Tirant and Christian Perol, Editors, Design Guides for Offshore Structures, Editions TECHNIP, Paris, France 1993.

[4] "East Line Profile, Mackinaw Straits Crossing, Underwater Inspection", Lakehead Pipeline Company, Inc., 4/14/64, Updated 1972, 1975 and 1979, http://www.michigan.gov/documents/ag/164-00-1_700-10483-01_523921_7.pdf?20160819195501

[5] "West Line Profile, Mackinaw Straits Crossing, Underwater Inspection", Lakehead Pipeline Company, Inc., 4/14/64, Updated 1972, 1975 and 1979, http://www.michigan.gov/documents/ag/164-00-1_700-10483-01_523922_7.pdf?20160819195501

[6] "Table 2 ROV Inspection and Span Support Installation History of Line 5, Straits of Mackinac", Appendix 2B, Table 2, p. 4 (document Appendix_B4_493991_7.pdf, MPP Task Force Record).

[7] "Current flow through the Straits of Mackinac", James Saylor and Gerald Miller, Great Lakes Environmental Research Laboratory Ann Arbor, Michigan, Technical Report, 1991

[8] "Re: *Enbridge Lakehead System Line 5 Pipelines at the Straits of Mackinac",* Letter from Michigan Attorney General Bill Schuette to Brad Shamla, Vice President U. S. Operations, Enbridge Energy Limited Partnership, August 3, 2016.

[9] " Predicting the oscillating bi-directional exchange flow in the Straits of Mackinac", Eric J. Anderson and David J. Schwab, Journal of Great Lakes Research, December, 2013.