

**Water Resources Program Report:
Mabou Harbour Watershed**

Prepared For:

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1. Organizational Profile

1.1 Brief Profile and History of Organization

The Inverness-Victoria Federation of Agriculture is a non-profit, volunteer run association that represents the interests of the agriculture community in Inverness and Victoria Counties and has been in existence for over 80 years. It operates under the umbrella of the provincial body of the Nova Scotia Federation of Agriculture and is involved in many activities and services to benefit the industry and rural communities. The Federation mission is to ensure a competitive and sustainable future for the agriculture industry and a high quality of rural life in Nova Scotia.

In 2015-16, there were approximately 170 farms in Inverness and Victoria Counties representing a wide variety of products and services such as blueberry, beef, bees, dairy, sheep, agri-tourism, wool, vegetables, organic production, strawberry, greenhouse production and many others. While many areas of the province have seen drastic declines in the number of farms over the last few years, Inverness County has increased slightly. Farms contribute significantly to the economy of the area, in direct sales and many indirect spin-offs. Most recent statistics show that these farms account for over \$9 million in total gross farm receipts and a total farm value in excess of \$57 million in Inverness County.

The Inverness-Victoria Federation of Agriculture has been providing farm machinery rental services to its members for over 50 years. It is a well-established program that allows access to specialized farm equipment not available in this area. Many producers have come to rely on this equipment as an integral part of their business operations. The volunteer organization manages and maintains 49 pieces of equipment and stores them at a Federation owned building.

Current List of Board Members – 2017-2018

President: Chris van den Heuvel

Vice President: Jamie van den Hoogen

Director: Richard Heukshorst

Director: Byron Fraser

Director: Danford Murphy

Director: Rodney Beaton

Director: Troy van den Hoogen

Director: Andrew MacLennan

Director: William van den Heuvel

2. Project Information

2.2 Project Title

Mabou Harbour Watershed Study – Identifying Source of Bacteria Levels and Impact on Shellfish Harvesting

2.3 Project Contact

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2.4 Project Rationale

Recent testing by the Department of Fisheries and Oceans and the Department of Environment have indicated high coliform levels in the Mabou Harbour. Located within the boundaries of Mabou Harbour are 9 licensed shellfish harvesting operations and the shellfish industry is under fear of being permanently shut down due to the high coliform levels. Three times in the past two years the shellfish harvest has been temporarily banned due to high bacteria levels. This has a tremendous economic impact on the shellfish harvest which is estimated at \$1.6 million annually. In 2016 the Department of Fisheries ruled that the Mabou Harbour shellfish industry would be closed permanently unless the producers implemented an Integrated Management Plan. This plan would identify potential sources, identify factors to mitigate risks and develop a strategy to move the industry forward and reduce/eliminate the source of bacteria.

An initial meeting was held in Mabou with all relevant parties involved. At that meeting it was decided to go ahead with the Integrated Management Plan. The first order of business was to identify the major potential sources of bacteria. The group agreed that the three potential sources of bacteria were;

- 1) Avian: being a harbour there is of course a large contingent of avian wildlife that makes the Mabou Harbour its home. Seagulls, Canada Geese and cormorants were identified as the largest avian wildlife populations. The cormorants have become particularly troublesome as they have adapted to the local oyster fishery by roosting on the suspended oyster gear that is used by a few of the oyster fisherman with leases.
- 2) Human Waste: Located within the Mabou Harbour watershed is a municipal water and sewage treatment plant that discharges directly into the harbour and many homes along the harbour whose sewage beds would be located close enough to the water's edge to make them a potential source of bacteria.
- 3) Agricultural operations. Agriculture has been identified by DFO and DoE as a potential source of contamination. Large dairy and beef operations have been identified because it is well known that during the spring, summer and fall months that farmers spread manure collected from the animals during the winter to use as fertilizer. Rain events could cause bacteria to be flushed from

farmers fields into rivers and streams and ultimately this would make it way to the harbour. This could lead to negative publicity for the agricultural industry.

2.5 Project Goals

The goals of the Mabou Harbour watershed project are:

- 1) Map the entire watershed and any agricultural operations that exist within the watershed.
- 2) Identify testing sites from various defined zones of the harbour and from each of the major rivers/streams that empty into the harbour.
- 3) DNA test the water samples to determine the source of bacteria i.e. agricultural versus human versus avian waste.
- 4) Analyze testing results to determine highest probable cause of bacteria and prove if/not agriculture is the dominant cause.
- 5) Identify and reinforce sound practices and beneficial manure handling management practices to agricultural owner/operators within the watershed.

3. Project Activities

The project was divided up into the following main categories:

Mapping of the Watershed

Identification and Mapping of Agricultural Operations

Water Sampling and Testing

Data Summarization and Identification of Largest Potential Environmental Source of Bacteria

3.1 Watershed Mapping

The first step before undertaking any water testing or understanding where potential sources of contaminants were originating from was to map the water shed. This was subdivided into 3 activities:

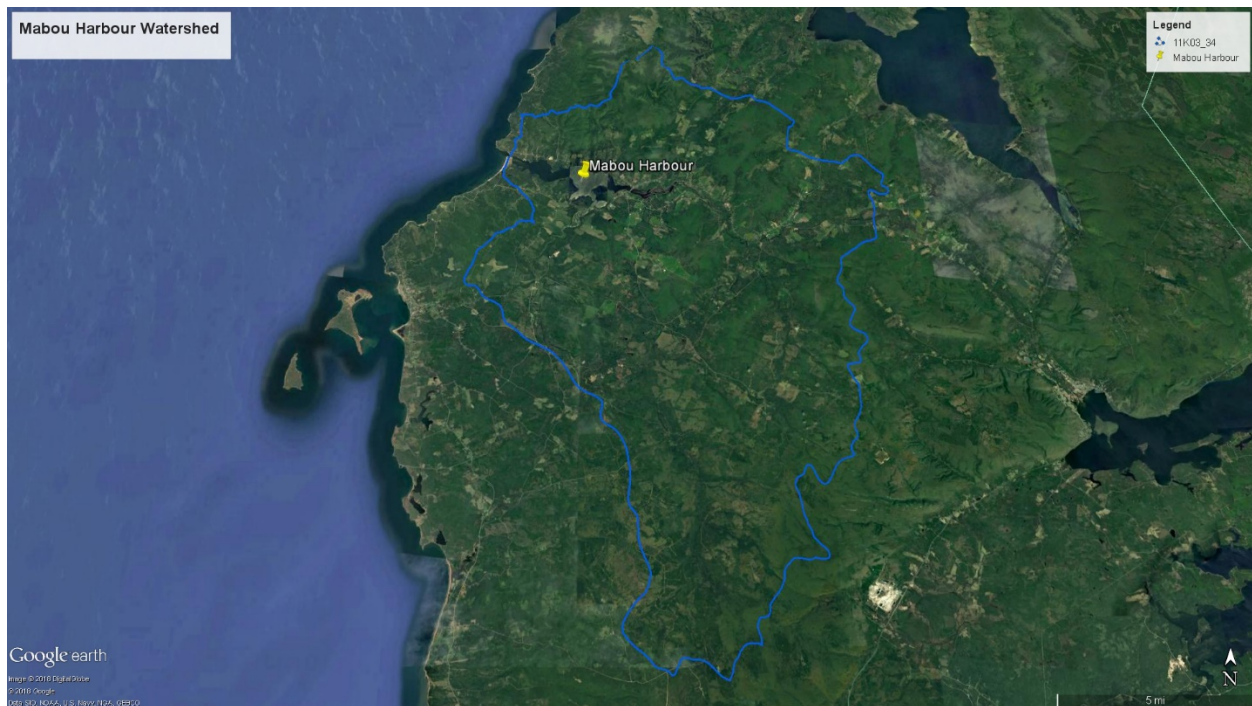
- 1) Mapping the boundaries of the watershed
- 2) Identifying the aquaculture sites within the watershed
- 3) Identifying test sites within the harbour

3.1.1 Watershed Boundaries

It was immediately apparent that mapping the watershed “manually” as part of the project was an immense task that would take up too many resources. To facilitate we asked local Department of Natural

Resource staff to help identify the boundaries of the watershed. They were only too glad to help. With the aid of their Geo-matics (sic) database we were able to obtain the boundaries of the watershed and identify all rivers/streams that empty into it. DNR printed a full-size map with their plotter equipment and also provided an electronic version in the form of a KMZ file. KMZ files can be imported into most GIS based applications. In this case we imported the file into Google Earth Pro. This allowed us to clearly see the boundaries of the watershed and more importantly it enabled us to interactively add “layers” to the map. In this manner we were able to add location pins for the water testing sites as well as the agricultural operations that were present within the watershed.

Figure 1: Mabou Harbour Watershed



As can be seen from the map the Mabou Harbour watershed is extensive. The outside boundary of the watershed is approximately 110 kms long and encompasses an area of roughly 90,000 acres.

There are 3 major rivers that drain directly into Mabou Harbour:

- 1) The Northeast River
- 2) The Mabou River
- 3) The Southwest Mabou River

Figure 2: Rivers draining into Mabou Harbour



Each of these rivers contain many streams and brooks that in turn drain into them.

3.1.2 Aquaculture Sites

The predominant aquaculture within Mabou Harbour is oyster farming with 9 oyster leases and 1 spat lease for seeding stock. For privacy purposes the owners of the oyster leases shall remain anonymous but the sites are shown below in Figure 3.

Figure 3: Oyster Lease Locations



Figure 4: Oyster Spat Lease (Big Cove)



The available oyster leases in Mabou Harbour are all located in the far western side of the harbour. This is due to the location of a municipal sewage treatment plant in the eastern end of the harbour. The sewage treatment plant empties into the harbour after waste goes through the treatment process.

Figure 5: Oyster lease boundary – no lease is allowed past the red boundary line



Figure 6: Municipal sewage treatment plant.



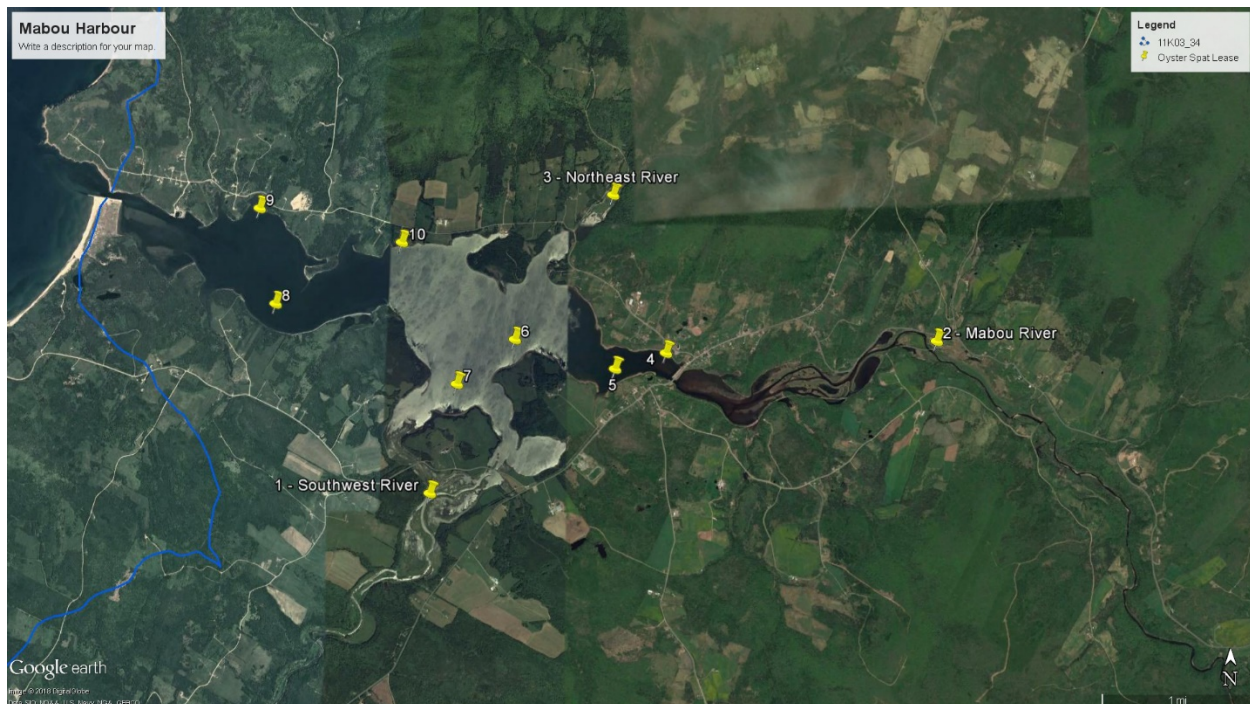
3.1.3 Test Sites/Water Sampling

Determination of the best test site locations for water sampling was key. In order to plan the site locations and do DNA testing on the water to determine source of bacteria we turned Dalhousie University and their Centre for Water Resources. There we were put in touch with Dr. Rob Jamieson. His areas of research are watershed modeling, contaminant transport, and passive wastewater treatment systems. He is a professional engineer with over 10 years' experience in water resources engineering, with particular expertise in hydrological modeling, water quality modeling, microbial water quality, and on-site and alternative wastewater systems.

During initial consultations with Dr. Jamieson we explained that we were trying to determine the source of bacterial contamination and after reviewing the budget that we could dedicate to water testing we came up with a water testing plan.

The plan would see us select 7 sample locations around the harbour and each of the 3 rivers for a total of 10 sample locations. These sample locations would be tested multiple times using DNA testing which would test for avian, human and bovine indicators. These indicators would determine the relative level of each of the sources. If any of the sources tested high for bovine, in particular any of the 3 river samples, we would be able to narrow down the search for potential source by visiting the farms upstream from the high test result. The samples were distributed and taken during various stages of tidal action (i.e. high/low tide) and during normal weather and after a large rain event.

Figure 7: Test Sites



3.2 Agricultural Operations

The Mabou Harbour watershed covers a large area as previously mentioned. Located within the watershed is often what's referred to as the agricultural breadbasket of Inverness County. That is the stretch of farms that begins in Port Hood, goes through Mabou/Mabou Ridge and out through Brook Village and Skye Glen. Almost all of Inverness County dairy farms are located within the watershed. Because of the intensive nature of farming in the area it was an easy target to identify agricultural operations as a major source of contaminants.

We turned to the Department of Agriculture in order to pinpoint the agricultural operations within the watershed. Again due to privacy reasons the names/owners of these operations shall remain anonymous. As part of the research a total of 58 farming operations were identified as being within the watershed. They spanned the following commodities:

- 1) Dairy
- 2) Beef
- 3) Mink/Fox
- 4) Greenhouse/Horticulture
- 5) Blueberry

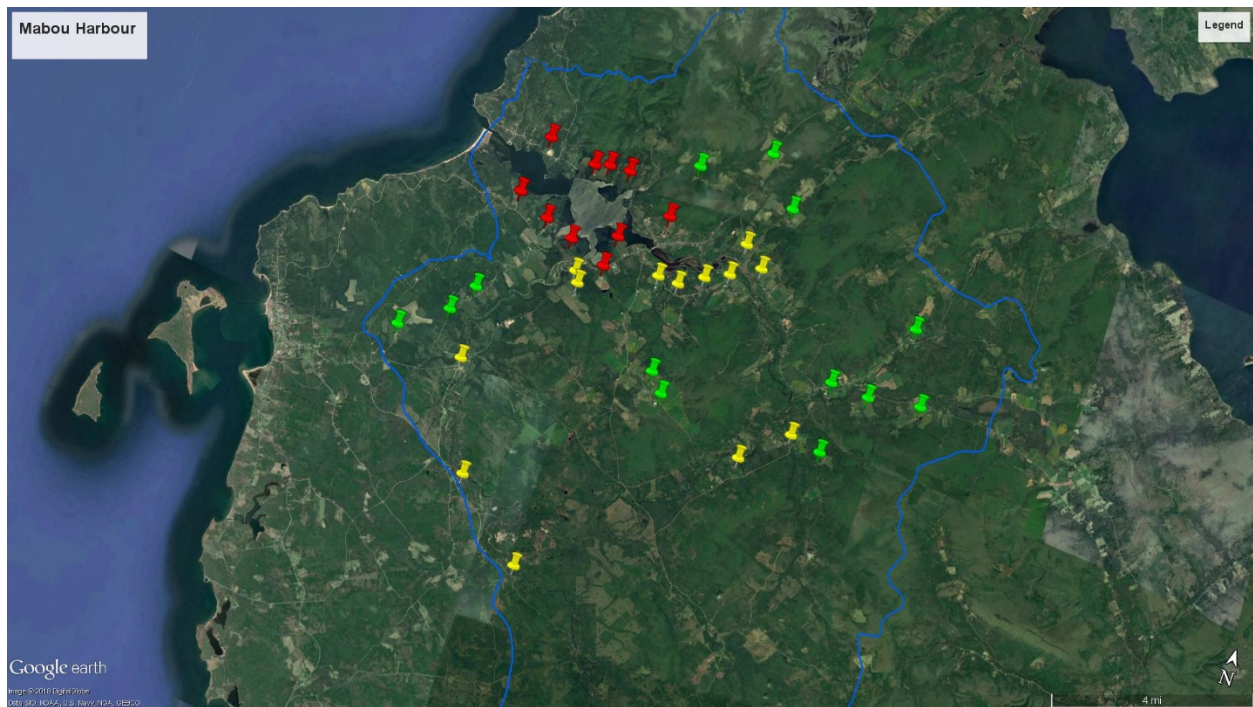
For purposes of this project we were only interested in the beef and dairy operations. The greenhouse/horticulture and blueberry operations wouldn't have any significant runoff and the mink/fox operation was determined to be too small to have any impact on bacteria levels.

The dairy and beef operations were divided into 3 categories:

- 1) Red – those operations that had land directly bordering the harbour
- 2) Yellow – those operations that had land directly on the major rivers entering into the harbour
- 3) Green – all other operations within the watershed

These designations were selected based on the degree of impact of agricultural runoff from manure. The idea being the closer to the harbour the easier it would be for contaminants to enter the harbour and the larger the affect would be.

Figure 8: Ag Operations on the Watershed



It was decided during the project that any farms within the red zone should be evaluated as to their manure management practices. Due to the sensitive nature of the issue we didn't feel it would be in the best interests of the project to confront farmers and interview them on their practices. Rather it was decided to simply determine if they had a valid environmental farm plan (EFP). Of the 10 farms within the red zone 5 (4 dairy farms and 1 beef farm) had an EFP. The other 5 beef operations did not have a EFP. Of these 5 beef farms, 3 of them had land bordering the water of the harbour however their fields were well back of the water and cattle were fenced away from the water. We determined that 3 beef operations had potential issue with contamination as they did not have animals fenced out of the streams crossing through their property. Once indicated they would rectify the situation once we explained the purpose of the project. The other was non-committal...but remains a works in progress.

3.2 Water Testing/Results

Fecal contamination is an issue for the oyster farmers in the harbour because oysters are filter feeders. Meaning they take water into their system and filter out organic material to feed on. It is known that a single oyster can filter as much as 50 gallons of water a day! They can retain particles as small as 2 microns. Unfortunately, that also means that any fecal material (i.e. bacteria) present in the water gets filtered as well. This material then stays in the oyster's system for up to 21 days. When bacterial levels in the oysters reach 330 MPN they are considered unfit for human consumption and harvesting is not allowed. In the past seasons the shellfish harvest in Mabou Harbour has been shut down temporarily on 3 separate occasions due to high bacterial levels. When oysters and surrounding waters in the oyster lease fail a bacteria test there is a process called "relaying" that allows oysters to be moved to a known "clean" area. They must stay in that relay area for at least 21 days in order to allow the bacteria they have stored in their system to clear out. After being relayed for 21 days oysters are cleared for human consumption again. These relay areas can either be in another body of water, for example the Mabou Harbour oysters could be relayed out in the ocean outside the harbour entrance (if the area was cleared by CFIA/ Department of Environment as being clean), or an on-land relay station could be used. This option however is expensive as it involves constructing a facility that can offer a proper clean relay area.

By far the best option is to ensure that bacteria levels in the current oyster leases remain below cutoff levels. To help ensure this the aforementioned committee comprised of The Mabou Harbour Watershed Committee, Department of Agriculture representatives, Department of Fishery representatives, Inverness/Victoria Federation of Agriculture representatives, the oyster lease representatives and Municipality of the County of Inverness representatives met and decided that having the Integrated Management Plan (IMP) was key based on the recommendations from inspectors that without it the fishery would be permanently closed.

As part of this IMP the Inverness/Victoria Federation of Agriculture agreed to apply for funding through the NSFA's water resource program funding. The successful application allowed us to perform additional testing throughout the watershed that the CFIA/Department of Fisheries/Department of Environment was not doing. The goal of the testing was to identify and ensure that agriculture was NOT the dominant source of bacteria in the harbour as was being implied by government officials because of the intensive nature of agriculture present in the watershed.

Listed below are the water testing results. The first data set is by sample date, test location and DNA marker identification. The two types of bacteria that were identified were Enterococci and E. Coli. These types of bacteria are the common indicators of fecal contamination in water.

October 11 2016					
Sample name	Enterococci (MPN/100 mL)	E. coli (MPN/100 mL)	Ruminant marker (Log copy/mL)	Avian marker (Log copy/mL)	Human marker (Log copy/mL)
1	41	42	0.05	2.28	1.94
2	12	28	0.84	2.28	1.69
3	9	9	1.12	2.20	1.77
4	574	30	1.56	2.53	2.26
5	90	70	0.97	2.16	1.87
6	503	26	1.92	2.17	2.03
7	495	37	1.04	2.27	1.56
8	456	11	2.04	2.55	1.88
9	295	7	0.66	2.23	1.60
10	411	6	0.99	1.94	1.82
November 6 2016					
Sample name	Enterococci (MPN/100 mL)	E. coli (MPN/100 mL)	Ruminant marker (Log copy/mL)	Avian marker (Log copy/mL)	Human marker (Log copy/mL)
1	1	20	0.51	1.18	0.84
2	2	4	0.36	0.87	0.53
3	2	3	0.53	1.19	0.99
4	2	3	0.35	1.23	1.79
5	5	5	0.16	0.86	2.27
6	2	4	0.92	1.02	1.60
7	7	8	0.50	1.18	1.47
8	25	3	0.42	1.12	1.43
9	209	1	0.16	0.99	Too low to detect
10	103	2	0.73	1.36	1.43
11	2	1	Too low to detect	1.09	0.86

August 21 2017					
Sample name	Enterococci (MPN/100 mL)	E. coli (MPN/100 mL)	Ruminant marker (Log copy/mL)	Avian marker (Log copy/mL)	Human marker (Log copy/mL)
1	951	203	1.36	2.25	Too low to detect**
2	12	128	0.93	0.43	Too low to detect
3	16	24	1.72	0.61	Too low to detect
4	240	107	0.96	0.68	1.87
5	361	130	0.66	0.77	2.07
6	128	47	<1 copy/mL*	0.47	0.96
7	130	71	<1 copy/mL	0.70	Too low to detect
8	52	57	<1 copy/mL	0.18	0.26
9	87	40	<1 copy/mL	0.49	Too low to detect
10	121	93	0.13	<1 copy/mL	0.18
11	94	294	<1 copy/mL	0.92	Too low to detect
12	213	572	<1 copy/mL	0.86	Too low to detect
* <1 copy/mL: marker detected however lower than 1 copy in 1 mL of water sample					
** Too low to detect: no qPCR signal above threshold (lower than 0.156 copies/mL)					
August 28 2017					
Sample name	Enterococci (MPN/100 mL)	E. coli (MPN/100 mL)	Ruminant marker (Log copy/mL)	Avian marker (Log copy/mL)	Human marker (Log copy/mL)
1	>2420	1667	<1 copy/mL	1.91	Too low to detect
2	24	117	1.40	1.03	0.37
3	14	19	1.89	0.77	0.48
4	202	572	<1 copy/mL	0.83	1.26
5	1252	732	1.61	1.12	1.13
6	186	730	<1 copy/mL	0.81	1.40
7	31	1483	0.37	1.43	0.92
8	407	465	<1 copy/mL	0.23	0.48
9	200	483	<1 copy/mL	<1 copy/mL	Too low to detect
10	203	805	0.28	0.69	Too low to detect
11	138	908	<1 copy/mL	0.58	Too low to detect
12	898	1670	<1 copy/mL	1.35	Too low to detect

Sept 11 2017					
Sample name	Enterococci (MPN/100 mL)	E. coli (MPN/100 mL)	Ruminant marker (Log copy/mL)	Avian marker (Log copy/mL)	Human marker (Log copy/mL)
1	107	47	0.72	1.54	Too low to detect
2	51	53	0.82	1.45	Too low to detect
3	49	50	1.58	0.82	Too low to detect
4	>2419.6	549	0.19	1.45	1.90
5	272	866	1.20	1.93	1.68
6	>2419.6	770	0.64	1.73	2.10
7	165	980	0.17	1.63	Too low to detect
8	>2419.6	328	<1 copy/mL	0.15	Too low to detect
9	328	1203	<1 copy/mL	0.54	Too low to detect
10	>2419.6	525	Too low to detect	0.70	Too low to detect
11	>2419.6	770	Too low to detect	1.29	Too low to detect
12	1046	816	Too low to detect	1.84	Too low to detect

Sept 25 2017					
Sample name	Enterococci (MPN/100 mL)	E. coli (MPN/100 mL)	Ruminant marker (Log copy/mL)	Avian marker (Log copy/mL)	Human marker (Log copy/mL)
1	579	228	1.04	<1 copy/mL	2.54
2	54	104	1.52	0.11	1.21
3	6	29	1.53	0.002	1.78
4	179	236	0.92	0.37	2.24
5	579	517	1.52	0.67	1.67
6	260	770	0.72	0.79	1.55
7	649	1553	1.36	1.20	1.13
8	96	81	0.18	<1 copy/mL	1.75
9	248	1046	0.68	0.69	1.95
10	66	154	<1 copy/mL	0.41	0.70
11	89	326	0.80	0.32	1.96
12	80	104	0.09	0.33	1.57

Dec 5 2017 - Sediment					
Sample number	<i>Enterococci</i>	<i>E. coli</i>	Ruminant marker	Avian marker	Human marker
8	2 MPN/g	2.4 CFU/g	<250 (copies/g) (Detection Limit:DL)	2902 copies/g	<250 (copies/g) (DL)
9	1 MPN/g	< 1 CFU/g	<250 (copies/g) (DL)	1667 copies/g	<250 (copies/g) (DL)
9a	< 1 MPN/g	< 1 CFU/g	<250 (copies/g) (DL)	467 copies/g	<250 (copies/g) (DL)
10	< 1 MPN/g	1.6 CFU/g	<250 (copies/g) (DL)	670 copies/g	<250 (copies/g) (DL)
11	1 MPN/g	< 1 CFU/g	<250 (copies/g) (DL)	565 copies/g	<250 (copies/g) (DL)

It became apparent after 6 rounds of testing that agriculture was consistently third as far as potential source of the bacteria contamination. To tabulate this, we decided to take a “sports analogy” approach. For each test the highest testing source of bacteria was assigned 3 points, next level 2 points and if the marker showed the lowest limit it was assigned 1 point. The points are broken down the tables below.

October 11 2016			
Sample	Avian	Human	Ruminant
1	3	2	1
2	3	2	1
3	3	2	1
4	3	2	1
5	3	2	1
6	3	2	1
7	3	2	1
8	3	1	2
9	3	2	1
10	3	2	1
Totals	30	19	11
November 6 2016			
Sample	Avian	Human	Ruminant
1	3	2	1
2	3	2	1
3	3	2	1
4	3	2	1
5	3	2	1
6	2	3	1
7	2	3	1
8	2	3	1
9	3	1	2
10	2	3	1
11	3	2	1
Totals	29	25	12

August 21 2017			
Sample	Avian	Human	Ruminant
1	3	1	2
2	3	1	2
3	1	2	3
4	1	3	2
5	2	3	1
6	2	3	1
7	3	1	2
8	2	3	1
9	3	1	2
10	1	3	2
11	3	1	2
12	3	1	2
Totals	27	23	22
August 28 2017			
Sample	Avian	Human	Ruminant
1	3	1	2
2	2	1	3
3	2	1	3
4	2	3	1
5	1	2	3
6	2	3	1
7	3	2	1
8	2	3	1
9	3	2	1
10	3	2	1
11	3	1	2
12	3	1	2
Totals	29	22	21

Sept 11 2017			
Sample	Avian	Human	Ruminant
1	3	1	2
2	3	1	2
3	2	1	3
4	2	3	1
5	3	2	1
6	2	3	1
7	3	1	2
8	3	1	2
9	3	1	2
10	3	1	1
11	3	1	1
12	3	1	1
Totals	33	17	19
Sept 25 2017			
Sample	Avian	Human	Ruminant
1	1	3	2
2	1	3	3
3	1	2	2
4	3	1	2
5	1	3	2
6	2	3	1
7	2	1	3
8	1	3	2
9	2	3	1
10	2	3	1
11	1	3	2
12	1	3	2
Totals	18	31	23

Dec 5 2017 - Sediment			
Sample	Avian	Human	Ruminant
8	3	1	1
9	3	1	1
9a	3	1	1
10	3	1	1
11	3	1	1
Totals	15	5	5

After the 6th test round we decided to switch gears a little and test the sediment in the oyster lease areas. During the sediment test both ruminant and human markers were below the detection limit for bacteria. Avian markers however were especially high. This, along with the results from the water testing, would indicate that avian was going to be the largest potential source of bacterial contamination. Taking the sediment examples into consideration the total points allocated to each source was:

Total Points		
Avian	Human	Ruminant
181	142	113

4. Conclusion and Next Steps

From the data results to date, the conclusion is that avian is the largest source of contamination in the Mabou Harbour. It will likely take many years to rid the sediment of the bacterial load that is already present. There are steps that can be taken to mitigate future avian impact on the harbour. This could include the purchase and installation of sound devices much like the agricultural industry uses to keep birds and animals away from crops. Another potential is to use drone technology to periodically fly by to scare birds away. The idea being that if it's done enough times the birds will find another resting place. A third mitigation step would be to eliminate the use of suspended oyster gear that gives birds a resting place within the oyster leases. This will cost money but won't solve the entire problem because high avian bacterial sources were found in oyster leases that use natural bottom oyster beds rather than suspended gear.

Even though human and ruminant sources have been found to be 2nd and 3rd respectively as the source of bacteria in the harbour they are still contributing to the overall bacterial load. There are steps that can be taken to help mitigate these as sources of bacteria.

With regards to human sources the obvious step is to reduce/eliminate human waste from entering the watershed/harbour. To that effect, the Municipality of the County of Inverness was eventually planning to replace the aging (50+ years) sewage treatment plant. When the shellfish industry was shutdown and preliminary results started to show a high human load the Municipality fast tracked the application for federal funding. They were successful in obtaining emergency funding and the sewage treatment plant is currently being replaced. It is due to be operational in 2018.

Agriculture also has their part to play in reducing bacterial load. While the agricultural bacterial levels were seen to be the least of the three, they are still present. Farmers can do their part by strictly following the Environmental Farm Plans, be ensuring buffer zones are followed and cattle are fenced out of water sources. Farmers can ensure that when spreading manure, they are following the generally accepted guidelines which has certain set backs from water sources for spreading, ensuring that they are not spreading on frozen ground, nor spreading immediately before a forecasted large rain event which would see washing. They can also inspect manure storage facilities to ensure they are adequate and not leaking.

Even though the water source funding from NSFA is depleted, Dalhousie University has agreed to perform a round of testing at no additional cost in the spring/summer of 2018. This will include an early season water sample to determine a baseline bacterial level before the heat of the summer and before agricultural operations typically start spreading manure on their fields. They will also perform DNA testing directly on the oysters themselves. This should see avian as the highest bacterial source present and correlate to the results found to date with water and sediment testing.