MEMORANDUM

TO: Jared Woolston, Town of Brunswick

FROM: Forrest Bell, FB Environmental

SUBJECT: Mare Brook Stressor Analysis Methodology

DATE: April 20, 2016

CC: Margaret Burns & Sabrina Vivian, FB Environmental; Jennifer Jespersen, Ecological Instincts

The purpose of this document is to provide the **Mare Brook Watershed Assessment & Community Engagement Project** Technical Advisory Committee (TAC) with an overview of the stressor analysis methodology developed by FB Environmental (FBE). The stressor analysis is designed to compile and assess the surface water quality data available for Mare Brook and its tributaries.

Water quality data has been collected by numerous entities overtime, including the Maine Department of Environmental Protection (Maine DEP), the U.S. Department of Navy, and private consultants. The stressor analysis builds upon the Mare Brook data directory (data deliverable #1) and data collection history (data deliverable # 2). Data used for the stressor analysis was extracted from the data collection history and includes all of the quantitative physical and chemical data that related to surface water in the watershed. This memo can be used in conjunction with the Data Collection History which identifies the Site Aliases for the 24 unique sites within the data.

TABLE OF CONTENTS

OBJECTIVE

The objective of the Stressor Analysis is to provide an efficient means by which to synthesize and evaluate available surface water data in the Mare Brook watershed in order to identify gaps in the data, to develop recommendations for long-term monitoring and assessment, and to provide project partners and the public a simple and dynamic visual tool for understanding the stressors that are affecting water quality. This memo outlines the stressor analysis methodology developed by FB Environmental. Nine 'stressor' categories were selected based on the best available data across all sites in the watershed. A 'stressor' is an environmental factor that has the potential to negatively affect water quality and result in the stream not meeting its Class B designated uses under the Federal Clean Water Act. The nine stressors proposed for the stressor analysis are as follows: bacteria, conductivity, dissolved oxygen, macroinvertebrates, metals, nutrients, pH, toxics, and temperature (Figure 1). The one exception is the "macroinvertebrates" category where monitoring of macroinvertebrates is a response to other water quality stressors in Mare Brook. It is still analyzed similarly; however, the interpretation needs to be approached from this angle. Poor macroinvertebrate communities could prove to be a stressor for other fish assemblages. For each of these stressor categories, threshold criteria was developed to represent poor "red", moderate "yellow", and healthy "green" water quality for that category.

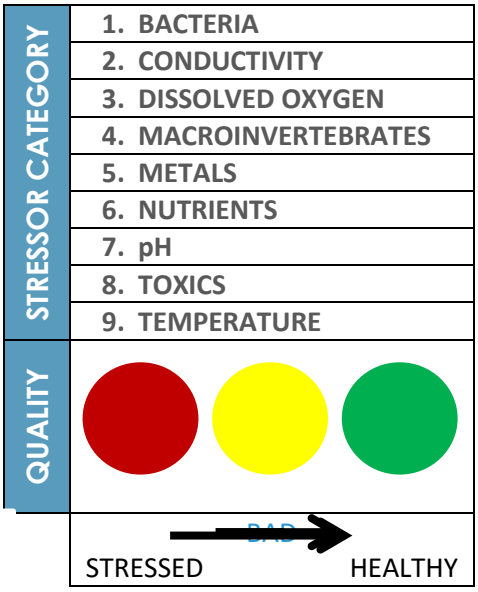

Figure 1. Conceptual representation of the nine stressor categories for Mare Brook and how they will be rated within the stressor analysis.

The stressor analysis can be applied to each monitoring site within the watershed to identify areas with degraded water quality as well areas where the stream is in relatively good condition. Furthermore, the analysis will provide information about existing data monitoring gaps. An understanding of the existing data and the breadth of the data gaps will help inform recommendations for future monitoring and restoration efforts in the Mare Brook watershed.

METHODOLOGY

DATA SELECTION

The data that will be used for the stressor analysis includes a compilation of data provided by the Maine DEP through their Environmental and Geographic Analysis Database (EGAD) database, the Town of Brunswick, and the U.S. Navy. The only Navy data used in the stressor analysis was data made available by the Maine DEP in their EGAD database. From all sources, only data designated as sampled from surface water will be used for the analysis. While other sample types such as groundwater, pore water, and sediments are important for understanding the hydrology and chemistry of the whole watershed, the stressor analysis is meant to prioritize the water quality within Mare Brook and its tributaries. The stressor analysis provides an efficient means by which specific areas of the stream can be targeted to further investigate the stressors that are identified including additional field surveys and/or monitoring or modeling the hydrology within the greater watershed area.

Once the data was aggregated within the data collection history, the following modifications were made to the data set in order to provide consistency for the stressor analysis:

- All sites were assigned an "FBE Alias" site name in accordance with the data collection history;
- All units within the data were standardized to match the criteria for a given parameter;
- For any values below the laboratory detection limit, the detection limit was used as a placeholder for the analysis.

STOPLIGHT CRITERIA

Synthesis of such a broad data set is difficult due to differences in sampling methodology, laboratory analysis techniques, and spatial and temporal scales. A "stoplight" system was developed to provide an overview of the available water quality data for Mare Brook and its tributaries. A total of nine stressors were evaluated using threshold criteria ranging from "poor" to "moderate" to "healthy" (Table 1). The criteria used to create the stoplight system is based on the Maine standards for Class B freshwater streams. While additional water quality parameters have been collected in Mare Brook over the historical sampling period beyond those presented in Table 1, they were not included in the analysis if they are not used to assess water quality in Class B streams. Estuarine data is not included in the stressor analysis because the criteria is not uniform across the freshwater-saltwater interface and there is insufficient data to run the analysis.

Table 1. Criteria developed to evaluate the data within each stressor category for the Mare Brook stressor analysis. This criteria is for the purpose of data assessment and visualization only, not for making attainment determinations.

BACTERIA CRITERIA	
Red	>75% of instantaneous samples are >236 MPN or geometric mean > 64 MPN
Yellow	25 - 75% of instantaneous samples are >236 MPN
Green	< 25% of instantaneous samples are >236 MPN
CONDUCTIVITY CRITERIA	
Red	3,292 µS/cm exceeded or > 854 µS/cm exceeded for >50% of samples
Yellow	854 µS/cm exceeded for < 50% of samples
Green	No exceedances of 854 µS/cm
DO CRITERIA	
Red	< 5 ppm or 60% saturation for any sample
Yellow	> 5 ppm and < 7 ppm or 75% for any sample
Green	DO > 7 ppm and > 75% saturation for all samples
MACROINVERTEBRATES	
Red	NA or never met Class B standard
Yellow	Met Class B standards for any one sample within any five year period
Green	Met Class B standards for two consecutive samples within any five year period
METALS CRITERIA	
Red	CMC exceeded or CCC exceeded for >50% samples for any metals
Yellow	CCC exceeded for 30-50% of samples
Green	No exceedances of CCC or CMC for any metals

NUTRIENTS CRITERIA

Red	0.02 mg/L Total Phosphorus exceeded or 0.38 mg/L Total Nitrogen exceeded for >50% of samples
Yellow	0.01 mg/L Total Phosphorus exceeded, or 0.38 mg/L Total Nitrogen exceeded for 30 – 50% of samples
Green	No exceedances of recommended Total Phosphorus or Total Nitrogen thresholds

pH CRITERIA

Red	>75% of samples are < 6.5 or > 8.5
Yellow	25 - 75% of available samples are < 6.5 or > 8.5
Green	<25% of samples are < 6.5 or > 8.5

TOXICS CRITERIA

Red	CMC exceeded or CCC exceeded for >50% samples for any toxic
Yellow	CCC exceeded for 30-50% of samples
Green	No exceedances of CCC or CMC for any toxic

TEMPERATURE CRITERIA

Red	Any individual sample exceeds 24°C
Yellow	All samples below 24°C
Green	All samples below 18°C

PARAMETER CRITERIA

Once the data was aggregated, a unique parameter list was created to identify all chemical and biological parameters within the data. A total of 168 unique parameters have been measured in the surface waters of Mare Brook and its tributaries. However, only 21 of these parameters have criteria that can be compared to Maine's Class B water quality standards (Table 2). Where available, criteria maximum concentration (CMC) and criteria continuous concentration (CCC) are used for the analysis. However, if a given parameter does not have a CMC or CCC, the threshold minimum and maximum values (listed in the "MIN CRITERIA" and "MAX CRITERIA" columns) are used to represent a combination of standardized and recommended thresholds provided by either the State of Maine or the U.S. Environmental Protection Agency (USEPA). Therefore the purpose in this analysis is not to determine water quality attainment, but rather to provide a common benchmark or benchmarks for evaluation of water quality in Mare Brook.

Table 2. Threshold criteria proposed to evaluate each of the unique parameters identified in the historical monitoring data. If available, criteria maximum concentration (CMC) and criteria continuous concentration (CCC) will be used for the analysis. If the parameter does not have a CMC or CCC, the threshold minimum and maximum values are listed in the "MIN CRITERIA" and "MAX CRITERIA" columns. Footnotes refer to the Maine Surface Water Toxics Program Chapter 584. NC = "No CMC or CCC Criteria". n/a = Not Applicable

UNIQUE PARAMETER ID	STRESSOR CATEGORY	CMC	CCC	MIN CRITERIA	MAX CRITERIA	UNITS	FOOTNOTE	SOURCE
E. COLI	BACTERIA	NC	NC	NC	236.00	MPN	n/a	Classification of Maine Waters: Class B Freshwater
SPECIFIC CONDUCTANCE	CONDUCTIVITY	NC	NC	NC	854	µS/cm	n/a	Developed from 2010-2011 Long Creek Annual Report
% DO	DO	NC	NC	NC	75.00	PERCENT	n/a	Classification of Maine Waters: Class B Freshwater
DISSOLVED OXYGEN	DO	NC	NC	NC	7.00	PPM	n/a	Classification of Maine Waters: Class B Freshwater
ALUMINUM	METAL	750	87.00	n/a	n/a	µg/L	G, L (for CCC only)	Maine Surface Water Toxics Program Chapter 584
ARSENIC	METAL	340	150.00	n/a	n/a	µg/L	A, K	Maine Surface Water Toxics Program Chapter 584
CADMIUM	METAL	0.42	0.80	n/a	n/a	µg/L	E, K, bb	Maine Surface Water Toxics Program Chapter 584
CHROMIUM III	*METAL*	*483*	*23.10*	*n/a*	*n/a*	*µg/L*	*E, K*	*Maine Surface Water Toxics Program Chapter 584*
CHROMIUM VI	*METAL*	*16*	*11.00*	*n/a*	*n/a*	*µg/L*	*K*	*Maine Surface Water Toxics Program Chapter 584*
COPPER	METAL	3.07	2.36	n/a	n/a	µg/L	E, K, cc	Maine Surface Water Toxics Program Chapter 584
IRON	METAL	NC	1,000.00	n/a	n/a	µg/L	F (for CCC only)	Maine Surface Water Toxics Program Chapter 584
LEAD	METAL	10.52	0.41	n/a	n/a	µg/L	E, bb, gg	Maine Surface Water Toxics Program Chapter 584
MERCURY	METAL			n/a	n/a			Maine Surface Water Toxics Program Chapter 584
NICKEL	METAL	120.2	13.40	n/a	n/a	µg/L	E, K	Maine Surface Water Toxics Program Chapter 584
SILVER	METAL	0.23	NC	n/a	n/a	µg/L	G, E (for CMC only)	Maine Surface Water Toxics Program Chapter 584
ZINC	METAL	30.6	30.60	n/a	n/a	µg/L	E, K	Maine Surface Water Toxics Program Chapter 584
pH	pH	NC	NC	6.50	8.50	STD UNITS	n/a	
TEMPERATURE	TEMPERATURE	NC	NC	NC	24.00	CELSIUS	n/a	Brungs and Jones 1977 (US EPA)
4,4'-DDT	TOXICS	1.1	0.00	n/a	n/a	µg/L	G, aa (for CCC only), ii	Maine Surface Water Toxics Program Chapter 584

SELENIUM	TOXICS	NC	5.00	n/a	n/a	µg/L	L, R (for CMC only)	Maine Surface Water Toxics Program Chapter 584
TOTAL NITROGEN	NUTRIENTS	NC	NC	n/a	0.38	Mg/L		USEPA Ecoregion VIII (northeast)
TOTAL PHOSPHOROUS	NUTRIENTS	NC	NC	n/a	>0.05	mg/L	n/a	USEPA Ecoregion VIII (northeast)

EXAMPLE STRESSOR ANALYSIS OUTPUT

BACTERIA

In 2015, Maine DEP collected bacteria samples from five sites along Mare Brook and Merriconeag Stream. To our knowledge, this is the only bacteria data available for the Mare Brook watershed. Maine bacteria standards for Class B freshwater streams allows an instantaneous count of 236 MPN/100 ml sample and a geometric mean of 64 MPN/100 ml from May 15 to September 30.

Each of the five sites were sampled across six dates in 2015- August 5, August 12, September 16, September 22, and October 14, except Baribeau Drive, which was not sampled in August. Two of these dates (8/12 and 10/14) were during periods of stormflow and consequently have elevated bacteria levels. Because the last sampling event took place after September 30th, data from this sampling event was not included in the stressor summary presented below. However, the geometric means for all sites remained above the 64 MPN/100ml criteria with the inclusion of this point.

All sites monitored for bacteria in 2015 had a geometric mean greater than 64 MPN/100ml and thus, had periods of elevated bacteria (Table 3). Instantaneous bacteria was highest during the August 12 storm event (0.85 inches of rain in the previous 24 hours) at all sites (except Baribeau Drive which was not sampled). The stressor analysis reveals that bacteria levels are highest at the upstream sites on Mare Brook including MB22 (Station S-1064) and MB24 (Baribeau Drive). These sites are within residential areas and elevated bacteria could be a result of human waste and pet waste inputs to the stream from this development. The stressor criteria categorizes any site with a geometric mean > 64 MPN as "red" and thus, even the sites with lower exceedances of 236 MPN (MB7 and MB8) receive a "red" stoplight. This suggests that one or few points are very high and are causing the elevated geometric mean.

Table 3. Summary table of bacteria data for Mare Brook. Bacteria data was collected at five locations in 2015. Sites labeled downstream → upstream.

SITE	SAMPLE COUNT	PERCENT >236 MPN/100ML	GEOMETRIC MEAN	STOPLIGHT
MB7	5	20%	106.3	RED
MB8	5	20%	108.0	RED
MB16	6	33.3%	196.6	RED
MB22	6	83.3%	584.1	RED
MB24	3	33.3%	236.6	RED

MACROINVERTEBRATES

Biomonitoring for macroinvertebrate abundance and diversity has been completed at seven sites within Mare Brook and its tributary streams beginning with two sites in 1991 and increasing to four sites in 2015. Of particular note is the gap in monitoring data between 2003 and 2015 where no sites were monitored.

Table 4. Summary table of macroinvertebrate data collected from 1991 – 2015 at seven different sites. Data from sites all are not consistent across years.

SITE (DEP SITE)	NUMBER OF YEARS SAMPLED	PERCENT ATTAINED	STOPLIGHT
MB3 (S-332)	3	0.0%	RED
MB7 (S-330)	9	0.0%	RED
MB8 (S-457)	8	0.0%	RED
MB9 (S-144)	10	0.0%	RED
MB13 (S-331)	8	28.6%	YELLOW
MB16 (S-143)	12	41.7%	GREEN
MB22 (S-1064)	1	0%	RED

Overall, macroinvertebrate sampling locations in the Mare Brook watershed indicate that stream conditions are unsuitable for stable and diverse macroinvertebrate communities. Poor macroinvertebrate communities in the downstream locations could be attributed to toxic pollutants from the airport and Navy land. However, macroinvertebrates collected in 2015 in the upper watershed are also indicating poor water quality. Site MB22 (S-1064) was non attaining (NA) in 2015 suggesting that macroinvertebrates are stressed even in the upper reaches of the watershed. The causes of this designation are unknown and warrant further investigation, however, low flows and loose bottom sediments could be responsible for poor macroinvertebrate habitat. Macroinvertebrates at this site are dominated by isopods with low abundance of sensitive organisms. Site MB16 (S-143) has previously met class in 1995, 1997, 1998, 1999, and 2003 and it met Class C in 2015. A higher abundance of mayflies and caddisflies is most likely responsible for the higher class designation (compared to S-1064), however, 2015 data still revealed a high abundance of isopods. This site has more water, which could be providing better habitat for macroinvertebrates in this area. *Macroinvertebrate data interpretation from personal communication with Leon Tsomides (Maine DEP).*

In this case, the stressor criteria assigns a “green” stoplight value to any site that has met attainment twice in ANY five year period. In this case, site MB16 (S-143) met attainment from 1995 – 1999 and so it classifies this site as “healthy”. However, these threshold criteria do not account for more recent data which has reached the classes of “NA” in 2003 and “C” in 2015, presenting a limitation in these criteria.

LIMITATIONS

Aggregating large datasets with various sampling methodologies has limitations, particularly concerning the interpretation of the data. In this section, six major limitations are presented that may affect interpretation of the proposed stressor methodology:

1. **Temporal Variability:** Each site within this dataset contains data from different years and at variable frequencies. Therefore, the stoplight result from the analysis might be weighted by sampling events from a given time. *For example:* If a site has a lot of data from the 1990s but no recent data, the stressor activity will flag this site as having "poor" water quality, despite potential undocumented improvements to the water quality in recent years.
2. **Spatial Variability:** The stressor analysis can only be completed for documented monitoring locations. Stream water quality could be variable between these sites. Recommendations from the stressor analysis might include sampling at specific locations where a problem is identified (for example an outfall) upstream or downstream of an existing monitoring site to bracket the input.
3. **Sampling Methodologies:** Samples collected by multiple entities may have different sampling protocols, field equipment, and quality assurance plans. This document is a summary of existing data and does not analyze the variability between methodologies.
4. **Parameter Limitations:** Parameters that lie outside these nine stressors and have no recommended state or federal criteria were not included in the analysis.
5. **Stoplight Thresholds:** Because this analysis is not intended for making water quality attainment determinations, the parameter criteria developed for the analysis are subjective in nature. For these reasons, individual interpretation of the stoplight colors could result in misinterpretations of the results.
6. **Lack of Raw Data from Navy:** The Navy has collected a large volume of data related to Mare Brook below the airport. This data is currently available through various reports and (in some cases) through the Maine EGAD database. Synthesizing this data would require substantial time and effort and therefore, much of this data is not included in the stressor analysis.

PRELIMINARY GAPS AND RECOMMENDATIONS

The following section outlines the preliminary gaps and recommendations identified to date. It is important to note that a gap analysis is an evolving task, with initial gaps being filled as data becomes available from project partners, and new gaps will be identified through review of existing data, the stressor analysis, and field surveys. It is the role of the TAC to provide input and feedback to help fill in the identified data gaps. Major gaps and associated recommendations to help address these gaps are presented below.

- **Bacteria:** Only 2015 data is available for bacteria. Elevated levels of bacteria at all sites indicate the need for more frequent sampling to identify sources of bacteria to the stream.

  Recommendations: Repeat bacteria grab samples collected in 2015 to establish baseline conditions at these sites. Increase the frequency of bacteria sampling to include major tributaries and road crossings to help identify the bacteria sources. Following 2016, collect bacteria every other year or after any significant remediation effort. Bacteria data should be collected across both stormflow and baseflow with a minimum of six samples per season. Perform bracket sampling for sites with high hits and use bacteria source tracking canines to determine human inputs, if needed. Enterococci sampling should be added within the estuary to test for bacteria in the saltwater portion of the watershed.

- **Chloride:** Mare Brook has significant data for specific conductivity but no data has been collected to identify chloride levels in the watershed. While the two parameters are related, specific conductivity cannot be used for attainment determinations according to Maine state standards.

  Recommendations: Include chloride grab sampling at the same frequency and locations as the bacteria sampling (these sites will represent a good spatial distribution within the watershed and will also save on costs due to travel and any bulk laboratory fees). Use chloride data to develop a chloride-specific conductivity relationship specific to Mare Brook.

- **Dissolved Oxygen:** Historical dissolved oxygen data focused in the lower portion of the watershed in the 1990s and early 2000s. Data from the upper watershed is only available from 2015. Deploying continuous loggers in the upper watershed can inform the TAC on how DO levels compare to seasonal standards that include multiple days.

  Recommendations: Deploy continuous loggers for a minimum of two weeks during baseflow at multiple sites above and below the airport and U.S. Navy land.

- **Macroinvertebrate Data:** Macroinvertebrate data was collected from 1991 – 2003 and was not collected again until 2015. Data collected in the 1990s was focused around and below the airport and U.S. Navy land.

  Recommendations: Increase frequency of macroinvertebrate data collection, with collection occurring at least twice every five years at sites with long-term data history. In 2016, repeat sites MB8 (S-457) and MB7 (S-330) in their original locations (currently inaccessible due to locked gates). Also include site MB9 (S-144) which was inaccessible in 2015. Repeat at least one site in the upper watershed in 2016 (recommend site MB22 (S-1064)).

- **Fisheries:** Very little data is available to assess the extent and location of fish within Mare Brook. The only data available is from limited counts taken in 2015, a 1995 study and 2007 follow-up study, and modeled locations in the Maine Habitat Viewer.

  Recommendations: Conduct fish counts across the entire stream to identify the species present and extent of these species. Work with the Department of Marine Resources (Maine DMR) to perform an investigation to see if Mare Brook is used by smelt.

- **Influence of Merriconeag Stream:** While groundwater-surface water investigations of Merriconeag Stream have been conducted (as recently as 2012), these studies are limited in their scope.

  Recommendations: It would be most helpful for the U.S. Navy to provide the town with annual summary data of Merriconeag Stream.

- **Flow:** Flow data only exists as property of the U.S. Navy and their independent consultants. No flow data is available upstream of the airport.

  Recommendations: Monitor flow (at least with gauges) upstream of the airport to identify how high and low flows might be an additional stressor to aquatic life within the stream. Work with the U.S. Navy to provide a summary report of flow data from the gauges along Merriconeag Stream.

QUESTIONS FOR THE TAC

It is important that the TAC provide feedback for the final stressor analysis. We are asking the TAC to review the stressor analysis methodology and come prepared to discuss the following questions:

1. Do you think the nine identified stressors are suitable for identifying the water quality issues in the Mare Brook watershed?
2. Are there additional stressors that you think would be better suited for assessing existing data and if so, is there sufficient data to support that stressor?
3. Do you have any recommendations or changes to the criteria used to determine the “red”, “yellow”, and “green” stop lights proposed for the stressor analysis?
4. Do you have any additional monitoring recommendations?