10-1971

Special Studies

Walter A. Lawrance
Bates College

SPECIAL STUDIES
ANDROSCOGGIN RIVER WATER FOAM
1971

A. Surface Tension B. Conductivity

Introduction. The presence of large areas of foam at certain locations on the surface of the Androscoggin River water is objectionable. The color is usually off-white to light brownish but often is a dark, dirty-brown and presents a very unaesthetic appearance. The general public usually associates extensive foam with gross water pollution.

The Technical Committee has discussed this problem on several occasions in previous years and at the April 1971 meeting decided to conduct preliminary investigations of the relation of river water foaming to (A) Surface Tension and (B) Conductivity.

Foam. Foam may be described as a collection of small bubbles formed on the surface of a liquid by agitation. For the purposes of this report the liquid is Androscoggin River water and the agitation is produced by the passage of the water over dams, rips or by mechanical means. The major consituents of the river water are colloids, Lignin compounds and tall oil soaps; carbohydrates,cations (sodium, calcium) etc., etc.

To obtain a foam of any reasonable stability a stabilizing agent is essential. Most foaming agents are hydrophilic colloids, such as water soluble soaps, saponins, proteins, clays and certain polymers, methyl cellulose, etc. The thickness of the stabilizing adsorbed film, whether a mono- or poly- layer and the manner in which it contributes to the overall stability is often a function of the boundary tension. The objective of this very preliminary study was to discover the relation (if any) between the surface tension of a sample of river water and the extent and persistence of the foam at a given location. In the Androscoggin river the areas where foaming is extensive are:

A.	1 Gilead	2 Bethel	
B.	1 Dixfield	2 Canton Point	
C.	1 Riley	2 Jay	3 Livermore Falls
D.	1 North Turner	2 Gulf Island Dam	3 Deer Rips Dam
		4 Lewiston Falls	

The C sector is a major foam problem area due to the agitation at the Dams and the close proximity of two mills.

River water samples were obtained at most of the regular sampling stations on June 3, June 8, June 16-17, and June 23-24, 1971. On June three a series of tests were made for exploration, testing methods, equipment and defining parameters. Data obtained in Series Two, Three and Four are tabulated on adjacent pages.

A few tests were made on water samples from the Androscoggin Pool at the usual sampling locations. The results of the laboratory tests are recorded in the accompanying tables.

Conclusions

1. The generally accepted theory, that the lower the surface tension the greater is the tendency to formation of foam, may not always be correct, under conditions existing in

the river. At times the volume and persistence of foam may vary within wide limits, when the measured surface tensions of the river water show only very small variations. However, a decrease of six to ten dynes per centimeter in Androscoggin river water, indicates a high potential for foaming, under suitable conditions of agitation.

2. Temperature control during the tests and cleanliness of the dish and platinum ring are very important.
3. At times, the presence of very fine suspended solids appeared to increase the stability of the foam. There was no apparent relation between the volume of laboratory made foam and river foam.
4. Some river water samples formed an "oily" foam, in the volumetric flask, which adhered to the glass and only slowly flowed down when the water was decantered. This phenomenon occurred only in samples taken just below the mills.
5. Filtration of the river water samples usually, but not always, lowers the surface tension one to two and one half dynes/cm, however, the volume of foam produced in the laboratory was not appreciably changed.
6. After considering the results of the surface tension experiments and predictive probabilities, the work in this phase of foaming was discontinued.

ANDROSCOGGIN RIVER

FOAM STUDIES

SURFACE TENSION

1971

Series Two Location	pH	S.T. 20°C dynes/cm	Foam on River	Foam Laboratory	Suspended Solids
Berlin (Bell's)	6.85	75.6	0	0	0
Gorham	6.72	71.5	1	0.25"	moderate
Gilead	6.68	62.2	2	0.5"	"
Bethel	6.70	65.1	1	0.25"	"
Rumford (VB)	6.5	66.7	2	0.25"	small dirty
Dixfield (SP)	6.6	73.2	1	0.25"	?
Canton	6.6	73.6	1	0.25"	moderate
Riley	6.5	73.2	2	0.25"	"
Jay	6.9	73.6	2	trace	dirty brown
Otis	6.6	73.8	3	0.25"	small "
Liv. Falls	6.6	73.8	2	0.5"	"
N.T. Bridge	6.7	74.4	1	0.25"	"

Sampled June 8, 1971

ANDROSCOGGIN RIVER

FOAM STUDIES

SURFACE TENSION

1971

Series Three Location	pH	S.T. 20°C dynes/cm	Foam on River	 Laboratory	Suspended Solids
*Berlin(Bell's)	6.30	73.2	0	0	very slight
*Gorham	6.30	72.0	0	trace	large amount
*Gilead	6.32	73.2	1	0.125"	" "
*Bethel	6.45	73.2	0.5	0.125"	moderate
Rumford (VB)	6.6	70.7	2	0.125"	Trace
Dixfield (SP)	6.6	73.2	1	0.25"	moderate
Canton	6.7	72.0	1	0.375"	"
Riley	6.4	73.2	2	0.125"	"
Jay	6.8	72.0	3	0.125"	"
Otis	6.5	73.2	1	0.375"	
Liv. Falls	6.6	73.2	3	0.375"	"
N.T. Bridge		73.2	2	0.375"	"

Sampled June 16* and 17

ANDROSCOGGIN RIVER

FOAM STUDIES

SURFACE TENSION

1971

Series Four Location	pH	S.T. 20°C dynes/cm	Foam on River	Foam Laboratory	Suspended Solids
*Berlin(Bell's)	6.5	75.6	0	0	Trace
*Gorham	6.4	74.4	0	0.25"	Large
*Gilead	6.3	74.4	1.5	0.25"	"
*Bethel	6.4	75.0	1	0.125"	moderate
Rumford (VB)	6.7	74.4	2	0.125"	Small; very fine
Dixfield (SP)	6.8	73.5	1	0.188"	moderate
Canton	6.8	73.2	1	0.375"	"
Riley	6.7	74.4	3	0.125"	"
Jay	7.2	70.5	4	0.75"**	"
Otis	6.8	73.5	3	0.5	"
Liv. Falls	6.8	72.0	4	0.188"**	"
N.T. Bridge	6.9	61.6	3	0.375"**	"

June 23* and 24 **Foam oily and "sticky"

Foam Test. About 800 ml of river water was placed in a one-liter volumetric flask and after replacing the glass stopper, the water was vigourously shaken for about one minute. River water was then added until the level of the liquid was about two inches in the neck. After additional shaking for one minute and allowing a one minute resting period the height of the foam was then measured and reported in inches.

Equipment. The DuNouy instrument was graduated 0 to 180, the platinum ring had an effective circumference of 4.0 cm, (manufacturers certificate) and the glass dish had a diameter of 75 cm.*
Scale graduations were checked and the data were:

Scale reading	Platinum weights	Dynes/cm per scale graduation
39.5	0.3945	1.22
49.5	0.4945	1.22
59.5	0.5945	1.22
62.0	0.6150	1.22

All Surface Tension measurements were made at 20°C.

*Platinum ring was kept very clean by immersing in chromic acid solution washed and heated to dull red in a Fisher burner flame.

B. CONDUCTIVITY

During a period of five weeks, July eight to August ten, ten samples of river water were obtained at each of sixteen regular sampling stations from Berlin, New Hampshire to Deer Rips Dam, Maine.

For the purposes of this report the river is considered to be that sector which extends from Berlin (Bell's) to North Turner Bridge, the Pool, that area between North Turner Bridge and Deer Rips Dam. Pool data are recorded in Part Three.

The river water at "bell's" has a low "natural" pollution load averaging about 0.7 ppm B.O.D.5 and a conductivity about thirty-two Mmhos; average flow for the period was 1800 cfs.

Conductivity increases as the water passes each of the three pulp and paper company's mills. The following table illustrates the changes of conductivity in the water upstream and downstream from each mill.

The accompanying tabulated data indicate that the contribution of conductive material is somewhat different at each of three pulp and paper company's mills. The differences are due to volume and process of production, type and grade of final product ets. During the test period the average increase was:

1.	Brown Company	38 Mmhos
2.	Oxford Paper Company	33 "
3.a	International Paper Company	28 "
b	International Paper Company	3 "

There appears to be only a very slight increase in conductivity between the mills; a small decrease was recorded between Livermore Falls and North Turner.

ANDROSCOGGIN RIVER

CONDUCTIVITY 1971

Series ONE

Station	Mmhos	pH	Foam on River	Flow cfs
Bell's	32.4	6.78	0	1754
Gorham	75.0	6.72	0	1914
Gilead	66.9	6.57	3	1956
Bethel	66.1	6.60	2	1972
Rumford VB	83.0	6.6	1	2060
Dixfield SP	114.7	6.6	1	2074
Canton	101.9	6.7	2	2081
Riley	116.5	7.0	3	2084
Jay	124.6	7.0	3	2087
Chisholm	132.4	7.0	3	2087
Liv. Falls	138.5	7.2	3	2087
N.T. Bridge	133.4	6.91	2	2096
T.C. Bridge	87.6	6.59	0	2109
Mile 4½	92.0	6.51	0	2110
Mile 2½	98.2	6.49	0	2110
Deer Rips Dam	125.6	6.48	0	2110

Series TWO

Station	Mmhos	pH	Foam on River	Flow cfs
Bell's	32.4	6.65	0	1832
Gorham	64.4	6.65	0	1725
Gilead	70.4	6.60	1	1790
Bethel	67.5	6.68	½	1814
Rumford VB	81.0	6.7	0	1950
Dixfield SP	107.3	6.7	2	1941
Canton	113.9	6.7	2	1936
Riley	102.5	6.6	2	1935
Jay	135.0	6.5	0	1933
Chisholm	116.8	6.6	1	1933
Liv. Falls	128.6	6.6	1	1933
N.T. Bridge	139.1	6.79	1	1928
T.C. Bridge	126.6	6.62	0	1919
Mile 4½	133.9	6.52	0	1920
Mile 2½	114.0	6.42	0	1920
Mile 1	110.2	6.43	0	1920
Deer Rips Dam	110.2	6.43	0	1920

ANDROSCOGGIN RIVER

CONDUCTIVITY 1971

Series THREE

Station	Mmhos	pH	Foam on River	Flow cfs
Bell's	31.1	6.75	0	1916
Gorham	74.3	6.75	0	1930
Gilead	92.6	6.80	1½	1990
Bethel	77.9	6.65	1	2013
Rumford VB	64.8	6.4	1	2140
Dixfield SP	112.5	6.7	2	2113
Canton	112.5	6.8	2	2110
Riley	124.6	6.9	1	2096
Jay	132.8	7.1	1	2091
Chisholm	144.6	6.7	1	2090
Liv. Falls	152.8	6.8	2	2090
N.T. Bridge	136.7	6.73	2	2074
T.C. Bridge	127.6	6.52	0	2049
Mile 4¼	132.8	6.45	0	2050
Mile 2½	113.3	6.40	0	2050
Mile 1	107.3	6.40	0	2050
Deer Rips Dam	111.7	6.38	-	2050

Series FOUR

Station	Mmhos	pH	Foam on River	Flow cfs
Bell's	31.1	6.60	0	1856
Gorham	66.1	6.45	0	1923
Gilead	67.5	6.50	2	2002
Bethel	63.3	6.60	0	2033
Rumford VB	75.4	6.6	0	2200
Dixfield SP	101.3	6.6	2	2234
Canton	103.8	6.7	2	2252
Riley	111.7	6.7	3	2258
Jay	126.6	6.9	2	2265
Chisholm	145.9	6.8	2	2266
Liv. Falls	160.4	6.7	2	2266
N.T. Bridge	133.9	6.90	1/	2287
T.C. Bridge	145.9	6.61	0	2319
Mile 4¼	139.7	6.60	0	2320
Mile 2½	132.8	6.4	0	2320
Deer Rips Dam	117.4	6.49	-	2320

ANDROSCOGGIN RIVER

CONDUCTIVITY 1971

Series FIVE

Station	Mmhos	pH	Foam on River	Flow cfs
Bell's	31.5	6.7	0	1600
Gorham	71.7	6.5	0	1832
Gilead	68.9	6.5	2	1883
Bethel	73.6	6.6	1	1903
Rumford VB	67.2	6.5	0	2010
Dixfield SP	94.2	6.7	1	1978
Canton	104.5	6.8	2	1962
Riley	107.3	6.9	3	1956
Jay	119.1	6.9	3	1950
Chisholm	133.9	6.6	1	1949
Liv. Falls	140.9	6.7	2	1949
N.T. Bridge	129.6	6.7	1	1929
T.C. Bridge	127.6	6.7	0	1899
Mile 4¼	139.7	6.5	0	1900
Mile 2½	135.7	6.5	0	1900
Deer Rips Dam	129.6	6.4	-	1900

Series SIX

Station	Mmhos	pH	Foam on River	Flow cfs
Bell's	30.9	6.8	0	1832
Gorham	67.5	6.7	0	1848
Gilead	69.4	6.6	2	1918
Bethel	67.5	6.6	2	1944
Rumford VB	67.5	6.5	0	2090
Dixfield SP	105.9	6.8	2	2168
Canton	103.8	6.8	1	2207
Riley	105.2	6.7	3	2221
Jay	124.6	7.0	3	2236
Chisholm	130.6	6.5	1	2239
Liv. Falls	133.9	6.5	1	2239
N.T. Bridge	130.6	6.81	1	2287
T.C. Bridge	130.6	6.63	0	2359
Mile 4¼	135.0	6.53	0	2360
Mile 2½	133.9	6.49	0	2360
Deer Rips Dam	130.6	6.49	-	2360

ANDROSCOGGIN RIVER

CONDUCTIVITY 1971

Series SEVEN

Station	Mmhos	pH	Foam on River	Flow cfs
Bell's	31.1	6.7	0	1798
Gorham	62.3	6.4	0	1869
Gilead	64.3	6.4	2	1927
Bethel	58.3	6.5	1	1949
Rumford VB	67.5	6.7	0	2070
Dixfield SP	102.5	6.7	2	2067
Canton	109.5	6.7	1	2065
Riley	107.3	6.8	3	2065
Jay	126.6	6.9	2	2064
Chisholm	144.6	6.7	1	2064
Liv. Falls	140.9	6.7	1	2064
N.T. Bridge	135.0	6.9	2	2062
T.C. Bridge	140.9	6.6	0	2059
Mile 4¼	130.6	6.5	0	2060
Mile 2½	133.9	6.5	0	2060
Deer Rips Dam	135.0	6.4	-	2060

Series EIGHT

Station	Mmhos	pH	Foam on River	Flow cfs
Bell's	31.6	6.9	0	1820
Gorham	74.7	6.4	0	1918
Gilead	73.6	6.6	3	2076
Bethel	66.9	6.5	1	2138
Rumford VB	77.1	6.6	0	2470
Dixfield SP	111.7	6.7	1	2559
Canton	111.9	6.7	0	2604
Riley	103.9	6.7	3	2620
Jay	120.0	6.9	0	2638
Chisholm	140.9	6.7	2	2641
Liv. Falls	130.6	6.6	1	2641
N.T. Bridge	139.7	6.82	2	2697
T.C. Bridge	129.4	6.63	0	2779
Mile 4¼	129.6	6.51	0	2780
Mile 2½	129.6	6.48	0	2780
Deer Rips Dam	132.4	6.49	-	2780

ANDROSCOGGIN RIVER

CONDUCTIVITY 1971

Series NINE

Station	Mmhos	pH	Foam on River	Flow cfs
Bell's	34.3	6.7	0	1809
Gorham	70.4	6.5	0	1975
Gilead	85.3	6.5	2	2071
Bethel	67.5	6.5	0	2108
Rumford VB	64.3	6.5	0	2310
Dixfield S P	91.0	6.7	2	2402
Canton	107.3	6.8	1	2449
Riley	92.6	6.5	2	2465
Jay	117.4	6.7	2	2483
Chisholm	119.1	6.7	1	2486
Liv. Falls	125.6	6.7	1	2486
N.T. Bridge	124.6	6.9	1	2544
T.C. Bridge	138.5	6.6	0	2629
Mile 4¼	124.6	6.5	0	2630
Mile 2½	128.6	6.4	0	2630
Deer Rips Dam	130.6	6.4	-	2630

Series TEN

Station	Mmhos	pH	Foam on River	Flow cfs
Bell's	33.8	6.9	0	1776
Gorham	72.3	6.4	0	1768
Gilead	81.0	6.5	3	1829
Bethel	72.3	6.5	½	1852
Rumford VB	72.0	6.7	0	1980
Dixfield SP	97.6	6.7	1	1982
Canton	103.8	6.7	1	1984
Riley	119.1	6.4	3	1984
Jay	130.6	6.5	3	1985
Chisholm	133.9	6.7	3	1985
Liv. Falls	133.9	6.7	3	1985
N.T. Bridge	120.0	6.7	2	1987
T.C. Bridge	120.0	6.5	0	1989
Mile 4¼	120.9	6.6	0	1990
Mile 2½	128.6	6.5	0	1990
Deer Rips Dam	128.6	6.4	-	1990

Please remember that these figures are not fixed, they will vary by dilution (increased flow) and excessive losses from a mill. However, comparison of conductivity just above and below a mill will provide a basis for judging the nature and origin of the change.

	Mmhos Ten Test average	Flow average cfs
Brown Company		
Gorham	70	1870
Berlin ("Bell's")	32	1800
Increase (average)	38	
Oxford Paper Company		
Rumford (VB)	72	2128
Dixfield (SP)	105	2152
Increase (average)	33	
International Paper Company		
Riley Dam	108	2168
Otis (into)	136	2174
Increase (average)	28	
Otis (into)	136	2174
Livermore Falls	139	2174
Increase (average)	3	
North Turner Bridge	134	2189
Livermore Falls	139	2174
Decrease(average)	5	

For more detail, refer to the data listed on the Series pages.

The change in conductivity due to main-stem or tributory dilution was studied.

1. Dilution of water obtained at Gorham with river water sampled at "Bell's", and
2. Dilution of water sampled at Dixfield (SP) with water obtained from the Swift river.

The results are tabulated on an adjacent page together with plots to obtain a comparison of the two rivers. Both graphs are linear but the degree of slope is slightly different.

Dilution of Gorham River Water

with

Androscoggin River Water ("Bell's")
25°C

Gorham*	July 30,1971	"Bell's"	Mmhos
100 per cent	+	0 per cent	62.3
90 " "	+	10 " "	58.9
80 " "	+	20 " "	55.5
70 " "	+	30 " "	53.3
60 " "	+	40 " "	50.0
50 " "	+	50 " "	46.6
40 " "	+	60 " "	44.0
30 " "	+	70 " "	41.5
20 " "	+	80 " "	37.7
10 " "	+	90 " "	35.6
0 " "	+	100 " "	31.1

*Flow at Gorham 1856 cfs

Dilution of Dixfield (SP) River Water

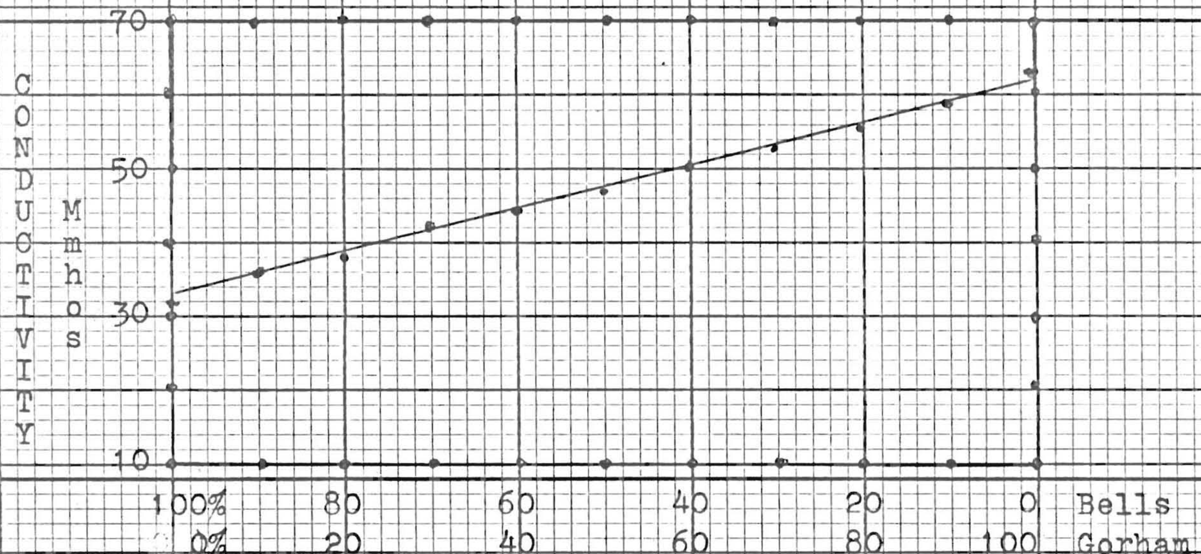
with

Swift River Water
25°C

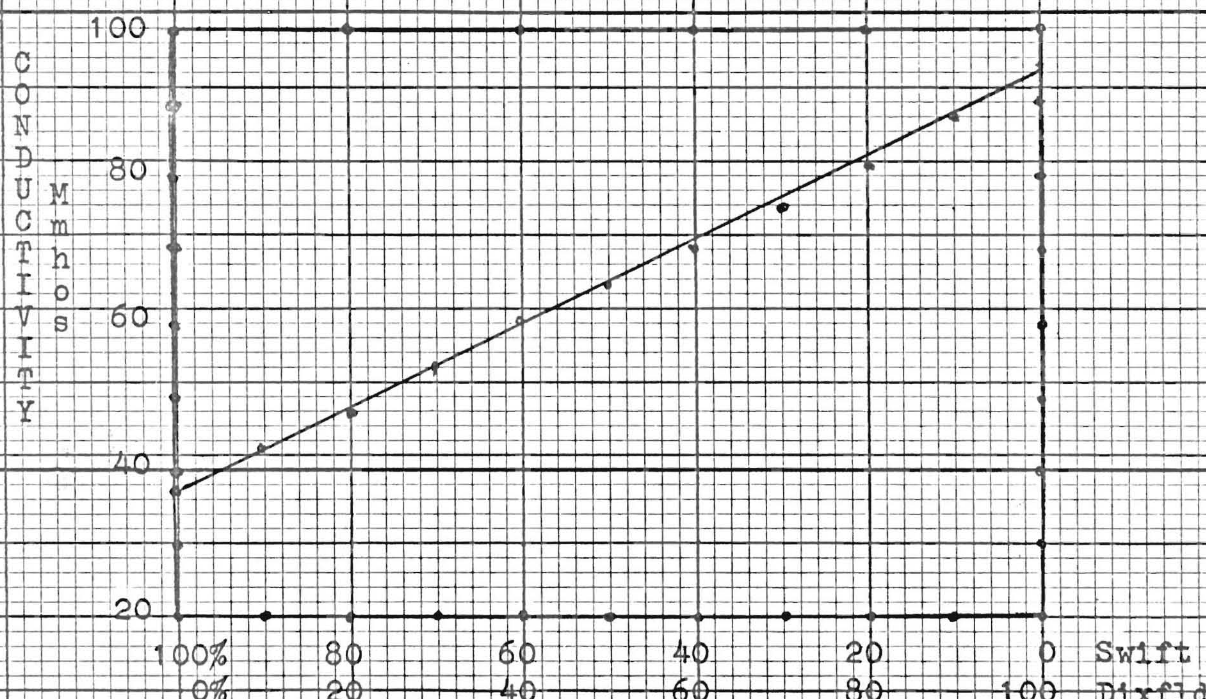
Dixfield	August 5, 1971	Swift River	Mmhos
100 per cent	+	0 per cent	95.3
90 " "	+	10 " "	87.6
80 " "	+	20 " "	81.0
70 " "	+	30 " "	75.5
60 " "	+	40 " "	70.4
50 " "	+	50 " "	64.8
40 " "	+	60 " "	60.0
30 " "	+	70 " "	52.9
20 " "	+	80 " "	47.4
10 " "	+	90 " "	42.6
0 " "	+	100 " "	36.8

*Flow 2795 cfs

CONDUCTIVITY Mmhos 25°C
ANDROSCOGGIN RIVER WATER
Dilution Effect
100% Gorham to 100% 'Bells'
July 30 1971



CONDUCTIVITY Mmhos 25°C
ANDROSCOGGIN RIVER WATER
Dilution Effect
100% Dixfield (Swans Pit)
to
100% Swift River Water.
August 5 1971



The highest conductivity recorded during these tests was 160 Mmhos on July 20 at Livermore Falls, about twenty Mmhos above the test average for this station. No attempt was made to calculate the effect, if any, of a difference in flow when comparing statistics from stations "just above and below" the mills. In most cases the difference was too small to make an appreciable change in the data.

Laboratory Procedure

a. Equipment Industrial Instruments conductance instrument. It has a graduation 20 to 2500 ohms with a 0.01 to 100 multiplier, but no temperature compensator. The glass immersion cell with platinized (black) platinum electrodes had a cell constant 0.81 when determined witn N/10 potassium chloride solution. cf Standard Methods. The water bath for the river water samples was maintained at 20°C. A large beaker 800 ml, containing distilled water at 25°C was used to keep the cell at 25°C during the tests.

b. Procedure. River water samples at 25°C were transferred to two wide mouth bottles with sufficient height so that the cell electrodes were completely immersed. The first bottle sample is used to wash off the distilled water (by immersion of the cell); the second is the test sample. (Experience may indicate that the first bottle procedure may be omitted).

c. All results are reported as Micromhos (Mmhos), at 25°C. Also, record pH, river flow, and foam conditions. There is some evidence that ligno-compounds are a factor in foaming, therefore, it is recommended that a tyrosine determination be made and recorded.

The following ideas were explored in attempting to develop the above-mentioned test:

I. The Waring blender was tried. Only a few air bubbles were generated.

II. A column which circulated the water was tried. The volume of river water was varied from 0.5 to 4.0 liters. A minute quantity of foam was generated.

III. A sample (approx. 1 liter) of river water was aerated for 30 minutes, but again the amount of foam generated was small.

IV. A pressurized dispenser was tried. Only a minute quantity of foam was generated.

V. Different "catalysts" were added to river water to make it foam. In some cases, a measurable amount of foam was generated. However, nearly the same amount of foam was generated when the same "catalysts" were added to distilled water. The following "catalysts" were tried:

1) glycerin
2) disodium phosphate
3) black liquor
4) 50% caustic
5) starch solution from Stock Prep
6) size solution from Stock Prep
7) binderine
8) a sample from the clarifier effluent
9) a sample from the acid sewer
10) concentrated Triton X100
11) 1% solution of Triton X100
12) white liquor

VI. The rate of dissipation of the foam, which had been generated with black liquor in river water, was determined. A similar rate was also noted using distilled water.

VII. The effect of pH on "foaming potential" was investigated. The values of pH used was from 1.6 to 11.0. No differences were observed.

VIII. The effect of heating on "foaming potential" was also investigated. No differences were observed.

IX. An air sparger was tried. Approximately 90lb/in^2 of air pressure was used to aerate 9 liters of river water for 10 minutes. The quantity of foam generated was again too small to attempt to measure.

X. A pool of water was maintained in a barrel by having an inlet and an outlet. River water was passed through the barrel. This was to explore the idea that any foam generated would remain on the surface and eventually build up to a point where a measurement could be made.

The results of this experiment showed that this idea could perhaps be developed to determine the "foaming potential" of one point along the river. However, since a very large volume of river water would have to be used, the apparatus which would be needed, I feel, would require much time to design, build and to put into operation.