BACKGROUND INFORMATION CONCERNING BIG STONE LAKE

DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION
UPPER MISSISSIPPI RIVER BASIN PROJECT
MINNEAPOLIS PROGRAM OFFICE

JULY, 1967

TABLE OF CONTENTS

Physical Description

Big Stone Lake lies on the Minnesota - South Dakota border for approximately 26 miles at the headwaters of the Minnesota River (Figure 1). The lake is about one-half to one and one-half miles wide, encompassing an area of approximately 12,500 acres and is separated from Lake Traverse in the Red River Basin by a sub-continental divide. The two lakes are four miles apart with the community of Browns Valley, Minnesota lying between them. Average depth of Big Stone Lake is 8 to 10 feet with a maximum depth of 16 feet.

The Big Stone Lake watershed, above Ortonville, Minnesota drains an area of about 1,200 square miles which includes part of Big Stone County in Minnesota and parts of Roberts and Grant Counties in South Dakota. Approximately 950 square miles of this area lie in South Dakota.

The soils in the study area range from fine sandy loams to silty clay loams. The area is capable of producing good yields of farm crops wherever the soil is not too wet or the slopes too steep. Native grasses occupy the steeper slopes, a few of which are grazed.

Economic Features

The principal cities in this area are Milbank, South Dakota, 1960 population of 3,500; Sisseton, South Dakota, 1960 population of 3,300; Ortonville, Minnesota, 1960 population of 2,700; and Browns Valley, Minnesota, which had a 1960 population of 1,000.

The economy of the area is mainly dependent upon diversified agriculture and small service industries. A canning factory is located at

Ortonville, Minnesota. In South Dakota 75% - 80% of the land is classified as farm while in Minnesota 80% is farmed. Considerable areas of land are classified as diverted acres and therefore are not under cultivation nor used for pasture or grazing. The number of livestock raised in the basin is subject to great fluctuation as would be suspected. In the fall of 1966 approximately 7,000 head were in the drainage area with 4,000 grazing in South Dakota.

Since this area lies within the prairie - pothole country noted for its waterfowl and pheasant hunting, hunter expenditures presently contribute a sizeable though undetermined amount of money to the economy of the area each autumn. Fishermen also contribute significantly to the economy.

Water Uses

The outstanding water use in this area is for livestock watering. Big Stone Lake is also used extensively for recreation. Permanent homes number 249 (180 on the Minnesota side) around the lake. Approximately 620 cottages (325 on the Minnesota side) are located around the lake for use by vacationers.

Both commercial and sport fishing are practiced on Big Stone Lake. Sport fishing is a year around activity with heavy use during the summer months. Commercial fishing is permitted on a contract basis with licenses issued in alternate years by the two States. In the years 1955 - 1965 the average commercial catch per year was approximately 664,000 pounds.

Body contact sports such as boating, water skiing and swimming are practiced during the recreation season of May to October.

Municipal and industrial usage of surface water is confined to one industry. The 15,000 kilowatt Ortonville Plant of the Otter Tail Power Company obtains condenser cooling water from Big Stone Lake.[1]

Waste Sources

Accurate information is not available as to specific waste inputs, but a number of waste sources are evident in the drainage area which contribute to the degradation of the water quality in Big Stone Lake. The following table summarizes the information gathered during a Big Stone Lake waterfront survey conducted by a Milbank, South Dakota Game and Fish Club.

Sources with Direct Access to Lake	Minnesota	South Dakota
Permanent homes	180	69
Cottages	380	395
Livestock (cattle)	542	1,285
Feed lots	7	10
Farms	22	18
Privies	64	59

In addition to the above information, an aerial survey by the Club showed an estimated 2,700 cattle grazing in the South Dakota portion of the basin and 2,500 cattle in the Minnesota portion. The overall total of 7,000 cattle has a waste population equivalent of nearly 100,000 people.[2] It must be remembered that the cattle population in an area is subject to wide fluctuation due to market price, etc. As an indication of this, a recent report showed Roberts and Grant Counties in South Dakota to have cattle populations of 80,000 and 61,000, respectively, on January 1, 1962.[3]

Sources of municipal and industrial waste which discharge to the basin and thereby contribute to the nutrient input and/or cause low levels of dissolved oxygen and excessive bacterial contamination are shown in the following table:

Source	Receiving Water	Type of Treatment	Treatment Needs
Sisseton, So. Dak.	Trib. of Little Minnesota River	Stabilization Pond	Pond expansion
Browns Valley, Minnesota	Little Minnesota River	Secondary	None
Wilmont, South Dakota	Tributary to Whetstone River	Stabilization Pond	None
Big Stone City (Cheese) S. D.	Whetstone River	Spray irrigation and ridge and furrow irrigation	Expansion
Big Stone City, South Dakota	Whetstone River	Stabilization Pond	None
Big Stone Canning Ortonville, Minn.	Whetstone River	Spray Irrigation	Expansion
Ortonville, Minnesota	Minnesota River	Secondary	None

Localized dissolved oxygen and bacterial contamination problems exist mainly because of the intermittent nature of the streams into which the municipalities and industries discharge.

In addition to the above sources, nutrients enter the Lake from land runoff directly and from the 460 square mile Little Minnesota River basin and the 400 square mile Whetstone River basin.

Water Quality

Nuisance growths of algae and aquatic plants occur when warm temperatures, abundant sunshine, and excessive nutrients (over fertilization), especially nitrogen and phosphorus are present. Sources of nutrients to a lake include sewage, surface runoff, the interchange with bottom sediments, and precipitation from the atmosphere. Surface runoff from animal feedlots and heavily fertilized agricultural lands is especially rich in nutrients.

Current knowledge indicates that a 0.3 mg/l concentration of inorganic nitrogen (N) and a 0.01 mg/l concentration of soluble phosphorus (P) at the start of the active growing season could produce nuisance algal blooms provided other conditions (e. g. temperature and sunlight) are also suitable. A continued input of nutrients is not necessary for continued algal production. After an initial stimulus, the recycling of nutrients within the lake basin is sufficient to promote algal blooms for a number of years without substantial inflow from contributing sources.

During the summer of 1966 large growths of algae were observed on Big Stone Lake. The Lake, being relatively shallow, has been plagued with weed growths and algal blooms for many years. The year 1966, however, was the most severe. A dense algal bloom existed that was composed of *Aphanizomenon*, a blue-green algae often found in lakes in an advanced stage of over fertilization. The decomposition product, which looks like light blue paint, coated the sides of boats and other waterline objects. This slime creates a putrid odor upon decaying. Recent reports (winter of 1966-67) received from ice fishermen on Big Stone Lake indicate that upon sawing through the ice a very strong odor was emitted. This present condition, if unchecked, will degrade the lake to a level that fish and wildlife propagation and recreation, as well as other uses, will become nonexistent. Property values will also be affected.

Over fertilization of the lake waters is caused by excessive concentrations of nitrogen and phosphorus compounds. Records of the Minnesota Department of Health (1962-1963) for a station near the outlet of Big Stone

Lake showed an average concentration of 0.26 mg/l total phosphorus expressed as "P".[4] Total nitrogen was not available for this same period but for 1958 - 1959 at this station the total nitrogen averaged 3.1 mg/l. Highest values for both nitrogen and phosphorus occurred during the winter at the low lake level and during early spring at times of high runoff. Nutrient levels in the Lake then, are definitely at levels which will support algal blooms.

Suspended sediment loads carried by the rivers to Big Stone Lake are also a problem. Most of the material in suspension is clay and silt. Soil erosion is the primary source of sediment with stream bank and gully erosion being secondary sources. This is especially true of the Whetstone River which is discussed in greater detail under "Miscellaneous Background Information" below. It is most likely that vast bottom deposits containing nutrients of a level sufficient to cause nuisance algal growths are present in Big Stone Lake.

Water Quality Standards

Both Minnesota and South Dakota have submitted to the Secretary of the Interior, water quality standards on this interstate body of water. Presented below are the most significant parameters and their limits as proposed by each state for Big Stone Lake.[5,6] Differences are still evident between the criteria of these two States but this should be resolved soon.

Parameter	Minnesota	South Dakota
Coliform (Maximum)	1000 MPN/100 ml	1000 MPN/100 ml
Dissolved Oxygen (Minimum)	5 mg/l at all times 6 mg/l April 1 - May 31	4.0 mg/l at all times
Temperature (Maximum)	85°F.	90°F.
Nutrients	Such that no nuisance algal blooms occur.	Such that no nuisance algal blooms occur.
pH (Range)	6.5 - 9.0	6.3 - 9.0
Ammonia (Maximum)	1 mg/l	———
Turbidity (Maximum)	25	100

In order to meet the standard on nutrients, extreme measures will have to be taken to comply. Directly related is the standard on dissolved oxygen. During periods of darkness it is entirely conceivable that algal respiration could lower the dissolved oxygen concentration below the set levels.

Miscellaneous Background Information

The Big Stone Lake - Whetstone River Project was constructed in the 1930's to restore a desirable conservation level on Big Stone Lake and to provide downstream flood protection. This joint State of Minnesota - Federal project included a concrete stop-log control structure on the Minnesota River about one-half mile below the outlet of Big Stone Lake, realignment of the lower reach of the Whetstone River to join the Minnesota River above the dam and improvement of a short reach of the Minnesota River below the dam.

In 1958 the State of Minnesota, with cost sharing by the State of South Dakota, constructed a steel sheet-pile dam (silt barrier) in the Minnesota River between the outlet of Big Stone Lake and the mouth of the Whetstone River diversion channel. The structure was expected to reduce the movement of the silt from the Whetstone River into Big Stone Lake.

Serious differences between State and local interests have arisen with respect to operation of the control structure. Residents located along the Lake shore object to the use of the Lake for flood storage. Diversion of the Whetstone River into Big Stone Lake has resulted in above normal lake levels. Thus, flood damages to properties bordering the Lake were increased. In efforts to prevent unnecessary damaging lake stages, the State has on occasion released water from the Lake when not desired by lakeshore residents or by the agricultural interests below the lake. Although the Whetstone River diversion into the lake actually reduced peak discharges from the Whetstone River to the Minnesota River, the necessity for release of stored water in the lake following flood periods at rates in excess of Minnesota River channel capacity resulted in prolonged periods of flooding on agricultural lands below the lake. The flooding was not only prolonged but also proved to be more damaging since the period of flooding extended further into the growing season.[5]

An additional problem of appreciable consequence is that of silt deposition in Big Stone Lake. Although construction of the silt barrier in 1958 was expected to reduce and/or eliminate the problem, no significant change in rate of siltation has occurred. Here again lakeshore interests are affected and damage to fish life and recreation occurs.

The Corps of Engineers has developed a plan of improvement which has the concurrence of other local, State, and Federal agencies. The plan provides for a multiple-purpose project for flood control, wildlife conservation, and recreation.[6] The proposed improvements include modifications of the existing Big Stone Lake outlet control structure, construction of approximately two miles of channel enlargement and one mile of channel realignment in the reach of the Minnesota River immediately below the outlet structure, and construction of an earth dam with spillway to create a flood-retarding impoundment area. This impoundment area would be used for flood control and would be managed, together with about 1,600 acres of additional bordering lands, as a national wildlife refuge. The plan also includes provision for a one-foot rise on the silt barrier to secure a more desirable recreation level for Big Stone Lake.

This project is in its pre-construction planning stage. Indications are that funds for the project may be appropriated in Fiscal Year 1968 or Fiscal Year 1969. Once completed, it should significantly reduce the silt load contributed by the Whetstone River but will have little, if any, effect on the occurrence of algal blooms in Big Stone Lake.

As a result of the 1966 algal bloom, Big Stone Lake has received a great deal of attention in the newspapers of northeast South Dakota. This type of pressure has been felt in the State Capitol of South Dakota as the Long Range Air and Water Pollution Control Committee (appointed by the Governor) has called for the "clean up" of Big Stone Lake as an immediate goal. Another group called the Northeast (South Dakota) Lakes Region Association has announced its principal goal as the clean up of "pollution" in Big Stone Lake. This will then be used as a model of what can be accomplished to develop a lake for full usage.

Improvements Needed

The largest source of nutrients and sediment by far appears to be the surface runoff from the surrounding area including that from cattle feedlots. The homes and summer cottages around the lake undoubtedly contribute some nutrients as well, but their contribution is probably quite minor by comparison.

Primary emphasis on abatement efforts should be directed toward the control of land runoff by better management of the land area draining to Big Stone Lake. Examples of good management practices include contour farming and seeding the bottomland to permanent grass or reforestation. These practices would not only lead to improvement of water quality in

Big Stone Lake but would also benefit the land owners by conserving the soil and reducing nutrient losses. Improvement of land use practices can best be attained by educating the land owners on the value of these and other soil conservation measures.

Waste from beef cattle feedlots adjacent to the Lake should receive the best practicable degree of treatment. If the effluent is to be discharged to the Lake some form of advanced waste treatment may be necessary to ensure that nutrients do not reach the Lake.

Wastes from homes and summer cottages should also receive the best practicable degree of treatment. This may mean collection in central systems and a high degree of treatment, again possibly including advanced waste treatment methods to reduce the nutrient load.

Control of waste deposition along the shoreline by self-watered livestock will require fencing them out and piping their water some distance away from the Lake into tanks. Areas below these watering points should be grassed or other means provided such that a minimum of overland flow to the Lake occurs.

An important aspect to realize is that if all the waste inputs to Big Stone Lake were immediately discontinued nuisance algal blooms might still occur for some time to come because of the nutrients contained in the Lake's bottom deposits. To remove all possibility of nuisance algal growths would therefore require removal of nutrients already in the Lake through dredging of the bottom areas where deposits are in abundance and/or harvesting algae. Removal of all waste inputs to the Lake without removing nutrients presently in the Lake will probably result in a lake recovery time of many years.

Other Federal agencies besides the Corps of Engineers and Federal Water Pollution Control Administration have an expressed interest in the Big Stone Lake area: The Fish and Wildlife service for the wildlife refuge and the development of sport and commercial fishing, the Department of Agriculture' Soil Conservation Service for the development of soil conservation districts with the possibility of supplying additional water to the Lake; and the Bureau of Reclamation for possible watershed projects. All of these agencies, in addition to State agencies, undoubtedly have a wealth of information that is pertinent to this area's development and the solution to the present problem.

BIBLIOGRAPHY

1. The Minnesota River Valley, Minnesota Outdoor Recreation Resources Commission, State Capitol, St. Paul, Minnesota, April, 1965.

2. Animal Waste Disposal, Agricultural Experiemtn Station Journal, South Dakota State University, Brookings, South Dakota, August, 1966.

3. South Dakota Agriculture - 1966, South Dakota Crop and Livestock Service, Sioux Falls, South Dakota.

4. Water Quality Sampling Program Reports, Minnesota Lake and Streams, Minnesota Department of Health, Section on Water Pollution Control.

5. Water Quality Standards for the Surface Waters of South Dakota, South Dakota Committee on Water Pollution, February 16, 1967.

6. Water Quality Standards for the Interstate Waters of Minnesota, Minnesota Water Pollution Control Commission, June, 1967.

7. Big Stone Lake and Whetstone River, Minnesota and South Dakota Project Modification, House Document Number 579, 87th Congress, 2nd Session.

A

H. Grounds
2/6/67

000R67105

SECOND MONTHLY PROGRESS REPORT
LAKE SUPERIOR BASIN
COMPREHENSIVE WATER POLLUTION
CONTROL STUDY

January, 1967

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

Great Lakes-Illinois River Basins Project
Chicago, Illinois

Purpose

The purpose of this report is to summarize briefly the progress of the comprehensive water pollution control study of the Lake Superior Basin. The report is based upon a meeting of staff personnel held on January 24, 1967. Those present included, Scarce, Fisher, Buchanan, Ownbey, Verber, Fuller, Abbott, Libby and Minkin with Grounds acting as chairman. It is the intent that progress reports completed monthly will keep the Region informed of activities in this area of its responsibility.

Summary

Work completed to date includes:

1. Selection and placing of current meter stations in Lake Superior.

2. Collection of initial samples from seven stations in the Lake.

3. Chemical, biological, and radiological analyses of these samples.

4. Initial reconnaissance of waste sources along the St. Louis River.

5. Reconnaissance of possible laboratory sites.

6. Preparation of a preliminary draft of population and economy.

7. Additional work on a report of "Immediate Water Pollution Needs of the St. Louis River and Montreal River Basins, Lake Superior Basin." This special report, which is scheduled to be completed in initial draft form by March 1, 1967, is being

prepared in answer to Rainwater's request of October 31, 1966.

8. Completion of a municipal waste inventory.

9. Initial evaluation of chemical and biological data.

10. Review of the initial progress report issued January 3, 1967.

Previous Progress Report

Comments on the first monthly progress report were called for. Several items were raised concerning the chemical data. A revised, dated 1-24-67, Table I entitled "Lake Superior Chemical Data, October 17 - November 6, 1966" was distributed and used as a basis of discussion. Items of discussion which concerned this revised table are summarized below:

1. The units of measurement (mg/l, etc.) should be included in the Table.

2. Two columns should be added in place of "depth." These are to be called "Station Depth" and "Sample Depth." The latter replaces the letters T, M, and B.

3. The chemical and biological data should be presented on our "standard" 8½ inch by 10 inch sheets.

A revised Table 1 is attached.

Considerable discussion ensued concerning the significance of the values given in Table 1. Of particular interest was the total phosphate values which ranged between 0.03 and 0.05 mg/l (as PO_4). It was generally decided that an evaluation should be made of all analytical data collected thus far with special emphasis on a comparison of similar data on the other Great Lakes as well as the data which could be obtained from other agencies with comment, where practicable, on differences in analytical techniques (see "Specific Assignments.")

TABLE I

LAKE SUPERIOR CHEMICAL DATA
Oct. 17 - Nov. 6, 1966

CHEMICAL FINDINGS

Sta. No.	Sta. Depth (Feet)	Sample Depth (Feet)	Location (Latitude) (Longitude) (° ' ")	Temp. (°C)	pH	Alkalinity (mg/1 as $CaCO_3$)	Dissolved Oxygen (mg/1)	Saturation (%)	Chemical Oxygen Demand (mg/1)	Org. Nitro. (mg/1 as N)	Ammo. (mg/1 as N)	Nitr (mg/ as N
10	100	3	46-30-54	10	7.4	44	11	103	8	0.07	0.03	0.19
		50	84-48-20	9	7.5	45	11	105	11	0.34	0.02	0.20
		100		9	7.5	44			9	0.21	0.03	0.16
7	210	3	46-44-54	10	6.6	40	11	103	8	0.05	0.01	0.18
		105	89-24-40	10	6.1	40	11	103	7	0.06	0.01	0.18
		210		9	6.8	40	11	105	6	0.02	0.02	0.10
3	210	3	46-51-12	7	6.7	40	12	102	8	0.03	0.02	0.20
		105	91-20-15	5	6.9	45	12	107	12	0.04	0.01	0.18
		210		5	7.1	41	12	107	14	0.06	0.01	0.22
2	235	3	46-58-20	7	6.8		12	102	9	0.05	0.01	0.18
		120	91-42-30	7	6.9	41	12	102	7	0.05	0.01	0.20
		235		5	6.8	59	12	107	5	0.04	0.01	0.18
8	240	3	46-44-54	8	7.3	52	11	108	13	0.05	0.02	0.21
		120	90-24-20	8	7.4	47	11	108	8	0.03	-	-
		240		8	7.5	45	11	108	8	0.06	0.03	0.19
1	320	3	47-01-12	7	6.9	40	12	102	9	0.06	0.01	0.10
		160	91-05-50	6	7.3	40	12	104	14	0.06	0.01	0.09
		300		5	6.9	41	12	107	-	0.05	0.02	0.10
9	294	3	47-28-36	8	7.0	40	11	108	10	-	-	-
		150	88-09-00	7	6.5	40	11	111	7	0.06	0.01	0.11
		254		7	6.9	40	11	111	2	0.07	0.01	0.13

TABLE I (Continued)

LAKE SUPERIOR CHEMICAL DATA
Oct. 17 - Nov. 6, 1966

CHEMICAL FINDINGS

Sta. No.	Sta. Depth (Feet)	Sample Depth (Feet)	Location (Latitude) (Longitude) (° ' ")	Specific Conductance (10^{-6}mhos)	Dissolved Solids (mg/l)	Total Soluble Phosphate (mg/l as PO_4O)	Total Phosphate (mg/l as PO_4)	Sodium (mg/l)	Potass. (mg/l)
10	100	3	46-30-54	100	57	0.04	0.04	1.2	0.8
		50	84-48-20	103	54	0.03	0.04	1.2	0.7
		100		105	55	0.03	0.03	1.2	0.5
7	210	3	46-44-54	99	62	0.03	0.03	1.2	0.5
		105	89-24-40	97	60	0.03	0.03	1.2	0.5
		210		100	72	0.03	0.05	1.3	0.6
3	210	3	46-51-12	100	54	0.03	0.04	1.1	0.6
		105	91-20-15	97	67	0.03	0.04	1.2	0.6
		210		100		0.04	0.05	1.3	0.7
2	235	3	46-58-20	100	62	0.03	0.03	1.5	1.0
		120	91-42-30	99	64	0.03	0.03	1.3	0.6
		235		100	66	0.03	0.03	1.2	0.6
8	240	3	46-44-54	110	56	0.03	0.04	1.3	2.1
		120	90-24-20	105	57	0.03	0.03	1.2	1.3
		240		103	61	0.03	0.04	1.2	0.8
1	320	3	47-01-12	97	60	0.03	0.03	1.2	0.5
		160	91-05-50	98	56	0.03	0.04	1.2	0.5
		300		98	64	0.03	0.03	1.2	0.5
9	294	3	47-28-36	99	58	0.03	0.03	1.2	0.6
		150	88-09-00	100	67	0.03	0.04	1.2	0.6
		254		97	59	0.03	0.03	1.2	0.5

TABLE I (Continued)

LAKE SUPERIOR CHEMICAL DATA
Oct. 17 - Nov. 6, 1966

CHEMICAL FINDINGS

Sta. No.	Sta. Depth (Feet)	Sample Depth (Feet)	Location (Latitude) (Longitude) (° ' ")	Chloride (mg/1)	Sulfates (mg/1)	Calcium (mg/1)	Magnesium (mg/1)
10	100	3	46-30-54	1.1	2.4	14	2.7
		50	84-48-20	1.1	2.4	14	2.7
		100		1.1	2.3	14	2.7
7	210	3	46-44-54	1.3	2.4	14	2.8
		105	89-24-40	1.3	2.7	14	2.8
		210		1.3	2.6	14	2.8
3	210	3	46-51-12	1.2	2.1	14	2.8
		105	91-20-15	1.3	2.1	14	2.8
		210		1.5	2.2	14	2.8
2	235	3	46-58-20	1.3	2.4	14	2.8
		120	91-42-30	1.3	2.3	14	2.9
		235		1.4	2.4	14	2.8
8	240	3	46-44-54	2.4	2.5	14	2.7
		120	90-24-20	2.0	2.7	14	2.7
		240		2.0	2.5	14	2.6
1	320	3	47-01-12	1.3	3.3	14	2.8
		160	91-05-50	1.2	3.1	14	2.8
		300		1.2	2.5	14	2.8
9	294	3	47-28-36	1.3	2.1	14	2.8
		150	88-09-00	1.5	2.2	14	2.8
		254		2.0	2.3	14	2.8

TABLE I (Continued)

LAKE SUPERIOR CHEMICAL DATA
Oct. 17 - Nov. 6, 1966

CHEMICAL FINDINGS

Sta. No.	Sta. Depth (Feet)	Sample Depth (Feet)	Location (Latitude) (Longitude) (° ' ")	MBAS (mg/l)	Silicon Dioxide (mg/l)	Phenol mg (ug/l)	Turbidity (Hellige) (mg/l as SiO_2)
10	100	3	46-30-54	0.03	2.0		0.6
		50	84-48-20	0.03	2.0		0.6
		100		0.03	2.1		1.0
7	210	3	46-44-54	0.05	1.9		0.6
		105	89-24-40	0.05	2.0		0.5
		210		0.04	1.9		0.4
3	210	3	46-51-12	0.05	2.2		0.3
		105	91-20-15	0.05	2.3		0.2
		210		0.04	2.2		0.4
2	235	3	46-58-20	0.04	1.9		0.1
		120	91-42-30	0.04	2.0		0.3
		235		0.04	2.2		0.5
8	240	3	46-44-54	0.04	2.0		0.2
		120	90-24-20	0.04	2.0		0.6
		240		0.04	2.0		0.6
1	320	3	47-01-12	0.04	2.1		0.2
		160	91-05-50	0.05	2.0		0.3
		300		0.04	1.9		0.1
9	294	3	47-28-36	0.04	2.1		0.1
		150	88-09-00	0.04	2.1		0.2
		254		0.04	2.2		0.1

TABLE I (Continued)

LAKE SUPERIOR CHEMICAL DATA
Oct. 17 - Nov. 6, 1966

CHEMICAL FINDINGS

Sta. No.	Sta. Depth (Feet)	Sample Depth (Feet)	Location (Latitude) (Longitude) (° ' ")	Copper (mg/l)	Cadmium (mg/l)	Nickel (mg/l)	Zinc (mg/l)
10	100	3	46-30-54	*	*	0.022	0.015
		50	84-48-20	*	*	0.014	*
		100		*	*	*	*
7	210	3	46-44-54	*	*	*	*
		105	89-24-40				
		210					
3	210	3	46-51-12	0.036	*	*	*
		105	91-20-15				
		210					
2	235	3	46-58-20	0.037	*	*	*
		120	91-42-30				
		235					
8	240	3	46-44-54	*	*	0.008	*
		120	90-24-20	*	*	*	*
		240		*	*	*	*
1	320	3	47-01-12	*	*	*	*
		160	91-05-50				
		300					
9	294	3	47-28-36	*	*	*	*
		150	88-09-00				
		254					

TABLE I (Continued)

LAKE SUPERIOR CHEMICAL DATA
Oct. 17 - Nov. 6, 1966

CHEMICAL FINDINGS

Sta. No.	Sta. Depth (Feet)	Sample Depth (Feet)	Location (Latitude) (Longitude) (° ' ")	Chromium (mg/1)	Lead (mg/1)	Total Iron (mg/1)
10	100	3	46-30-54	*	*	0.05
		50	84-48-20	*	*	0.07
		100		*	*	0.02
7	210	3	46-44-54	*	*	0.07**
		105	89-24-40			
		210				
3	210	3	46-51-12	*	*	0.40**
		105	91-20-15			
		210				
2	235	3	46-58-20	*	*	0.11**
		120	91-42-30			
		235				
8	240	3	46-44-54	*	*	0.04
		120	90-24-20	*	*	0.05
		240		*	*	0.05
1	320	3	47-01-12	*	*	0.05**
		160	91-05-50			
		300				
9	294	3	47-28-36	*	*	0.05**
		150	88-09-00			
		254				

* Not detected at sensitivity of test (0.005 mg/1) ** Composite of all depths

Personnel Comments

Scarce. The laboratory has completed checking its analyses and suggested changes have been made in the results previously reported in Table 1 of the first progress report. Radiological and biological results are now available. Literature search is partially completed and a brief memo has been written on the subject. (See Exhibits 2, 5, 6 and 7 attached to this progress report and also revised Table 1.)

Minkin. Basin maps of the St. Louis and Montreal Rivers have been assigned to the draftsman. The community inventory is 95% complete for the entire Lake Superior Basin. It is entirely complete for the St. Louis and Montreal River Basins. Only communities of 100 population or greater are included. (See Exhibits 3 and 4 attached to this report.)

Fisher. Biological analyses of the October and November sampling period have been completed. Fisher pointed out the difficulty in comparing our work with that of others. As one example, in counting organisms some consider a clump of organisms as being equivalent to a count of one whereas other workers may count each individual organism. Another example cited was the difference in magnification which mey be used in counting procedures. (See Exhibit 2 attached to this report.)

Buchanan. It was suggested that all tables prepared for this and other reports contain the initials of the person who prepared it as well as the date on which it was prepared.

Ownbey. Ray commented that the idea of the progress report was a good one.

Verber. Jim indicated that space had been obtained for the Lake Superior Field Station at Duluth. He further mentioned that it was necessary to make personnel assignments as soon as possible. Scarce, Verber, Ownbey and Kehr are charged with this responsibility.

Kee. The population of the St. Louis and Montreal River Basins has been determined. (See Exhibit 8.)

Specific Assignments

1. Scarce-Fuller. Prepare a brief report which discusses our laboratory analyses of Lake Superior samples and compare our results with:

a) The work of other laboratories studying Lake Superior.

b) Similar analyses performed on samples collected from the other Great Lakes.

Particular attention should be paid to phosphate analysis.

2. Fisher. Prepare a brief report which discusses the biological findings in Lake Superior (See Exhibit 2 attached.)

3. Libby-Verber. State estimated sampling depths and station depths (completed).

4. Verber. Check longitude and latitude of Lake Superior current meter stations (Completed).

5. Verber-Ownbey. Appoint and obtain Project Director and other personnel for the Lake Superior Program Office.

6. Minkin. Minkin is assigned the responsibility of preparing the industrial waste inventory for the Lake Superior Basin.

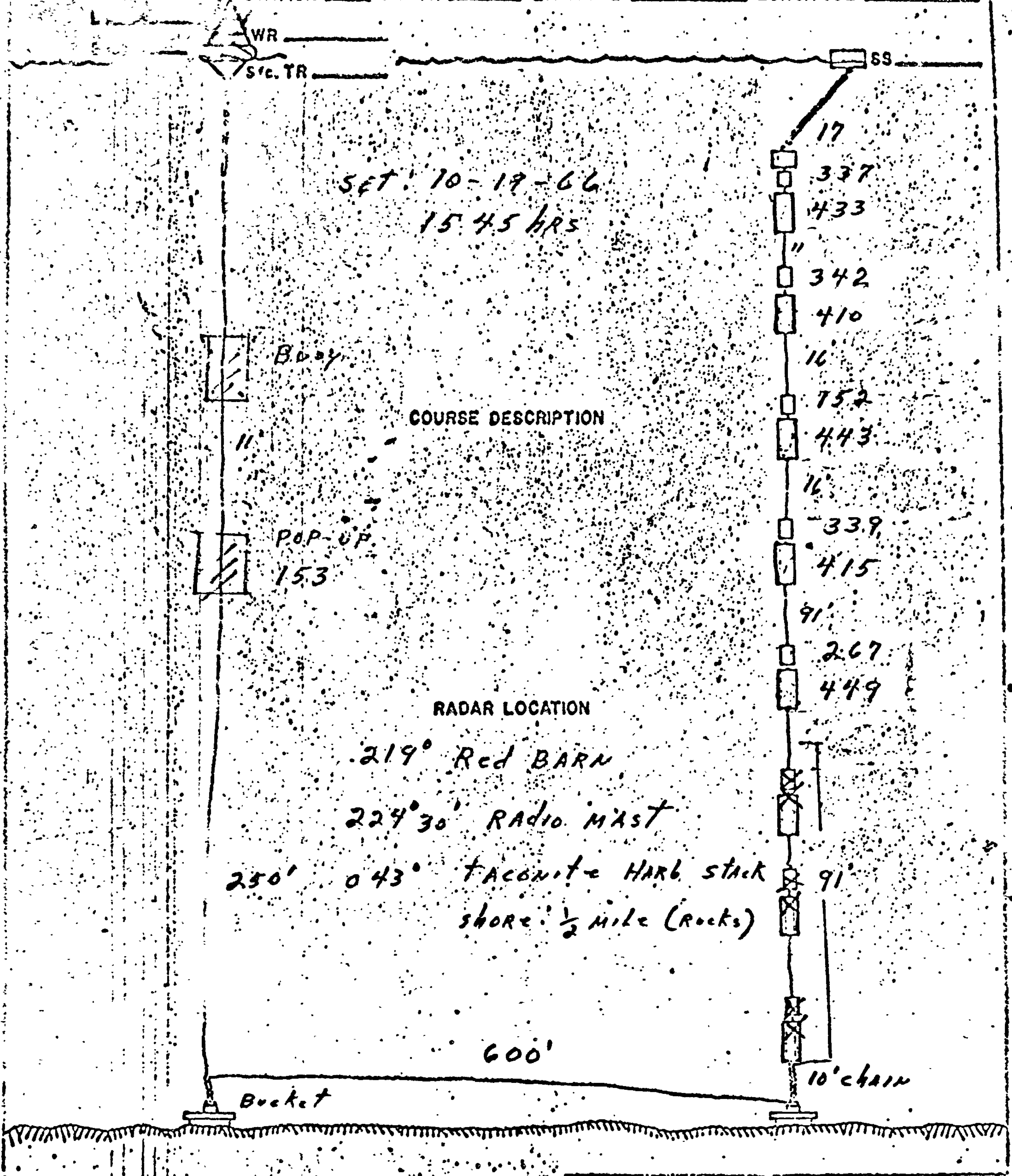
Suggestion

It is suggested that those receiving copies of the progress reports on the Lake Superior Comprehensive Study bind the succeeding issues together so that a complete picture of the work is maintained.

Exhibit 1

Current Meter Stations Descriptions

STATION L DEPTH 320 LATITUDE 47°24.06 LONGITUDE 91 05 50"

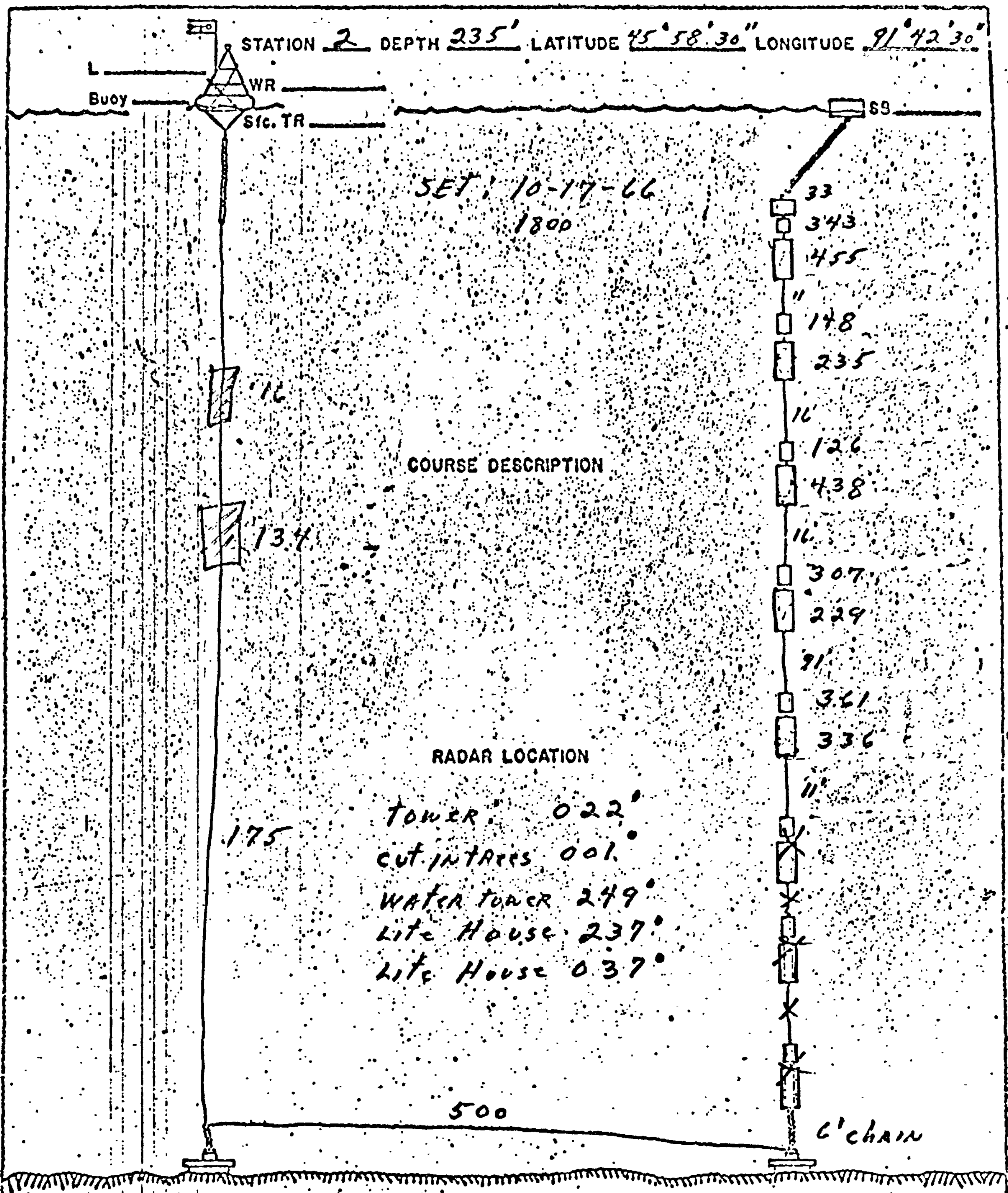


GREAT LAKES & ILLINOIS RIVER BASINS PROJECT

LAKE SUPERIOR

U.S. DEPT. OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION V

STATION 2 DEPTH 235' LATITUDE 45°58'30" LONGITUDE 91°42'30"



COURSE DESCRIPTION

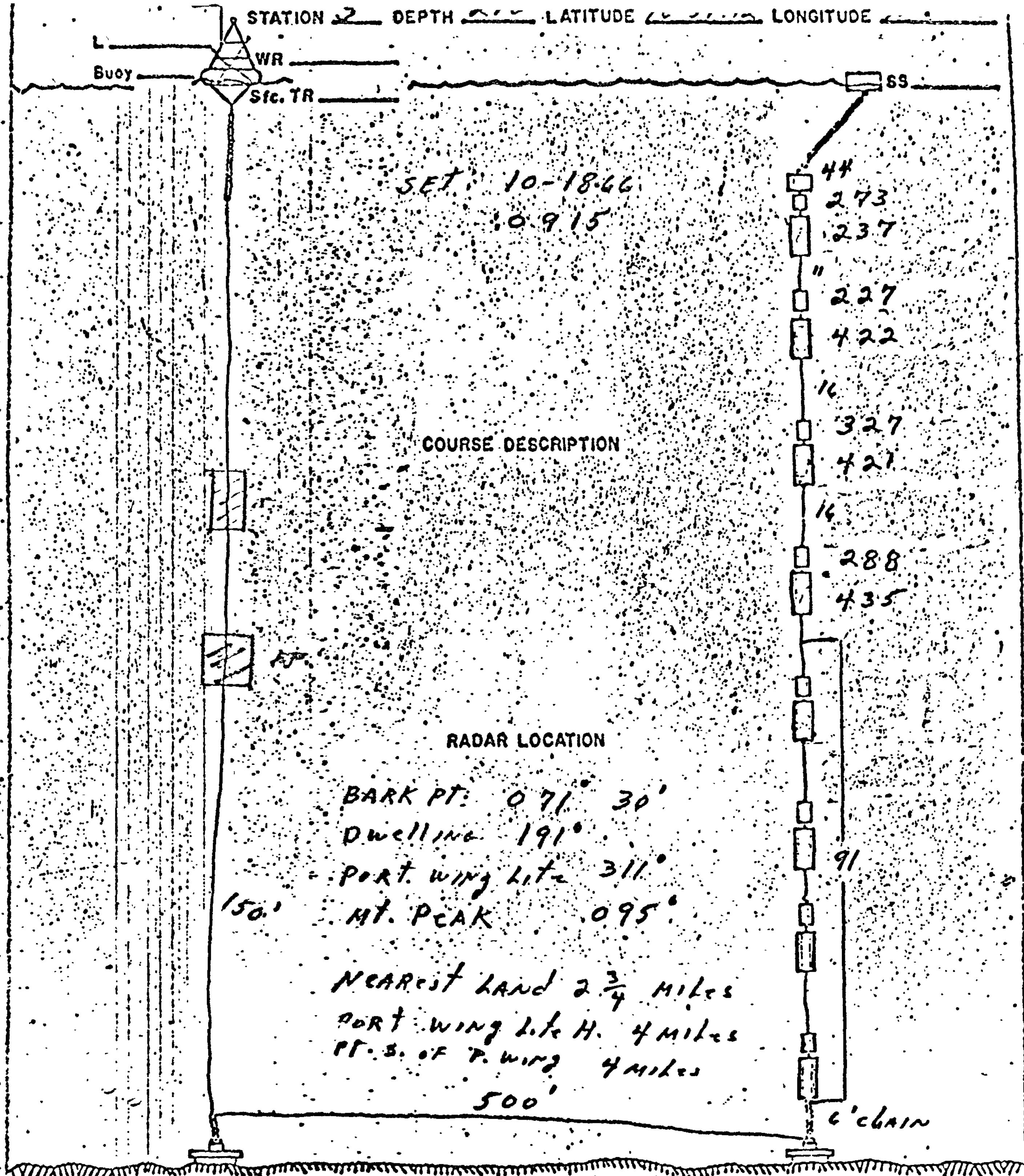
RADAR LOCATION

tower 022°
cut in trees 001°
water tower 249°
Lite House 237°
Lite House 037°

GREAT LAKES & ILLINOIS RIVER BASINS PROJECT

LAKE SUPERIOR

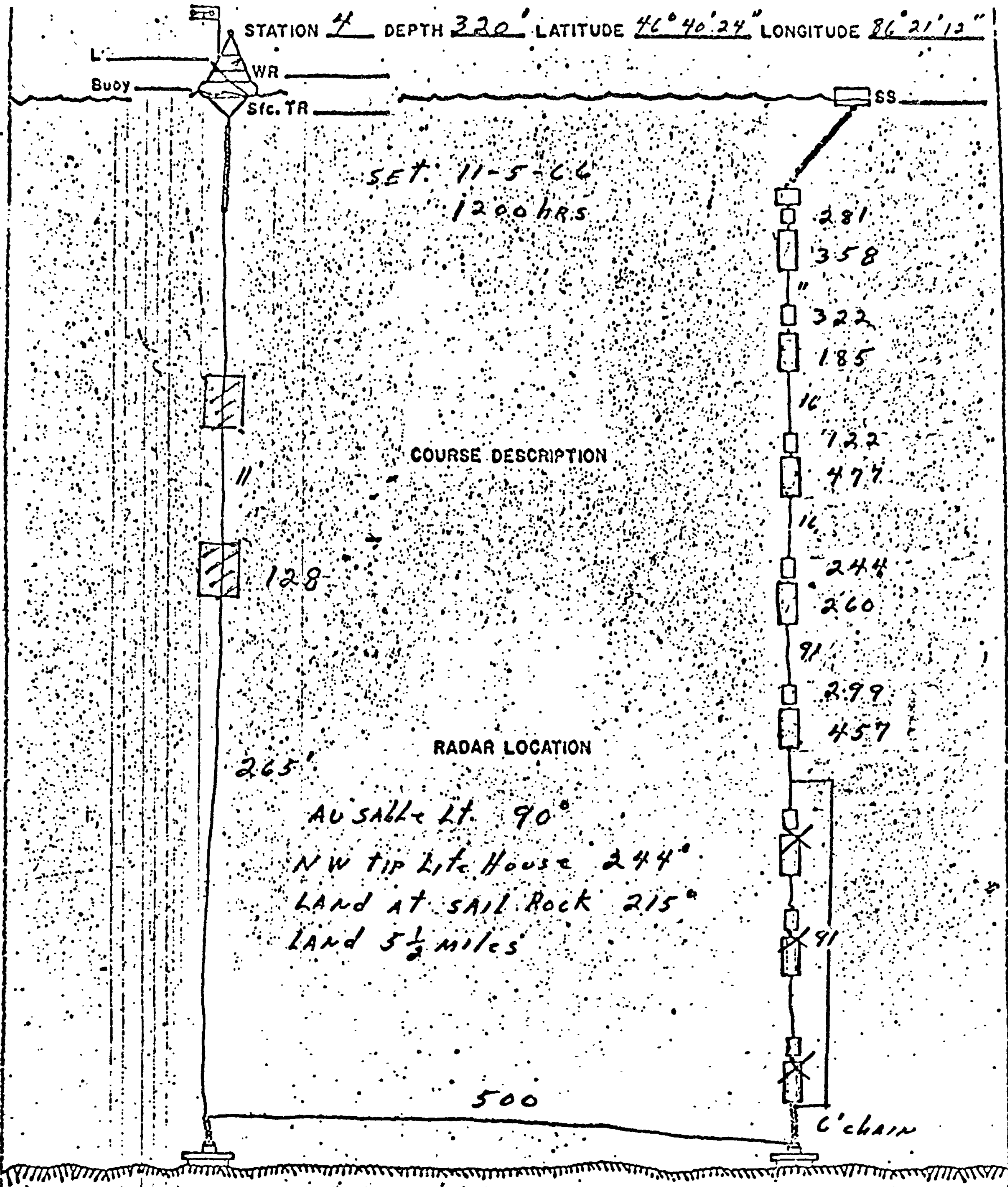
U.S. DEPT. OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION V CHICAGO



GREAT LAKES & ILLINOIS RIVER BASINS PROJECT

LAKE SUPERIOR

U.S. DEPT. OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION V CHICAGO

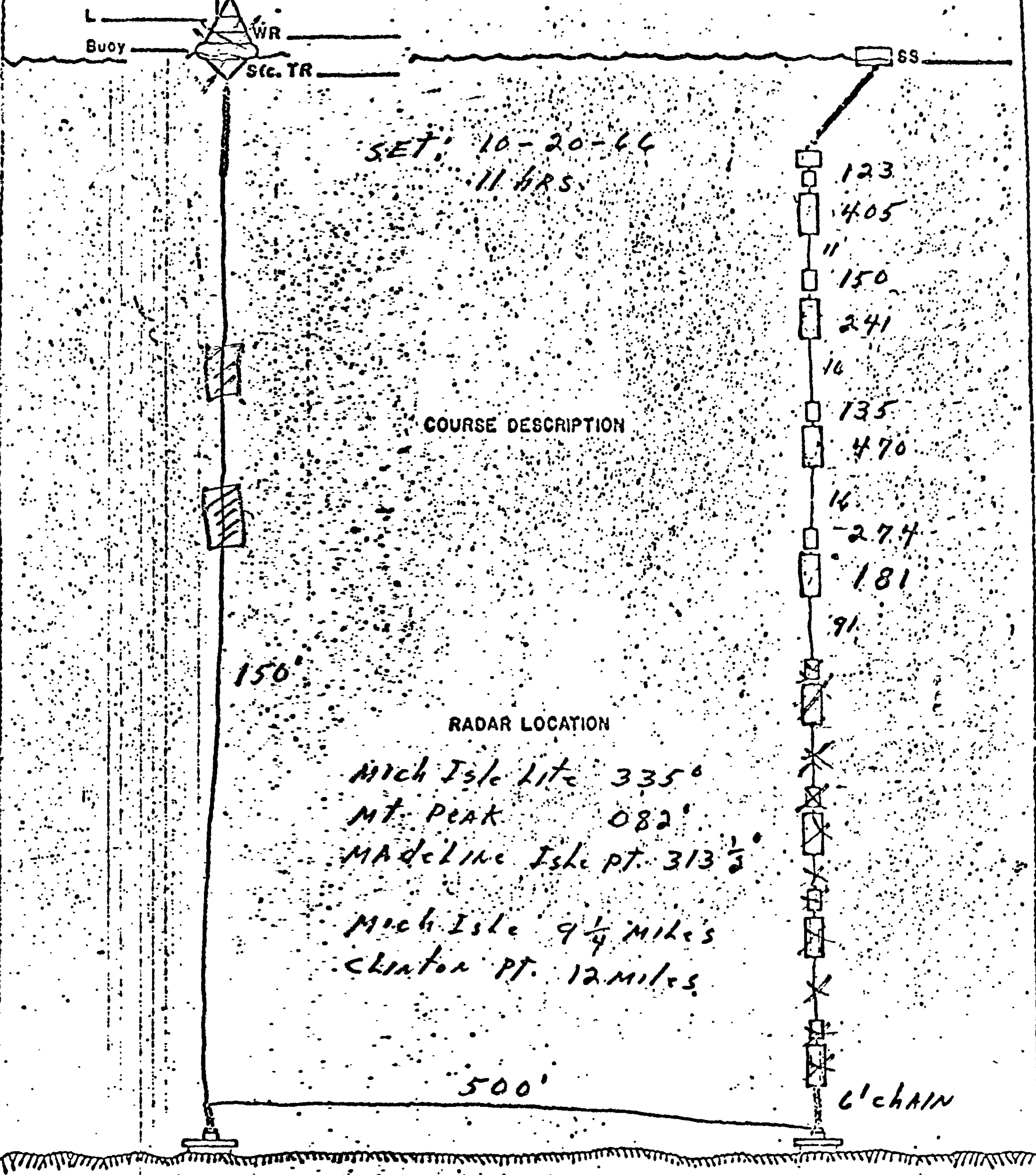


GRE[illegible] LAKES & ILLINOIS RIVER [illegible]ASINS PROJECT

LAKE SUPERIOR

U.S. DEPT. OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION V CHIC[illegible]

STATION 7 DEPTH 210 LATITUDE 46°44'54" LONGITUDE 90°24'40"

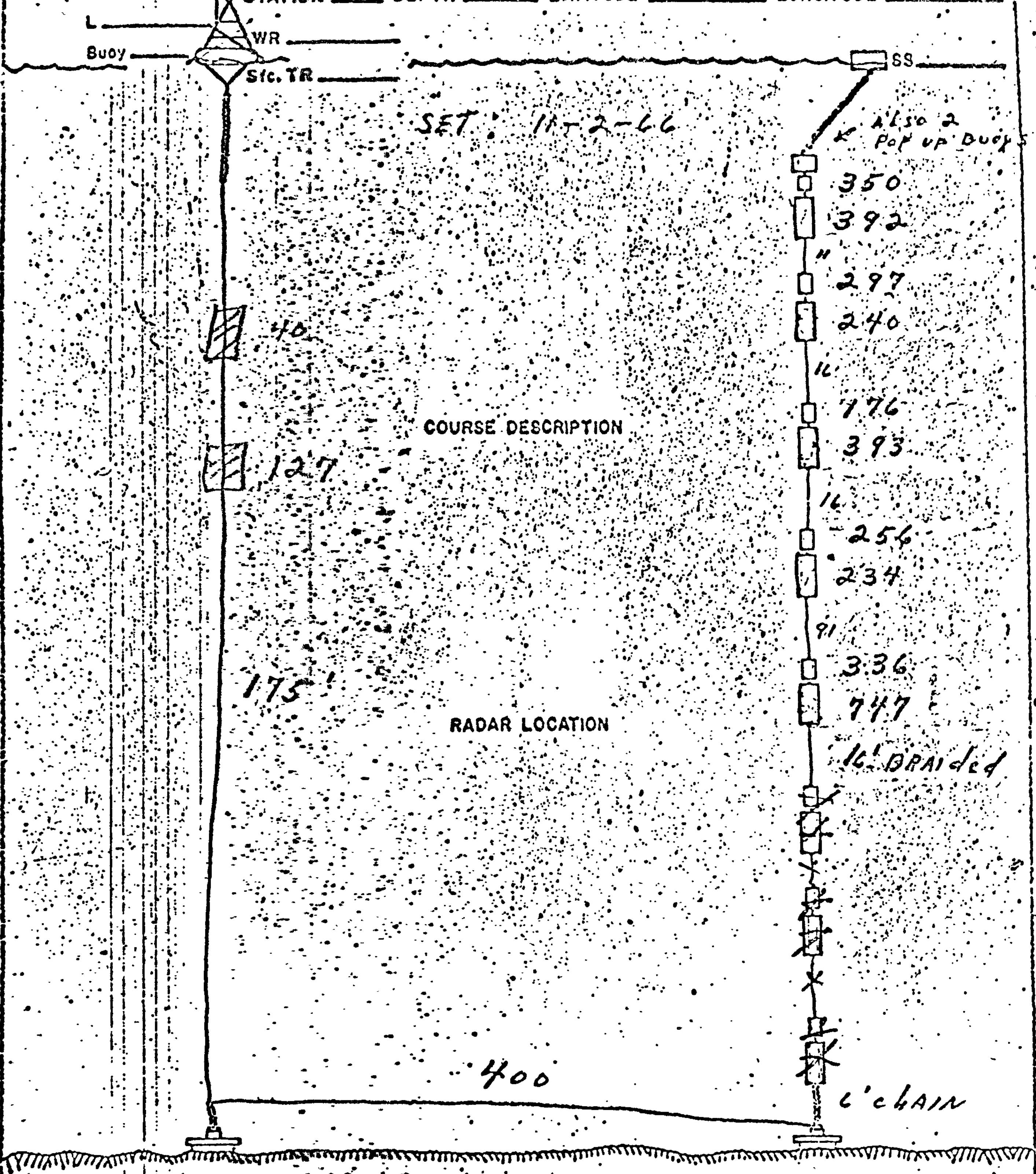


GREAT LAKES & ILLINOIS RIVER BASINS PROJECT

LAKE SUPERIOR

U.S. DEPT. OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION V CHICAGO, ILLINOIS

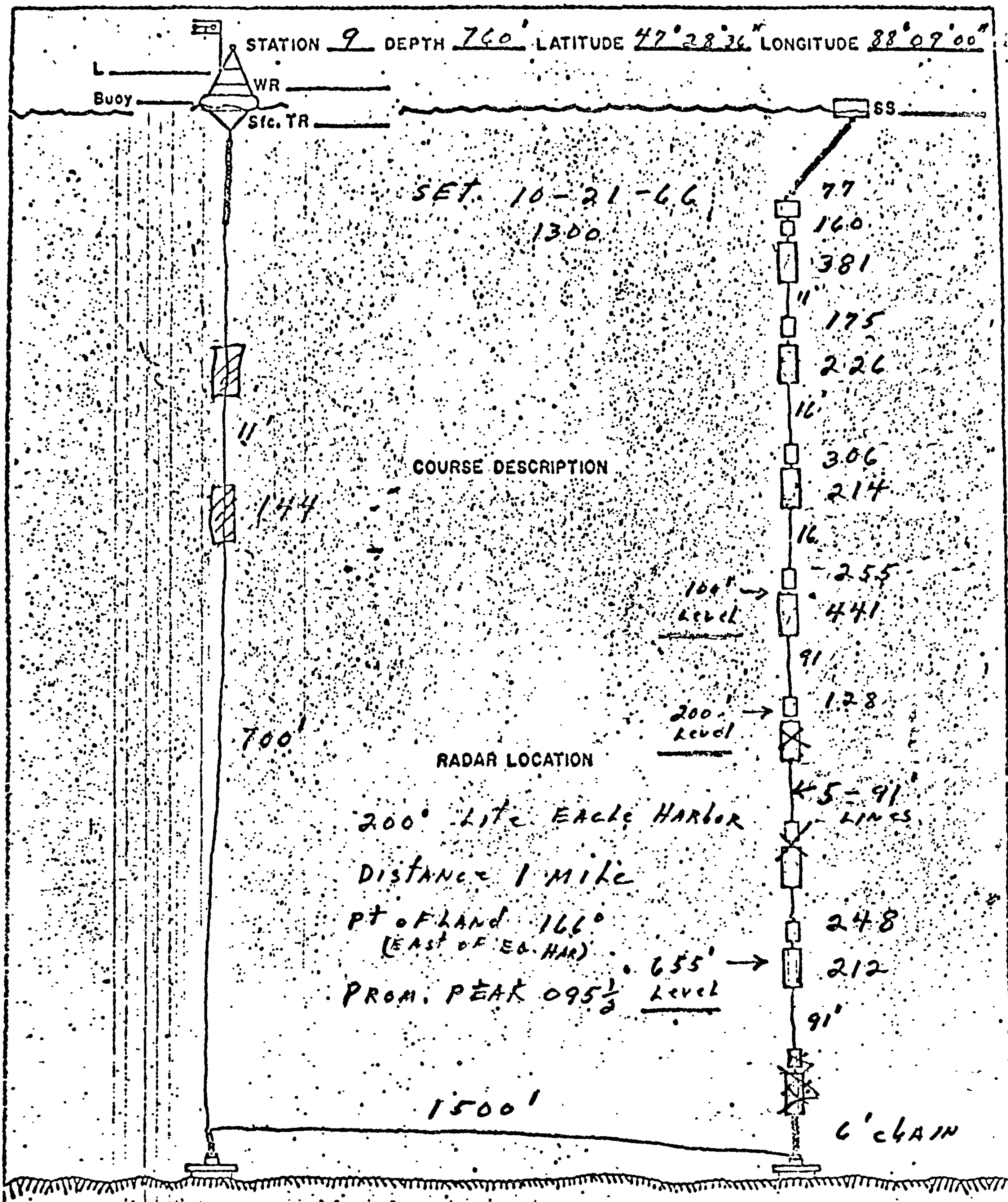
STATION 8 DEPTH 240 LATITUDE 47 01' 12" LONGITUDE 88 15' 54"



GREAT LAKES & ILLINOIS RIVER BASINS PROJECT

LAKE SUPERIOR

U.S. DEPT. OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION V CHICAGO



Note: Sampling station lies some 450 feet shoreward of this current meter station.

GREAT LAKES & ILLINOIS RIVER BASINS PROJECT

LAKE SUPERIOR

U.S. DEPT. OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE

HJF
1/31/67

Exhibit 2

Lake Superior Biological Findings
October November 1966

A DISCUSSION ON THE BIOLOGICAL FINDINGS OF THE LAKE SUPERIOR SPECIAL CRUISE OCTOBER-NOVEMBER 1966

Herbert J. Fisher

Introduction

Information on the planktonic life and bottom fauna in Lake Superior is quite limited. Early non-quantitative phytoplankton investigations included those of Eddy (1934) and Taylor (1935). Some later quantitative studies included those of Putnam and Olson (1961), Williams (1962), Williams and Scott (1962), Putnam (1963) and Holland (1965). Information on the benthos of the Lake is even more scarce. Some early works on this subject were those of Smith (1871 a, b, c; 1874 a, b), Smith and Verrill (1871) and Eddy (1943).

On the dates of Oct. 19-20, Nov. 2 and 6, 1966, a special cruise was made on Lake Superior to obtain some present-day information on conditions in the Lake. In addition to other samples, biological samples were collected at six widely scattered stations in the Lake proper and at one station in Whitefish Bay (Fig. 1). All collections were made from the deck of the Telson Queen, a contract vessel.

The Use of Some Biological Findings

The kinds and numbers of benthic fauna inhabiting a particular lake area are determined by characteristics of the substratum, the quality of the water and certain physical features such as morphometry of the basin, wave action, currents, temperature, light and depth. Usually, organic sediments provide a suitable habitat for oligochaetes and tendipedids but not for some of the amphipods and molluscs.

Phytoplankton increase with favorable conditions of light, temperature, water movements, and available nutrients. Certain other organic substances also are required for plankton growth. Certain species of green algae, brown algae, and diatoms are common in oligotrophic lakes. Some of these are Tabellaria, Asterionella, Synedra, and Fragillaria. In contrast, some of the blue-green algae, euglenoids, and other diatoms favor nutrient-enriched waters of eutrophic lakes. Some of these include species of Anacystis, Oscillatoria, Stephanodiscus, Cyclotella, and Melosira.

In areas not receiving such suspended organic matter as sewage, the amount of organic seston per cubic meter of the water is a gross measure of biological productivity. When considered with light penetration, phytoplankton densities, the measure of organic matter may be useful in the evaluation of abnormal values for phytoplankton and certain bacteriological and chemical data.

Methods

Benthic fauna and planktonic algae were sampled in the biological study. Weather conditions, water temperatures, transparency as measured with a secchi disc, bottom type and conditions of the water and bottom were recorded.

Methods of sample collection and methods of laboratory analyses used on these samples followed the procedures listed in Water Pollution, Biology, Field and Laboratory Manual, GLIRBP, FWPCA, Department of Health, Education, and Welfare, February 1966. A discussion on these methods follows:

The Petersen dredge was used for collecting bottom samples during the fore part of the survey. However, it was later replaced by the Shipek sampler. Since this device is equipped with springs for tension, it was able to close with considerable force. Usually three samples were collected. The dredgings were washed through a square, wood-framed sieve of U.S. Standard No. 3 mesh sieve cloth. All of the material retained on the sieve was preserved with formalin. The bottom animals were separated from this material in the laboratory and then sorted, identified, counted and reported as numbers per square meter of lake bottom.

Samples for phytoplankton analyses were collected at three different depths at each station: surface, mid-depth, and bottom by means of PVC bottles. One-half gallon samples were collected. Formalin was added to result in a four percent solution.

In the laboratory the sample was shaken by inverting the jar about twenty times. An aliquot was taken with a plastic dropper and the chamber of a Sedgwick-Rafter counting cell was filled with one milliliter of the sample as quickly as possible. The contents of the slide were then allowed to settle for fifteen minutes before counting.

Microscopic examination of the sample was made using 10X oculars, one of which was fitted with a Whipple ocular micrometer, and a 20X objective. The microscope was also equipped with a mechanical stage. A measurable portion of the slide was then counted. Two "strips" across the cell, each one Whipple field wide, were ordinarily scanned unless the sample was very sparsely populated in which case four or eight strips were inspected. If the phytoplankton were extremely dense, only one strip was viewed. The "clump" count was used, that is, clumps or colonies or organisms were counted as one. The results were tallied on a bench sheet. At this magnification (200X), identifications to genera were usually attempted. If this was impossible, then the plankters were put into the proper class, e. g. "unidentified green coccoids."

Since the Sedwick-Rafter counting cell is standardized at 50 mm X 20 mm X 1 mm and the size of the Whipple field could be measured with a stage micrometer, the number of algae on the entire slide was found by multiplication with the factor appropriate to the number of strips counted. Results were tabulated as number of organisms per milliliter and should be rounded to two significant figures.

Suspended organic matter in the water was sampled by the use of the vertical plankton tow, a conical-shaped No. 20 mesh nylon bolting cloth net, 1.5 meters in length, 0.5 meter in diameter at the top and 0.008 meter in diameter at the bottom. Attached to the bottom is a small metal bucket with openings covered with the same fine mesh netting. The net was lowered to the bottom of the lake and then raised to the surface at a constant speed. When the net was brought up, the plankton trapped on the inside surface were washed down into the bucket. The plankton were then drained from the bucket and preserved in a pint-size glass jar with sufficient formalin to effect a three percent solution.

The sample was run through a Foerst continuous centrifuge until all green color was removed from the sample. The plankton concentrate was then washed with distilled water into a tared porcelain evaporating dish and dried in a constant-temperature oven at 60°C (approximately 24 hours). The dish was then weighed and the tared weight subtracted to give the dry weight of the sample. The sample was then ashed in a muffle furnace at 600°C for 30 minutes, cooled and weighed again. Ash weight was determined by subtracting the tare weight from the last reading. Subtraction of the ash weight from the dry weight provided the loss due to ignition or the weight of the organic matter present in the sample. The volume of the column of water filtered through the half-meter diameter net was then determined. The formula for a half-meter net is:

Cubic meters of water filtered = 0.196 X length of tow.

The results were expressed as milligrams of organic matter in one cubic meter.

Results and Discussion

Benthic Fauna

Table 1 presents the average number of bottom-dwelling organisms found in the samples collected.

The average in numbers per square meter for the seven stations sampled was 80. Scuds composed about 70 percent of the benthic organisms found and sludgeworms composed about 20 percent. Other benthic organisms noted in the samples included fingernail clams, bloodworms, roundworms and Diptera.

It is interesting to compare biological data collected in Lake Superior during the present study with GLIRBP biological findings in the other Great Lakes. Analyses of benthic samples collected at 42 deepwater stations in Lake Ontario in September 1965 indicated an average of 475 benthic organisms per square meter[a/]. In the northern part of Lake Michigan and in the deepwater stations in the southern part, 500 or less amphipods per square meter were recorded[b/].

Phytoplankton

Phytoplankton populations per milliliter for the seven stations are presented in Table 2. The average for the surface samples for the seven stations was about 50 with a range of 20 to 110. Pennate diatoms composed 64 percent of the phytoplankton, centric diatoms and green coccoids composed 18 percent each. Some of the more important organisms in order of abundance were Cyclotella, Navicula, Tabellaria, and Scenedesmus. Predominant genera found at each station are listed in Table 3.

Putnam and Olson (1961) reported an average of 168 phytoplankton per milliliter near Duluth from mid-July to mid-October 1960. Williams (1962) reported about 100 phytoplankton per milliliter near the same station about the same time. Holland (1965) reported on the analyses of samples collected at 14 offshore stations, some in mid-lake. According to her, diatoms varied in number from 2,200 per milliliter near the Apostle Islands to 65 to 78 per milliliter in the middle of the lake northwest of the Keweenau Peninsula.

Comparison of the above data may be questioned. Putnam and Olson were not specific as to methods of counting. Williams used the clump system of counting. Putnam and Olson examined slides under 200 power magnification; Holland examined the slides under 970 power magnification.

The phytoplankton populations recorded in Lake Superior are rather small in comparison with those reported for some of the other Great Lakes. Spring 1962 phytoplankton counts averaged 300 or less per milliliter in the northern and southern deepwater areas of Lake Michigan[b/]. The average phytoplankton population of samples collected at 42 deepwater stations in Lake Ontario in September 1965 was 648 per milliliter with a range of 196-1,372[a/]. Phytoplankton collected in November 1965 averaged 714 per milliliter from 11 deepwater stations in Lake Huron[c/]. Casper (1965) reported that during a phytoplankton bloom in an area of western Lake Erie on September 10, 1964, 14,656 per milliliter were recorded of which 91.8 percent were blue-greens, 6.9 percent were greens and 1.3 percent were diatoms.

Seston

Determinations of seston were conducted to provide a gross estimate of the standing crop. Suspended organic matter in milligrams per cubic meter for the seven stations are presented in Table 4. All values were low. The concentrations varied from 1 milligram per cubic meter at Station 1 to 26 milligrams per cubic meter at Station 10. These values are low compared to those recorded for another Great Lake. Anderson and Clayton (1959) conducted vertical plankton tows in Lake Ontario in October 1958 and obtained values ranging from 8 milligrams per cubic meter to 80 milligrams per cubic meter.

Light Penetration

Light penetration as measured by the secchi disc was recorded for all stations except Station 10. The water at each station was quite clear. The secchi disc readings ranged from 6 to 9 meters. Secchi disc readings ranged from about 2 to 8 meters at 42 Lake Ontario deepwater stations in September 1965[a/].

Observations of Physical Conditions

Bottom materials consisted of clay at Station 3, sand at Stations 7, 8, 9 and 10 and rock at Stations 1 and 2. No ooze nor detritus was noted in any of the bottom samples. The odor of the water and of the bottom material was normal at all stations. Surface temperatures ranged from 7 to 10 degrees C at the various stations.

Summary

Biological samples were collected at seven widely scattered stations in Lake Superior during the period October 19-November 6, 1966. Analyses of the samples indicated low populations of both benthic organisms and phytoplankton. The values were also low compared to those recorded for other of the Great Lakes.

Some other indications of a rather clean habitat were the presence of pollution sensitive benthic organisms, small amount of suspended organic matter, and lack of ooze and/or detritus in the bottom samples.

Briefly, analyses of the biological samples and observations made at the stations indicated that the water of Lake Superior at the stations sampled was quite clean and free of pollution during the late fall of 1966.

Fig. 1. LAKE SUPERIOR BIOLOGICAL SAMPLING STATIONS
OCT-NOV. 1966

TABLE 1

BENTHIC MACROINVERTEBRATES, LAKE SUPERIOR SPECIAL CRUISE, OCT.-NOV. 1966

Station	Latitude	Longitude	Date	Depth (meters)	Numbers of Benthic Organisms per Square Meter					
					Scuds	Sludge-worms	Fingernail Clams	Blood-worms	Others	Total*
1	47°24'06"	96°05'50"	10/19/66	97	40	20	x	10		70
2	46°58'30"	91°42'30"	10/19/66	67		x				x
3	46°51'12"	91°20'15"	10/19/66	70	270	30	10		a, b	310
7	46°44'54"	90°24'40"	10/20/66	63		60	30	x		90
8	47°01'12"	88°15'54"	11/2/66	73	50					50
9	47°28'36"	88°09'00"	10/21/66	98	40					40
10	46°30'54"	84°48'20"	11/6/66	30						0

Key a-Nematoda (3)

b-Diptera (3)

*Three significant figures

x-Less than 10 individuals

TABLE 2

PHYTOPLANKTON, LAKE SUPERIOR SPECIAL CRUISE, OCT.-NOV. 1966

Station	Latitude	Longitude	Date	Depth of Sample (meters)	Number per Milliliter: Centric Diatoms	Pennate Diatoms	Green Coccoids	Blue-Green Coccoids	Blue-Green Fila-mentous	Total	Predominant Genera (10% o more)
1	47°24'06"	96°05'50"	10/19/66	0		90	20			110	d, f, h, k
				50		40	20			60	f, g, k
				97	40					40	a
2	46°58'30"	91°42'30"	10/19/66	0		20				20	f
				35	20	90				110	a, h, g
				67	20	40	40			100	c, e, k, j
3	46°51'12"	91°20'15"	10/19/66	0	20					20	a
				35		20				20	g
				70	40	40				80	a, b, h, g
7	46°44'54"	90°24'40"	10/20/66	0		40	20			60	e, h, k
				32		20				20	h
				63	20	20	20			60	a, g, k
8	47°01'12"	88°15'54"	11/2/66	0	20	20				40	a, g
				40	40				20	60	a, n
				73		20				20	h
9	47°28'36"	88°09'00"	10/21/66	0	20		20			40	a, k
				50	40	20	20			80	a, g, k
				98	20	40	60	20		140	a, e, h, k, l m
10	46°30'54"	84°48'20"	11/6/66	0		60				60	e, i
				15		20				20	d
				30	60	120				180	a, c, e, f, i

TABLE 3

KEY TO PREDOMINANT PHYTOPLANKTON GENERA

Centric Diatoms

a. Cyclotella-Stephanodiscus
b. Melosira
c. Rhizoselenia

Pennate Diatoms

d. Asterionella
e. Navicula
f. Nitzschia
g. Synedra
h. Tabellaria
i. Unidentified

Green Coccoids

j. Ankistrodesmus
k. Cosmarium
l. Scenedesmus

Blue-Green Coccoids

m. Anacystis

Blue-Green Filamentous

n. Oscillatoria

TABLE 4

ORGANIC MATTER CONCENTRATIONS, LAKE SUPERIOR SPECIAL CRUISE, OCT.-NOV.1966

Station	Latitude	Longitude	Date	Length of Plankton Tow (meters)	Organic Matter (milli-grams per cubicmeter)
1	47°24'06"	96°05'50"	10/19/66	95	1
2	46°58'30"	91°42'30"	10/19/66	65	3
3	46°51'12"	91°20'15"	10/19/66	68	4
7	46°44'54"	90°24'40"	10/20/66	61	17
8	47°01'12"	88°15'54"	11/2/66	71	7
9	47°28'36"	88°09'00"	10/21/66	96	9
10	46°30'54"	84°48'20"	11/6/66	28	26

LIST OF REFERENCES

Anderson, D.V. and D. Clayton. 1959. Plankton in Lake Ontario. Physics Research Note #1. Ontario Department of Lands and Forests, Maple, Ontario.

Casper, V.L. 1965. A Phytoplankton Bloom in Western Lake Erie. University of Michigan, Great Lakes Research Division, Pub. 13: 29-35.

Eddy, S. 1934. A Study of Fresh-Water Communities. Illinois Biol. Monogr., 12 (4) : 93 p.

Eddy, S. 1943. Limnological Notes on Lake Superior. Proc. Minnesota Acad. Sci., 11:34-39.

Holland, R.E. 1965. The Distribution and Abundance of Planktonic Diatoms in Lake Superior. Proc. 8th Conf. Great Lakes Res.; Univ. Michigan, Great Lakes Res. Div. Pub. 13: 96-105.

Putnam, H.D. 1963. A Study of the Nutrients, Productivity and Plankton in Western Lake Superior. Ph.D. Thesis, Univ. Minnesota, 288 p.

Putnam, H.D. and T.A. Olson. 1961. Studies on the Productivity and Plankton of Lake Superior. Univ. Minnesota, School Public Health. 24 p. + 14 tables and 13 plates (multigraphed).

Smith, S.I. 1871a. Preliminary Report on the Dredgings in Lake Superior. Rep. U.S. Sec. War, Pt. 2:1-7.

__________ 1871b. Dredging in Lake Superior under the Direction of the U.S. Lake Survey. Amer. J. Sci. Arts, 34d Ser. , 2:373-374.

__________ 1871c. The Fauna of Lake Superior at Great Depths. Amer. Natur. 5:722.

__________ 1874a. The Crustacea of the Fresh Waters of the United States. Rep. U.S. Fish. Comm. (1872-1873), Pt. 2:637-665.

__________ 1874b. Sketch of the Invertebrate Fauna of Lake Superior. Rep. U.S. Fish. Comm. (1872-1873), Pt. 2:690-707.

__________ and A.E. Verrill. 1871. Notice of the Invertebrata Dredged in Lake Superior in 1871 by the U.S. Lake Survey, under the direction of General C.B. Comstock, S. I. Smith, Naturalist. Amer. J. Sci. Arts, 3rd Ser., 2:448.

Taylor, W. R. 1935. Phytoplankton of Isle Royale. Trans. Amer. Microscop. Soc., 54:83-97.

Williams, L.G. 1962. Plankton Population Dynamics. U.S. Public Health Serv., Nat. Water Qual. Network, Suppl., 2. 90 p.

Williams, L.G. and C. Scott. 1962. Principal Diatoms of Major Waterways of the United States. Limnol. Oceanogr., 7:365-379.

a/ Lake Ontario Program Office. 1966. Report on the Biological Investigations, Lake Ontario Basin.

b/ Great Lakes-Illinois River Basins Project. 1966. Comprehensive Water Pollution Control Programs, Lake Michigan Basins, Appendix 4, Biology. June 1966.

c/ Unpublished G.L.I.R.B.P. data on Biology in Lake Huron.

Exhibit 3

Municipal Waste Inventory Data St Louis
River Basin Minnesota and
Wisconsin

TABLE
PROVISIONAL
SUMMARY SHEET - LAKE SUPERIOR 23B-C

SOURCES OF SIGNIFICIANT POLLUTION

Major Basin: Lake Superior | State: Minnesota and Wisconsin | County: St. Louis, Carlton, Itasco, Minnesota; Douglas, Wisconsin

Subbasin: St. Louis River Level 1

Community, Sewer or Sanitary District, Institution (1)	Receiving Stream (Direct) (2)	Location Level (3)	Miles Above Last Jct. (4)	Miles Above Mouth of Subbasin (5)	Treatment (6)	Estimated Population Connected to Sewers (7)	Estimated Sewered Population Equivalent (BOD Basis) Untreated (8)	Estimated Sewered Population Equivalent (BOD Basis) Discharged (9)
County Totals for Subbasin								
St. Louis County (Places 25)						165,124	205,675	79,900
Carlton County (Places 6)						10,468	10,570	5,325
Itasca County (Places 0)						--	--	--
Douglas County (Places 3)						32,358	30,955	23,675
Totals for subbasin (Places 34)						207,950	247,200	108,900

Insufficient Information

	Places	Population
St. Louis County	10	3,859
Carlton County	0	-
Itasca County	1	150
Douglas County	3	547
Totals	14	4,556

1/24/67 JLM

TABLE
PROVISIONAL
SUMMARY SHEET - Lake Superior 23 B-C

SOURCES OF SIGNIFICIANT POLLUTION

Major Basin: Lake Superior — State: Minnesota — County: St. Lous, Carlton and Itasca, Minnesota; Douglas County, Wisconsin

Subbasin: St. Louis River - Level 1

Community, Sewer or Sanitary District, Institution (1)	Receiving Stream (Direct) (2)	Location Level (3)	Miles Above Last Jct. (4)	Miles Above Mouth of Subbasin (5)	Treatment (6)	Estimated Population Connected to Sewers (7)	Estimated Sewered Population Equivalent (BOD Basis) Untreated (8)	Estimated Sewered Population Equivalent (BOD Basis) Discharged (9)
St. Louis Cty., Minnesota								
Aurora	Creek to St. Louis R.	2			Sec.	2,520	4,400 E	660 E
Babbitt	Embarrass R.	2			Sec.	2,330	5,000 E	750 E
Biwabik	Biwabik Dr. to Embarras R.	3			Minor*	1,650	1,200 E	960 E
					*Plant under construction			
Buhl	Buhl Cr. to East Swan R.	3			Sec.	1,370	2,200 E	330 E
Chisholm	Chisholm Cr. to E. Swan R.	3			Sec.	6,430	7,800 E	1,170 E
Duluth (4 plants)						107,500		
Main Plant	Lake Superior	01	0	0	Primary		125,000 E	60,000 E
Smithville Plant	St. Louis R.	1			Primary		5,000 E	2,500 E
Fairmont Park Plt.	St. Louis R.	1			Primary		7,000 E	3,500 E
Gary-New Duluth Plt.	Mud Lake to St. Louis R.	2			Primary		2,600 E	1,300 E
(Proctor) Served by Duluth Fairmont Pk. Plt. (2,670)					Primary			
Subtotal (Places 7)						121,800	160,200	71,170

TABLE
PROVISIONAL
SUMMARY SHEET - LAKE SUPERIOR - 23 B-C

SOURCES OF SIGNIFICIANT POLLUTION

Major Basin: Lake Superior — State: Minnesota — County: St. Louis, Carlton & Itasca, Minn. Douglas Cty, Wisconsin

Subbasin: St. Louis River - Level 1

Community, Sewer or Sanitary District, Institution (1)	Receiving Stream (Direct) (2)	Location Level (3)	Miles Above Last Jct. (4)	Miles Above Mouth of Subbasin (5)	Treatment (6)	Estimated Population Connected to Sewers (7)	Estimated Sewered Population Equivalent (BOD Basis) Untreated (8)	Estimated Sewered Population Equivalent (BOD Basis) Discharged (9)
St. Louis County, Minnesota 23C								
Eveleth (Fayal Twp. served by Eveleth (300 P.E.))	Cr. to Elbow Lake	3			Sec.	5,150	5,000 E	750 E
Floodwood	Cr. to St. Louis R.	2			None	610	610	610*
					*Has sewer facilities without sewage treatment			
Gilbert	Ditch to Lake to Emb. R.	4			Sec.	2,330	4,200 E	630 E
Hibbing	Hibbing Cr. to E. Swan R.	3			Sec.	15,590	16,000 E	2,400 E
Hoyt Lakes	Lower Partridge Lake				Sec.	2,810	2,800 E	420 E
Iron Junction	Cr. to St. Louis R.	2			Minor	170	200 E	160 E
Kelly Lake	Kelly Lake to W. Swan R.	3			Minor	600	600 E	480 E
Kerr location	West Swan Lake	3			Minor	200	200 E	160 E
Kinney	Creek to McQuade R.	4			Primary	220	220 E	110 E
		Subtotals (Places 10)				27,680	29,830	5,720

TABLE
PROVISIONAL
SUMMARY SHEET - LAKE SUPERIOR 23 B- C

SOURCES OF SIGNIFICIANT POLLUTION

Major Basin: Lake Superior — State Minnesota — County St. Louis, Carlton, and Itasca Ctys., Minn. Douglas Cty., Wisconsin

Subbasin St. Louis River - Level 1

Community, Sewer or Sanitary District, Institution (1)	Receiving Stream (Direct) (2)	Location Level (3)	Miles Above Last Jct. (4)	Miles Above Mouth of Subbasin (5)	Treatment (6)	Estimated Population Connected to Sewers (7)	Estimated Sewered Population Equivalent (BOD Basis) Untreated (8)	Estimated Sewered Population Equivalent (BOD Basis) Discharged (9)
St. Louis County, Minnesota 23 C								
Mahoning Location	West Swan R.	2			Minor	225	225 E	180 E
Meadowlands	Cr. to Whiteface R.	3			Minor	160	160 E	130 E
Monroe Location	East Swan R.	2			Minor	400	400 E	320 E
Mountain Iron	Cr. to West Two R.	3			Sec.	1,650 E	1,630 E	240 E
McKinley	Lake to Cr. to Embar. R.	4			Primary	370	400 E	200 E
Nichols Twp. (Inc.)	Cr. to Mashkenode Lake	3			Minor	X	X	X
Nopeming Sanitarium	Ditch to Mission Cr.	3			Sec.	229	230 E	40 E
Virginia	East Two R. to Three Mile Lake	3			Sec.	12,630	12,600 E	1,900 E
			Subtotal (Places 8)			15,644	15,645	3,010

TABLE
PROVISIONAL
SUMMARY SHEET - LAKE SUPERIOR 23 B-C

SOURCES OF SIGNIFICIANT POLLUTION

Major Basin: Lake Superior | State: Minnesota | County: St. Louis, Carlton, Itasca, Minnesota; Douglas, Wisconsin

Subbasin: St. Louis River - Level 1

Community, Sewer or Sanitary District, Institution (1)	Receiving Stream (Direct) (2)	Location Level (3)	Miles Above Last Jct. (4)	Miles Above Mouth of Subbasin (5)	Treatment (6)	Estimated Population Connected to Sewers (7)	Estimated Sewered Population Equivalent (BOD Basis) Untreated (8)	Estimated Sewered Population Equivalent (BOD Basis) Discharged (9)
St. Louis County, Minnesota 23 C								
Communities with insufficient information:								
Arnold (700)								
Brookston (144 - without sewer system)								
Elcor (170)								
Embarrass (210)								
Hermantown (700)								
Leetonia (175)								
Nopeming (210)								
Parkville (900)								
Redore (150)								
West Virginia (500)								

Subtotal (Places 10)
(Population 3,859)

TABLE
PROVISIONAL
SUMMARY SHEET - LAKE SUPERIOR 23 B-C

SOURCES OF SIGNIFICIANT POLLUTION

Major Basin: Lake Superior State Minnesota County St. Louis, Carlton & Itasca, Minnesota Douglas, Wisconsin

Subbasin St. Louis River - Level 1

Community, Sewer or Sanitary District, Institution (1)	Receiving Stream (Direct) (2)	Location Level (3)	Miles Above Last Jct. (4)	Miles Above Mouth of Subbasin (5)	Treatment (6)	Estimated Population Connected to Sewers (7)	Estimated Sewered Population Equivalent (BOD Basis) Untreated (8)	Estimated Sewered Population Equivalent (BOD Basis) Discharged (9)
Carlton County, Minnesota 23 C								
Carlton	St. Louis R.	1			Primary	780	780 E	390 E
Cloquet	St. Louis R.	1			Primary	8,110	8,110 E	4,050 E
Esko (Part of Thomas Twp)	Midway River	2			Sec.	200	300 E*	50 E*
					*Influent contains some industrial wastes			
Scanlon	St. Louis R.	1			Primary	1,010	1,010 E	505 E
Thomson Twp. (Partial) Without Sewer System	St. Louis R.	1			None	179	180 E	180 E
Wrenshall	Ravine to Brook to St. Louis R.	3			Minor	189	190 E	150 E
			Total for County (Places 6)			10,468	10,570	5,325

TABLE
PROVISIONAL
SUMMARY SHEET - LAKE SUPERIOR 23 B-C

SOURCES OF SIGNIFICIANT POLLUTION

Major Basin: Lake Superior — State: Minnesota — County: St. Louis, Itasca, Minnesota; Douglas, Wisconsin

Subbasin: St. Louis River - Level 1

Community, Sewer or Sanitary District, Institution (1)	Receiving Stream (Direct) (2)	Location Level (3)	Miles Above Last Jct. (4)	Miles Above Mouth of Subbasin (5)	Treatment (6)	Estimated Population Connected to Sewers (7)	Estimated Sewered Population Equivalent (BOD Basis) Untreated (8)	Estimated Sewered Population Equivalent (BOD Basis) Discharged (9)
Itasca County, Minnesota 23 C								
Swan River (150) Insufficient Information								
(Places 1)								

TABLE
PROVISIONAL
SUMMARY SHEET - LAKE SUPERIOR 23 B-C

SOURCES OF SIGNIFICIANT POLLUTION

Major Basin: Lake Superior — State: Wisconsin — County: St. Lous, Carlton, Itasca, Minnesota; Douglas, Wisconsin

Subbasin: St. Louis River - Level 1

Community, Sewer or Sanitary District, Institution (1)	Receiving Stream (Direct) (2)	Location Level (3)	Miles Above Last Jct. (4)	Miles Above Mouth of Subbasin (5)	Treatment (6)	Estimated Population Connected to Sewers (7)	Estimated Sewered Population Equivalent (BOD Basis) Untreated (8)	Estimated Sewered Population Equivalent (BOD Basis) Discharged (9)
Douglas County, Wisconsin 23 B								
Hawthorne Douglas Co. Hosp.	Middle River	2			Sec.	578	575 E	175 E
Superior	St. Louis R.	1			Primary	31,400	30,000 E	23,200 E
Superior Village	Pokegama River	2			Minor	380	380 E	300 E
Foxboro (175) Insufficient Information								
Oliver (222) Insufficient Information								
South Range (150) Insufficient Information								
(547)								
			Totals for County (Places 3+3=6)			32,358	30,955	23,675

Exhibit 4

Municipal Waste Inventory Montreal River
Basin Michigan and Wisconsin

TABLE
PROVISIONAL
SUMMARY SHEET - LAKE SUPERIOR 23 A-B

SOURCES OF SIGNIFICIANT POLLUTION

Major Basin: Lake Superior | State: Michigan | County: Gogebic County, Michigan; Iron County, Wisconsin

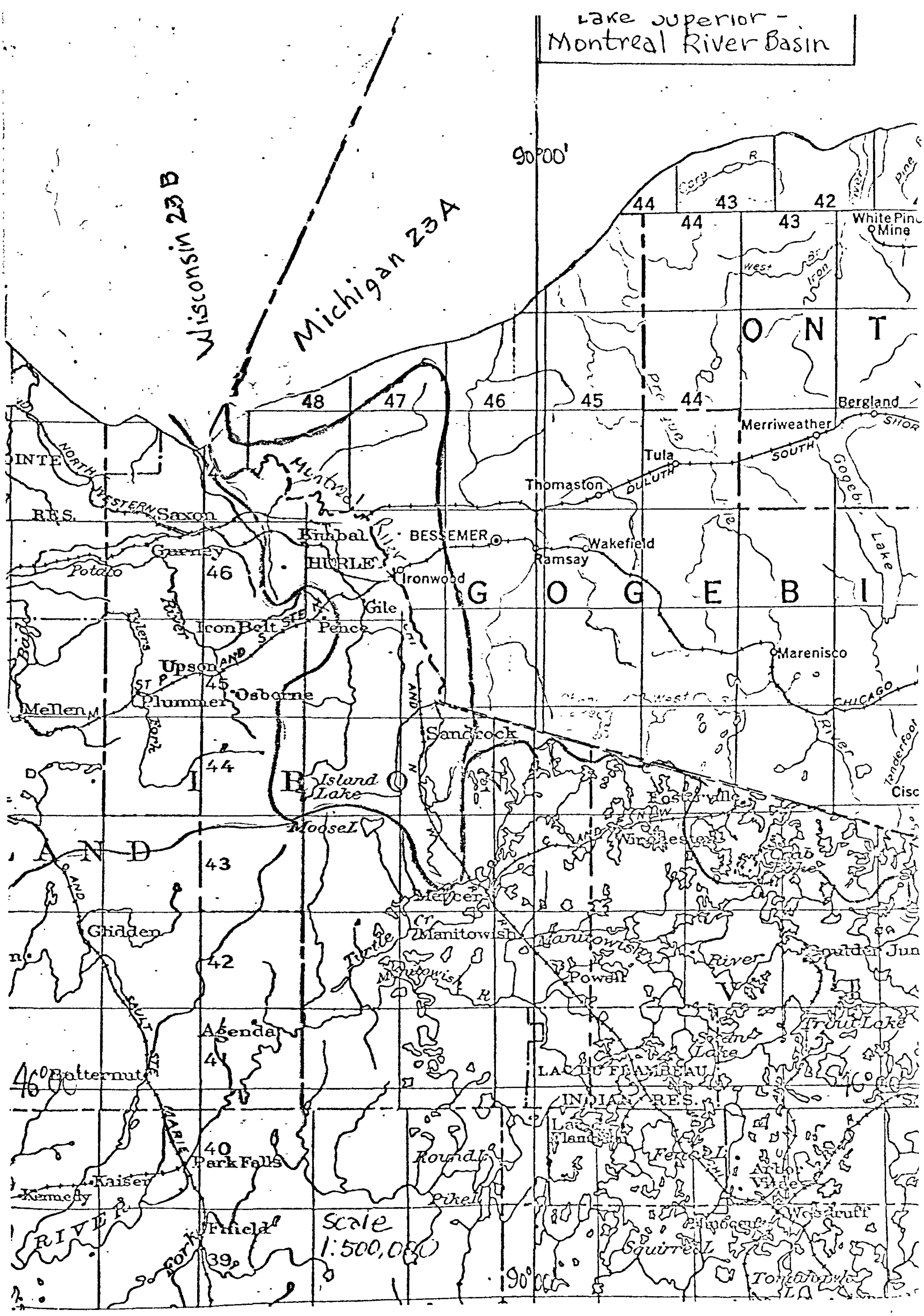
Subbasin: Montreal River Basin - Level- 1

Community, Sewer or Sanitary District, Institution (1)	Receiving Stream (Direct) (2)	Location Level (3)	Miles Above Last Jct. (4)	Miles Above Mouth of Subbasin (5)	Treatment (6)	Estimated Population Connected to Sewers (7)	Estimated Sewered Population Equivalent (BOD Basis) Untreated (8)	Estimated Sewered Population Equivalent (BOD Basis) Discharged (9)
Gogebic Cty., Michigan 23A								
Ironwood	Montreal River	1			Sec.	10,260	5,300	830
Ironwood Twp.	Welch Creek	2			Sec.	420	420E	85E
Ironwood Granview Hospital	Swamp	2			Sec.	100	100E	15E
Hillcrest (475) Insufficient information								
Puritan (150) Private septic tanks								
Iron County, Wisconsin 23 B								
Hurley	Montreal R.	1			Primary	2,765	2,765E	2,460E (1965 Surve
Montreal	West Br. Montreal R.	2			Primary	1,361	1,350E	900E
Totals for basin						14,906	9.935	4,290

(Places 3+2=5)

Insufficient Information

Places 2
Population 625



Lake Superior -
Montreal River Basin
Wisconsin 23 B
Michigan 23 A
90°00'
Montreal River
Saxon
Gurney
Potato
Kimbal
HURLEY
BESSEMER
Ironwood
Ramsay
Wakefield
Thomaston
Tula
Merriweather
Bergland
White Pine Mine
Gile
Pence
Iron Belt
Upson
Plummer
Osborne
Mellen
Sandrock
Island Lake
Moose L
Mercer
Manitowish
Manitowish River
Powell
Glidden
Agenda
Butternut
Park Falls
Kaiser
Kennedy
Fifield
Marenisco
Round L
Pike L
Squirrel L
Trout Lake
LAC DU FLAMBEAU INDIAN RES.
Woodruff
G O G E B I
O N T
I R O N
L A N D
DULUTH SOUTH SHORE
CHICAGO
SAULT STE MARIE
NORTH WESTERN
Scale 1:500,000

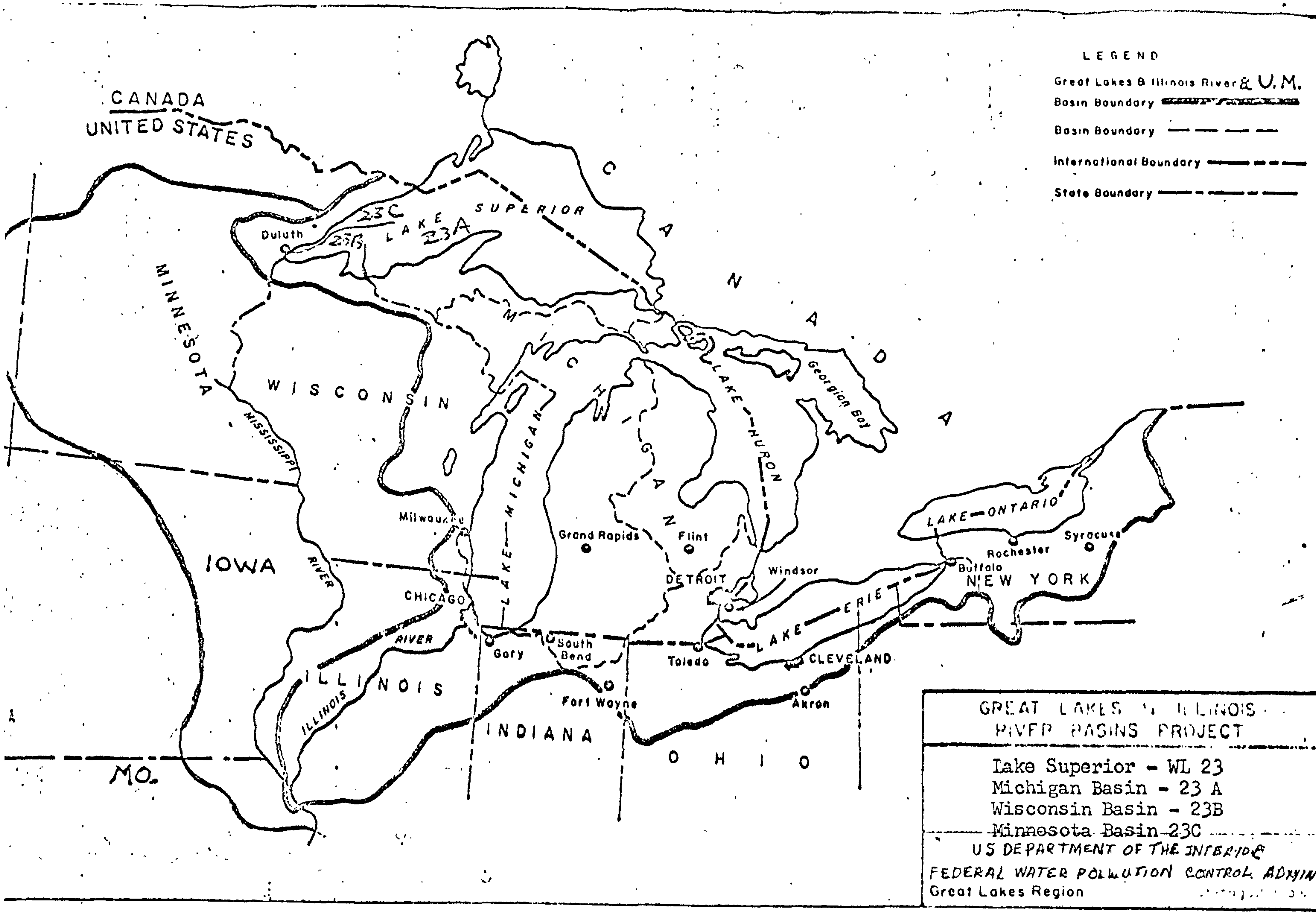

LEGEND
Great Lakes & Illinois River & U.M. Basin Boundary
Basin Boundary
International Boundary
State Boundary
CANADA
UNITED STATES
LAKE SUPERIOR
23C
23B
23A
Duluth
MINNESOTA
WISCONSIN
MISSISSIPPI RIVER
IOWA
MO.
Milwaukee
CHICAGO
ILLINOIS RIVER
ILLINOIS
LAKE MICHIGAN
MICHIGAN
Gary
South Bend
Fort Wayne
INDIANA
Grand Rapids
Flint
DETROIT
Windsor
Toledo
LAKE HURON
Georgian Bay
LAKE ERIE
CLEVELAND
Akron
OHIO
LAKE ONTARIO
Rochester
Syracuse
Buffalo
NEW YORK
GREAT LAKES & ILLINOIS RIVER BASINS PROJECT
Lake Superior - WL 23
Michigan Basin - 23 A
Wisconsin Basin - 23B
Minnesota Basin 23C
US DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN
Great Lakes Region

Exhibit 5

Radiological Data Lake Superior
October-November, 1966

Lake Superior Progress Report.

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

USDI, FWPCA, Great Lakes Basin
GLIRBP

TO : H. Grounds, Chief
Engineering Unit

DATE: January 11, 1967

FROM : W. L. Abbott, Acting Chief
Radiochemistry Unit

SUBJECT: Radiochemistry Results from Lake Superior

Enclosed is a listing of all of the radiochemistry results I have obtained from analysis of Lake Superior samples. These tables are intended for inclusion in the next Lake Superior Progress Report.

Table 1 shows the water samples to contain essentially no radioactivity.

Table 2 lists the activities of bottom sediment samples for five of the seven stations on Lake Superior. Gamma scans on these five samples showed the activity to probably be very low levels of naturally occurring members of the Uranium-238 decay series, which includes Radium-226. Due to the low activities encountered, however, these findings are not conclusive.

Bill

W. L. Abbott

For inclusion in January 31, report.

cc: L. E. Scarce

TABLE 1
LAKE SUPERIOR WATER SAMPLES
Radiochemistry Results
Picocuries per liter
Count Date: January 5, 1967

Latitude	Longitude	Depth (Meters)	Sample Date	Suspended Solids		Dissolved Solids	
				Alpha ± E_{95}	Beta ± E_{95}	Alpha ± E_{95}	Beta ± E_{95}
46°58'30"	91°42'30"	0	10/19/66	0.0 ± 0.2	1.0 ± 0.9	0.0 ± 0.4	1.5 ± 1.1
		33		0.0 ± 0.2	0.0 ± 0.8	0.0 ± 0.4	1.9 ± 1.1
		66		0.0 ± 0.2	0.5 ± 1.2	0.0 ± 0.6	1.8 ± 0.9
46 51 12	91 20 15	0	10/19/66	0.0 ± 0.3	0.0 ± 0.8	0.0 ± 0.4	1.8 ± 1.1
		35		0.0 ± 0.2	0.9 ± 0.9	0.0 ± 0.3	1.6 ± 1.1
		70		0.0 ± 0.3	0.2 ± 0.8	0.4 ± 0.5	1.7 ± 1.1
47 24 06	91 05 50	0	10/19/66	0.0 ± 0.3	0.0 ± 0.8	0.0 ± 0.5	0.7 ± 1.0
		48		0.0 ± 0.2	0.6 ± 0.9	0.0 ± 0.4	1.6 ± 1.1
		96		0.0 ± 0.2	0.8 ± 0.9	0.0 ± 0.4	1.8 ± 1.1
46 44 54	89 24 40	0	10/20/66	0.0 ± 0.2	0.7 ± 0.9	0.0 ± 0.4	2.6 ± 1.2
		31		0.0 ± 0.2	0.4 ± 0.8	0.1 ± 0.3	2.7 ± 1.2
		62		0.0 ± 0.3	0.6 ± 0.9	0.0 ± 1.0	2.2 ± 1.4
46 30 54	84 48 20	0	10/20/66	0.0 ± 0.2	1.0 ± 0.9	0.0 ± 0.3	2.5 ± 1.2
		15		0.2 ± 0.4	0.4 ± 0.8	0.0 ± 0.4	2.1 ± 1.1
		30		0.2 ± 0.4	0.5 ± 0.9	0.0 ± 0.5	1.6 ± 1.1
47 28 36	88 09 00	0	10/21/66	0.0 ± 0.3	0.4 ± 0.8	0.0 ± 0.4	2.6 ± 1.2
		49		0.0 ± 0.3	0.5 ± 0.7	0.0 ± 0.4	2.9 ± 1.2
		98		0.0 ± 0.2	0.5 ± 0.9	0.0 ± 0.5	2.7 ± 1.2
47 01 12	88 15 54	0	11/2/66	0.0 ± 0.2	0.3 ± 0.8	0.0 ± 0.4	2.2 ± 1.2
		36		0.2 ± 0.4	0.1 ± 0.8	0.0 ± 0.4	2.5 ± 1.2
		72		0.0 ± 0.2	1.2 ± 0.9	0.0 ± 0.4	3.6 ± 1.3

TABLE 2
LAKE SUPERIOR BOTTOM SEDIMENTS
Radioactivity Results
Picocuries per gram
Count Date: October 24, 1966

Latitude	Longitude	Depth (Meters)	Sample Date	Alpha ± E_{95}	Beta ± E_{95}
46°58'30"	91°42'30"	67	10/19/66	9.8 ± 4.7	29 ± 4.1
46 51 12	91 20 15	70	"	11 ± 5.2	38 ± 5.7
47 24 06	91 05 50	97	"	6.0 ± 4.1	16 ± 3.1
46 44 54	89 24 40	63	10/20/66	8.7 ± 4.7	27 ± 3.9
47 28 36	88 09 00	98	10/21/66	4.9 ± 4.0	36 ± 4.0
46 30 54	84 48 20	No sample obtained			
47 01 12	88 15 54	" " "			

Exhibit 6

Literature Search of Chemical Data
Lake Superior Basin

LITERATURE SEARCH

All Values in mg/l

Fuller 1/24/67 *

Source	Date	Parameter	Range	Approx. Avg.	Remarks
L. Superior, L. Huron	1961	Temp.	.7-5.4	2.0	Lower than ours
& Georgian Bay Data	6/60-12/60	Temp. °C	1.8-6.6	4.0	All surface samples
Report, Great Lakes		pH	7.5-7.8	7.6	Good agreement
Institute, University		pH	6.6-7.8	7.2	" "
of Toronto		Sp. Cond.	79-98	92	Not run at 25°C
		" "	78-100	80	" "
L. SuperiorLimnological	1951-1957	Temp. °C	0-20	-	All times of the year
Data-Fish & Wildlife		DO	5.9-16	12	Good agreement
Service		pH	6.9-8.0	7.4	" "
		Alk.	39-49	45	" "
		NH_3-N	0.08-0.51	0.11	Frozen-direct nesslerization
		Sp. Cond.	66-94	80	Not run at 25°C
		T. PO_4 as PO_4	Trace-0.59	0.03	Not same method
		Na	0.8-2.9	1.1	Good agreement
		Ca	12-13	12	" "
		Mg	1.6-4.4	3.0	" "
		SiO_2	4.0-13	5.0	About 2.0 mg/l higher than ours
An Investigation of	7/21-9/15/59	Org-N	0.09-0.77	0.15	Higher than ours
Nutrients in Western		T. PO_4 as			
L. Superior, Univ.		PO_4	0.01-0.28	0.05	" " ", same method
of Minn.		NO_3-N	0.22-0.46	0.35	Higher than ours, different method
		DO	5.1-14	10	Same as ours
		Temp. °C	4-19	16	Summer values-ours wer Fall values
		SO_4	Trace-13	1.0	1 mg/l lower than ours Turbidimetric vs AutoAnalyzer
		SiO_2	1.7-4.9	2.1	Same as ours
		Alk.	38-53	40	" "
		pH	7.0-8.1	7.7	" "
		D. Sol.	16-188	70	Ours were a little lower
A Preliminary Investiga-	1958-1959	NH_3-N	<0.1-<0.1	<0.1	We found 0.05
tion of Nutrients in		Org-N	0.08-0.28	0.15	Higher than ours
Western L. Superior		NO_3-N	0.55-1.15	0.90	Much higher than our:
		T. PO_4 as PO_4	0.01-0.05	0.02	Good agreement
		DO	9.2-13	11	" "
		Temp. °C	4-17	13	" "
		SO_4	0.9-2.9	1.7	Turbidimetric vs. AutoAnalvzer-lower than ours
		Alk.	32-42	40	Good agreement
		pH	7.1-7.9	7.7	" "
		T. Sol.	48-70	60	" "

Source	Date	Parameter	Range	Approx. Avg.	Remarks
National Water Quality Network Data	1957-1962	Temp. °C	1-17	4	Good agreement
		DO	9.4-14	13	" "
		pH	7.3-8.0	7.7	" "
		COD	1.8-12	5.3	We got twice as high
		NH_3-N	0.00-0.30	0.04	Higher than our values
		Alk.	39-48	43	Good agreement
		SO_4	1-5	2	" "
		T. PO_4 as PO_4	0-0	0	Much lower than ours
		D. Sol.	35-78	55	Good agreement

Exhibit 7

Survey of Lake Superior Literature

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

USDI, FWPCA, Great Lakes Region
GLIRBP

TO : Laboratory Unit Chiefs

DATE: Jan. 19, 1967

FROM : L. E. Scarce
Acting Director of Laboratories

SUBJECT: Survey of Lake Superior Literature

Literature pertaining to Lake Superior is located in my office as follows:

<u>From laboratory office files</u>

Anderson, D.V. and G. K. Rodgers "A Synoptic Survey of Lake Superior," Proceedings of the Sixth Conference on Great Lakes Research 1963, Great Lakes Research Division, Pub. 10, pp 79-89.

Publications from the School of Public Health, University of Minnesota:

"Water Movements and Temperatures of Western Lake Superior" November 1958.

"A Preliminary Investigation of Nutrients in Western Lake Superior 1958-1959" June 1959.

"An Investigation of Nutrients in Western Lake Superior " June 1960.

"Studies on the Productivity and Plankton of Lake Superior" June 1961.

<u>From Mr. Verber's files</u>

"Lake Superior Study-1956" published by the School of Public Health, University of Minnesota, June 1957.

"Lake Superior Limnological Data, 1951-57," Special Scientific Report-Fisheries No. 297, published by the U.S. Dept. of the Interior, Fish and Wildlife Service, April 1959.

"Georgian Bay and Lake Superior Data Report 1961," Preliminary Report No. 4, published by the Great Lakes Institute, University of Toronto, April 1962.

Survey of Lake Superior Literature (1-19-67)

Each of you is requested to review these and all other available publications pertaining to past studies on Lake Superior. In addition, you are requested to make a brief summary which will summarize existing knowledge in relation to each parameter pertaining to your discipline. It is requested that you indicate where the various publications are in agreement on scientific findings and where there appears to be discrepancies.

These literature reviews have two objectives: 1) to provide immediate information which will be utilized in planning our Lake Superior Study, 2) to provide a historical survey which may be included in your individual reports on Lake Superior.

You are requested to complete as much of this survey as you can before Wednesday, January 25, so that you may present your findings*at the monthly Lake Superior meeting to be held on that date.

The above publications are the ones that have come to my attention as available here on the Project. Should you have other publications, you are requested to either so advise me or contribute them for temporary inclusion in the material to be located in my office. Also, please advise me regarding other publications cited in the literature which may be available either at a local library or from the author or publisher.

L. E. Scarce

cc: C. Ownbey
J. Verber

*particularly those pertaining to deepwater.

Exhibit 8

Population Data St. Louis and Montreal Rivers Basins

Economics Unit - D. Kee

The total and municipal population of the St. Louis and the Montreal River Basins has been compiled. The St. Louis River Basin had a 1960 population of 260,000 with a municipal population of 210,000 or 81% of the total. The Montreal River Basin was slightly less urbanized with 14,000 or 75% of its total population of 19,000 considered municipal.

The major communities in each subbasin and their 1960 populations are shown below.

St. Louis River Basin

Duluth (106,884)

Hibbins (17,731)

Virginia City (14,034)

Superior (33,563)

Montreal River Basin

Ironwood (10,265)

Hurley (2,763)