BIOLOGY AND MEDICINE
PROGRAM BUDGET

May 1970

CONTRACT W-31-109-ENG-38
SUPPLEMENT NO. 16

ARGONNE NATIONAL LABORATORY
U of C-AUA-USAEC

1. TITLE
Land and Fresh Water Environmental Sciences - Great Lakes Ecology Study

2. BUDGET ACTIVITY NO.
AEC 06-02-04
ANL 65200 (RPY, CHM)

3. SCIENTIST RESPONSIBLE R. E. Rowland, M. S. Matheson, P. F. Gustafson, and see specific activities

4. WORK STARTED
FY 1970

5. RELATED WORK (With Same Contractor or Others)
Programs at The University of Michigan.

6. MANPOWER AND COST DATA

	ESTIMATED FOR FISCAL YEARS 1970	1971	1972
6a. DIRECT MANPOWER (Man Years)			
SCIENTIFIC			
REGULAR	0.5	5.3	11.2
TEMPORARY PAID BY ANL	-	-	-
TEMPORARY PAID BY OTHERS	-	-	-
TOTAL SCIENTIFIC	0.5	5.3	11.2
OTHER TECHNICAL			
REGULAR	-	-	2.5
TEMPORARY PAID BY ANL	-	-	-
TOTAL OTHER TECHNICAL	-	-	2.5
TOTAL MAN YEARS	0.5	5.3	13.7
6b. OPERATING COSTS (In Thousands)			
EFFORT-RELATED COSTS	$15	$169	$444
MATERIALS AND SERVICES	2	27	89
MAJOR PROCUREMENTS	-	-	-
TOTAL COST	$17	$196	$533

6c. Cost (Recap of Subactivities) (In Thousands)

Not Applicable

6d. Major Procurements (In Thousands)

None

6e. Equipment Obligations (In Thousands)

See next page

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6e. Equipment Obligations (In Thousands) (Contd.)

	FY 1970	FY 1971	FY 1972
Radiological Physics Division			
Trailer	-	$24	-
Meteorology Tower (in lake)	-	20	-
Boat and Automatic Sample Changer	-	15	-
Meteorology Instrument Trailer	-	-	$ 20
Minor Items	-	4	40
Total RPY Division	-	$63	$ 60
Chemistry Division			
Liquid-Liquid Chromatograph	-	-	$ 20
Gas Chromatograph	-	-	8
Minor Items	-	-	12
Total CHM Division	-	-	$ 40
Total 65200	-	$63	$100

7. Description

A. Environmental Chemistry of Lake Michigan (D. N. Edgington and M. A. Wahlgren)

Purpose and Methods. The siting of nuclear power plants around the shores of Lake Michigan is of considerable economic and ecological importance. The operation of these reactors will lead to the release of heated water and small concentrations of radionuclides which may profoundly affect the ecology of the lake. A major problem to be faced in determining these effects is the almost total lack of basic scientific data relating, in particular, to the chemistry of most of the elements in the lake. A change in the temperature of the water may cause subtle effects in the solubility and other relationships between chemical compounds which, in turn, may affect the metabolism and distribution of each biological species. The physical distribution and biological activity of the radionuclides released will also depend largely on the chemistry of their stable element counterparts. The partition of chemical species between the water, sediments, and biota is also an important parameter in determining the water quality of the lake as it will affect greatly the residence times of these species.

The distribution and relationships of chemical elements and compounds in the water, sediments and biota of Lake Michigan will be determined, using a variety of techniques. It is anticipated that these will include neutron activation, atomic absorption spectrophotometry, mass spectrometry, anodic stripping and polarography, and chromatography.

Accomplishments FY 1969 and FY 1970. The study of trace element distribution in the biota of the Great Lakes has continued. The concentrations of 14 trace elements have been determined in fish from Lakes Erie, Michigan, and Superior. The content of several trace elements has been found to vary with species and site collection, with cadmium, arsenic, and chromium having the greatest variability. A preliminary investigation has been made of sediments collected in Green Bay where there is a sharp boundary between the nonpolluted and polluted areas. The results point to a marked difference in trace element distribution between the two areas.

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Measurable differences have been observed using a mass spectrometer in the isotopic ratio $^{12}C/^{13}C$ and $^{32}S/^{34}S$ of water samples collected from different sources which suggests that this technique may have some utility in tracing pollutants.

Anticipated Program FY 1971 and FY 1972. The first step in understanding the chemistry of the lake is to determine the inventory of all chemical species entering and leaving the lake. To this end a detailed sampling of all the major streams entering the lake will be carried out. These samples will be analyzed for as many different chemical species as possible. Experiments will be performed to determine the best methods of storing the samples after collection, preconcentration of trace components, and analysis. In addition, methods of automated techniques for sampling and analysis will be evaluated. This effort will be coordinated with The University of Michigan program and will take strong cognizance of similar work in progress at the Battelle Northwest Laboratories.

Further sampling and analysis of water, sediment and biota collected from Green Bay will be studied in order to evaluate the role of a changing environment on the water-sediment interface and the concentrations of trace elements in the biota.

A more detailed study will be made of the variations in the concentration of trace elements in a limited number of species of fish and other aquatic organisms collected from the Great Lakes with particular emphasis on food webs and the more polluted areas.

B. Great Lakes Research Program - Task 3, Field Site Studies (P. F. Gustafson and G. P. Romberg)

Purpose and Methods. The Field Site Studies are a vital portion of the overall Great Lakes Research Program at Argonne whose major objective is the determination of the influence of nuclear power stations upon the Great Lakes' environment. Initial emphasis is upon Lake Michigan because of the greater number of nuclear plants along its shores, plus its proximity to Argonne. This task is the one under which intensive biological and physical sampling will be conducted in the vicinity of currently operating power generating stations, be they coal-fired or nuclear. Such sampling will include the collection of water, bottom sediments, and biota, and the determination of ambient water and air temperatures, and temperature distributions in water, and lastly

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7. Description (Contd.)

measurements of currents, and heat loss to the atmosphere. There will also be field and laboratory measurements of productivity, and laboratory studies of specific aspects such as viability of biota passing through the condenser, subjected to algaecides, etc.

In addition, this task group will serve as the operation whereby field data required by other tasks will be collected, and there will be close coordination between this task and those more theoretically based.

Accomplishments FY 1970. This program started in FY 1970, and its initial effort has been to recruit aquatic biologists, determine sampling sites, methods, and equipment needs. In addition, other interested, active research groups on Lake Michigan have been consulted and plans for coordinated field work in early FY 1971 have been formulated. Foremost among these other parties is the Great Lakes Research Division of The University of Michigan with whom we have had close associations since the inception of the Great Lakes Research Program at Argonne. Close ties have also been established with the Center for Great Lake Studies at The University of Wisconsin, Milwaukee, and the Sea Grant group at The University of Wisconsin, Madison. More recently we have been actively discussing joint research plans with the group under Dr. McWhinney at De Paul supported by the EPRD Foundation. In addition, plans at the working level are being formulated with BCF and the Lake Michigan Basin office of the FWPCA.

Anticipated Program FY 1971 and FY 1972. Field work in the following areas of physical and biological research and proposed means for their accomplishment are discussed below. It is also intended that laboratory work, ideally at lakeshore sites such as the Waukegan plant, will be initiated to investigate the effects of transit through the cooling system of a power station on entrained biota. The major field effort will be conducted at the Waukegan and Zion sites, the latter in conjunction with the De Paul study at Zion. A suitable area for control measurements appears to exist south of Waukegan. Plans are also made to conduct studies at the Big Rock Nuclear Plant in cooperation with the Dept. of Natural Resources of the State of Michigan. Finally, it should be stated that close contact, and perhaps assistance, will be maintained with the thermal plume study of the Ginna Plant on Lake Ontario.

Physical Studies

1. Temperature. A general knowledge of water temperature characteristics (including thermal plumes) which exist in proposed study areas is needed to determine (1) sampling locations, (2) frequency of sampling, and (3) types of experiments. Temperature data from previous studies in these areas will be helpful, but should be supplemented with a limited number of first-hand temperature measurements made in the study areas prior to initiating a routine sampling program.

Off-Shore Measurements. These measurements are to be made from the Boston Whaler which the Radiological Physics Division is about to purchase for the lake studies.

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A. Bathythermograph Measurements. A bathythermograph is an instrument which provides readings of temperature as a function of depth in a body of water. This instrument is relatively simple to use and is comparatively inexpensive. It is recommended that daily soundings be made starting immediately at various distances from shore. Such soundings should be made two or three times daily until sufficient information including that related to seasonal effects is at hand.

B. Air Temperature. Measurement of air temperature from the Boston Whaler at a fixed distance above the water surface is essential; these should be made routinely with the bathythermograph measurements.

C. Position Measurements. The location of the measurement point must be known. This can easily be determined from sightings at two or more points, preferably three. All one needs is to determine the angle subtended by pairs of fixed objects whose spacing is known.

2. Currents. A general knowledge of the predominant direction, speed, and direction of inshore currents near proposed study areas is necessary to evaluate (1) the experimental approach and design, and (2) the possible influence of such currents on the data to be obtained. Some of this information can be obtained by a brief literature survey, but here again, a limited number of first-hand measurements should be made in the study areas. Measurements at one station centrally located in each area should be sufficient. Data gathered from an extensive study of currents in relation to thermal plume dispersion will also be valuable.

3. Oxygen. Measurements of the dissolved O_2 concentration in the water at each station is necessary to (1) establish baseline levels, and (2) to determine if there is any alteration due to the thermal discharge. Water samples will be returned to the laboratory for analysis.

4. Biological Oxygen Demand (B. O. D.). Levels of B. O. D. should be measured to (1) establish baseline data, and (2) determine if there is an increase in O_2 demand due to thermal discharges. This may also give some indication as to whether or not there is an increased organic load due to organisms that are killed in passing through the condenser. Measurements would probably be made in situ.

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7. Description (Contd.)

5. Nutrients. Information on nutrient levels (phosphate, nitrate, silicate) in the water (1) provide baseline data, and (2) give an indication of the potential productivity in the area. Water samples would be returned to the laboratory for analysis.

6. Turbidity. Measurements of turbidity will give some indication as to the depth of the photic zone and hence the depth to which productivity extends. Measurements would include secchi disc readings and laboratory measurement of water samples.

7. Radioactivity. Information on the concentration of radionuclides in lake water is necessary to (1) establish baseline data, and (2) determine the levels released by nuclear electric plants. Ion exchange beds would be used to concentrate the radionuclides from large volumes of water.

8. Algaecides and Fungicides. It is necessary to determine (1) whether algaecides and fungicides are detectable in the discharge water, and (2) the area of influence in the plume. Water samples would be returned to the laboratory for analysis.

Biological Studies

1. Bottom Organisms (Benthos). The objective is to determine the type and quantity of organisms present. Bottom samples will be collected by either dredge or scuba diver. Macroinvertebrates will be sieved out, identified, and counted with the sediment being retained. Both the biota and the sediment will be radioanalyzed.

2. Artificial Substrate. The objective is to supply a standard surface area and determine what organisms colonize it and their abundance. The information is used as a measure of species diversity and productivity. Flagstones are placed on the bottom and collect macroinvertebrates. Peraphyton trays are suspended in the water and collect microorganisms.

3. Plankton (primary productivity). Samples of plankton will be collected by either net tows or straining water samples. The species will be identified and the abundance determined to give information on species diversity. Phytoplankton productivity will be determined in situ by either O_2 difference in light and dark bottles or the ^{14}C method. When large enough samples are available they will be radioanalyzed.

4. Attached Algae. Observations will be made to determine the abundance of attached algae along the shore and on submerged objects in the area. When sufficient quantity is available, it will be radioanalyzed.

5. Fish. Pelagic fish will be collected with a gill net and benthic fish will be taken with an otter trawl. The size, abundance, and variety of fish will be determined. Stomach contents will be examined to identify food sources. Fish carcasses will be radioanalyzed.

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6. Bacteria and Parasites. The objective will be to determine if there is a change in the occurrence of bacterial infection or parasites in fish and possibly some other organisms near the area of thermal outfalls. Major emphasis would be placed on those infections or parasites that are detrimental to the fish or can be detrimental to man if transferred to him through the food chain or from the water.

Additional Studies

1. Exposure Time for Planktonic Organisms. The objective would be to determine the length of time plankton either passing through the condensers or floating into the thermal plume will be exposed to a significant temperature change (ΔT of 5°F). Small floating devices with a large submerged surface area would be used to simulate planktonic organisms. By releasing these at various positions and observing their movements, the time to pass out of the plume can be determined.

2. Sedimentation. The objective would be to measure the rate of sedimentation near thermal outfalls to see if it differs from the rate at other near-shore locations. Standard types of containers would be secured on the bottom and then collected at time intervals to measure the amount of deposition.