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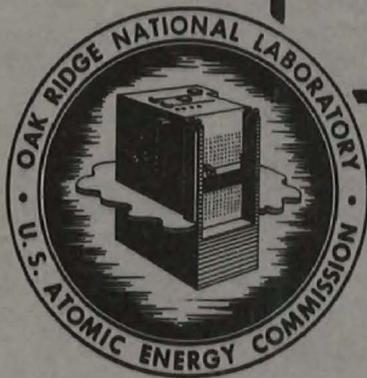


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ORNL 873  
Waste Disposal

8A

HEALTH PHYSICS DIVISION  
RADIOACTIVE WASTE DISPOSAL RESEARCH  
AND DEVELOPMENT SECTION  
PROGRESS REPORT JULY 1-  
SEPTEMBER 30, 1950



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Waste Disposal  
Progress Report

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PROGRESS REPORT  
RADIOACTIVE WASTE DISPOSAL RESEARCH AND DEVELOPMENT SECTION  
HEALTH PHYSICS DIVISION

For Period July 1 to September 30, 1950

R. J. Morton, Section Leader

Date Issued: NOV 21 1950

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GENERAL

INTRODUCTION

This is the first extensive progress report on the program of Radioactive Waste Disposal Research and Development in the Health Physics Division of ORNL. Prior to July 1, 1950 monthly reports on the personnel and activities of this program were issued for limited distribution, largely in the Oak Ridge Area.

The main purpose is to describe periodically studies and progress for which the Radioactive Waste Disposal Research Section is primarily responsible. Since this is a cooperative program, however, certain related or joint studies administered by other groups are mentioned. The general plan of this report is to give a brief indication of the nature, status, and preliminary results of long term study projects, to refer to reports issued or in preparation on particular studies, and to give more specific details on items that appear to be of interest but which do not justify separate reports.

PERSONNEL

The professional and technical personnel regularly engaged in the Health Physics Waste Research Program includes qualified workers in several fields, notably sanitary engineering, chemical engineering, chemistry and biology. During this quarter they have included eight workers employed directly in this Section and three on extended full-

[REDACTED]

time loan from outside cooperating agencies (two from the U.S. Public Health Service and one from the Tennessee Valley Authority). The number of other personnel assigned on a temporary or joint-work basis has varied from two to four research workers during the three months period. The above does not include personnel employed directly on cooperative projects that are administered by others, such as the AEC-Geological Survey Study or the TVA-AEC Ecological Study of White Oak Creek Drainage Area.

#### Laboratory Facilities

Work space for laboratory and small pilot plant operations by the group has been limited largely to several small laboratory rooms in the Health Physics Building. A program of pilot plant experiments has been set up temporarily in a tent located near the settling basin. Final plans and specifications have been completed for the Health Physics Waste Research Building number 3504 which has been authorized and which is designed to relieve the present serious deficiency of work space particularly for the conduct of pilot scale experimentation on water and liquid waste decontamination processes.

#### WATER TREATMENT STUDIES

##### Experimental Water Treatment Plant

Several runs were completed during the period to determine the reduction in  $I^{131}$  by the experimental water treatment plant. This model

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water purification unit, constructed of stainless steel, has a capacity of 250 gallons per day. The steps included in the process are the same as in a standard plant and include: mixing, chemical coagulation (flocculation), settling, and filtration through various sand and Anthrafilt media. This plant is shown in figures 1 and 2. Figure 1 shows the mixing, flocculation and sedimentation basins and figure 2 shows sand and Anthrafilt filters.

The test material used was  $I^{131}$  contaminated tap water with 100 ppm of added turbidity. The coagulant used was aluminum sulphate with lime alkalinity and sodium silicate added to produce desirable flocculation characteristics. The results of the study indicate that:

1. Alum flocculation was not effective in reducing the activity of the mixed solution - less than 1% of the total activity was removed by settling and filtration.
2. The addition of 5 ppm of activated carbon with the turbidity accounted for an increased reduction in radioactivity to about 15% by coagulation and settling.
3. Filtration of the carbon treated water accounted for an additional 11% reduction in activity, or a total of approximately 25% removal obtained by carbon treatment, coagulation, sedimentation, and filtration.

Quite a number of jar test studies were carried out during the period. These are best summarized in tabular form and will be found in Table I.

[REDACTED]

Table I

Results of Jar Tests

<u>Run No.</u>	<u>Purpose and Treatment</u>	<u>Results and Remarks</u>
1	Effect of varying concentrations of sodium silicate on $I^{131}$ removal.	No effect indicated other than an increase in sludge volume with an increase in sodium silicate used.
2	Removal of $I^{131}$ by lime treatment alone. Dosages varied from 0 to 30 gpg.*	Removals indicated varied from 0 to 20 per cent with little variation above pH 11 which was reached at approximately 14 gpg.
3	Removal of $I^{131}$ by activated carbon treatment alone. Dosages varied from 0 to 50 gpg.	Removal efficiencies increased with an increase in activated carbon added. A removal of 48 per cent indicated for a dose of 50 gpg of activated carbon.
4	Removal of W-6 evaporator-concentrate waste activity by lime alone. Dosages varied from 0 to 60 gpg.	Approximately 30 per cent removal for dosages of 8 gpg or more.
5.	Removal of W-6 evaporator-concentrate waste activity by sodium hydroxide alone. Dosages varied from 0 to 60 gpg.	Approximately 25 per cent reduction in activity for dosages above 2 gpg. Not much increase in removal for increased concentrations of sodium hydroxide.
6	Removal of W-6 evaporator-concentrate waste activity by sodium carbonate alone. Dosages varied from 0 to 60 gpg.	Less than 3 per cent of the initial activity removed.

\* gpg = grains per gallon

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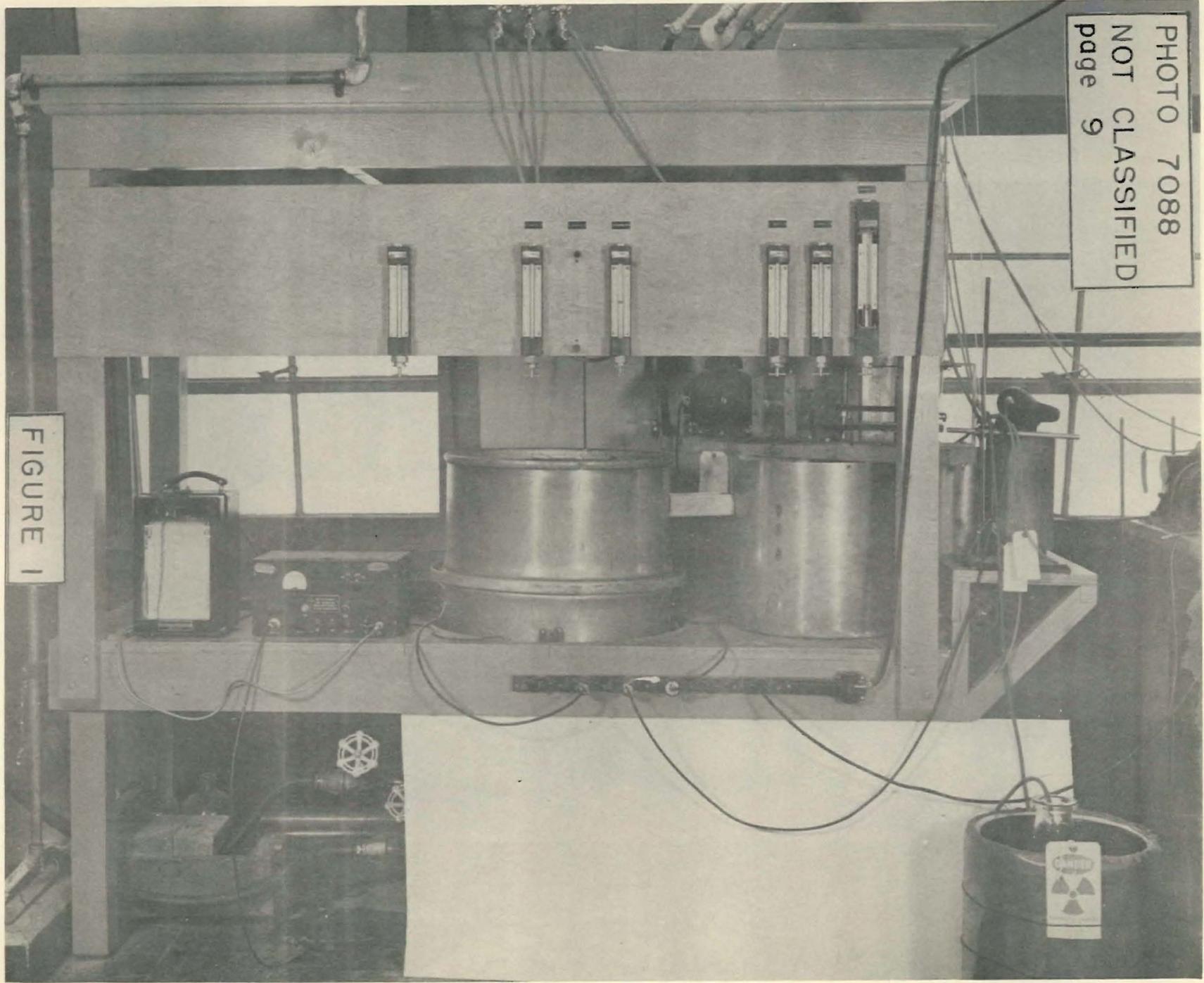


FIGURE 1

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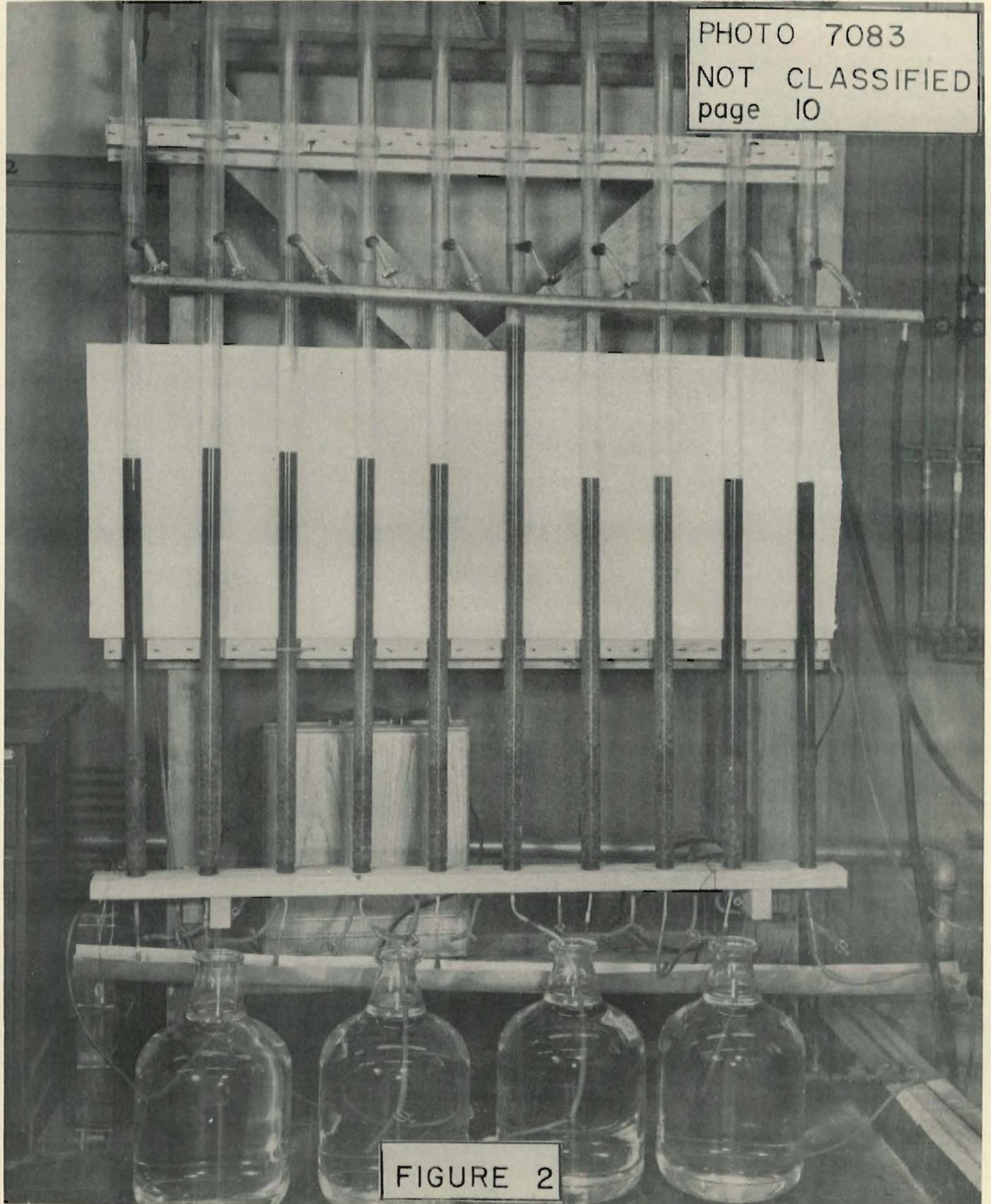


FIGURE 2

Since the pilot plant runs showed that  $I^{131}$  was not removed efficiently by flocculation and coagulation, studies were carried out with the thought of using  $I^{131}$  as a means of indicating the detention time in the various tanks comprising the experimental plant. Several runs were made and the results obtained were in very good agreement with theoretical computations. For continuous measurement of the activity discharging from the settling tank, a continuous monitor has been built and will be used in future studies.

#### Laboratory Studies

Various isotopes were subjected to a series of standardized laboratory tests designed to approximate average conditions which might be encountered in water purification processes. The objective was essentially fact finding with regard to the order of removal of isotopes by these processes. Two coagulants were used, alum and ferric chloride. No significant difference, due to coagulant, was noted. Although these data have not been thoroughly analyzed, the following approximate magnitudes of removal are indicated.

Isotope	Per cent Removal	Remarks
I <sup>131</sup>	10	Addition of small amounts of Cu, Ag, or C indicate increased removals up to 75%.
P <sup>32</sup>	98	
Sr <sup>89</sup>	10	
Y <sup>91</sup>	45 98	The lower percentage obtained with NaOH alkalinity, the higher with Na <sub>2</sub> CO <sub>3</sub> alkalinity.
Ce <sup>144</sup>	98	
Sr <sup>90</sup> - Y <sup>90</sup>	98 for Y 10 for Sr	
Iodine dissolver solution	84	

The amount of turbidity (clay) present may influence the removal of isotopes. As examples, indicated removals for turbidity alone at 50 and 1000 p.p.m. are approximately the following:

Sr <sup>89</sup>	6% and 20%
Y <sup>91</sup>	17% and 82%
Ce <sup>144</sup>	70% and 86%

It should be noted also that a coagulation process may temporarily disrupt an existing equilibrium condition such as prevails with Sr<sup>90</sup> - Y<sup>90</sup>, where the yttrium is essentially retained in the floc and the majority of the strontium is found in the effluent.

Preliminary computations indicate that the data obtained for individual isotopes may be used to predict the behavior of mixed fission products, such as iodine dissolver solution, providing a reasonably accurate analysis is available.

#### Research Participation

During the quarter, Earnest F. Gloyna, a research participant and Assistant Professor of Sanitary Engineering, University of Texas, worked with the Section. A condensed abstract of his report entitled, "Some Basic Investigations in the Treatment of Water Contaminated with Fission Products" follows.

The classic theories on the formation of radioactive aggregates and their behavior served as the basis for studying processes which might remove fission products from domestic water supplies. Single isotopes and mixed fission products were added to distilled water, tap water and untreated Clinch River water in various adsorption, co-precipitation and exchange experiments.

Raw Clinch River water when spiked with mixed fission products and subjected to various water softening and flocculation processes indicated removals of radioactivity ranging from 68.3 to 96.2 per cent.

In another series of experiments tap water containing mixed fission products was treated with variable quantities of tri-sodium phosphate and clay. Maximum removals were approximately 98% using 20-100 ppm of clay and 120-180 ppm of  $\text{Na}_3\text{PO}_4$ .

A series of experiments using exchange columns filled with burned clay were used. The average removals obtained for Sr<sup>89</sup> and Cs<sup>137</sup> were 97.6% and 100% respectively. Fission product mixtures received a two stage treatment. The first stage consisting of a tri-sodium phosphate treatment removed 88% of the activity; and a second stage column containing burned clay increased the overall activity removal to 98.9%.

#### WASTE TREATMENT STUDIES

##### Phosphate Flocculation

Work has continued on the removal of radioisotopes from liquids by the process of precipitating calcium phosphate flocs from solutions of high pH. The efficiency of the process appears to be due to either the co-precipitation of the radioactive elements during the formation of the calcium phosphate floc, or the adsorption of radio-colloids which are formed in the pH range at which the precipitation takes place.

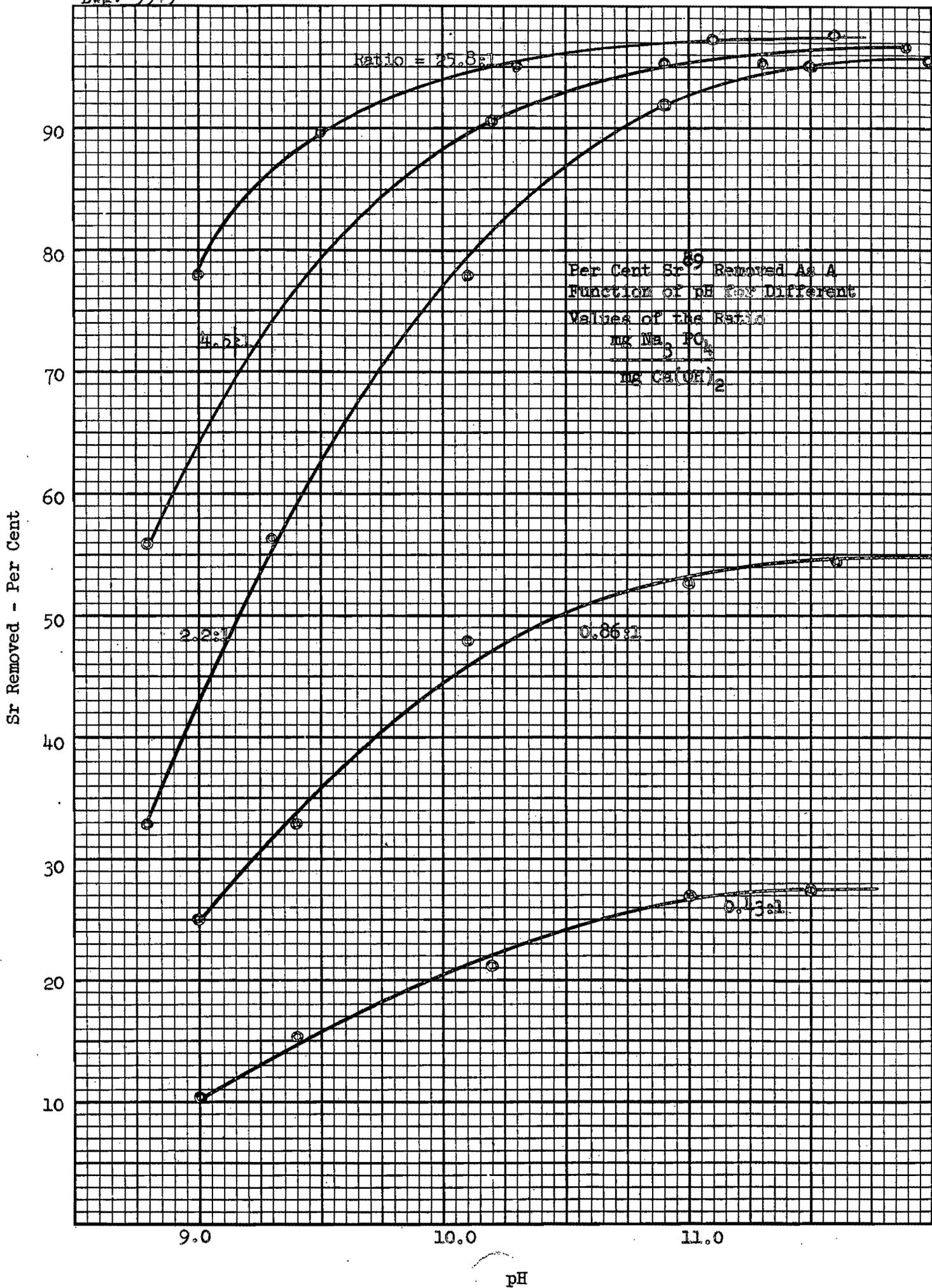
In the previous quarter, tracer type studies were made with various isotopes to gain background information and to evaluate the variables involved. Summary data for a number of isotopes are given below.

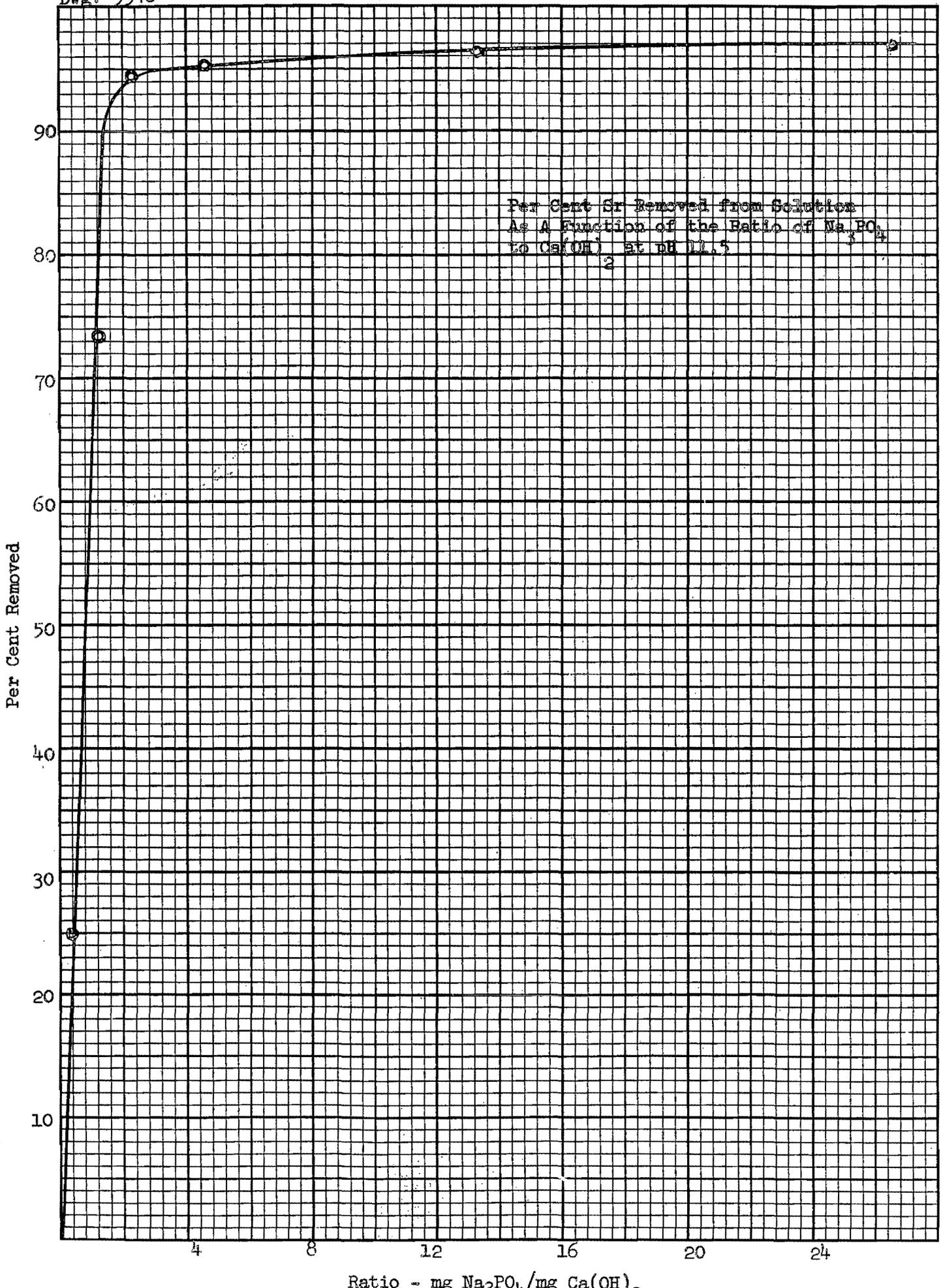
Isotope	Coagulant	mg/liter (coagulant)	Per Cent Removal
Ce <sup>144</sup>	KH <sub>2</sub> PO <sub>4</sub>	200	99.8
Ce <sup>144</sup>	Na <sub>3</sub> PO <sub>4</sub>	120	99.9
Sr <sup>89</sup>	KH <sub>2</sub> PO <sub>4</sub>	100	81.3
Sr <sup>89</sup>	Na <sub>3</sub> PO <sub>4</sub>	240	97.8
Y <sup>91</sup>	KH <sub>2</sub> PO <sub>4</sub>	100	99.9
Sb <sup>124</sup>	KH <sub>2</sub> PO <sub>4</sub>	100	66.1
Sb <sup>124</sup>	Na <sub>3</sub> PO <sub>4</sub>	120	67.4
Zn <sup>65</sup>	KH <sub>2</sub> PO <sub>4</sub>	50	99.6
W <sup>185</sup>	KH <sub>2</sub> PO <sub>4</sub>	200	10.7

A study of the variables of pH and ratio of Na<sub>3</sub>PO<sub>4</sub> to Ca(OH)<sub>2</sub> indicated, as illustrated in figures 3 and 4, that the highest efficiency of removal would be obtained if an excess of phosphate were used with a pH value, during precipitation, in excess of 11.3.

During the past quarter the procedure which had been developed was applied in a study of a mixed fission product solution with the following analysis:

Tri-valent rare earths	43.5%
Cerium	27.0%
Strontium	17.4%
Barium	5.1%
Ruthenium	2.9%
Cesium	1.1%





This solution was diluted with tap water to give solutions counting between 1200 c/m/ml and 14,000 c/m/ml, depending on the test to be made. To obtain a floc it was necessary to add only the phosphate solution, as calcium was already present in the dilution water. In some tests the phosphate treatment was supplemented by additional treatment with  $\text{FeCl}_3$ , fuller's earth, carbon, or a natural kaolinitic clay. In the later tests the liquid and floc were separated by filtration through a sand filter. Typical data for the treatment of the fission product mixture are given in Table II.

#### INSTRUMENT DEVELOPMENT

##### Sub-Surface Mud Probe

Purpose - To detect the radioactivity of the mud in White Oak Creek and Lake from 1 inch to 18 inches below the surface of the mud.

Description - At present, the instrument consists of a thick-wall stainless steel GM tube detector  $3/8$  inch O.D., 6 inches long with a sensitive length of 1 inch near the tip. The detector is mounted on the end of a jointed aluminum tube that may be varied in length from approximately 4 to 13 feet so that it can be used in various depths of water up to 12 feet. By means of the aluminum tube the detector may be pushed into the mud to various depths and the C.P.M. (counts per minute) read on a TracerLab Survey Meter modified for use with the probe. The instrument has been calibrated in mr/hr with a radium standard and has a range of from 0.01 to 100 mr/hr on four scales.

Table II

Treatment of Mixed Fission Products by Phosphate Precipitation

Test	Initial c/m/ml	Stage	Treatment	pH	Overall Decontamination Factor	Method of Separation
I	14050	1	220 ppm clay 220 ppm Na <sub>3</sub> PO <sub>4</sub>	11.5	28	Centrifuged
		2	100 ppm Ca(OH) <sub>2</sub>	11.5	53	Centrifuged
II	13300	1	200 ppm Na <sub>3</sub> PO <sub>4</sub> 50 ppm carbon	11.5	17	Centrifuged
		2	100 ppm Ca(OH) <sub>2</sub>	11.5	33	Centrifuged
III	13475	1	200 ppm Fuller's earth	8.3	4	Centrifuged
		2	125 ppm Na <sub>3</sub> PO <sub>4</sub>	11.5	31	Centrifuged
IV	1295	1	50 ppm carbon 100 ppm FeCl <sub>3</sub>	8.0	3.7	Centrifuged
		2	200 ppm clay 200 ppm Na <sub>3</sub> PO <sub>4</sub>	11.5	67	Centrifuged
V	3758	1	200 ppm Na <sub>3</sub> PO <sub>4</sub>	11.5	24	Centrifuged
		2	100 ppm Ca(OH) <sub>2</sub> 100 ppm Na <sub>3</sub> PO <sub>4</sub>	11.5	37	Centrifuged
		3	200 ppm clay 50 ppm Ca(OH) <sub>2</sub>	11.5	100	Centrifuged
VI	4810	1	100 ppm clay 100 ppm Na <sub>3</sub> PO <sub>4</sub>	11.5	165	Filtered
VII	2150	1	100 ppm clay 100 ppm Na <sub>3</sub> PO <sub>4</sub>	11.5	67	Filtered
		2	100 ppm Ca(OH) <sub>2</sub> 100 ppm Na <sub>3</sub> PO <sub>4</sub>	11.5	125	Filtered
VIII	2935	1	100 ppm clay 100 ppm Na <sub>3</sub> PO <sub>4</sub>	11.5	250	Filtered

Progress - The instrument was field tested during this quarter and was used to estimate the probable exposure received by organisms submerged in the mud below White Oak Dam.

Field use indicated that it would be desirable to shorten the length of the 3/8 inch GM tube and to increase the sensitivity of the tube to gamma rays. It is also desirable to be able to measure the beta rays.

A new gamma detector has been designed and construction work started.

A beta detector has also been designed.

Measuring and Recording of Water Level and Radioactivity Levels at White Oak Dam with Telemetry to the X-10 Area

Purpose - To improve the present system of water level measurement and recording at White Oak Dam and also to provide continuous measurement and recording of the radioactivity in the water discharged from White Oak Lake as indicated by radiation measurements.

Description - The system will consist of a mechanical water level recorder, water level detector with telemetry to a recorder and alarm system at X-10, beta and gamma detectors with count rate meters and recorders at the dam and with telemetry to a recorder at X-10.

Progress - An underwater detector would be ideal for this installation, however, attempts in this direction have met with failure

to date. Organisms and silt particles that concentrate radioactivity from the water become attached to the underwater detectors and raise the background so that the activity of the water cannot be measured adequately.

A gamma detector using GM tubes was designed that would give satisfactory results when suspended over the water and shielded from the dam, banks of the lake and any fixed object in the water. A minimum of six feet of water over the mud bottom was also needed. Since the installation of the evaporator at X-10 the activity of the water at the dam has dropped to such a level that a more sensitive detector is needed. The design of a new gamma detector has been started, and some consideration has been given to the design of a beta detector.

The count rate meters, water level recorders and most of the telemetering equipment has been purchased. A building for housing part of the equipment has been moved to the dam and the stilling well for the water level measuring equipment has been installed. Work orders for the construction of mounting brackets and housing over the stilling well, for the water level meters and recorders, have been issued.

#### Monitoring Equipment for Continuous Flow Processes

In some of the experiments of the Waste Disposal Research Section there is a need for continuous qualitative measurements at from 1 to 10 points in systems involving continuous flows of liquids. Continuous monitoring and recording assemblies have been set up and used

on two experiments. To reduce the amount of equipment needed an automatic switching system will be used to switch the output of four detectors, in a pre-arranged time sequence, to one counting rate meter. Provision will be made for adjusting the high voltage on each detector separately.

#### Instruments for Measuring the Radioactivity of Live Fish

These instruments are being developed so that a measurement of radioactivity may be obtained from fish caught in nets and the fish returned to their natural habitat without injury.

Fish probes, consisting of a handle, a 3/8 inch OD stainless steel GM tube and about 4 feet of RG8U cable have been constructed. The probes are water tight so that they may be used under water. Two types were built: (1) Gamma probes with GM tubes that have thick stainless steel walls, and (2) Beta probes with GM tubes having thin ribbed stainless steel walls ( $0.002" \pm 0.001"$ ). These probes are used with a battery operated scaler. In making measurements the GM tube is inserted into the fish through the mouth.

Field tests suggested several improvements that are being incorporated in new probes. A scintillation type of gamma detector may have to be used to obtain the desired gamma sensitivity.

The final probes will be calibrated by taking readings from a number of fish and then sacrificing them for radioassay.

Flounders

These are two sensitive gamma and beta detectors designed to detect small quantities of radiation in water or at the surface of muds.

Twelve thin-wall glass GM tubes and a cathode follower are housed in a water proof housing 15-1/2" x 15-1/2" x 1-1/2". The sides of one are made of 1/32" cellulose acetate and the other of 1/4" lucite. The Flounders are connected to counting rate meters and power supplied by 29 yards of rubber covered cable. The Flounders can be trolled in water from a boat or lowered in water to various depths up to 28 yards for detecting radioactivity in water. They may be lowered to the bottom of a body of water for measurements of the radioactivity of the mud. The Flounder with the 1/4" lucite sides has been calibrated in mr/hr with a radium standard. Calibration in terms of microcuries per milliliter of water and microcuries per gram of mud for the radioelements found in the water and mud in this area is planned.

Mud Samplers

There is a need for a mud sampler that will take undisturbed depth mud samples. A sampler that will take a sample of the water and mud interface is also needed. An auger-type of sampler has been built and some tests made. The sampler shows promise but is still in need of improvement. Some work has been done on the design and construction of a sampler for taking samples of the water and mud interface.

SURVEY STUDIES

Well Logging Studies

An intensive study of the geology of the X-10 area has been made as a part of the AEC Geological Survey Project. This has included a systematic investigation of the migration of underground water. Fifty-one wells have been drilled around the settling basin, White Oak Creek and the burial grounds. A direct, simple method, requiring a minimum of man hours of work, for measuring the radioactivity of the water in these wells is needed.

The temporary equipment used to date consists of a thin-wall glass GM tube, with pre-amplifier and impedance matching network, housed in a water proof 1-1/2" OD, 1/16" wall bakelite tube, connected to a counting rate meter and E.A. Recorder by about 310 feet of cable.

To date this equipment has been used to make radio-logs of 23 wells around the settling basin and White Oak Creek. Logs have been made of some of the wells several times during the past few months.

The wells vary in depth from 50 to 300 feet. Measurements for radioactivity have been made at 3 feet intervals by lowering the probe by hand. Where radiation has been indicated the region is explored at 1 foot intervals.

In order to save time and to detect thin strata carrying radioactive ground water, that might be missed by taking measurements

[REDACTED]

at 3 feet intervals, a motor driven automatic device, with a cable reel, has been designed. This device will lower the detector at a predetermined rate giving a continuous log of the well. The equipment will be housed in a trailer so that it will be easy to transport and set up at different locations. It should operate without attention until the entire well has been logged. This equipment is nearing completion and should be ready for field tests soon.

Part of the rock strata that the wells pass through contain natural radioactivity. Since the alpha and beta activity of these rocks should be filtered out by the water in the wells, the gamma activity of the rocks probably is the main source of background counts in the GM tube detector. Some work has been done on the design of a thin-walled GM tube, that would withstand the water pressure, so that its sides could be exposed directly to the water in the wells. If this can be done a better background count of the water activity should be obtained.

Ecological Study of White Oak Creek (designated ESWOC)

In January 1950 the Atomic Energy Commission entered into a contract with the Tennessee Valley Authority under which the TVA will investigate the physical and biological effects of the dissemination of radioactive liquid wastes into the waters of the region.

The broad objectives of the ecological survey follows:

[REDACTED]

1. A thorough biological survey of all flora and fauna (microscopic and macroscopic) in and immediately surrounding the lake, and, if possible, a comparison with the biota of similar nearby uncontaminated ponds and streams.
2. Specimens taken to be monitored for gross radioactivity, part preserved for permanent reference (plant materials, fishes, bottom organisms, characteristic plankters), and part sacrificed for histological study and for autoradiography, ashing and counting.
3. The relative abundance of the different forms of life to be enumerated, studied, and recorded for later reference, and with special attention to differences in the abilities of the various species to concentrate radioactive materials. Such data should be kept for long-term reference, for a species which tends to concentrate radioactive materials in quantity generally, or in highly vulnerable organs, may die out or mutate in ways which would alter the original ecological balance.
4. The level of alpha, beta, and gamma activity in the water, the muds, and adjoining shores will be determined repeatedly throughout the year, and any relationship between such activity and that of both sessile and motile organisms watched for.

The overall study is directed by an advisory committee consisting of administrative and consultative personnel from AEC, TVA and ORNL.

Local coordination occurs through a member of the Waste Disposal Research Staff. Technical personnel consist of a fisheries biologist, a limnologist, a botanist, and a biological aide. Intensive study was begun during the quarter.

Radiochemical and radiological work is done by members of the Waste Disposal Research Section. To date such autoradiography as has been required has been done by Area Monitoring, ORNL. Chemical analyses are made by the Stream Sanitation Section, TVA. Hydraulic and hydrological investigations are done by the Hydraulic Data Branch, TVA, with cooperation from the U.S. Geological Survey Surface Water Division. Ground water studies and geology are handled by geological consultants of AEC with collaboration from the U.S.G.S., Ground Water Division. Meteorological data are obtained by AEC meteorologists.

The technical personnel, engaged full-time in the study, have undergone orientation; and instruction in modern and health physics has been provided by the Education and Training Section of the Health Physics Division.

Physical Studies - As a part of the physical survey, stream gages have been installed on White Oak Creek above the waste outfalls, above White Oak Lake, and at White Oak Dam. The principal waste outfalls were intercepted for measurement and sampling purposes by ORNL and the data will be available to ESWOC. Silt range monuments were installed at

100 feet intervals around White Oak Lake and a silt survey was made to determine the quantity of silt in the bottom of the lake and the storage capacity of the lake. Mud sampling on these ranges and analysis by Area Monitoring was performed during September and will be available to ESWOC to establish a 1950 "base line" for future reference. Maps have been produced for the study showing the entire drainage area to a scale of 1 inch to 1000 feet and of the lake and swamp area to a scale of 1 inch to 100 feet. The latter map will show lake depths, silt range monuments, and a reference grid system in addition to contours. Time of water travel studies were planned to extend over a considerable period of time to determine the rate of travel in the channel and dispersion in the lake at different flows and different lake elevations.

A schedule of routine water sampling for limited chemical analysis was established. The first samples collected from the lake on August 2 indicated thermal stratification with lower temperatures and complete oxygen depletion in the deepest part of the lake. This situation was unexpected in a lake of this size (50 acres) since the maximum depth was only eleven feet. Extensive temperature measurements using thermocouples confirmed the findings. Sampling on August 22 yielded essentially the same results but by September 12 the stratification had broken up. No efforts have yet been made to correlate the stratification with runoff, atmospheric temperature and other factors.

Fisheries Biology - A fish population study was made to approximate the numbers, ages, and sizes of different species of fish in White Oak Lake. A number of hoop nets placed at various locations in the lake were lifted every day for several weeks and the data on each haul and returns of previously caught fish recorded. Results of the first population study have not yet been compiled.

During the population study scale samples were saved for subsequent study of age and growth rates of the fish in the lake. Notes were kept on the physical condition of the fish and injuries were noted for future study.

Studies will be made of the weight distribution in different organs or tissues of different species and the specific isotopes concentrated in different organs will be determined. Studies will be made to determine tolerance limits of fish to specific isotopes encountered.

Botany - Plant collections from the study area totalled over 500 sheets of specimens which were prepared, treated for insects and preserved for future study. This is expected to comprise over half of the collections to be made during 1950.

Transects were established at a number of locations on the lake and creek and observations are made along these transects. Early indications are that the "percentage of total cover" occupied by each

species in the transect is important and that comparisons between different contour levels around the lake rather than between transects should be made.

Preliminary autoradiograms indicate very satisfactory results using 14 x 17 inch Eastman Blue Brand X-ray films but poor results with the dental size films used in film badges. No plant specimens have yet been assayed or examined by radiochemical separation and analysis but some work has been done on the development of techniques.

Limnology - Since equipment for the collection and examination of plankton specimens had not arrived regular collections were impossible. Transects and collecting locations were established and marked by floats and routine water sample collections for chemical analysis (previously mentioned) and radiological assay were begun.

Information for future comparisons was obtained by investigating the fresh water fishes and invertebrates in streams and pools of the region. It appears that the fauna is typical for the Tennessee and Cumberland River systems.

#### ANALYTICAL METHODS

##### Fish Tissue Preparation

An effort has been made to devise an efficient, routine technique for the preparation of fish tissues for gross activity studies. Previously tissue samples were ashed at high temperatures with resulting

ignition losses which were difficult to evaluate. The method outlined below utilizes a nitric acid and hydrogen peroxide digestion followed by volumetric aliquot techniques in the preparation of mounted samples.

#### Outline of Proposed Tissue Preparation

1. Prepare a volumetrically calibrated 25 ml glass stoppered Erlenmeyer flask.
2. Add the sample (3 to 10 grams) and weigh.
3. Add concentrated  $\text{HNO}_3$  (1 to 5 ml) and heat gently until the organic specimen is in solution. Control the foaming by adding 0.1% aerosol solution and reducing the heat.
4. When the sample has evaporated down to about 3 ml, add 30%  $\text{H}_2\text{O}_2$ , 0.5 ml at a time, until the solution becomes light yellow to colorless.
5. Add 2 ml  $\text{H}_2\text{O}$ , remove from heat, and cool. Make up to volume with  $\text{H}_2\text{O}$ . The final volume can be varied depending on the activity level and the salt concentration which may be tolerated on the aliquot plate.
6. Suspended oil and fat globules appear to contain no activity, but may be extracted with ether if desired. The solution may be counted in a liquid counter or aliquots may be plated on stainless steel dishes for counting.

#### Preparation of Mount

1. Shake sample to suspend any precipitated solids.
2. Pipette duplicate 1 ml samples into stainless steel counting dishes.

3. Add 3 or 4 drops of 0.1% aerosol and dry under infra-red lamps at a distance of about 12 inches.
4. Remove when dry, cool and count.

#### Counting Methods

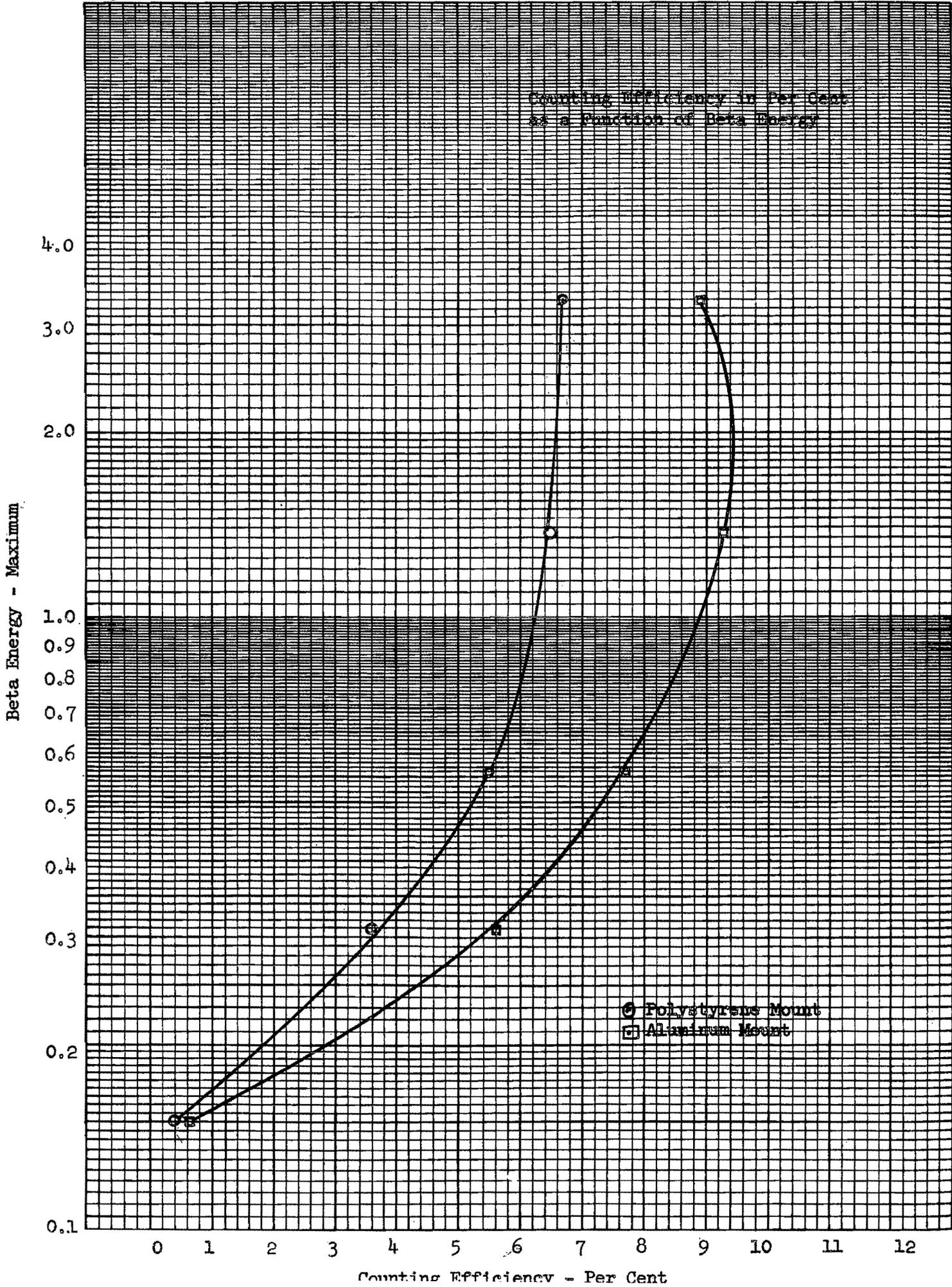
In a large part of the work in Health Physics it is necessary to obtain beta disintegration rates which will at least approach absolute rates. The nature and number of samples make it desirable to do the counting with end window type counters. For these reasons a study has been undertaken to determine the feasibility of developing end window counting methods which will yield results convertible to absolute beta disintegration rates with reasonable accuracy. The accuracy of any such method will be limited by the energy of the particle emitted from the sample; and will be dependent on the standardization of mounting techniques, and on the evaluation of such factors as backscatter, self-absorption and window adsorption. The problem is complicated even more by the fact that for a sample with isotopes of mixed energies, each isotope will be counted with an efficiency dependent on its energy.

In order to simplify the method as much as possible, an attempt is being made to include the corrections for backscatter, and air and window absorption in the counting efficiency expression. This should be possible if the counter is calibrated with standard solutions which have been mounted in the same fashion as the samples to be counted. Counting efficiency has been defined then as the ratio of the actual

counting rate of the sample to the absolute disintegration rate. No extrapolations are made to correct for window and air absorption as this has been included in the counting efficiency. The problem may be resolved into two parts:

1. To determine the counting efficiency of beta particles as a function of the energy of the particle, and
2. To develop a method to determine a mean energy for a mixture of isotopes from which a mean counting efficiency may be obtained.

Data for part one of the problem have been obtained with standard solutions (calibrated by ionization chamber or beta-gamma coincidence methods) of Ru<sup>106</sup>, Na<sup>24</sup>, Co<sup>60</sup>, Nb<sup>95</sup>, and Cs<sup>137</sup> mounted on 1 mil polystyrene, 1/2" watch glasses, and on the aluminum dishes ordinarily used for preparing liquid samples. Curves of the type shown in figure 5 have been obtained for a number of counters by plotting the counting efficiency as a function of energy. For standards having beta particles of more than one energy, a mean weighted energy was calculated. The curves indicate that the minimum energy which can be counted is between 0.1 and 0.15 Mev. In the highest energy range it was found that for samples mounted on aluminum and counted in instruments with windows thicker than 2.1 mg/cm<sup>2</sup>, a maximum counting efficiency occurred at an energy of about 2 Mev. It is believed that this apparently anomalous result can be explained by a study of backscatter phenomena.



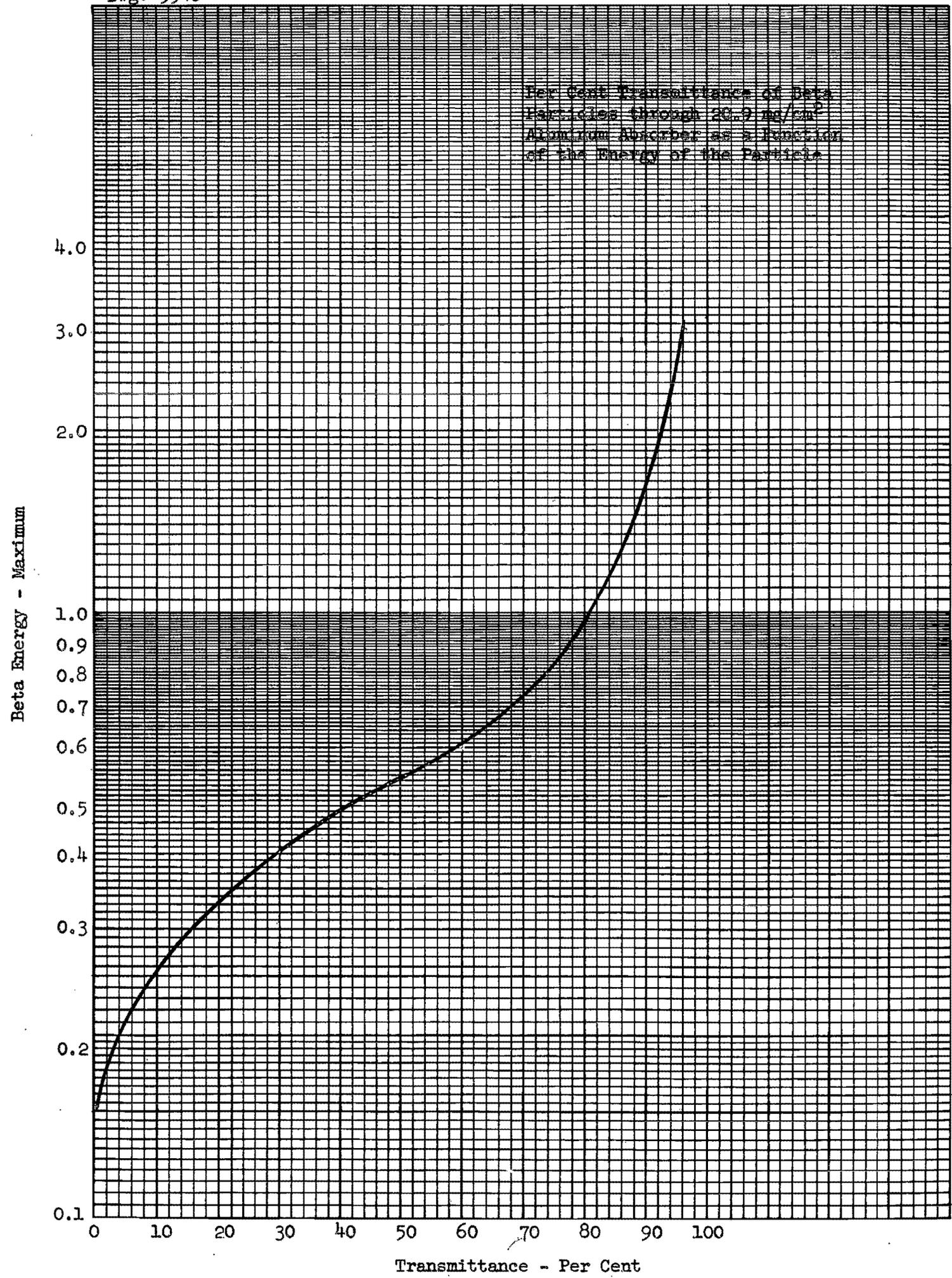
To determine a mean counting efficiency for an unknown mixture a method has been proposed for determining the mean energy of the sample radiation. This involves making two counts of each sample, one with no absorber added and a second with a thin aluminum absorber. It is believed that the decrease in counting rate can be related to the mean energy of the sample, and that a mean counting efficiency can then be obtained from a curve of the type illustrated in Figure 5. In Figure 6, the percent transmittance through a thin aluminum absorber, has been plotted as a function of energy.

Preliminary checks using known mixtures of isotopes indicate that the method will be sufficiently accurate for routine counting. The work will be continued in an effort to evaluate the factors affecting the accuracy of the method.

#### Concentration for Monitoring Purposes

In an attempt to develop adequate procedures for the monitoring of low activity-level water samples, a program was outlined and preliminary work was begun during July. The objective is to investigate the feasibility of a concentration method, capable of routine application, employing coagulation rather than evaporation.

Iodine dissolver solution was selected as a suitable contaminant for the study. The analysis of this solution is given on page 15.



These experiments were performed in the laboratory by means of jar tests using ferric chloride as a flocculant for the removal of activity. The selection of the coagulant is based on the ease and range of precipitation of iron salts. In the tests thus far, ferric chloride dosages ranging from 5 ppm to 400 ppm have been tried and pH values ranging from 6.5 to 11.5 have been induced to determine the optimum conditions for the maximum removal of activity.

From available data it was indicated that with a ferric chloride dosage of 120 ppm and a pH of 8.5, one may expect to remove 85-88% of the activity found in iodine dissolver solution.

Work on this experiment has been halted at the present time due to other activities, but will be resumed in the near future.

#### Algae Analyses

The following analyses are reported herein as they may be of general interest and will not be reported elsewhere.

Samples of algae and water were collected from the settling basin on June 5, 1950. The algae had a concentration of 6,000 beta counts per minute per milligram dry weight (27 microcuries of beta activity per dry gram). The water had a beta concentration of 140 counts per minute per milliliter ( $6.3 \times 10^{-4}$  microcuries of beta per milliliter).

A comparison of the percentage of beta activity concentration in the algae and in the settling basin water is given below.

Fission Product	Per cent of gross beta activity	
	Algae	Water
Sr <sup>90</sup> + Y <sup>90</sup>	4.4	92.0
Sr <sup>89</sup> + 90	2.4	58.0
Ru <sup>106</sup>	3.5	< 1.0
Ce <sup>144</sup>	61.0	1.3
Cs <sup>137</sup>	11.4	< 1.0
Per cent identified	80.3	94.0

Fission Product	Algae c/m/dry gram	Water c/m/milliliter
Sr <sup>90</sup> + Y <sup>90</sup>	2.67 x 10 <sup>5</sup>	126
Sr <sup>89, 90</sup>	1.45 x 10 <sup>5</sup>	79
Ru <sup>106</sup>	2.09 x 10 <sup>5</sup>	2
Ce <sup>144</sup>	3.67 x 10 <sup>6</sup>	1.8
Cs <sup>137</sup>	6.85 x 10 <sup>5</sup>	2
Gross Beta c/m	6.0 x 10 <sup>6</sup>	140

It is interesting to note that these data apparently indicate a concentration of rare earths in algae.

SEWAGE STUDIES

Trickling Filter Studies

Laboratory column, trickling filter studies were carried on during the quarter. This work is being conducted by a graduate student from the Department of Public Health, Georgia Institute of Technology, as a research problem for the degree of Master of Science. It has been facilitated through the grant of a research fellowship by the Oak Ridge Institute of Nuclear Studies.

The general problem selected is concerned with the degree of removal of radioisotopes, when present as a contaminant in sewage, by means of the trickling filter process of sewage treatment.

To implement this study, four of six experimental columns, previously designed, constructed and set up were used. The columns, constructed of lucite, are six feet in depth, with a two inch internal diameter and filled with 1/2" to 1" broken stones. The filters are provided with sampling points at each one foot increment of depth. The experimental trickling filters are shown in Figure 7.

For this study, it was decided that several flow rates for applied sewage would be investigated and that all should be in the standard or low rate range for trickling filter operation. The rates selected were 2, 4 and 6 million gallons per acre per day (mgad). The supernatant, from

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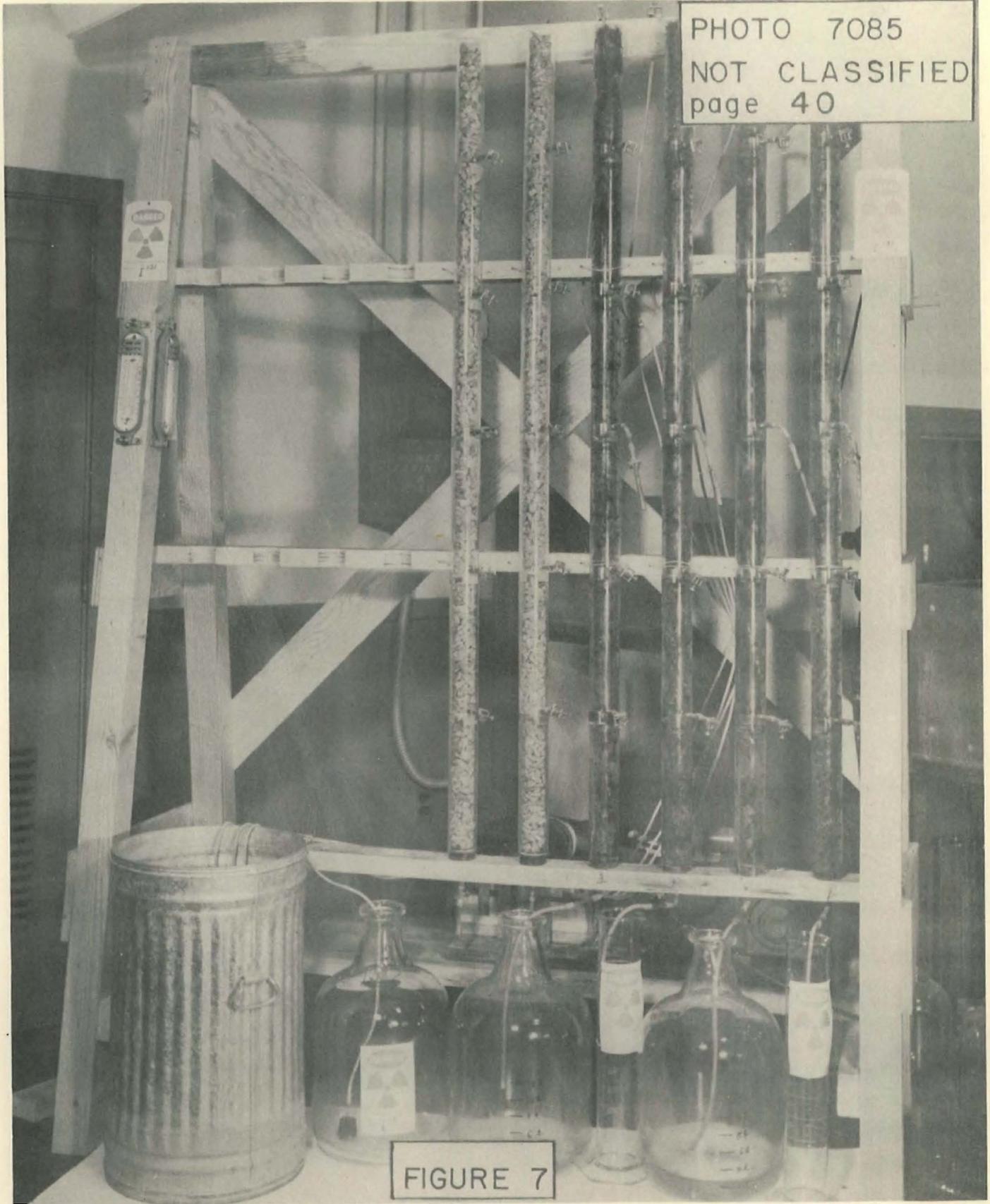


FIGURE 7

settled ORNL sewage, is used as a test material. The Biochemical Oxygen Demand (BOD) test is used as the criterion of filter operation.

Two phases of filter operation are involved:

1. The establishment of background data and loading curves for all filters for the three previously mentioned operating rates. These curves will establish the relationship between the percentage of BOD remaining and depth within the filter and will determine whether or not the filters are operating normally.
2. The use of radioactively contaminated sewages as filter influents and the determination of the same general type of curves with radioactivity rather than BOD as the criterion will constitute the second phase.

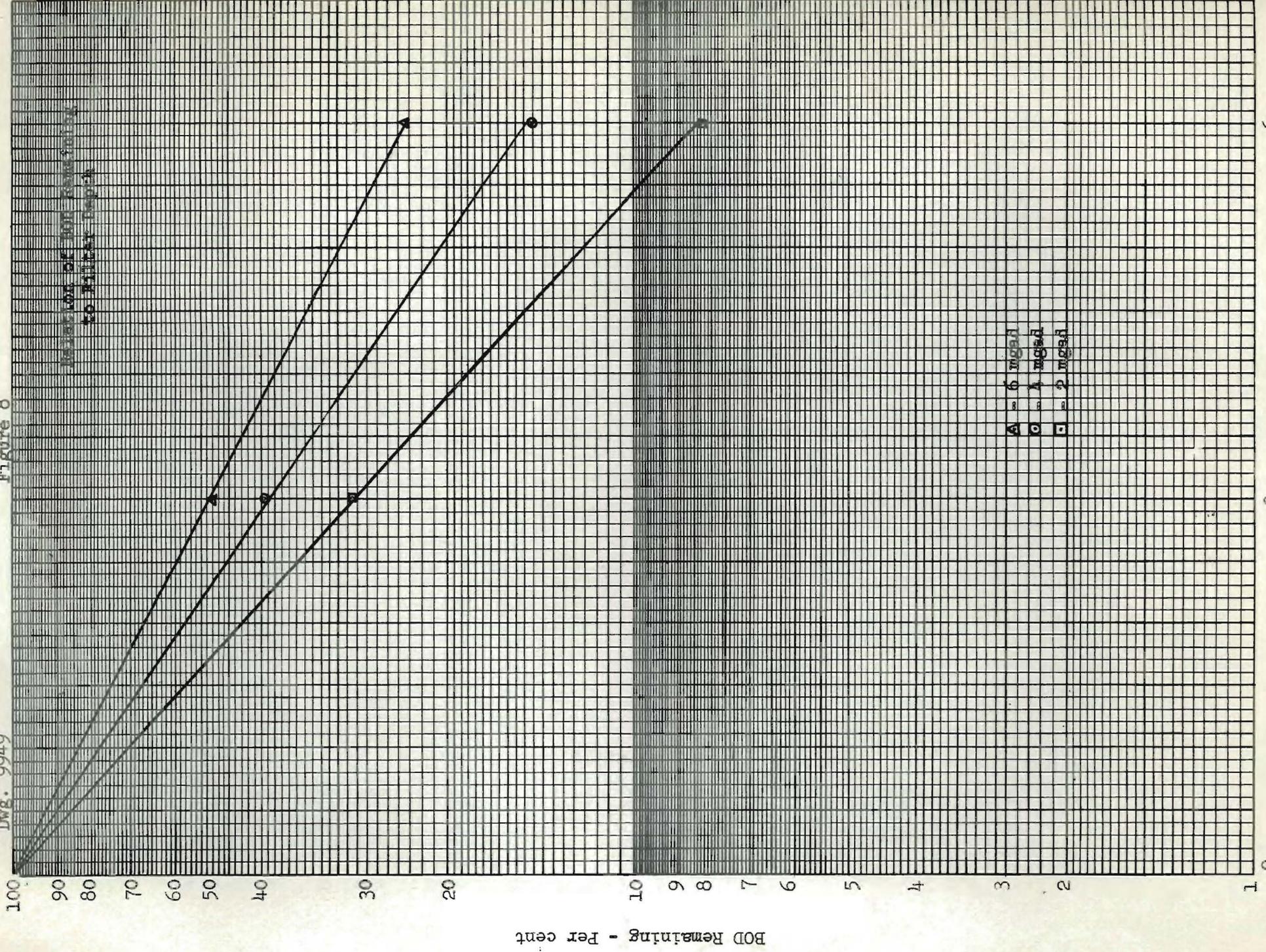
The first phase is completed and is summarized in the attached curves (see Figure 8). The plotted points represent thirty-four observations, each point being the average of five or more observations.

Work on phase two has been initiated.

RoyJMorton/ORPlacak:rr

Figure 8

Dwg. 9949



Filter Depth - Feet

6

3

10  
9  
8  
7  
6  
5  
4  
3  
2  
1

BOD Remaining - Per cent