INTERNATIONAL REFERENCE GROUP ON GREAT LAKES POLLUTION FROM LAND USE ACTIVITIES
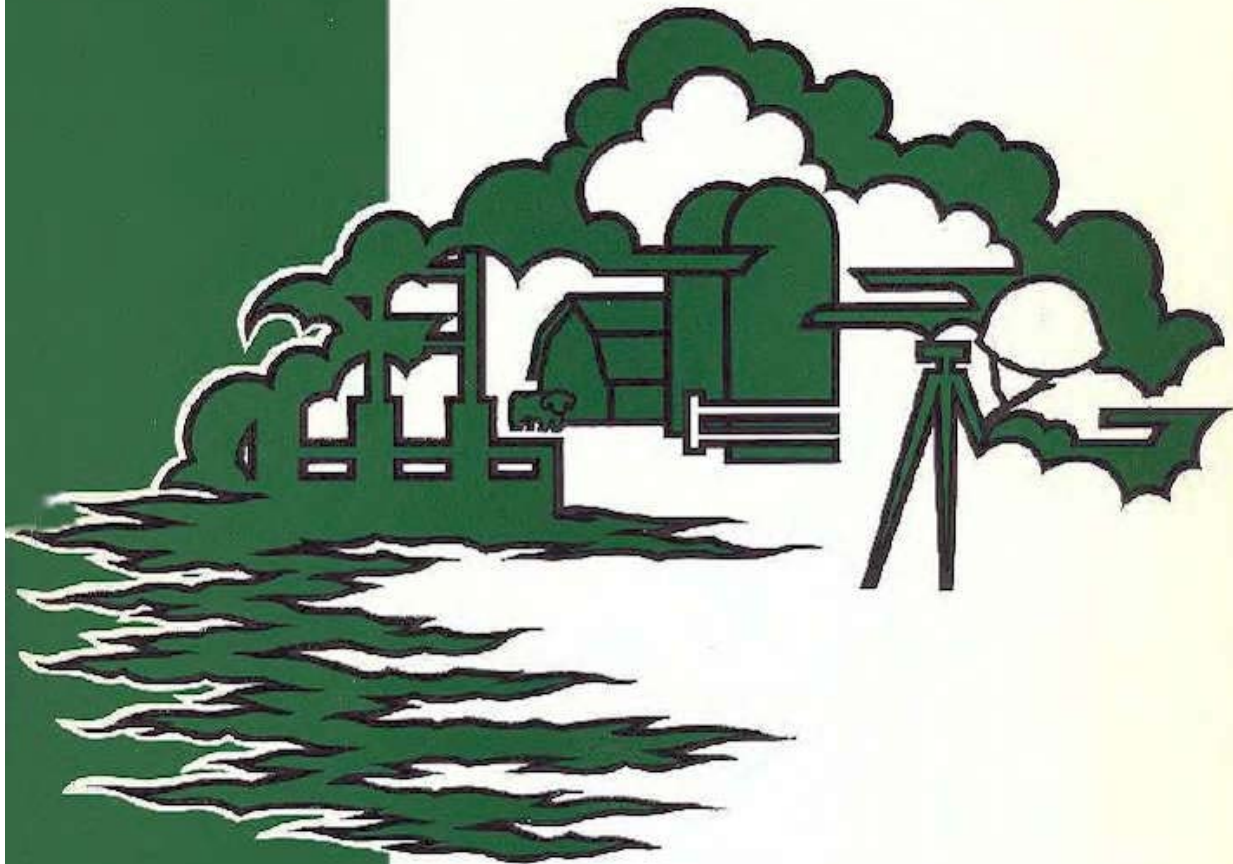

INTERNATIONAL JOINT COMMISSION

QUALITY CONTROL HANDBOOK FOR PILOT WATERSHED STUDIES

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FOR
PILOT WATERSHED STUDIES

INTERNATIONAL REFERENCE GROUP
ON GREAT LAKES POLLUTION
FROM LAND USE ACTIVITIES
(PLUARG)

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July 1975

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1. INTRODUCTION

The primary reason for quality control is to ensure that the conclusions of the various investigators, and the summaries developed therefrom, are based upon (comparable) *compatible and reliable* data. In addition, the program will aid investigators in ascertaining whether their needs for *analytic and sampling* precision and accuracy are being met and will contribute to overall proficiency by providing opportunities for scientists to discuss solutions to common problems.

A secondary reason for quality control is to ensure that data accumulated in PLUARG studies are accurate and precise contributions to the data base for future use in the Great Lakes Basin.

This Handbook is intended to give investigators associated with Task Group C studies under PLUARG the guidelines for quality control. The looseleaf arrangement of the Handbook will facilitate updating as additional information becomes available. In this regard, all pages will be dated at the time of issuance.

Changes from the previous issuance ~~will be~~ are indicated by a vertical line in the right margin of the page. Deletions ~~will be~~ made in the 1975 issuance were enclosed in parentheses "(...)", and additions ~~will be~~ were typed in <u>Italics,</u> unless otherwise noted. Deletions made in the 1976 issuance are shown by ~~strikeout~~, and additions are typed in <u>SCRIPT,</u> unless otherwise noted.

(The TABLE OF CONTENTS lists the sections included in the initial issuance of the Handbook. Additional sections will be added as required.) During the 1975 field season, the Handbook (will be) *was used as* a Working Document. (in effect on the date of issuance. Users are requested to send the River Basin Studies Coordinator, in the IJC Regional Office, Windsor, Ontario N9A 6T3 suggestions for improving the Handbook.) *Suggestions received from users, the Task C Technical Advisory Committee and the Data Quality Subcommittee were the basis for changes made in the Spring of 1976.*

Representation of PLUARG on the Data Quality Subcommittee of the Implementation Committee of the Water Quality Board will enhance the efforts of PLUARG in carrying out a data quality control program. The results of that Subcommittee's work will be appropriately incorporated in the Handbook.

2. PARAMETER LISTS

The parameter lists will be considered to contain the general parameters necessary to satisfy the reference, i.e. those parameters believed to be significant causes of degradation to Great Lakes water quality or those parameters likely to be implicated in the transport of pollutants. To the extent possible and feasible, all parameters on the list will be investigated in all PLUARG river basin studies.

Some parameters are essential to enhance the use of data from the pilot watersheds for predictive capability to the Great Lakes Basin. Each watershed project manager will (propose to the River Basin Studies Coordinator, for consideration by PLUARG), *select those specific parameters on the list pertinent to the scope and objectives of (the individual) his project. The Water Quality Objectives Subcommittee (WQOS) of the Implementation Committee has ranked the several parameters according to their importance as possible causes of Great Lakes water quality degradation. The ranks assigned are indicated on the lists under Sections 2.11 and 2.23 as follows:*

     *   *Highly Important*
     **   *Medium Importance*
     ***   *Desirable*

2.1   WATER SAMPLES

2.11   Parameters
      See 3.41 -- Filtration

(2. 111)

(The following parameters are to be run on all water quality samples.)
A.   Nutrients
    *1.   Phosphorus
        a.   Total Phosphorus on Unfiltered Sample
        b.   Total Phosphorus on Filtered Sample
        c.   Dissolved Reactive Phosphorus on Filtered Sample

    **2.   Nitrogen
        a.   Organic Nitrogen
        b.   Ammonium Nitrogen
        c.   Nitrate Nitrogen plus Nitrite Nitrogen
            Note: Where nitrite N is known to be an important contaminant, nitrite and nitrate N will be determined independently.

B.   Salts
    **1.   Alkalinity - Specify whether Filtered or Unfiltered
    ***2.   Calcium-Magnesium or Hardness - on Filtered Samples
    **3.   Chloride, and/or Sodium and Potassium-Chloride on Filtered Samples

C.   Organic Parameters
    **1.   Organic Carbon - Specify whether Total or Dissolved and whether Filtered or Unfiltered

D.   Field Analyses
    *1.   pH
    *2.   Dissolved Oxygen
    **3.   Conductivity - Specify if not Run in Field
    *4.   Temperature
    *5.   Flow

E.   Physical

**1.   Suspended Solids (and/or Turbidity)

(2.112)

(At the discretion of the watershed project manager, the following parameters will be run less frequently.)

(A) *F.*   Salts

***1.   Sulfate

 **2.   Dissolved Reactive Silicate as Silicon

***3.   Iron (and/or Aluminum) -- *Total*

(B) *G.*   Organics

**1.   Phenolics

**2.   Cyanide -- *Free HCN*

 *3.   Pesticide Scan

  4.   PCBs -- at discretion of investigator

  5.   Chlorophyll <u>a</u> -- At discretion of investigator

(C) *H.*   Metals *or Elements -- Total except Mercury*

***1.   Chromium

 **2.   Arsenic

***3.   Selenium

 **4.   Nickel

  *5.   Cadmium

  *6.   Mercury -- *filtered sample*

  *7.   Copper

  *8.   Lead

 **9.   Zinc

(D) *I.*   Bacteriological Analyses

**1. Total Coliform

**2. Fecal Coliform

**3. Fecal Streptococci

2.2   SEDIMENT, RIVERBANK MATERIALS AND SOIL SAMPLES

2.21   Introduction

The parameter list under 2.23 -- Parameters will be used for suspended sediments, bottom sediments, riverbank or shoreline materials, and soil samples.

Sample residuals will be retained for later analysis for parameters not initially investigated. Proper preparation and storage of such samples will be emphasized.

2.22   Definitions

Each investigator will adequately define sediments in terms of method of sampling, as well as method of handling -sieving, filtering, separation out of organics, etc., -- so that the study reports will show what an analysis of "sediment" means relative to the "sediment's" origin, mode of transport and fate.

All sediments will be labelled as organic, inorganic, or mixtures of the two.

The following definitions and discussion, provided by the U.S. Geological Survey, will be used for definition purposes by each investigator.

2.221   Sediment

In the broadest sense, sediment is defined as -"Solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity or ice and has come to rest on the earth's surface either above or below sea level." Sediment is further defined as "that material passing through a 2 mm screen and retained on a 0.45 μm filter".

2.222   Suspended Sediments

The amount and nature of materials dispersed in water -- streams, lakes, rivers, etc. -- is highly Variable. Some suspended materials become bottom sediment

as soon as quiescent conditions exist. Bottom sediments exposed to high hydraulic or energy conditions, specifically those fractions below 2 mm in diameter and particularly below 10 µm, become suspended sediments. The particulates filtered from water samples should be looked upon as suspended sediment.

For PLUARG studies, <u>suspended sediment</u> is defined as that sediment in suspension that can be sampled with existing samplers and are coarse enough to be retained on a 0.45 µm filter. For instance, <u>suspended inorganic sediment</u> is the inorganic or mineral portion of the sediments being carried in suspension that are coarse enough to be retained on a 0.45 µm filter.

2.223   <u>Bottom Sediments</u>

The problem of differentiating between "bedload sediment" and "bottom sediment" has been considered by technical advisors to PLUARG. The decision has been made to drop the term "bedload". The work underway under PLUARG in New York on evaluating the Bogardi Bedload Sampler may result in further consideration of this decision.

In the broadest sense, bottom sediment -- fluvial is defined as -- "The sediment which forms the bed of a stream or other body of water." The term, bed material, is used generally in the same sense; however, it generally refers to inorganic sediments.

For PLUARG studies, <u>bottom sediment</u> is defined as the unconsolidated material lying in the top 5 to 10 centimeters of a water course bottom, ranging in size between 0.45 µm and 2 mm, and that can be sampled using currently available sampling equipment. Examples of such samplers are the USBM-54 and USBMH-60.

Samples of bottom sediments collected by coring devices must be so defined in terms of depth of material sampled relative to the bed surface elevation, etc.

2.23 <u>Parameters</u>

(To the extent possible and feasible, the following parameters will be investigated in all PLUARG river basin studies.)

A.   Total Phosphorus
       *1. Non-Apatite Inorganic Phosphorus
       *2. Apatite Phosphorus
       *3. Organic Phosphorus

*B.   Total Kjeldahl Nitrogen

**C.   Ammonia Nitrogen (NH_4) -- Extractable -- Solution being 1N. or 2N. KCl

D.   Extractable -- *Extraction* Solution being 1N. $BaCl_2$.
     Note: 1N. NH_4OAc is recommended by U. S. Soil Conservation Service except for calcareous soils.
***1.   Calcium
***2.   Magnesium
***3.   Sodium
***4.   Potassium

E.   Dithionite - Citrate
**1.   Iron (Free iron oxides)
**2.   Manganese

F.   Oxalate -- Solution (1N.) *0.2M* $(NH_4)_2$ C_2O_4 at pH 3
**1.   Iron
***2.   Aluminum (Selected samples)

G.   Heavy Metals *or Elements -- Total*
***1.   Chromium
**2.   Arsenic
***3.   Selenium

4. Nickel

5. Cadmium

6. Mercury

7. Copper

8. Lead

****9.** Zinc

*****10.** Cobalt

*****11.** Tin

*****12.** Manganese

13. Others as appropriate in particular situations

*****H.** Total Sulfur (On selected samples, using Reference:
Soil Science Society of American Proceedings 34:62, 1970)
(See Thompson, J. F., under 9. -- REFERENCES)

***J.** Cation Exchange Capacity -- Direct Method, using 1N. $BaCl_2$.
Note: 1N. NH_4OAc is recommended by U.S. Soil Conservation Service.
1. On Total Sediment Sample
2. On Selected Samples of Clay Fraction (<2p)

****K.** Total Carbonates

***L.** Organic Matter
1. Total Carbon
2. Organic Carbon (Total Carbon - Inorganic Carbon)

***M.** pH (one to one soil-water, measured in the field)

***N.** Particle Size Distribution
1. Electrolyte Dispersed: sieve + sedimentation
2. Water Dispersed (on selected samples)

O. Organics -- At discretion of investigator
  1. Pesticides
  2. PCBs
  3. Organic-Pollutant Coextractives

(O) ~~P. Mineralogy -- Analyses will be made to permit mineralogical characterization of sediments in each watershed. Messrs. R. L. Thomas, L.P. Wilding, and G. J. Wall will prepare a proposal on this aspect. It appears likely that one laboratory in the U.S. and one in Canada will handle Clay (<2μ and Sand and Silt (>2μ mineralogy for all watersheds.~~

P. Mineralogy -- The clay mineralogy methodology used at the University of Guelph and Ohio State University is recommended for all pilot watershed studies.

Semi-quantitative estimations of clay minerals are determined on magnesium saturated clay by x-ray diffraction after the method of Johns, Grim and Bradley (Quantitative estimations of clay minerals by diffraction methods: Jour. Sed. Petrology, V. 24, 242-251, 1954). Four treatments are employed: air dry; ethylene glycol; heated to 400°C, and heated to 550°C.

REFERENCES:

Smeck, N.E., L.P. Wilding and N. Holowaychuk, 1968. Genesis of argillic horizons in Celina and Morely soils of western Ohio. Soil Sci. Soc. Am. Proc. 32: 551-556.

Wall, G.J. and L.P. Wilding, 1976. Mineralogy and related parameters of fluvial suspended sediments in northwestern Ohio. J. Environ. Qual. Val.. 5: 168-173.

3. SAMPLE COLLECTION

3.1 GENERAL

Please refer to 6.3 <u>DOCUMENTATION OF METHODOLOGY</u> in section 6. of this Handbook on ANALYSIS QUALITY CONTROL and to the publications listed under 9. REFERENCES.

Sample collection information available for loan in the IJC Regional Office Library is shown in section 9 -- REFERENCES.

3.2 SITE SELECTION

A statement of objectives will be examined for each site. This will allow for adequate consideration of:

- ▸ the land use activity to be studied -- i.e., what is to be measured?
- ▸ the stream use, i.e., can what is there be measured?
- ▸ the suitability of the site to meet the objectives,
- ▸ the history of the site, if available,
- ▸ the site access and utilities availability,
- ▸ the availability of instrumentation,
- ▸ the availability of historical data for the site.

Inherent in individual site selection are the basic considerations relating to the basin as a whole, such as basin characteristics -soils, geology, etc.; an adequate watershed description -- size, lots, housing, population density, etc.; the availability of (other hydrometric) *hydrologic* data -- precipitation, *streamflow* etc.; the degree of representativeness of the basin in terms of a larger area; the degree to which information from the basin can be used for prediction purposes outside the watershed; and the effects of basin characteristics on the parameters to be studied. Site selection depends upon the availability of a review of existing data so that the abovementioned factors can be considered.

3.3 STREAMFLOW MONITORING

Streamflow monitoring will be carried out on a continuous basis wherever

possible in order to provide a high degree of accuracy in the preparation of hydrographs. Where continuous monitoring is not possible and flows are estimated or extrapolated, an estimate of the precision -- confidence limits -- of the data will be given. At least daily hydrographs are required. (and) *Both high and* low flows are considered to be (the least) important measurements relative to determining total loadings to the Great Lakes.

3.4   <u>WATER QUALITY MONITORING</u>

Water quality monitoring will be carried out on a continuous basis -- automatic sampling -- wherever possible. The smaller the June 1976 watershed, the greater is the need for frequent sampling. Automatic sampling will be desirable to assess the response of small watersheds to climatological and physical events. Automatic sampling can be expected to cover the rising (limb) *stage* of the hydrograph (on the occasion of) *during* a rainfall/runoff event and to (cover a specific application of a chemical) *sample for specifically designated analyses* in a small watershed.

Although automatic sampling will be point sampling, for small watersheds the variability of water quality with time (or flow) will be more important than its variability as a result of the cross-sectional area. Even with automated sampling systems a manual backup provided by an on-site technician is necessary to ensure the operation of the automatic monitor, to collect and ship bacteriological samples, and to carry out those tests which cannot be delayed until the samples reach the laboratory.

Provisions will be made in all data storage systems to identify the data-collection technique -- manual or automatic. An event marker, or equivalent device will be employed so that sampling time can be accurately determined and equated to a corresponding, instantaneous discharge value.

All materials comprising the automatic sampler will be inventoried and documented for possible contamination sources. Analysis of distilled water samples that have passed through the automatic sampler system, will provide a quantitative check on the degree of contamination attributable to the sampler. Special attention in this regard should be given to samples for heavy metals analyses.*

The duration and efficiency of the purging cycle will be documented for each station. It is preferable that the intake line be comprised of transparent material, so

that sediment buildup can be noted and corrected by additional back-wash. To avoid lengthy delays from sample collection to sample analysis, the automatic sampler installation will be serviced as frequently as possible. Some absorption on container walls can be expected since the containers cannot be pre-rinsed with a representative sample of stream water. The temperature of the housing structure for the automatic sampler should be controlled to an optimum storage temperature of 4°C. Winter thermostat regulation makes this task simple in the winter months and impossible in the summer heat, unless refrigeration units are installed. Immediate field filtration through an automated system presently appears impossible.

When field technicians service the automatic sampler installations, a comparison sample will *be taken by sampling in the prescribed manual fashion and then immediately activating the automatic sampler. Periodic manual samples are necessary at all automatic sampler locations to determine the horizontal as well as vertical cross-sectional variations at various stream stage conditions. Since the intake location of the automatic sampler is fixed near the streambed, it is anticipated that suspended sediment samples collected automatically during high flow conditions* will *be comprised largely of bedload. Comparing automated and manually collected samples through a* full range of *streamflow discharge values will yield specific relationships for determining true chemical and physical concentrations at each site. Floating automatic sampler intakes appear as the solution to the unrepresentative single point sample. However, floating intakes are subject to ice and livestock damage, vandalism, and additional contamination from elaborate screening and protective devices.*

The documentation of storage time is essential so that emphasis will be assigned to values obtained from fresh samples.

3.41   Filtration

Field filtration through a 0.45µ filter will be done on samples to be analyzed for *soluble* nutrients; and, if possible, for other parameters for which analysis on filtered samples is indicated. (Laboratory filtration may be required for parameters, other than nutrients, if field filtration of large volumes of samples is not feasible.) *When filtration times are excessive due to high sediment content, samples may be filtered in the field through a 1 or 2µm glass fibre filter. The filtrate will be forwarded to the laboratory preferably refrigerated at 4° C, where a portionbe filtered through a suitable 0.45µm*

pore-size filter before analysis.

Samples and results must he identified as to whether they were filtered in the field and/or the laboratory indicating the type and make of the filter or filters used in the field and/or the laboratory.

Regardless of the filtration procedures used, documentation of methodology is required as indicated in 6.3 -- DOCUMENTATION OF METHODOLOGY.

3.5   <u>SEDIMENT SAMPLING</u>

Sediment sampling will be carried out above and below reservoirs and in proximity of the Great Lakes so that an estimate of total *sediment and sediment associated chemical* loadings can be determined. Additionally, in selected watersheds sediment samples will be taken at progressively *distant* locations from the headwaters and downstream locations to investigate transport mechanisms and changes in pollutant content associated with streamflow. The frequency of sampling needs to be adequate to relate to the total flow hydrograph to establish total loading volumes.

3.51   <u>Suspended Sediment</u>

The problem of obtaining (an adequate quantity and) representative sediment samples *of adequate size* is recognized. Compositing (particulates) *sediment* from several separate samplings over the season, however, in order to have a sufficient quantity of sediment for analysis, can produce questionable data.

New York has been successful in analyzing particulates collected on a 0.45 millipore filter from 2-liter water samples from the Genessee River. They report that this method of suspended sediment colletion and subsequent analysis is reliable and reproducible.

The Canadian Centre for Inland Waters (CCIW) has been using for some years a continuous centrifuge for separating particulates from 600-1200 liters of sample. The unit is transported from site to site to permit separation of fresh samples. The estimated cost of the centrifuge unit, including truck and generator, is $70,000. Those desiring further information on this technique should contact CCIW.

3.52   <u>Bottom Sediment</u>

(Samples) *Sediments* will be (removed from) *sampled at* locations that have had deposition from upstream. It is appropriate to composite the individual field samples for laboratory analysis. A sufficient number of samples will be taken to ensure representative results, realizing that it is not feasible to predetermine the minimum number of samples generally needed to be taken for all locations in the basin. Investigators are referred to publications listed under 9. -- REFERENCES for information on this subject.

3.6   SAMPLING FREQUENCY

3.61   General

NOTE: This Subsection is being added to the Handbook in March 1977 and is not typed in script.

REFERENCE: Sampling Techniques, *Second Edition,* William G. Cochran, John Wiley & Sons, Inc., New York, 1963.

Sampling frequency is defined as the number of samples to be taken over a specified period of time. In IJC work on the Great Lakes the period of time specified, unless otherwise noted, is the water year, which has been generally understood to be October 1 to September 30. In the discussions which follows, sampling frequency is understood to mean the number of samples to be obtained over a water year.

In calculating the number of samples necessary, it is assumed that random sampling will be employed, and unless otherwise noted, that simple random sampling will be employed. By simple random sampling it is understood that each individual in the population has an equal probability of being in the sample and that the probability of an individual's being in the sample is not related to the presence or absence of any other individual in the sample.

If sampling schemes which do not incorporate random sampling are employed in the collection of data, it is difficult to know what nontrivial inferences, if any, may be made from the data.

In dealing with the question of the required number of samples, the desired precision at a specified probability of being correct is often expressed by the

investigator in terms of some percentage of the mean or total, e.g. within ± 10% of the true mean or total with a probability of 0.95 of being correct. However, since the population mean or total is not known, 10% of the mean or total is unknown also. Of course a guess or prior estimate of the mean or total could be used as a basis for setting the amount of deviation which can be tolerated, but usually a little thought can develop a better assessment of allowable deviation than a percentage of an unknown value. Moreover, it should be noted that in estimating the required number of samples, knowledge concerning the population mean or total is not necessary, rather some estimate of the population variance, $\hat{s}^2$, is needed, since the dispersion of the distribution is the characteristic crucial to estimation of the needed number of samples.

A simple example:

Suppose an estimate is required of the number of samples necessary to determine the mean daily phosphorus loading at a tributary mouth. From previous work an estimate of the population variance, $\hat{s}^2$, of 28.6 kg/day is available with 14 degrees of freedom. The investigator in charge of the project has decided that he can accept a deviation, d, of 2.74 kg/day from the true mean daily phosphorus loading and is willing to accept a probability of 0.95 of being correct. Accepting this probability is equivalent to accepting a probability, α, of 0.05 of being incorrect.

The formula for estimating the required number of samples, n, is:

$$n = t^2 \hat{s}^2 / d^2 \qquad \qquad \qquad \text{...(equation 1)}$$

where $\hat{s}^2$ and d are as explained above and t = 2.145, which is the value of the upper percentage point, 2-tailed = 0.05, of the t distribution with 14 degrees of freedom.

$$n = \frac{(2.145)^2 \times 28.6}{(2.74)^2} = 17.5$$

The required number of samples is therefore 18. It should be emphasized that the investigator has to make two decisions before the number of samples needed can be estimated; both acceptable deviation and probability of being correct must be specified. In the example, the acceptable deviation was selected so that the yearly

loading estimate would be within 1 metric ton of the true loading (2.74 kg x 365 = 1,000 kg = 1 metric ton). The probability level of 0.95 was chosen because odds of 19 to 1 of being correct were deemed an acceptable risk. In deciding on an acceptable risk the investigator must weigh the consequences of being incorrect.

The example assumes that the sample mean is the estimator which will be used to estimate the population mean. If a ratio estimator will be used rather than the sample mean, then in place of $\hat{S}^2$, the estimated population variance, another value should be used. It is the estimated mean-square-error of the ratio estimator multiplied by the number of measurements from which it was derived.

* * * * * * * * * * * * * * * * *

In the simple example given above there is an underlying assumption that the distribution of the population of phosphorus loadings is sufficiently well represented by the normal distribution to allow confidence in the variance estimate, together with the use of the t distribution. In some cases this assumption will be reasonable, but in many cases it will not be. Among the latter are estimations of tributary loadings when it is known that a major portion of the year's loading stems from a few high flow events. In the discussion which follows a method for dealing with such cases is given.

The method is to divide the population to be sampled into portions or strata. In the case of tributary sampling two strata should suffice; one strata is the periods of high flow events, and the second strata is the remainder of the water year. Within each strata, simple random sampling is to be practiced, but the overall sampling plan incorporates stratified random sampling.

As before the number of samples needed is to be determined. In addition, the allocation of sampling between the strata must be considered.

The prior information required includes estimates of the variances within strata and estimates of the sizes of the strata. In some sampling situations the sizes of the strata are known beforehand, but this will obviously not be the case with the number of days during which high flow events will occur, - a number which will vary from year to year. However, examination of the historic record for several years will provide an

estimate of how many such days to expect.

An example with stratified sampling:

Suppose an estimate is required of the number of samples necessary to determine the mean daily phosphorus loading at a tributary mouth. From previous work the following estimates of population variances are available: an estimate of the variance within periods of high flow events, $\hat{s}_1^2$, of 215.8 with degrees of freedom, f_1 = 9, and an estimate of the variance within the remainder of the water year, $\hat{s}_2^2$, of 23.3 with degrees of freedom, f_2 = 12.

In addition, examination of the historic record gives an average of 57 days per year of high flow events, N_1, leaving 308 days per year, N_2, for the expected strata size for the remainder of the year. $N = N_1 + N_2 = 365$.

As before the investigator has decided he can accept a deviation, d, of 2.74 kg/day from the true mean daily phosphorus loading and has decided on an $\alpha = 0.05$ as an acceptable risk of being incorrect.

The formula for estimating the required number of samples, n, is:

$$n = \frac{t^2\ [\Sigma\ (N_i\ /N)\ \hat{s}_i\ ]^2}{d^2} \qquad \qquad \text{... (equation 2)}$$

where all symbols are as given above except for t which now has to be determined.

There are two different separate variance estimates, $\hat{s}_1^2$, and $\hat{s}_2^2$, for the population variances within the separate strata. There are estimates of variances of different populations and may not be pooled in the usual manner for combining different estimates of the variance of the same population. The formula for determining the effective number of degrees of freedom, f, for the combined estimate of the variance of two populations is:

$$f = \frac{\left(\sum [N_i^2 /(f_i + 1)]\, \hat{S}_i^2 \right)^2}{\sum \dfrac{[N_i^2 /(f_i + 1)]^2\, \hat{S}_i^4}{f_i}} \qquad \ldots\text{(equation 3)}$$

For the given data:

$$f = \frac{\left([57^2/(9+1)] \cdot 215.8 + [308^2/(12+1)] \cdot 23.3 \right)^2}{[57^2/(9+1)]^2 \cdot 215.8^2/9 + [308^2/(12+1)]^2 \cdot 23.3^2/12} = 19.513$$

The effective number of degrees of freedom is therefore 19.513.

The value of the upper percentage point, 2-tailed = 0.05, of the t distribution with 19 degrees of freedom is 2.093; the corresponding value with 20 degrees of freedom is 2.086. Using linear interpolation a value of t = 2.089 is obtained. Utilizing this value for t in equation 2, the required number of samples, n, is:

$$n = \frac{2.089^2 \cdot [57/365\, \sqrt{215.8} + 308/365 \cdot \sqrt{23.3}\,]^2}{2.74^2} = 23.57$$

Either 23 or 24 samples will be required, depending upon rounding, following allocation of samples between the two strata.

The formula for determining the number of samples, n_i, to be obtained from each strata is:

$$n_i = n\, N_i\, \hat{S}_i / \sum N_i\, \hat{S}_i \qquad \ldots\text{(equation 4)}$$

The number of samples required from the high flow strata is given by,

$$n_i = 23.57\, \frac{57\, \sqrt{215.8}}{57\, \sqrt{215.8} + 308\, \sqrt{23.3}} = 8.49$$

Therefore 8 samples would be required from the high flow strata.

The number of samples required from the second strata is given by,

$$n_2 = 23.57 \ \frac{308 \ \sqrt{23.3}}{57 \ \sqrt{215.8} + 308 \ \sqrt{23.3}} = 15.08$$

Therefore 15 samples would be required from the second, non-high flow strata.

As was noted in the discussion of the simple example, if ratio estimators will be used rather than sample means, then the estimated mean-square-error of each ratio estimator, multiplied by the number of measurements from which it was derived should be used in place of the within strata population variance estimate, $\hat{s}_i^2$.

If once the water year has begun, it appears the year will be wetter than usual with a greater than expected number of high flow event days then sampling can be increased during such events. Similarily, if the unfolding year appears to be drier than usual then sampling can be increased within the non-high flow strata.

In practice, it is unlikely that true random sampling can be practiced during the strata of high flow events. If care is taken to sample such events through both the rising and falling periods of the hydrograph the results should not be unduly biased.

Finally, it should be emphasized that N is taken as 365 for convenience in calculation. It is recognized that no day is sampled completely; instead the results obtained at a moment during the day are attributed to the entire day. If a program involves sampling several times a day, the results can be attributed to shorter time periods and N appropriately increased.

Estimating the population mean and the variance of the estimate with stratified sampling:

Suppose that sampling were carried out using the estimated number of samples needed as indicated by the stratified sampling example, and the following results obtained. The mean daily sample loading for high flow events, m_1, is 41.5 kg/day with an estimated population variance for the strata, $\hat{s}_i^2$, of 311.7 with $f_1 = 7$ degrees of freedom. The mean daily sample loading for non-high flow periods, m_2, is 7.8 kg/day

with an estimated population variance for the strata, $\hat{s}_2^2$, of 19.6 with $f_2 = 14$ degrees of freedom. The number of high flow event days during the water year, N_1, is 48 days.

The formula for calculating the estimate of the mean daily loading, m, for the year is:

$$m = \frac{\Sigma\, N_i\, m_i}{N} \qquad \text{...(equation 5)}$$

For the data given,

$$m = \frac{48 \times 41.5 + 317 \times 7.8}{365} = 12.2 \text{ kg/day}$$

The estimated variance of the mean daily loading, $\hat{s}_m^2$, may be obtained from the formula:

$$\hat{s}_m^2 = 1/N^2\ \Sigma\, N_i^2\ \hat{s}_i^2/(f_i+1) \qquad \text{... (equation 6)}$$

For the given data,

$$\hat{s}_m^2 = 1/365^2\ [48^2/8 \cdot 311.7 + 317^2/15 \cdot 19.6] = 1.659$$

The effective degrees of freedom associated with this estimate may be found through equation 3,

$$f = \frac{[48^2/8 \cdot 311.7 + 317^2/15 \cdot 19.6]^2}{[48^2/8]^2 \cdot 311.7^2/7 + [317^2/15]^2 \cdot 19.6^2/14} = 20.512$$

The interpolated value of the t distribution with 20.512 degrees of freedom, 2-tailed = 0.05, is 2.083, which gives 95% confidence limits for m of

$$m \pm 2.083 \sqrt{1.659}$$

or

$$m \pm 2.68 \text{ kg/day}$$

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This method of estimating the population mean and its variance may be employed even though simple random sampling rather than stratified random sampling was the sampling method used, provided that the strata boundary was selected prior to examination of the sample data. However, the increased efficiency of stratified random sampling depends upon proper allocation of sampling between strata.

3.62 Water

Stream sampling will be scheduled periodically throughout the year. Where automated sampling is not possible, depth-integrated samples will be taken on a frequent basis.

Arrangements also will be made to obtain samples on an event, e.g. high runoff and "spring flush" periods basis. Every effort will be made to obtain *several* (event) samples *per event* to permit integrating data for the entire event.

3.63 Sediment

Bottom sediment samples will be (removed) *collected* to permit characterizing the geologic and mineralogic nature of the watersheds.

(Samples of) *The sampling frequency for* bottom and suspended sediments will be (taken frequently enough) *selected* to (permit estimating) *provide an estimate of* (1) the amount and nature of pollutant contributions moving from the pilot watersheds; and (2) the changes in the nature and amount of pollutants "carried" by sediments in streamflows; i.e. changes associated with transport and deposition. mechanisms.

Where automated sampling is not possible, depth-integrated grab samples will be taken on a frequent basis.

Sediment sampling, particularly suspended sediment, is especially important during the "spring flush". Specific plans and arrangements will be made by responsible investigators to obtain samples during this event.

3.7   *GROUND WATER SAMPLING*

There is no standardized method of sample collection in the ground-water studies. Hand bailers, hand vacuum pumps, battery-operated electric peristaltic tubing pumps, and gas-driven centrifugal pumps are al used for flushing out and sampling groundwater wells. The effect of these various methods on quality control is unknown. Specific research will be required in order to select the most efficient and accurate method for ground-water sample collection.

4. SAMPLE HANDLING

No recommendations for uniformity on sample handling between projects are provided at this time. Each responsible investigator will maintain a record of sample handling procedures and sample preservation techniques -- from field to laboratory -- for each parameter investigated. Refer to 6.3 <u>DOCUMENTATION OF METHODOLOGY</u> in section 6. ANALYSIS QUALITY CONTROL.

Sample residuals will be retained for later analysis for parameters not initially investigated.

Attention is called to Section 9.0 on REFERENCES; and, all investigators are requested to send the River Basin Studies Coordinator, IJC Regional Office, any information on this subject they wish to share with others involved in PLUARG.

Sample handling information available for loan in the IJC Regional Office Library is shown in section 9. -- REFERENCES.

5. SAMPLE PREPARATION AND ANALYSIS

Laboratory procedures will be at the discretion of the particular laboratory supervisor, except as noted above under 2. -- PARAMETER LISTS for certain specific parameters.

Please refer to 6.3 -- <u>DOCUMENTATION OF METHODOLOGY</u> in section 6. -- ANALYSIS QUALITY CONTROL and to the publications listed under 9. -- REFERENCES.

Sample preparation and analysis information available for loan in the IJC Regional Office Library is shown in section 9. -- REFERENCES.

6. ANALYSIS QUALITY CONTROL

United States and Canadian laboratory analyses will be coordinated under headings as follows:

- ▸ Blind Replicates from Field to Laboratories
- ▸ Reference and Natural Samples for Between-Laboratory Comparisons
- ▸ Documentation of Methodology
- ▸ In-Laboratory Quality Control.

6.1 <u>BLIND REPLICATES FROM FIELD TO LABORATORIES</u>

Each project in which field samples of water, sediment or soil are collected for laboratory analyses will be involved in this aspect of quality control.

Replicate samples will be taken in the field at the time and place of the base line sampling schedule -- not for special event sampling, unless the project manager desires to do so -- as follows:

- ▸ in any watershed or project with up to 25 sites, one site will be sampled in replicate;
- ▸ in any watershed or project with more than 25 sites, not less than one sample site in each 25 will be sampled in replicate, e.g. a watershed with 26 sampling sites will require that 2 sites be sampled in replicate.

The replicate samples will be (removed) *individually collected* from the *same* site (separately) -- not one sample removed from the site and dividing and allocating *it* (to two sample) *to two* containers. It is desirable to collect the replicate samples simultaneously. Recognizing the difficulty of doing so, however, the sampler should record the exact time each replicate sample is removed. *Where automatic samplers are used which cannot collect two samples simultaneously, replicate samples should be collected by manual grabs.* Samples will be *coded* (labelled without special designation in order) *so* that the replicate samples (will be submitted "blind" along with all other samples for) *cannot be identified prior to or during* routine analysis.

The project manager -- leader, principal investigator -- will be responsible for designating the site and timing of replicate samples and the ongoing evaluation of data from them. This will include (prompt notification of) *promptly notifying* the laboratory section chief (of the results) of his *data* evaluation (of data) for replicate samples. The project manager will (notify) *provide* the River Basin Studies Coordinator (of) *with* the schedule and results of replicate sampling *and a discussion of problems. Such reports will be submitted at least quarterly.*

6.2   REFERENCE AND NATURAL SAMPLES FOR BETWEEN-LABORATORY COMPARISONS

6.21   Reference Samples

The ~~River Basin Studies Coordinator~~*, Senior Scientist*, located in the IJC Regional Office, will be responsible for periodically sending reference samples, both synthetic and stabilized natural, to the participating laboratories for analyses. The participating laboratories will promptly analyze the samples and send their results to the ~~Coordinator~~ *Senior Scientist*.

6.22   Round-Robins

Participating laboratories will be asked to identify existing intercomparisons in which they are participating, or have participated, and to provide a tabulation of the data and identify their performance to the ~~River Basin Studies Coordinator~~ *Senior Scientist.*

The ~~Coordinator~~ *Senior Scientist* will identify the projects requiring similar laboratory analytical functions. He will then ask the managers of such projects to initiate regular sample exchange programs to assess on a continuing basis the degree of data compatibility. Program managers are to inform the ~~Coordinator~~ *Senior Scientist* of the details of the exchange program in advance and have the laboratory results forwarded directly to the ~~Coordinator~~ *Senior Scientist* for compilation and evaluation.

6.23   Special Studies

As problems are identified, or suspected, special intercomparison studies may be initiated by 1) the project managers, 2) the laboratory analysts, or 3) the ~~Coordinator~~ *Senior Scientist*. The purpose of these studies will be to clarify the nature and effect of various sources of data (incompatibility) *inconsistency.* Certain participants in these special studies may be requested to study these effects in depth.

The ~~River Basin Studies Coordinator~~ *Senior Scientist* will be informed of the structure and intent of all special studies.

6.3   DOCUMENTATION OF METHODOLOGY

All project managers and analytical scientists will be required to document their current techniques for sampling; sample handling, preservation and storage; sample preparation; and final analysis. Two questionnaires 1) Sampling Procedures and Sample Handling and, 2) Analytical Methodology (will be) *have been* used for the documentation (to be) filed in the Regional Office of IJC at Windsor, Ontario, (and used:) *for use:*

- ‣ to assist in identifying possible causes of data (incom-patability) *inconsistency* that are detected in the interlaboratory comparison program so that (incompatability) *inconsistencies* may be corrected,
- ‣ to initiate and assist in discussion of the rationale for use of differing techniques and to lead to a consensus as to preferred procedures and,
- ‣ as a permanent record of the procedures employed by participants during various stages in the PLUARG program.

Modifications of the procedures also (will) require documentation as they occur.

Copies of the documentation available in the Regional Office Library for loan are listed in Section 9 -- REFERENCES. Requests for loans should be addressed to: Librarian, IJC Regional Office, 100 Ouellette Avenue, 8th Floor, Windsor, Ontario N9A 6T3. Loans are made for a period not to exceed one week and machine copies may be made of the documentation by borrowers.

(NOTE: The questionnaires are under development and will be provided later.)

6.4   IN-LABORATORY QUALITY CONTROL

The variety of techniques available to the analysts will require one or more workshops to deal with this aspect of overall quality control. The information obtained from the questionnaires referred to under 6.3 -- DOCUMENTATION OF METHODOLOGY will be useful. in organizing the workshops. It will be desirable to devote a part of the workshop(s) time to separate sessions of the analysts involved in a group of parameters to relate specific quality control procedures to the specific problems associated with those parameters. The following parameter groups will be established:

- ▸ Nutrient and Water Quality
- ▸ Metals and Industrial Wastes
- ▸ Pesticides
- ▸ Microbiological
- ▸ Physical, including sample preparation techniques for sediments, soils and sludges.

NOTE: A meeting of analysts was held at the Ontario Ministry of Environment Laboratory, Rexdale, October 27 - 28, 1976.

Some form of documentation for data quality procedures will be required, but may vary according to laboratory involvement in PLUARG projects or studies.

~~Work Group C of the Data Quality Subcommittee, Implementation Committee of the Water Quality Board is preparing a query on this subject fo use with watershed study investigators and analysts~~

6.5   PROTOCOL FOR DATA QUALITY EVALUATION

6.51

Analytical results of inter-laboratory samples -- Reference and Round-Robins -- wil be sent to the ~~River Basin Studies Coordinator~~ Senior Scientist in an envelope marked "CONFIDENTIAL".

6.52

       The ~~River Basin Studies Coordinator~~ *Senior Scientist* will *tabulate the results from all participating analysts and send the tabulation to* all *participating analysts on a confidential basis without identifying the laboratories. The tabulation* will *be sent with a covering memorandum calling attention to obvious discrepancies and a preliminary evaluation of the data developed by the IJC Regional. Office Statistician. Addressees will be requested to give the* ~~River Basin Studies Coordinator~~ *Senior Scientist their evaluation of the data. Participating analysts* will *indicate whether or not they wish their response to be held in confidence.*

6.53

       The ~~River Basin Studies Coordinator~~ *Senior Scientist will provide the U.S. Principal Investigators, Canadian Project Officers, and appropriate Project Leaders with a tabulation of the analytical results from all laboratories, including the reactions received from each participating analyst concerning the results from his or her laboratory. U.S. Principal Investigators and Canadian Project Officers will be informed which laboratories are providing analytical services for studies for which they are responsible.*

6.54

The ~~River Basin Studies Coordinator~~ *Senior Scientist will personally consult with any analyst who reports analytical results which appear to be questionable. The* ~~Coordinator~~ *Senior Scientist* will *contact the project manager or contractee for whom the analyst is providing analytical services and invite their participation in meeting with the analyst. In such consultation, use* will *be made of the appraisal of data sets, not identifying the other participating analysts, from the Regional Office Statistician, and the participating analysts.*

6.55

In those instances that problems cannot be resolved with the participating analysts, the ~~Coordinator~~, *Senior Scientist and River Basin Studies Coordinator together with the project manager or contractee, will go to the next* level *of authority for the particular laboratory in an attempt to resolve problems.*

6.56

The leadership of Task C and PLUARG, using the appropriate Regional Office staff members, will consult with the appropriate member of the Water Quality Board regarding any quality control matters needing the attention of that member of the Board.

7.   DATA HANDLING AND PROCESSING

NOTE: This entire Section has been completely rewritten and is not typed in italics. The Section dated July 1975 may be discarded.

7.1   SYSTEM FUNCTION

The function of the Data Handling and Processing -- Data Management -- System is to provide water quality and quantity data to PLUARG participants, particularly Task C and D participants.

7.2   FILE FORMATS

Three separate formats will be used -- sample results, station description and parameter description. The latter two are seen as being exchanged once between investigators with updates as necessary. The sample results are foreseen as being exchanged on the basis of specific requests. This method is not meant to rule out the establishment of an archive of data, if this eventually becomes practical. However, current limitations in time, money, and manpower make this impracticable.

In order to allow the studies to report quality information there are established up to five levels of validation limits allowed for in the parameter description. These limits can be referred to in the results file by use of the remark field.

The capacity to record up to sixty-four results allows all analyses recorded at one location and time to be grouped; or, alternatively to record a profile of results at different depths or across a stream.

See Section 7.22 --- PLUARG Data Exchange Standards-File Formats

Each agencies' existing codes for station, sample number and parameter type and methodology will be used.

See Section 7.23 -- PLUARG Data Exchange Standards-Codes

7.22   PLUARG Data Exchange Standards - File Formats

7.221   Sample Results Master File

Field	Length	Type*	Position	Mandatory Else Optional
Agency Code	20	AN	43119	M
Station Code	15	AN	21-35	M
Sample Date	6	N	36-41	M
Sample Time:				
▸ Time Zone	1	N	42	
▸ Hour	2	N	43-44	
▸ Minute	2	N	45-46	
Composite Sample Information:				
▸ Time to:				
- Hour	2	N	47-48	
- Minute	2	N	49-50	
▸ No. of Samples	2	N	51-52	
▸ Time Interval	2	N	53-54	
▸ Depth Interval	5	N	55-59	
Time Precision	1	N	60	
Sample Number	10	AN	61-70	M
Sample Depth (in metres)	5(3.2)	N	71-75	
Sample Type	2	N	76-77	
Bearing from Reference (in degrees)	3	N	78-80	
Distance from Reference (in metres)	5(3.2)	N	81-85	
Filler	115	AN	86-200	
Number of Results in Variable Portion of Record	2	N	201-202	M
First Result:				
▸ Parameter Code	6	AN	203-208	M
▸ Result--in metric (SI) units mg/L except pesticides which should be µg/L	10(7.3)	AN	209-218	M
▸ Remark	2	AN	219-220	
▸ Sign	1	AN	221	
▸ Exponent Code	1	N	222	
▸ Analysis Method Code	2	N	223-224	
Up to 64 results may be entered (64 x 22 = 1408 positions)			203-1610	

*   AN - Alphanumeric; N - Numeric

7.222 Sample Station Description File

Field	Length	Type	Position	Mandatory Else Optional
Agency Code:				
‣ Country	2	AN	43101	M
‣ Province/State	2	AN	43162	M
‣ Organization	2	AN	43225	
‣ Organization Unit	2	AN	43288	
‣ Project/Study	5	AN	43355	
‣ Filler	7	AN	14-20	
Station Code	15	AN	21-35	M
Station Location:				
‣ UTM	19	AN	36-54	M
‣ Lat/Long	18	N	55-72	
‣ Hydrologic/Storet Code:				
• Major Basin*	3	N	73-75	M
• Minor Basin**	3	N	76-78	M
• Terminal Stream***	4	N	79-82	M
• Mileage	6	N	83-88	
• 1st Level				
- Stream Code	3	N	89-91	
- Mileage	6	N	92-97	
• up to 15 levels possible (15x9 - 135 positions)			89-223	
Station Description	200	AN	224-423	M
Station Description	100	AN	424-523	
Additional Optional Information				
Station Parameters:				
‣ Parameter Code	6	AN	43450	
‣ Result	10(7.3)	N	530-540	
Up to 10 parameters possible	160		524-683	

*   "Major Basin" refers to the Great Lakes Drainage Basin
**   "Minor Basin" refers to the individual lake (e.g. Huron)
***   "Terminal Stream" refers to the stream or river which terminates in the lake which comprises
         the "Minor Basin".

See notes which follow.

Notes -- <u>Sample Station Description File</u>

Latitude and Longitude Fields consist of the following subfields:

(1)   DEG (Two and three digits respectively): the degrees latitude or longitude.

(2)   MIN (two digits): the minutes latitude or longitude.

(3)   SEC (four digits): the seconds in the first two digits and the fraction of a second (decimal) in the last two digits. If this fraction is not available, then two zeros (0's) must always be entered after the decimal point.

(4)   PR (one digit): precision used to indicate accuracy of the latitude and longitude coordinates. For instance, if the location is determined to the nearest ten seconds, then a 5 is entered in the PR column. If the locations are determined on a 1:250,000 or 1:500,000 scale map, then most likely the location is determined to the nearest minutes; therefore a PR equal to 7 will be used.

UTM (Universal Transverse Mercator Grid) Coordinates Field consists of the following subfields:

(1)   UTM Zone - given on topographical maps.

(2)   Northing and Easting - obtained from topographical maps. These values must be entered with one decimal position.

(3)   PR: precision.

Latitude (W=-)   Longitude (W=-)   Pr Zone Northing (N=-)   Easting   Pr

| - | 4 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 4 | 0 | 5 | 3 | 0 | 0 | 0 | 6 | |

7.223 Sample Parameter Description File

Field	Length	Type	Position	Mandatory Else Optional
Agency Code	20	AN	43119	M
Parameter Code	6	AN	21-26	M
Analysis Method Code	2	N	27-28	
Unit of Measurement Code	2	N	29-30	
Parameter Description:				
▸ Full Description				
▸ Abbreviated Description	100	AN	31-130	M
▸ Abbreviated Column Description (5 x 12)	60	AN	131-190	
Analysis Method Description:				
▸ Full Description	660	AN	191-850	
▸ Abbreviated Column Description (5 x 12)	60	AN	851-910	
Unit of Measurement Description:				M
▸ Full Description	30	AN	911-940	
▸ Abbreviated Column Description (1 x 12)	12	AN	941-952	
Result Format	10	AN	953-962	M
Place of Analysis Code	1	AN	963	
Validation Limits:				
▸ From and to Up to 5 levels possible	20		964-983	
(5 x 20)	100		964-1063	

7.224 Land Use Description File

This section is under development.

7.225 Meteorological Data Description File

This section is under development.

7.3   PLUARG DATA EXCHANGE STANDARDS - CODES

Agency Code:

Country: U.S.A.   = US
                                Canada   = CN
Province/State: Ontario   = ON
                                Wisconsin   = WI
                                New York   = NY
                                Pennsylvania = PA
                                Ohio   = OH
                                Indiana   = IN
                                Michigan   = MI
                                Minnesota
                                Illinois

Station Code:
            Each Agency to use its own code.

Sample Date:

                                Year = NN
                                Month = NN
                                Day= NN

Sample No:
            Each agency to use its own codes.

Parameter Code:
            Each agency to use its own codes.

Station Location:
    UTM:
            Zone   = NN
            Easting   = NN NN NN NN
            Northing   = NN NN NN NN
            Precision   = N

Hydrologic/Storet Code:
            Major Basin - Each agency to use its own codes.
            Minor Basin - Each agency to use its own codes.
            Terminal Stream - Each agency to use its own codes.

7.4 REPORTING LOW LEVEL DATA

There are specific problems in the reporting of low level data which are associated with the question: is a substance present? While this question is seldom germane in IJC work concerned with loading estimation, it has so influenced thinking about reporting low level data that it seems best to consider it in some depth before dealing with how such data are to be reported for PLUARG's purposes.

In answering the question "is a substance present?", there are two possible correct conclusions which may be reached. One may conclude that the substance is present when it is present, and one may conclude that the substance is not present* when it is not present. Conversely, there are two possible erroneous conclusions which may be reached. One may conclude that the substance is present when it is not, and one may conclude that the substance is not present when it is. The first kind of error, finding something which is not there, is called a TYPE I ERROR. The second kind of error, not finding something which is there, is called a TYPE II ERROR.

_____

* Since Avogadro's number is very large, a pedant could argue that one should never claim that a substance is not present. A common sense meaning of not present is intended here, i.e. if measurement is being made in micrograms per litre the presence of a few nanograms per litre is irrelevant.

If the standard deviation, σ, of an analytical procedure has been determined at low concentrations including 0, then the probability of making a Type I error can be set by choosing an appropriate α level to determine the Criterion of Detection. †

For example, suppose that the standard deviation, σ, of an analytical procedure is 6 µg/litre and that an α of 0.05 is deemed acceptable so that the probability making a Type I error is set at 5%. The Criterion of Detection can then be found from a table cumulative normal probabilities to be 1.645 σ = 1.645 X 6 µg/litre ~ 10 µg/litre.


---
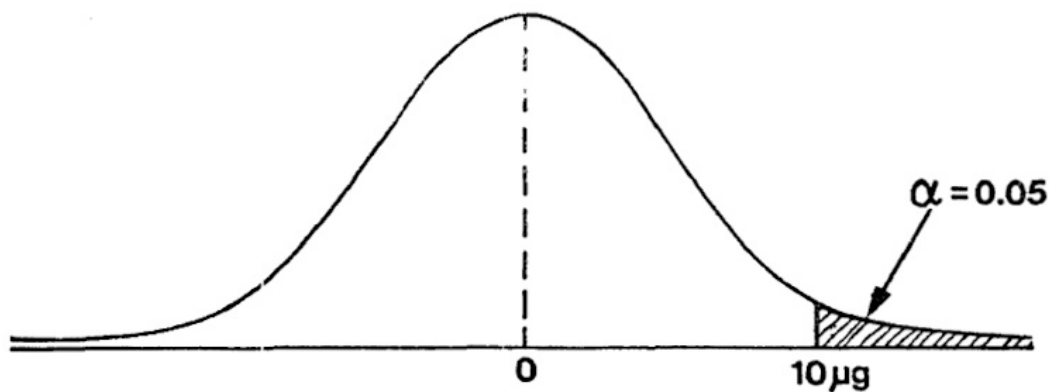
† Criterion of Detection may be a new term to some. It refers to the minimum analytical result which must be observed before it can be stated that a substance has been discerned with an acceptable probability that the statement is true. The terms Detection Limit or Limit of Detection are often used with this meaning, but in this Handbook they are reserved for a more appropriate usage.

Any value observed below 10 μg/litre would be reported as less than the Criterion of Detection, since to report such a value otherwise would increase the probability of making a Type I error beyond 5%.

Once the Criterion of Detection has been set, the probability of making a Type II error, β, or its complement 1-β, the probability of discerning the substance when it is present, can be determined for <u>given true situations.</u> (The probability 1-β is sometimes called the power of the test).

Consider the same analytical procedure as above with a Criterion of Detection of 10 μg/litre. Suppose that the concentration of the sample being analyzed is 10 μg/litre, i.e. the concentration is equal to the Criterion of Detection. If, all analytical results below the Criterion of Detection were reported as such, then the probability of discerning the substance would be 0.5 or 50%.
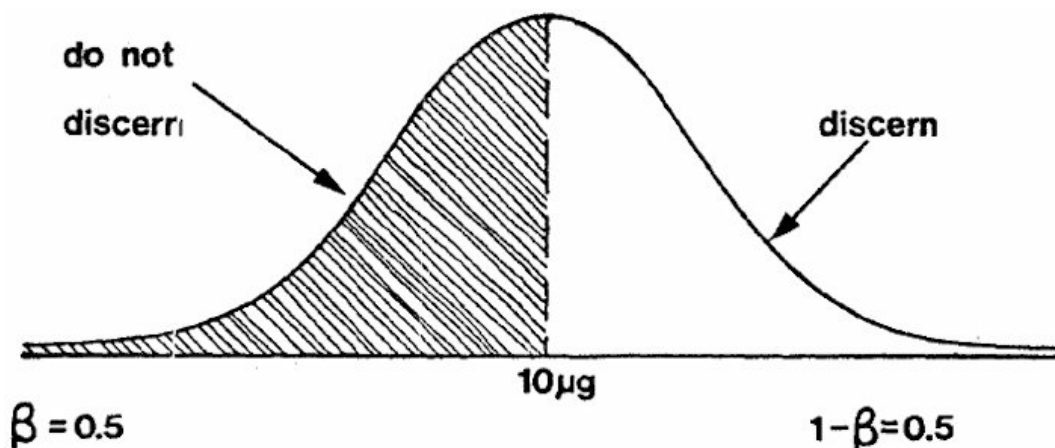
Conversely, the probability of making a Type II error and failing to discern the substance would also be 0.5. From this example it can be seen that the probability of discerning a substance when its concentration is equal to the Criterion of Detection is hardly overwhelming. In order for the probability of a Type II error to be equal to the probability of a Type

I error, β= α, then the concentration of the sample being analyzed must be twice the Criterion of Detection.
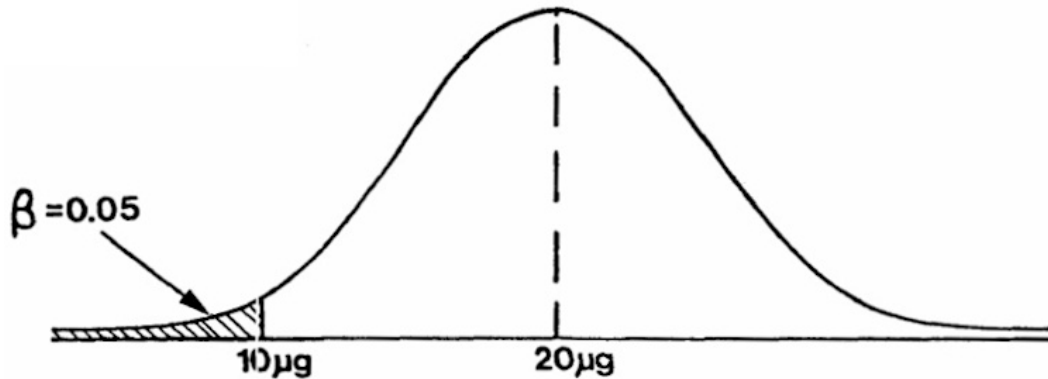
This concentration of twice the Criterion of Detection is the _Limit of Detection_ when it has been decided that the risk of making a Type II error is to be equal to the risk of making a Type I error.

The concept of Type II error has been emphasized because it usually ignored. Generally, attention is paid to the avoidance of Type I error with no consideration given to the probability of making a Type II error. It should be recognized that when the probability of making a Type I error is decreased, i.e. setting a smaller, the probability Of making a Type II error is increased.

Having, it is hoped, made clear the conceptual context in which an α-level set and the difference between the Criterion of Detection and the Limit of Detection, PLUARG's requirements in the reporting of low level data can be considered.

In general, only under highly exceptional circumstances need there be a concern with avoiding Type I error when reporting data for IJC purposes.

There are two reasons why Type I error is not a concern. First, the IJC is not an enforcement agency, and therefore not concerned that a single datum will lead it into a false accusation that a substance is present when it is not. Second, in virtually all cases data are aggregated for IJC purposes in order to provide estimates of loadings and/or concentrations; therefore the avoidance of Type I error relates to data sets and not to the individual datum.

In practice, these considerations mean that the Criterion of Detection may be set as low as possible. To state it another way, the α-level may be high.

On the other hand, when reporting data for IJC purposes every effort must be made to avoid Type II error.

The reason is obvious. When data are reported ass "below the Limit of Detection", they are virtually useless for either estimating loadings or concentrations.

In practice, this consideration means that if a numbers can be obtained, it is to be reported.

7.41   Codes To Be Used In Reporting Low Level Data

At its April 12, 1976 meeting the Data Quality Subcommittee of the Water Quality Board passed a resolution that 2 new codes be made available in data storage systems for remarks concerning data used in IJC reports.

The codes are T and W.

The T code has the following meaning: "Value reported is less than Criterion of Detection." The use of this code warns the data user that the individual datum with which it is associated does not, in the judgement of the laboratory which did the analysis, differ significantly from 0.

It should be reccgnized that an implied significance test which fails to reject the null hypothesis that a result does not differ from a standard value in no way diminishes the value the result as an estimate. To illustrate: a result of 9 μg on a test whose σ = 6 μg can not be regarded as significantly different from 0 for any α-level less than 0.067; however, if a significance test were made with α = 0.1, then the null hypothesis would be rejected and the result deemed significantly different from 0.

So the result, 9 μg, could be reported as "Below the Criterion of Detection" for all α less than 0.067 and could be reported as simply "9 μg" for all α a greater than 0.067. But however reported, the result of 9 μg remains the best estimate of the true value since changing the risk of making a Type error neither augments or diminishes the value of an estimate.

It may be added that low level results are better estimates, in the sense of being more precise, than higher results since for all analytical tests with which we are acquainted the standard deviation of the test increases with the concentration.

The W code has the following meaning: "Value observed is less than lowest value reportable under T code". This code is used when a positive

value is not observed or calculated for a result. In these cases the lowest reportable value, which is the lowest positive value which is observable, is reported with the W.

The following example illustrates the use of the codes:

Suppose that a laboratory has determined that its Criterion of Detection for total phosphorus is 10 µg/litre, and suppose in addition that the smallest increment that can be read on the analytical device corresponds to a concentration of 2 µg/litre. Given these conditions, any Value observed ≥10 µg/litre would be reported without an accompanying code; any value observed ≥2 µg and <10 µg would be reported with the T code; if no instrument response were observed, the result would be reported as 2W.

7.5   ESTIMATING TRIBUTARY LOADINGS

NOTE: This is a new Subsection added in March 1977, and is not typed in script.

The efficient estimation of tributary loadings when supplementary information such as the mean annual flow is available, requires the use of a "ratio estimator". The ratio estimator described below has been tested in the IJC Regional Office through random sampling experiments using actual tributary data sets. Estimates of 1975 water year tributary loadings reported by the Surveillance Subcommittee have been recalculated with this (Beale's) estimator, and it will be used for 1976 and subsequent years to ensure that estimates will be compatible.

7.51   Ratio Estimator for Estimating Tributary Loadings

The estimator given below is due to E.M.L. Beale. In the form given below terms 1/N, where N is the population size, have been ignored since for a year N approximates

the number of seconds in a year.

$$\tilde{\mu}_y = \mu_x \cdot m_y /m_x \cdot \frac{[\ 1 + 1/n \cdot S_{xy} /m_y\ m_x\ ]}{[\ 1 + 1/n \cdot S_x^2 /m_x^2\ ]}$$

where μ_x = mean daily flow for the water year

m_y = mean daily Loading for the days concentrations were determined

m_x = mean daily flow for the days concentrations were determined

n = number of days concentrations were determined

$$S_{xy} = \frac{\sum\limits_{i=1}^{n} X_i\ Y_i - n \cdot m_y\ m_x}{n-1}$$

$$S_x^2 = \frac{\sum\limits_{i=1}^{n} X_i^2 - n \cdot m_x^2}{n-1}$$

and the X_i and Y_i are the individual measured flow and calculated loading, respectively, for each day concentrations were determined.

The mean-square-error of this estimator may be estimated to terms of the order n^{-2}, assuming the population size is very large by,

$$\hat{E}\ (\tilde{\mu} - \tilde{\mu}_y)^2 = m_y^2 \cdot \left[\ 1/n \cdot (S_x^2 /m_x^2 + S_y^2 /m_y^2 - 2\ S_{xy} /m_x\ m_y)\right.$$

$$+ 1/n^2 \cdot \{\ 2\ (S_x^2 /m_x^2\ )^2 - 4\ S_x^2 /m_x^2 \cdot S_{xy} /m_x\ m_y$$

$$\left. + (S_{xy} /m_x\ m_y\ )^2 + S_x^2 /m_x^2 \cdot S_y^2 /m_y^2\ \}\ \right]$$

Where S_y^2 is calculated analagously to S_x^2.

The estimator is discussed in:

TIN, M., Comparison of some ratio estimators, J. Amer. Statist. Ass., Vol. 60,

pp. 294ff., 1965.

KENDALL, M.G. and STUART, A., The Advanced Theory of Statistics Vol. 3, 2nd Edition, Hafner Pub. Co., N.Y., 1968, pp. 217f. and p. 233 (exercise 40.14).

8. DATA ASSESSMENT

Assessment of data during the course of the study will facilitate making any desirable adjustments in the watershed studies to meet the needs of PLUARG.

8.1 _ASSESSMENT OF QUALITY CONTROL_ DATA

The Regional Office Senior Scientist will assess the data from between-laboratory comparisons as outlined in Subsection 6.5 -- PROTOCOL FOR DATA QUALITY EVALUATION.

The River Basin Studies Coordinator will assess the data from blind replicate samples as called for in Subsection 6.1 -- BLIND REPLICATES FROM FIELD TO LABORATORIES.

8.2 ANNUAL DATA

In addition to the continuing assessment of data by _each_ study leader for his or her project or subproject, an overall annual assessment of data is desirable. To permit this latter assessment the following procedures will be used.

8.21

As soon after the close of the field season as possible, each study leader will send ~~a summary~~ _an appraisal_ of the data ~~covering analyses~~ for each parameter monitored in that study to the Coordinator. _For data on parameters analyzed by_ two _or more laboratories,_ the summary should consist of a tabulation of the raw data, including sample source, date of sampling and analytical results. ~~for each of the parameters analyzed in duplicate.~~ Data, should be grouped chronologically according to 8.211. _For data covering blind replicate samples, the summary should consist of actions taken by project study leaders and analysts to correct any observed deficiencies._

8.211   Format for Annual Data Assessment

COMPARISON OF WATER QUALITY ANALYSES*
LABORATORY X AND LABORATORY Y
Agricultural Watershed K, Site 4

Date	Total N (Mg/L)		Nitrate N (Mg/L)		Total P (Mg/L)	
1975	Lab. X	Lab. Y	Lab. X	Lab. Y	Lab. X	Lab. Y
Apr.19	9.3	8.8	8.2	7.7	0.182	0.15
May 29	3.7	6.9	5.5	5.6	0.656	0.29
July 10	6.5	6.6	5.6	5.6	0.279	0.27
Oct.28	2.8	3.6	1.9	2.8	0.150	0.15
Dec.23	13.4	13.6	12.3	13.0	0.166	0.11

*   The information required under 6.3 -- DOCUMENTATION OF METHODOLOGY and,
if appropriate, under 6.1 -BLIND REPLICATES FROM FIELD TO LABORATORIES will
be used for data assessment in association with the analyses results.

8.22

The Coordinator will review the data and take the necessary steps for
clarification of questionable data with the study leaders reporting on the same
parameter(s).

9. REFERENCES

NOTE: This Section has been completely revised and is not typed in italics. The Section dated July 1975 may be discarded.

NOTE: References available in the IJC Regional Office Library for loan to investigators and analysts are indicated by "*" in front of the listing. Requests for loans should be addressed to: Librarian, IJC Regional Office, 100 Ouellette Avenue, Windsor, Ontario N9A 6T3. Loans are made for a period not to exceed one week and borrowers may make machine copies of items if they desire.

Agriculture Research Service, USDA; Control of Water Pollution from Cropland; November 1975. May be purchased from Superintendent of Documents, USGPO, Washington, D. *C.* 20402.

Anderson, James R., Hardy, Ernest E., and Roach, John T.; 1972; A Land Use Classification System for Use with Remote Sensor Data; USGS Circular 671; U.S. Geological Survey, Washington, D. C. 20242.

*Armstrong, D. E., *et. al.*, Minutes of July 16-17, 1974 meeting Subcommittee on Analytical Methods, Task Group C Technical Committee, PLUARG.

Baker, D. B., Jackson, W. B. and Prater, B. L.; Proceedings, Sandusky River Basin Symposium; Heidelberg College, Tiffin, Ohio; May 2-3, 1975.

*Braun, H. E., OMAF, Guelph – Analytical Methodology for O.P. & O.C. insecticides & PCBs.

*Budde, W. L. and Teuschler, J. M.; Improved Analytical Quality Assurance for Laboratory Automation; U. S. EPA, Cincinnati, Ohio.

*Burger, Allan, OMOE, Laboratory Services Branch, Rexdale, Ont. --
Sampling total coliforms, fecal coliforms, and fecal streptococcus in water.
Analytical Methodology for Total coliform; fecal coliform; fecal streptococcus.

*Chan, H. T., OMOE, Toronto, Ont. –
Analytical Methodology for phosphorus, nitrogen, salts & organic parameters; total coliform, fecal coliform, background colonies, fecal streptoccocci; phosphorus extractable from soil; PO_4 Isotherm grain-size distribution;

permeability; Atterberg's limits (plasticity index).

*Clark, J. C., Calculation of Tributary Loadings; (Method approved by Surveillance Subcommittee, Implementation Committee, Water Quality Board, IJC); February 19, 1976.

*Coote, D. Richard, Agriculture Canada, Ottawa - <u>Sampling</u> feedlot and manure storage runoff.

*Costescu, Leslie, Agriculture Canada, Ottawa – <u>Analytical Methodology</u> for organic matter in sediments.

*Darcel, F. C., OMOE, Rexdale, Ont. – Preparation of sediment and soil samples and <u>Analytical Methodology</u> for metals in sediment and soils.

*Derbyshire, J. B., University of Guelph, Guelph, Ontario - <u>Analytical Methodology</u> for bovine enteroviruses.

*Dieken, Fred, OMOE, Toronto Central Lab. –
<u>Analytical Methodology</u> for filtered alkalinity; turbidity; pH (at Lab.); total iron; filtered sulphate; filtered reactive silicates; filtered nitrate + nitrite; filtered chloride; unfiltered ammonium; filtered ammonia; filtered reactive phosphates; filtered total phosphorus; total phosphorus, and total Kjeldahl nitrogen.

*Dube, D. J., State Hygiene Lab., U. of Wis. --
<u>Analytical Methodology</u> for total and soluable P; total ammonia; filtered dissolved solids; organic nitrogen; nitrite - N; nitrate - N; conductivity; sulfate; chlorides; dissolved reactive silicates.

Environmental Protection Service, Environment Canada; Spray Irrigation of Treated Wastewater Effluents -- Seminar Notes; April 9, 1975.

*Fairless, Billy, U.S. EPA, Chicago – Proposed <u>Analytical Methods</u> for PLUARG Shore Line Erosion Study with attached reactions to the proposal by:
    Dr. Larry Wilding, Ohio State University
    Dr. R. L. Thomas, CCIW
    Mr. F. C. Darcel, OMOE, Rexdale
    Dr. C. G. Kowalenko, Soil Res. Inst., Ottawa
    Dr. M. Ihnat, Chem. & Bio. Res. Inst., Ottawa

Federal Advisory Committee on Water Data, Summary of Eighth Meeting, May 9, 1973; Office of Water Data Coordination, U. S. Geological Survey, National Center, MS 417, Reston, Virginia 22092.

Federal Interagency Work Group on Designation of Standards for Water Data Acquisition, 1972, Recommended Methods for Water Data Acquisition; Chief, Office of Water Data Coordination, U. S. Geological Survey, National Center, MS 417, Reston Virginia 22092.

*Glutek, David, OMOE, London Regional Lab. --
Analytical Methodology for phenols; pH; filtered sodium; filtered potassium; filtered calcium; filtered magnesium; conductivity total iron; suspended solids; filtered alkalinity; total phosphorus; filtered total phosphorus; filtered dissolved reactive phosphours; filtered nitrate + nitrite; total Kjeldahl nitrogen; filtered free ammonia; unfiltered free ammonia; filtered sulphate; filtered chloride; filtered reactive silicates.

*Goerlitz, D. F. and Law, L. M., Determination of Chlorinated Insecticides in Suspended Sediment and Bottom Material, U. S. Geological Survey; Reprint from Journal of the AOAC, Vol. 57, No. 1, 1974.

Guy, Harold P., 1969, Laboratory Theory and Methods for Sediment Analysis; Techniques of Water-Resources Investigations; Book 5, Chapter CI, U. S. Geological Survey; U. S. Government Printing Office, Washington, D. C. 20402 -- Stock Number 2401-0501, Price 65 cents.

Guy, Harold P., and Norman, Vernon W., 1970; Field Methods for Measurement of Fluvial Sediments -- Techniques of Water-Resources Investigations; Book 3, Chapter C2, U. S. Geological Survey; U. S. Government Printing Office, Washington, D. C. 20402 -- Stock Number 2401-0936, Price 70 cents.

Horowitz, J. Adams, J. R. and Bazel, L. A.; Water Pollution Investigation: Maumee River and Toledo (Ohio) Area; January 1975; May be purchased from National Technical Information Services Springfield, VA 22151.

*Hynes, H. B. N., and Dance, K. W., University of Waterloo, Waterloo --
Sampling solid organic matter, coarse material and fine particle; bottom sediment; autumnal leaf fall.
Analytical Methodology for solid organic matter; bottom sediments; autumnal leaf fall and blow into stream.

*Ihnat, Milan, Agriculture Canada, Ottawa - <u>Analytical Methodology</u> for total Cu, Zn, Cd, Pb.

*King, D. E., OMOE, Rexdale, Ont. --
    <u>Sampling</u> streams for phosphorus parameters. Sample filtration and handling for dissolved total phosphorus and filtered reactive phosphorus.

*Knap, Katherine, Ontario Ministry of Natural Resources -
    <u>Sampling</u> river bank material.
    <u>Analytical Methodology</u> for total nitrogen; exchangeable ammonia; cation exchange capacity; exchangeable cations; total mercury; clay mineralogy; extractable Fe; oxalate extractable Fe & Al; heavy metals; total carbonates; organic matter; pH; particle size distribution.

*Kowalenko, G., Soil Research Institute, Ottawa -
    <u>Analytical Methodology</u> for soil samples.

*Krishnamurty, K. V., Shpirt, E. and Reddy, M. M., N. Y. Dept. Health -- Trace Metal Extraction of Soils and Sediments by Nitric Acid - Hydrogen Peroxide.

*LaHay, Katherine L., Acton, C. J. and Wall, G. J., University of Guelph --
    <u>Sampling</u> soils, bottom sediments and suspended sediments, including physical measurements in the field and stream at the time sediments are collected.
    <u>Analytical Methodology</u> for particle size distribution; suspended sediment concentration; clay mineralogy; sample pH; iron; amorphous content; organic matter; total carbonates; and cation exchange capacity.

*Logan, Terry J., The Ohio State University, Columbus -
    <u>Sampling</u> surface runoff - all samples:

Nutrients:	Filtered - Reactive ortho P; NO_3, NH_4 Unfiltered - total N; total P	
Minerals:	Filtered - Ca, Mg, K, Na, CO_3, HCO_3 Unfiltered - Carbonates, <2μ mineralogy	
Physical:	Filtered - pH, electrical conductivity Unfiltered - cation exchange capacity, particle-size distribution, sediment concentration	
Organic:	Filtered - none	
	Unfiltered - organic carbon	

    <u>Sampling</u> surface runoff - selected samples (in addition to parameters for all samples):

Nutrients: Filtered   - Total N
Unfiltered - Organic P, P Forms, Available P, Exch. NH_4
Minerals: Filtered - Si, Al, Fe
Unfiltered - Free Fe and Al; amorp. Fe, Al, Si; exch. Ca, Mg, K, Na; >2μ mineralogy; trace metals
Physical: Filtered - none
Unfiltered - Cation exchange capacity (CEC)
Organic: Filtered - organic carbon Unfiltered - pesticide scan; BOD

<u>Sampling</u> tile drainage - all samples:
Nutrients: Filtered - ortho-P, NH_3, NH_4
Unfiltered - Total N, total P
Minerals: Filtered - Ca, Mg, K, Na, CO_3, HCO_3
Unfiltered - Carbonates
Physical: Filtered - pH, E.C.
Unfiltered - sediment concentration
Organic: None

<u>Sampling</u> tile drainage - selected samples (in addition to parameters for all samples):
Nutrients: Filtered - Total N, Total P
Unfiltered - None
Minerals: Filtered - Si, Al, Fe
Unfiltered - Free Fe, Al; amorphous Fe, Al, Si
Physical: Filtered - None
Unfiltered - 2 μ mineralogy; CEC;
particle size distribution
Organic: Filtered - Organic carbon
Unfiltered - organic carbon

<u>Sampling</u> stream samples - selected samples. Parameters include those for surface runoff selected samples.

<u>Sampling</u> bottom sediment - selected samples. Parameters include those for surface runoff selected samples. In addition, dissolved oxygen (DO) is measured in the field.

<u>Analytical Methodology</u> for reactive orthophospate; total phosphorus; amorphous Silica; NO_3 + NH_4-N; sediment concentration; heavy metals in sediment and water; pH; cations; organic carbon; particle size distribution; carbonate in sediment; electrical conductivity; carbonates and bicarbonates; amorphous iron and aluminum; mineralogy.

*MacLean, A. and Schnitzer, M.,
<u>Sampling</u> and <u>Analytical Methodology</u> for metals in soils and sediment and

<u>Sampling</u> water for trace metal analysis (preliminary).

*Misterek, D. L., Wis. DNR, Milwaukee
<u>Sampling</u> river water for selected nutrients, minerals, physical and organic parameters, metals, pesticides, bacteria and phenols.

National Institute of Environmental Health Sciences; Heavy Metals in the Environment; Vol. 12, Environmental Health Perspectives, DHEW publication No. (NIH) 76-218, Box 12233, Research Triangle Park, North Carolina 27709.

Nelson, D. E. and Coakley, J. P., Techniques for Tracing Sediment Movement; Scientific Series No. 32, Canada Centre for Inland Waters, Burlington, Ontario, 1974.

*Nicolson, John A., Canadian Forestry Service, Sault Ste. Marie -
<u>Sampling</u> stream water for selected nutrients, minerals, and physical and organic parameters.
<u>Analytical Methodology</u> for unfiltered ammonia; dissolved nitrate + nitrite; total dissolved Kjeldahl nitrogen; particulate nitrogen; total dissolved phosphorus; particulate phosphorus; dissolved chloride; dissolved sulphate; dissolved reactive silicate; particulate carbon; dissolved sodium; dissolved potassium; dissolved magnesium; dissolved calcium; dissolved iron; dissolved organic carbon (filtered); conductivity; pH.

*Odom, Paul, Beak Consultants Ltd., --
<u>Stream Sampling</u> and sample handling for pH, Cond., total hardness, total alkalinity, NO_3, NO_2, PO_4, dissolved PO_4, total coliforms, fecal coliforms, NH_3, TKN, Ortho PO_4.

Omernik, J. M.; The Influence of Land Use on Stream Nutrient Levels; Corvallis Environmental Survey Branch, Corvallis, Oregon; January 1976. May be purchased from National Technical Information Service, Springfield, VA 22151.

*Onn, Dennis, OMOE, Toronto, Ontario --
<u>Sampling</u> streams for water quality, including pesticides, PCBs, metals, and bacteriological parameters; and sediments for sediment discharge and chemical and physical characterization of sediments.

*Patni, N. K., Animal Research Institute, Ottawa, Ont. --
<u>Sampling</u> subsurface tile water and surface stream drainage water.
<u>Analytical Methodology</u> for total phosphorus (filtered and unfiltered); total

Kjeldahl nitrogen (unfiltered); ammonia and nitrate nitrogen (unfiltered); potassium (unfiltered); total solids; non-filterable solids; non-filterable volatile solids; and bacteria.

*Payne, David A., U. S. EPA, Chicago --
  Brochure for Ecolo-Trol, regarding reference materials for suspended solids analysis.

Peck, John H., Michigan Water Quality Control Laboratory -
  <u>Sampling</u> and <u>Analytical Methodology</u> for water samples; Dept. of Natural Resources, Stevens T. Mason Bldg., Lansing, Michigan 48926.

Porterfield, George, 1972, Computation of Fluvial-Sediment Discharge; Techniques of Water-Resources Investigations; Book 3, Chapter C3, U. S. Geological Survey; U. S. Government Printing Office, Washington, D. C. 20402 -- Stock Number 2401-2061, Price 75 cents.

*Reddy, M. M., N. Y. State Dept. of Health --
  Summary of Procedures for "The <u>Chemical Analysis</u> of Water and Sediments" -- selected nutrients and metals.

*Robinson, J. B., Environmental Biology, University of Guelph -<u>Sampling</u> stream water.
  <u>Analytical Methodology</u> for NH_4-N; Nitrate-N; Chloride; and Organic N.

*Sanderson, Marie, and Osborne, Robert, University of Windsor -
  <u>Sampling</u> precipitation for selected nutrients, minerals and physical parameters.
  <u>Analytical Methodology</u> for sulfate (SO_4); sulfite (SO_3); unfiltered chloride (Cl); magnesium; calcium; potassium and sodium; conductivity (in lab); filtered nitrate + nitrite; unfiltered total Kjeldahl nitrogen; dissolved and suspended phosphate; total suspended and volatile suspended solids.

Sedimentation Committee, U. S. Water Resource Council; Proceedings of the Third. Federal Inter-Agency Sedimentation Conference, 1976. Inquiries regarding availability may be addressed to John N. Holman, Soil Conservation Service, Washington, D. C. 20250.

*Sheppard, Steve C., and Miller, M. H., University of Guelph -
  <u>Sampling</u> suspended sediment collected in farm fields; composite field soil samples.
  <u>Analytical Methodology</u> for particle size distribution of suspended sediment in

cropland runoff; particle size distribution of field soil samples; digested N + P in suspended sediment in cropland runoff and field soil samples; dissolved orthophosphates on filtered samples of cropland runoff; ammonium nitrogen in cropland runoff water; nitrate + nitrite nitrogen in cropland runoff water.

*Sliwinski, J. F., Beak Consultants Limited, Toronto -
    Analytical Methodology for total coliform; alkalinity; total hardness; conductivity; pH; fecal coliform; total phosphorus; unfiltered nitrate; unfiltered total Kjeldahl nitrogen; unfiltered ammonia (all in land runoff and drains).

*Sirons, G. J., OMAF, Guelph --
    Analytical Methodology for Triazines; Dicamba + ce-phenoxy alkanoic acids.

*Soil Conservation Service, U. S. Dept. Agriculture --
    "Soil Survey Laboratory Methods and Procedures for Collecting Soil Samples." Soil Survey Investigations Report No. 1, April, 1972; U. S. Government Printing Office, Washington D. C. 20402 -- Stock Number 0107-0298, Price 65 cents.

*Stainton, Capel and Armstrong, Environment Canada --
    "The Chemical Analysis of Fresh Water." Misc. Special Publication No. 25, 1974, Freshwater Institute, Dept. of the Environment, 501 University Crescent, Winnipeg, Manitoba R3T 2N6.

*Thomas, R. L., CCIW, Burlington, Ont. --
    Methods used at CCIW for the determination of P fractions in sediment fractions: apatite and non-apatite P; organic P; acid-extractable P; orthophosphate in solution.

Thompson, J. F., Manual of Analytical Methods: Prepared by the Pesticides and Toxic Substances Effects Laboratory, National Environmental Research Center, Research Triangle Park, North Carolina 27711. (Those wishing this Manual should contact Mr. Thompson at the above address.)

*Topp, G. C., Soil Research Institute, Ottawa --
    Sampling and Analytical Methodology for in situ physical properties of soils.

U.S. Agricultural Research Service; Factors Involved in Land Application of Agricultural and Municipal Wastes; July 1974; National Program Staff; Soil, Water and Air Sciences, Beltsville, Md. 20705.

U.S. EPA; Evaluation of Land Application Systems --
Evaluation checklist and Supporting Commentary; Sept. 1974; Office of Water Program Operation, U. S. EPA, Washington D. C. 20460.

U.S. EPA; Handbook for Analytical Quality Control in Water and Wastewater Laboratories; EPA Analytical Quality Control Laboratory; National Environmental Research Center, Cincinnati, Ohio; June 1972.

U.S. EPA; Non-Point. Source Pollution Seminar -- Section 108(a) Demonstration Projects -- Pollution Control in Great Lakes; November 20, 1975; May be purchased from National Technical Information Service, Springfield, Va. 22151.

U.S. EPA, U. S. Dept. Agriculture and National Assoc. State Universities and Land Grant: Colleges; Proceedings of the Joint Conference on Recycling Municipal Sludges and Effluents on Land, July 9-13, 1975; Inquiries regarding availability should be addressed to: National Assoc. of State Universities and Land Grant Colelges, One Dupont Circle, N. W., Washington D. C. 20036.

U. S. Soil Conservation Service; Agricultural Waste Management Field Manual; August 1975.

Uttormark, P. D. Chapin, J. D. and Green, K. M.; Estimating Nutrient Loadings of Lakes from Non-Point Sources; Water Resources Center, University of Wisconsin, Madison, Wisconsin; August 1974. May be purchased from Superintendent of Documents, USGPO, Washington, D. C. 20402. Price $l.90.

*Walker, R. J., and Gaynor, J. D., Dept. of Agriculture, Harrow, Ontario --
Sampling stream water for selected nutrients, minerals, heavy metals and physical parameters.
Analytical Methodology for sediment-suspended solids; sodium (filtered); Ca, Mg (filtered); nitrite-N; total soluble phosphorus (filtered); reactive phosphate (filtered); potassium filtered); Cr (unfiltered); metals (unfiltered).

*Wiebe, H. A., Environment Canada, Downsview, Ont. --
Analytical Methodology for total dissolved phosphorus; dissolved nitrate + nitrite; dissolved chloride; dissolved sulfate.

* * * * *
ADDED March 1977

*Baker, D. B., *et. al.*, River Studies Laboratory, Heidelberg College, Ohio --
Sampling and Analytical Methodology for soluble ortho-phosphorus, ammonia, nitrate plus nitrite, chloride, silica, conductance, suspended solids, total phosphorus, total Kjeldahl nitrogen, total organic carbon, and metals in stream water.

Thomas, R. L., CCIW, Burlington, Ont --
A Note on the Relationship of Grain Size, Clay Content, Quartz and Organic Carbon in some Lake Erie and Lake Ontario Sediments; Journal of Sedimentary Petrology for June, 1969.

*Veska, Eric, Brock University, St. Catharines, Ont. -
Analytical Methodology for metals in sediments, stream water and well water.

10. INVESTIGATORS

NOTE: This Section has been revised and is not typed in italics, The Section dated July 1975 should be discarded.

      The following list was current on June 15, 1976. Additions, deletions, and changes of address or telephone numbers should be sent promptly and in writing to Dr. Darnell M. Whitt, River Basin Studies Coordinator, IJC Regional Office, 8th Floor, 100 Ouellette Avenue, Windsor, Ontario N9A 6T3.

      In Subsections 10.2 and 10.22, only the Project Leaders and Analysts for each project are listed, with no attempt to include researchers involved in other aspects of the projects.

10.1 <u>UNITED STATES</u>

10.11 <u>PRINCIPAL INVESTIGATORS</u>

Name, Address, Telephone	Responsibility or Interest
Dr. John Konrad Supervisor of Special Studies Wisconsin Dept. of Natural Resources P.O. Box 450 Madison, Wisconsin 53701 (608)266-1956	Menomonee River Basin Also, U. S. Chairman Task Group C, PLUARG
Dr. Thomas G. Bahr, Director Institute of Water Research Michigan State University East Lansing, Michigan 48823 (517)353-3743	Felton-Herron and Mill Creeks

Name, Address and Telephone	Responsibility or Interest
Dr. L. J. Hetling, Director Environmental Quality Research and Development Unit New York State Department of Environmental Conservation 50 Wolf Road, Room 519 Albany, New York 12233 (518)457-7470	Genesee River Basin
Dr. Terry J. Logan Agronomy Department The Ohio State University 1885 Neil Avenue Columbus, Ohio 43210 (614)422-2001	Maumee River Basin -- Ohio Supplement

10.12   Project Leaders and Analysts

Menomonee River Basin -- Wisconsin

Dr. John G. Konrad (Address above)	Project Leader
Mr. David L. Misterek Wisconsin Dept. of Natural Resources 9722 West Watertown Plank Road Milwaukee, Wisconsin 53226 (414)257-6936	Field Coordinator
Mr. Douglas J. Dube Wisconsin State Lab. of Hygiene 465 Henry Mall Madison, Wisconsin 53706 (608) 262-1293	Analyst for all parameters
Mr. Joseph J. Delfino (same address as Dube)	Analyst for all parameters

Felton-Herron and Mill Creeks -- Michigan

Dr. Thomas G. Bahr (Address Above)	Project Leader
Dr. Frank M. D'Itri Institute of Water Research Michigan State University East Lansing, Michigan 48824 (517)353-3744	Analyst for Water and Sediment parameters

Name, Address and Telephone	Responsibility or Interest

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Pesticide Research Center
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East Lansing, Michigan 48824
(517) 353-6376

<u>Genessee River Basin -- New York</u>

Dr. Leo J. Hetling (Address Above) — Project Leader

Dr. Michael Reddy
Environmental Health Center
Division of Laboratories and Research — Analyst for Heavy Metals and
New York State Department of Health — Sediments
New Scotland Avenue
Albany, New York 12201
(518) 474-7999

Dr. Arthur Richards
Environmental Health Center
Division of Laboratories and Research
New York State Department of Health — Analyst for Nutrients in Water
New Scotland Avenue
Albany, New York 12201
(518)474-5838

Mr. James C. Daly
Quality Control Officer
Environmental Health Center
N. Y. State Department of Health — Quality Control
99 Central Avenue
Albany, New York 12206
(518) 474-7999

<u>Maumee River Basin -- Ohio Supplement</u>

Dr. Terry J. Logan (Address Above) — Project Leader and
Analyst for all parameters

<u>Riverbank Erosion Study</u>

Mr. William F. Mildner, Geologist
U. S. Soil Conservation Service
269 Federal Bldg. No.1 — Project Leader
Hyattsville, Maryland 20782
(301)436-8655

Name, Address and Telephone	Responsibility or Interest
Dr. Terry J. Logan(Address Above)	Analyst for all parameters

10.13 Others

Black Creek (Maumee River)-- Indiana

Dr. R.Z. Wheaton
Agr. Eng. Dept.
Purdue University
Lafayette, Indiana 47907
(317)749-2971

Project Leader, Black Creek
(Section 108,P. L.92-500)

Dr. L. E. Sommers
Agronomy Dept.
Purdue University
Lafayette, Indiana 47907
(317) 749-2891

Analyst for all parameters

Dr. D. Nelson
(Same Address as Sommers)

Analyst for all parameters

Washington County Project -- Wisconsin

Dr.T.*C.*Daniel
Water Resources Center
University of Wisconsin
Madison, Wisconsin 53706
(608) 263-6990

Project Leader
(Section 108,P.L.92-500)

Red Clay Project -- Wisconsin, Minnesota

Mr. Stephen Andrews
Room 204
Douglas County Courthouse
Superior, Wisconsin 54880
(715) 394-0428

Project Leader
(Section 108, P.L.92-500)

U. S. Geological Survey
Madison, Wisconsin
(608) 262-2488

Analysts for QW, SS, pH

U. S. Geological Survey
St. Paul, Minnesota
(612) 725-7841

Analysts for QW, SS, pH

Name, Address and Telephone	Responsibility or Interest
Center for Lake Superior Environmental Studies University of Wisconsin Superior, Wisconsin (715) 392-8101x 303	Analysts for QW

Sandusky River Basin -- Ohio

Dr. David B. Baker Associate Professor Heidelberg College Tiffin, Ohio 44883 (419) 448-2198	Project Leader and Analyst for all parameters

10.2   CANADA

10.21   PROJECT OFFICERS

Name, Address and Telephone	Responsibility or Interest
Mr. Donald N. Jeffs Assistant Director Water Resources Branch Ontario Ministry of the Environment 135 St. Clair Ave. West Toronto, Ontario M4V 1P5 (416) 965-4590	Canadian Chairman Task Group C, PLUARG
Dr. H. V. Morley Research Coordinator (Environment and Resources) Agriculture Canada K.W. Neatby Bldg. Room 1113 Carling Avenue Ottawa, Ontario K1A 0C6 (613) 994-5402	Federal Agricultural Studies
Dr. R. Frank Provincial Pesticide Residue Testing Laboratory Ontario Ministry of Agriculture & Food University of Guelph Guelph, Ontario N1G 2W1	Provincial Agricultural Studies
Mr. R. C. Hore Water Resources Branch Ontario Ministry of the Environment 135 St. Clair Avenue West Toronto, Ontario M4V 1P5 (416) 965-2105	Urban, Industrial, Transportation and Waste Management Studies; and Network Monitoring Stations

10.22   Project Leaders and Analysts

10.221   Activity No. 1 -- Agricultural Watersheds

Dr. Richard Coote Engineering Research Service Agriculture Canada Ottawa, Ontario K1A 0C6 (613) 994-5247	Coordination of Agricultural Watershed Studies, Project No. 1A Data Handling, Transfer and Evaluation, Project No. 1B

Name, Address and Telephone	Responsibility or Interest
Mrs. E. M. MacDonald Soil Research Institute, Agriculture Canada Ottawa, Ontario K1A 0C6 (613) 994-9657	Coordination of Agricultural Watershed Studies, Project No. 1A Data Handling and Transfer
Mr. R. C. Hore and R. C. Ostry Water Resources Branch Ontario Ministry of the Environment 135 St. Clair Avenue West Toronto, Ontario M4V LP5 (416) 965-2105	Project Leaders forStream flow quantity (Project No.2)and quality (Project No.3 -Routine water and sediment quality).
Dennis Onn (Same address J.E. O'Neill as R. C. Ostry B. Bodo (416)955-6995)	Associates for Project No. 2 and 3
Dr. F. Dieken Water Quality Section Laboratory Services Branch, Resources Road Rexdale, Ontario M9W 5L1 (416) 968-3064	Analyst: Nutrients, Organic Carbon & Minerals in Water Samples,(Project Nos. 3 and 21)
Dr. B. Loesher Inorganic Trace Contaminants Section Laboratory Services Branch Resources Road, Rexdale, Ontario (416) 968-3775	Analyst: Heavy Metals in Water samples,(Project No. 3)
Mr.G.Rees Organic Trace Contaminants Section Laboratory Services Branch Resources Road, Rexdale, Ontario (416) 968-3743	Analyst: Pesticides and PCBs in water samples. (Project No.3)
Dr. Ansar Qureshi Ministry of the Environment Laboratory Services Branch Microbiology Section P.O. Box 213, Rexdale, Ontario M9W 5L1 (416) 248-3008	Project Leader and Analyst Microbiological parameters (Project No.3)
Dr. Richard Frank (Address Above)	Project Leader for Monitoring for pesticides in 11 Agric. Watersheds (Project No.4)

Name, Address and Telephone	Responsibility or Interest
Mr. Heinz E. Braun (Same Address as R. Frank)	Analyst for Organophosphorus insecticides & cyclodienes (Project No.4)
Micheline Holdrinet (Same Address as R. Frank)	Analyst for PCBs and Organochlorines & cyclodienes (Project No.4)
Mr. George J. Sirons (Same Address as R. Frank)	Analyst for Phenoxy and triazine herbicides. (Project No.4)
Dr. Richard Frank (Address Above)	Project Leader for Land Use Information(Project No.5)
Dr. M. Sanderson Department of Geography University of Windsor Windsor, Ontario N9B 3P4 (519) 253-4232	Project Leader for Precipitation Quantity and Quality (Project No.6)
Mr. Doug Smith Dept. Chemical Engineering University of Windsor Windsor, Ontario N9B 3P4 (519) 253-4232	Analyst for Ca, Na, Mg, k (Project No.6)
Clement Leung (Same Address as M. Sanderson)	Analyst for PO_4, Cl, SO_4, SO_3, Suspended Solids, and Specific Conductivity (Project No.6)
Dr. C.J. Acton Agriculture Canada Dept. Land Resource Science University of Guelph Guelph, Ontario N1G 2W1 (519) 824-4120	Project Leader for Soil Survey (Project No.7)
Dr. Gregory J. Wall Dept. Land Resource Science University of Guelph Guelph, Ontario (519) 824-4120, Ext.-3120	Project Leader for Nature and Enrichment of Sediment and Mineralogical and Physical Characterization (Project No.8)
Mrs. K. LaHay Dept. Land Resource Science University of Guelph Guelph, Ontario N1G 2W1 (519) 824-4120, Ext.3057	Analyst for clay mineralogy CEC, organic matter, particle size, amorphous content (Project No.8)

Names, Address and Telephone	Responsibility or Interest
Dr. A. J. MacLean Soil Research Institute Agriculture Canada Ottawa, Ontario K1A 0C6 (613)994-9657	Project Leader for Agriculture Sources, Transport and Storage of Metals (Project No.9)
Dr. Morris Schnitzer Soil Research Institute Agriculture Canada Ottawa, Ontario K1A 0C6 (613)994-9657	Project Leader (Project No.9)
Dr. Milan Ihnat Chemistry and Biology Research Institute Agriculture Canada Ottawa, Ontario K1A 0C6 (613) 994-9721	Project Leader and Analyst for heavy metals (Project No.9)
Dr. J.D. Gaynor Agriculture Canada Research Station Harrow, Ontario N0R 1G0 (519)738-2251	Project Leader and Analyst for Zn, Cu, Pb, Cd and Ni (Project No.9) Also, Project Leader, (Project No.10)
Dr. Leslie Costescu Soil Research Institute Agriculture Canada Ottawa, Ontario K1A 0C6 (613)994-9657	Analyst for heavy metals and organic materials (Project No.9)
Mr. A. D. Gordon (Same Address as Ihnat)	Analyst (Project No.9)
Mr. J. Vlasblom (Same Address as Gaynor)	Analyst for Zn, Cu, Pb, Cd, and Ni,(Project Nos.9 & 10)
Dr.J. M. Fulton (Same Address as Gaynor)	Project Leader for Sources of Nutrients and Heavy Metals in Hillman Creek (Project No.10)
Dr. C. G. Kowalenko K. W. Neatby Bldg. Soil Research Institute Agriculture Canada Ottawa, Ontario K1A 0C6 (613) 994-9657	Project Leader and Analyst for Nitrogen Transformation Processes in Watershed Soils (Project No.11 Analyst for NH_4, NO_2, NO_3 (Project No.13) Analyst for NH_4, NO_3, (Project No.14)

Name, Address and Telephone	Responsibility or Interest
Dr.G.C.Topp Soil Research Institute Agriculture Canada Ottawa, Ontario K1A 0C6 (613)994-9657	Project Leader and Analyst for Physical Properties of Soils in Agr. Watersheds 1 and 13 which control Moisture Storage and Transport (Project No.12)
Dr.D.R. Cameron Soil Research Institute Agriculture Canada Ottawa, Ontario K1A 0C6 (613)994-9657	Project Leader for Mathematical Model of Transformations and transport of nitrogen through soils to groundwater (Project No.13)
Dr. J. Cherry Department of Earth Sciences University of Waterloo Waterloo, Ontario N2L 3G1 (519)885-1211	Project Leader for studies of Agricultural Pollution of Groundwater and its Influence on Stream Water Quality in Two Agr. Watersheds (Project No.14)
Dr. E.O. Frind (Same Address as Cherry)	Same as J. Cherry
Dr. R.W. Gillham (Same Address as Frind)	Analyst for minerals (Project No.14)
Dr. H.R. Whiteley School of Engineering University of Guelph Guelph, Ontario N1G 2W1 (519)824-4120	Project Leader for Hydrologic Model (Project No.15)
Dr. G.J. Wall (Address Above)	Project Leader for Erosional Losses from Agricultural Land (Project No.16)
Dr. W. Trevor Dickinson School of Engineering University of Guelph Guelph, Ontario N1G 2W1 (519)824-7120	Project Leader for Sediment Delivery Ratios in Small Agr. Watersheds (Project No.17)
Dr. M.H. Miller Dept. of Land Resource Science University of Guelph Guelph, Ontario N1G 2W1 (519)824-4120, Ext.-2482	Project Leader for Contribution of Phosphorus from Agricultural Land to Streams by Surface Runoff (Project No.18)

Name, Address and Telephone	Responsibility or Interest
Mr. D. A. Tel Dept. of Land Resource Science University of Guelph Guelph, Ontario N1G 2W1 (519) 824-4120, Ext.-3507	Analyst for Soluble Reactive P and Total P (Project No.18)
Mrs. T. D. Nguyen Dept. of Land Resource Science University of Guelph Guelph, Ontario N1G 2W1 (519) 824-4120, Ext.-8170	Analyst for Soluble Reactive P and Total P (Project No.18)
Dr. J. B. Robinson Dept. of Environmental Biology University of Guelph Guelph, Ontario N1G 2W1 (519)824-4120, Ext.-3828	Project Leader and Analyst for Nitrogen Transport and Transformations in 2 Branches of Canagagique Creek (Project No.19A)
Mr. C. K. Lee and Mr. L. Kistoff (Temporary) (Same Address as J. B. Robinson)	Analytical Assistants of J. B. Robinson (Project No.19A)
Dr. H.B. N. Hynes Dept. of Biology University of Waterloo Waterloo, Ontario N2L 3G1 (519) 885-1211	Project Leader for Secondary Production and Organic Drift of Nutrients in 2 Branches of Canagagique Creek (Project No.19B)
Dr. N. K. Kaushik and Dr. J.B. Robinson (Address Above)	Analysts for N, P, Organic Matter in Solid Organic Matter (Project No.19B)
Mr.S. L.Hodd Beak Consultants Limited 6870 Goreway Drive Mississauga, Ontario L4V 1L9 (416)671-2600	Project Leader for Effects of Livestock Activities on Surface Water Quality (Project No.20)
Mr. Paul Odom (Same Address as S. L. Hodd)	Analyst for Total P, NO_3, (Project No.20)
Mr.J.F.Sliwinski (Same Address as S. L. Hodd)	Analyst for Ortho Phosphates, NH_3,(Project No.20)
Mr. F.R. Hore Engineering Research Service Agriculture Canada Ottawa, Ontario K1A 0C6 (613)994-9785	Project Leader for Feedlot and Manure Storage Runoff (Project No.21)

Name, Address and Telephone	Responsibility or Interest
Dr. N.K. Patni Animal Research Institute, Nutrition Bldg., C.E.F. Agriculture Canada Ottawa, Ontario K1A 0C6 (613)994-9723	Project Leader for Pollutant Transport to Subsurface and Surface Waters in an Integrated Farm Operation (Project No. 22
S. Kelly (Same Address as Patni)	Analyst for NH_3, TKN, NO_3, P, K (Project No.22)
M. Leuty (Same Address as Patni)	Analyst for Solids and Conductivity (Project No.22)
Dr. John A. C. Fortescue Dept. of Geological Science Brock University St. Catharines, Ontario L2S 3A1 (416) 684-7201	Project Leader and Analyst for Heavy Metals, Nutrients and Minerals in Agr. Watershed 10 (To be designated Project No.23)
Mr. Eric Veska (Same Address as Fortescue)	Analyst(Project No.23)

10.222   Activity No. 2 -- Forested Watersheds

Dr. J. A. Nicolson Great Lakes Forest Research Centre Dept. of the Environment Box 490 Sault Ste. Marie, Ontario P6A 5M7 (705)949-9461, Ext.-288	Project Leader for Impact of Forest Management Practices on the Boreal Ecosystem
Mr. Jim Prokopowich c/o FRB Camp Box 313 Kenora, Ontario P9N 3X4 (807)227-5414	Analyst for NH_3, NO_3, total dissolved N, total dissolved P, Conductivity, pH, and DOC (Activity No.2)
Mr. M. Capel Freshwater Institute Dept. of the Environment 501 University Crescent Winnipeg, Manitoba R3T 2N6 (204)269-7379	Analyst for Suspended P, C and N; Cl, SO_4, Na, K, Mg, Ca, Fe. (Activity No.2)

10.223   Activity No. 3 -- Land Uses Other Than Agricultural and Forest

10.2231   Urban Land

Name, Address and Telephone	Responsibility or Interest
Dr. Rao Avadhanula Hydrology and Monitoring Ontario Ministry of the Environment 135 St. Clair Avenue West Toronto, Ontario M4V 1P5 (416)965-6995	Project Leader for Water Studies
Mr. J.E. O'Neill Ontario Ministry of the Environment 135 St. Clair Avenue West Toronto, Ontario M4V 1P5 (416)965-6995	Project Leader for Sediment Studies
Dr. Fred Dieken (Address Above)	Analyst for Nutrients, organic carbon and minerals (water studies)
Dr. B. Loesher (Address Above)	Analyst for heavy metals (water studies)
Mr. G. Rees (Address Above)	Analyst for pesticides and PCBs(water and sediment studies)
Dr. Jerry Hipfner Ministry of the Environment Inorganic Trace Contaminants Section, Laboratory Services Branch Resources Rd., 401 & Islington Ave. Toronto, Ontario (416) 248-3037	Analyst for nutrients, exchange capacity, metals, minerals and C.O.D.(Sediment studies)
Mr. Dennis Donohue Ministry of the Environment Hydrology & Monitoring Section 135 St. Clair Ave. West Toronto, Ontario M4V IP5 (416) 965-6995	Analyst for particle size and total carbonates (sediment studies)
Dr. Ansar Qureshi (Address Above)	Project Leader and Analyst for Microbiological Studies

10.2232   Transportation and Utility Systems

Name, Address and Telephone	Responsibility or Interest
Mr. J.E. O'Neill (Address Above)	Project Leader

10.2233   Sanitary Landfills

Mr. Barrie Reynolds Ministry of the Environment 135 St. Clair Ave. W. Toronto, Ontario M4V 1P5 (416)965-1655	Project Leader for Violet Landfill Study
Mr. H. Mooij Solid Waste Management Branch. Environment Canada Ottawa, Ontario K1A 0H3 (613)997-3212	Project Leader for Landfill Contaminant Migration and Land Disposal of Industrial and Hazardous Wastes
Prof. Graham Farquhar Dept of Civil Engineering University of Waterloo Waterloo, Ontario N9L 3G1 (519)885-1211	Analyst for Soils -- Project. completed.
Dr. F.J. Philbert Water Quality Laboratory Canada Centre for Inland Waters P.O. Box 5050 Burlington, Ontario L7R 4A6 (416) 637-4642	Analyst for 35 parameters -- Analyses completed.
Dr. R. Frank (Address Above)	Analyst for PCBs
Barringer Research Ltd. 304 Carlingview Drive Rexdale, Ontario N9W 5L1 (416) 677-2491	Analyst for 39 parameters in industrial wastes -- Analyses completed.

10.2234   Processed Organic Waste Disposal

Mr. P. DeAngelis 135 St. Clair Ave. W. 6th Floor, Pollution Control Board Toronto, Ontario M4V 1P5 (416)965-1655	Project Leader

10.2235   Extractive Industries

Name, Address and Telephone	Responsibility or Interest
Mr. J.E. O'Neill and Dr. Rao Avadhanula (Address Above)	Project Leaders

10.2336   Private Waste Disposal (Septic Tanks)

Dr. H.T. Chan, Applied Sciences Section Pollution Control Branch Ministry of the Environment 135 St. Clair Ave. W. Toronto, Ontario M4V 1P5 (416) 248-3044	Project Leader
Mr. Lloyd Grigoriew, Soil Technician Applied Sciences Section, Ministry of the Environment Pollution Control Branch, 135 St. Clair Ave. West Toronto, Ontario M4V 1P5 (416) 248-3044	Analyst for soil tests, particle size distribution, laboratory permeability and density.
Miss Teresa Yeung Applied Sciences Section Pollution Control Branch Ministry of the Environment 135 St. Clair Ave. West Toronto, Ontario M4V IP5 (416) 248-3044	Analyst for extractable P from soil, P isotherm

10.224   Activity No. 4 -- Water Quantity and Quality Monitoring Framework

Mr. R.C. Ostry (Address Above)	Project Leader for Water
Mr. J.E. O'Neill (Address Above)	Project Leader for Sediment
Dr. Ansar Qureshi (Address Above)	Project Leader and Analyst for Microbiological Studies
Mr. Dennis Onn Ontario Ministry of the Environment 135 St. Clair Ave. West Toronto, Ontario M4V 1P5 (416) 965-1655	Field Coordinator

Name, Address and Telephone	Responsibility or Interest
Dr. Fred Dieken (Address Above)	Analyst for nutrients, organic carbon and minerals in water
Dr. B. Loesher (Address Above)	Analyst for heavy metals in water.
Mr. G. Rees (Address Above)	Analyst for pesticides and PCBs in water.
Dr. Jerry Hipfner (Address Above)	Analyst for nutrients, exchange capacity, metals, minerals and C.O.D. in sediment.
Mr. Dennis Donohue (Address Above)	Analyst for particle size and total carbonates in sediment.

10.225   Activity No. 5 -- Laboratory Support

Laboratory support is provided by Agriculture Canada, Ontario Ministry of Agriculture and Food, Ontario Ministry of the Environment, Canadian Center for Inland Waters, Universities, and private contractors as indicated under the several projects listed under Other Activities.

10.226   Activity No. 6 -- Riverbank Erosion Study

Mrs. Katherine Knap Ontario Ministry of Natural Resources c/o Dept. of Land Resource Science University of Guelph. Guelph, Ontario N1G 2W1 (519) 824-4120,Ext.- 2272	Project Leader
Miss Anna Lammerding (Same Address as Knap) (519) 824-4120, Ext. 8175	Analyst for clay mineralogy TKN, total P.