AQUATIC SYSTEM WORKSHOP

20 and 21 SEPTEMBER 1978

presented by

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Project WS 3.4

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ABSTRACT

A workshop on aquatic systems was held 20 and 21 September 1978 in Edmonton, Alberta. Participants included members of Alberta Environment, Alberta Recreation, Parks and Wildlife, Fisheries and Environment Canada, and consultants conducting research for the Alberta Oil Sands Environmental Research Program.

T.W. Chamberlin of the Resource Analysis Branch, British Columbia Ministry of the Environment and E.A. Harding, a former Project Biologist for the branch, presented the philosophy and structure of aquatic system inventory as conducted by the Resource Analysis Branch. Additional topics included data management and examples of detailed interpretive projects. Practical sessions provided air photo interpretation practice relevant to aquatic inventory.

ACKNOWLEDGEMENTS

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The organizers of the workshop wish to extend their appreciation to the British Columbia Ministry of the Environment for supplying an instructor.

1. INTRODUCTION

1.1 PHILOSOPHY OF AQUATIC MAPPING (T. CHAMBERLIN)

The group that I work with in British Columbia is called the Resource Analysis Branch (R.A.B.). It used to be an arm of what was known as the Environment and Land Use Committee, Secretariat, and was spawned as an historical offshoot of the old Canada Land Inventory. We have, however, shifted our emphasis during the last four years. We are no longer mapping with the same objectives as the old Land Inventory. We are mapping what we like to call bio-physical base data which start with an assumption about ecosystems: namely that the components of ecosystems, whether they are land, water, air, human, or whatever, are in fact interrelated and that the understanding of these interrelationships is useful.

Now most biologists take that assumption for granted and, yet, as you are probably well aware, particularly if you are in habitat protection, most management decisions do not take this into consideration. Government agencies and industries tend to behave as if they existed in isolation and most inventory structures reflect that. We have, for example, in the Alberta Oil Sands Environmental Research Program (AOSERP), a large number of projects inventorying this and that. But so far as I have been able to determine by talking to people involved in the program, there exists no purposive method of integrating the results other than by some-body sitting down and reading the separate reports from each of the sectors. The whole idea about the biophysical or ecological inven-tory as it has been developed in Canada presumes the value of looking at wholes; e.g., at a land system that includes water and air. There have been fairly rigorous methodological statements about the proce-dure, particularly from Quebec. We have gone off on a little dif-ferent tangent in British Columbia coming up from sectoral surveys and trying to integrate them at the top. It seems to me that, in Alberta, the situation is somewhere in the middle.

One of the primary ideas that we are trying to keep straight is to keep our interpretation separate from the information we are gathering. This is not to say that we don't get into interpretations and management, but we'd like to have a starting point that anyone can believe in. In other words, if I state that a particular stream is a Class 3 stream and that is what I publish, it leaves very little room for argument from people. They may not know what Class 3 means or they may disagree entirely and say it should be Class 5 or 1. We would rather say it's so deep, so wide, has so many critters in it, and this kind of gravel at the bottom. Then we can settle down and argue whether that is good or bad.

We find this is quite a useful approach in management from another aspect. We don't always know in what terms our clients are going to be speaking. The process of designing an inventory may presuppose you know what sort of questions you're going to answer. Now that is quite a trap because, if you are a line agency or if you are on a specific management mandate, it is very tempting to go out and do an inventory to answer the questions that you have to answer. Six months later along comes somebody else with a slightly different question and you look at your data base and say, "If only we'd looked at one other thing,...I guess we will have to do another inventory."

This becomes particularly obvious when you're dealing with land resources. Everybody really wants to know the same thing: what is the state of affairs, what are the important processes, what are the potentials of the land. (By the way, nothing I'm going to say is new. We have borrowed ideas extensively from others in North America and restructured them. [See Section 6, Annotated Bibliography.] I don't really think I'm going to give any insights that are at the level of exciting revelations in energy flow, or whatever. What we basically are after is communication, I think, and everything we've done is oriented to making something accessible to people who have to make decisions.) Figure 1 illustrates what I'm trying to get at. The left starts with a set of objectives with capital "O's" that Deputy Ministers and Ministers might worry about. Each of them have their agencies and so forth. The right ends with a range of kinds of inventory one can do - reconnaisance,

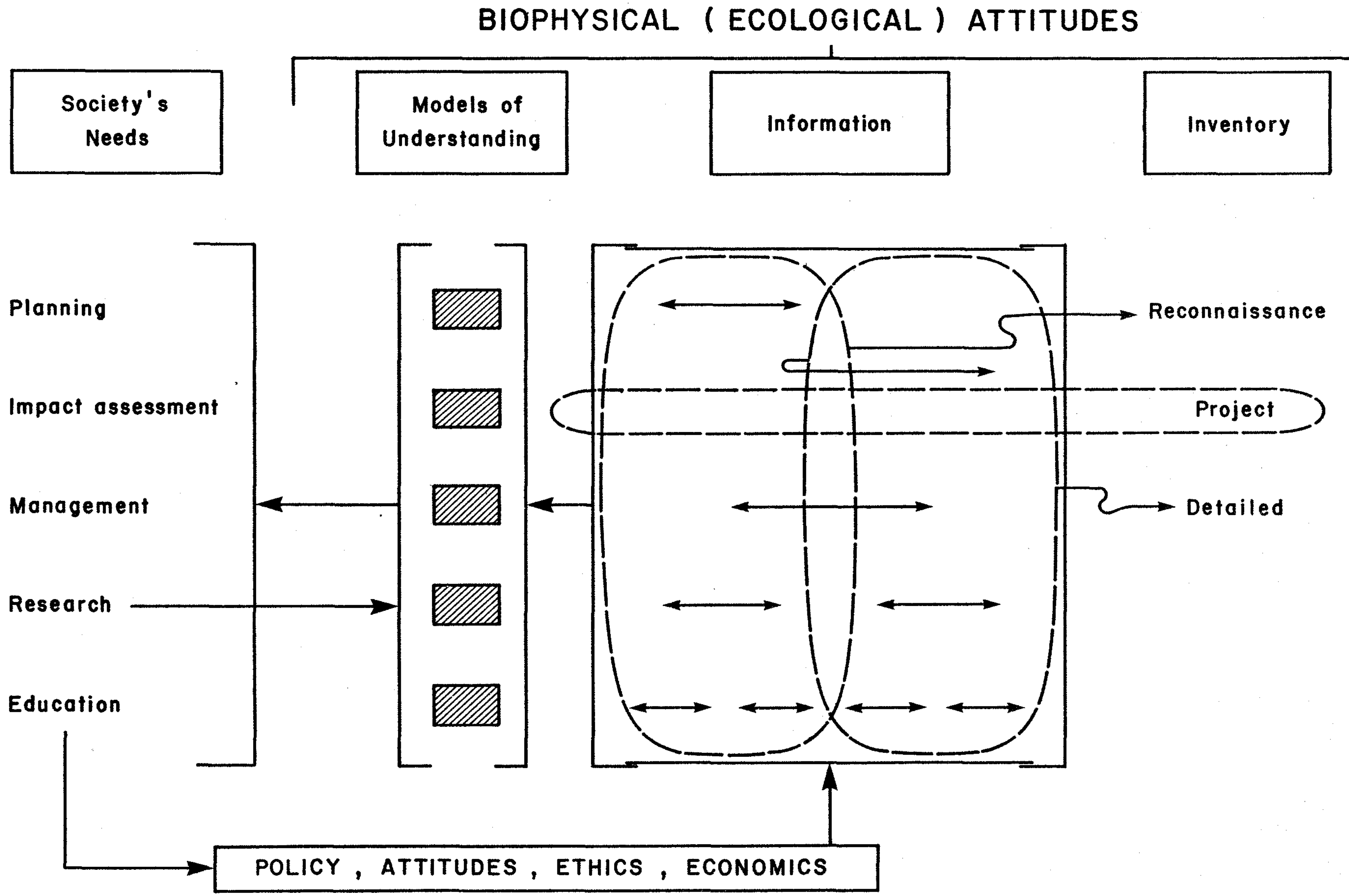


Figure 1. Relationship of objectives and kinds of inventory available.

very detailed, project oriented, problem oriented, firefighting, etc. It's our belief that the information base has extensive overlap in it between the various needs of the different users of the information, particularly when we're dealing with any given system, such as an aquatic system. Somewhere, in between that information and applying it, are a whole lot of models of understanding. These may be, for example, cost benefit assumptions, productivity models, habitat utilization assumptions on the part of biologists, and so forth.

One of the things that we find when we start getting into systematizing our inventory data is that we are really pretty crude in this area. For example, if a biologist goes out to a stream and says, "Ace number one cutthroat stream!" Why? He says, "It looks like it!" A year later six or eight things that can be measured along with the fact that cutthroat live there are noted down. This is somehow unsatisfactory in courtroom arguments with a logger.

Therefore, our effort really has been to separate the descriptive parameters from the models of understanding because one can argue about the models till the cows come home. Design research relevant to resolving some of those arguments, but above all else, get everybody to believe in the data base that we're gathering. Our final product, we hope, is a relatively unbiased data base. As soon as we think we're there, of course, we realize that we're making guesses just as much as anybody. Figure 2 illustrates an example of this separation. It's a watershed study dealing with the effects of land use on fish. Fish populations are at the bottom, base data are at the top, and the stuff in the middle represents the component studies with inputs and outputs going from one to the other. Structurally, it probably doesn't look much different from how AOSERP would look if you recast some of the projects. The point being that all those arrows represent some kind of functional relationships in theory, some kind of model, if you will, about which we frequently had no information at all. Maybe we knew the curve went generally upwards or downwards even though we hardly ever knew whether it was linear or exponential. We got into all sorts of problems trying to

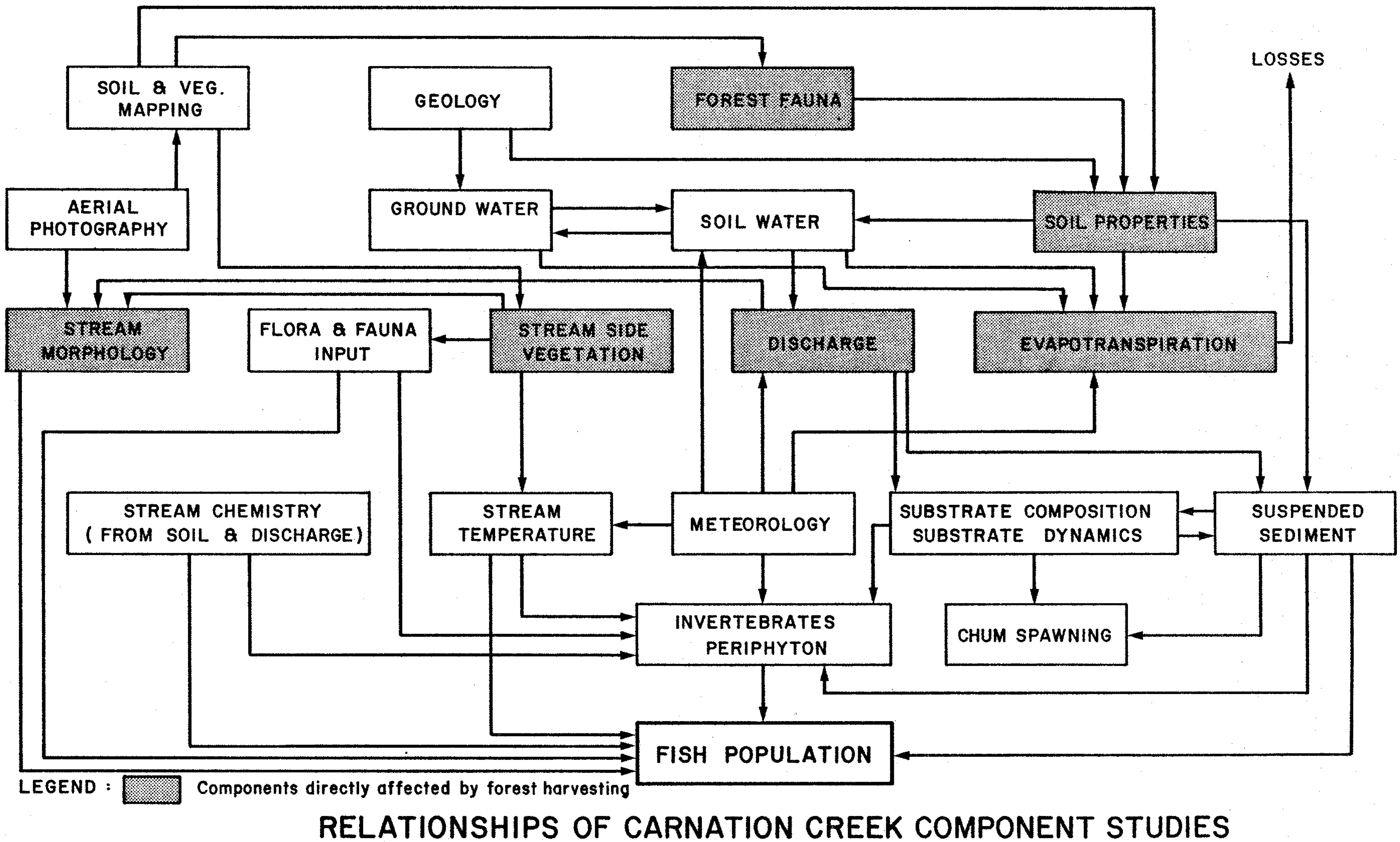


Figure 2. Separation of descriptive parameters from models of understanding.

quantify our output and lead to a management conclusion that was backed up by the data. This emphasizes the complexity of the systems we're dealing with. So when somebody says to you, "Let's inventory the stream, let's pick three most important parameters and measure them", they're really short selling the intricacies of the system. The question is how do we approach it for posterity?

Figure 3 is the working level of the Resource Analysis Branch in British Columbia. We have a Climate group (similar to your Air System). We have a Terrain Systems group which deals with soils and surficial geology, perhaps analagous to your Land System group in AOSERP. We have a Biological Systems group which deals with aquatics, wildlife, and recreation; I've seen many similarities in these components at this workshop. We have a Lab support backup. All groups never work independently. When we take on a project, there is usually a member of each on the field team and the final project then comes out of their joint mapping and data gathering.

Taking such a systematic approach, we follow three objectives:

(1) We want to reduce the uncertainty in our assumptions. If we only come up with high-medium-low capability streams, it's difficult to get at the areas of uncertainty in that conclusion.

(2) We want to provide input into the evaluation process. We're not going to cover much of this in the workshop. The inventory, of course, is only step one here. The question at the end is: "So what! So we've got 50 various exotic species of macro-invertebrates in a given reach of stream. What does that say about the value of that system to society?" As researchers you have to be thinking about it, because some economist or political level decision maker will take your data and say, "O.K., let's (or we can't) divert that stream, disrupt it, pollute it, or use its water for another purpose".

(3) The aspect of communication can't be overemphasized. The whole mission of getting into systematic inventory and discussing a biophysical approach to it is to make the material more useable for somebody else. We spend about a quarter of our time, in my section, working with users, such as habitat protection

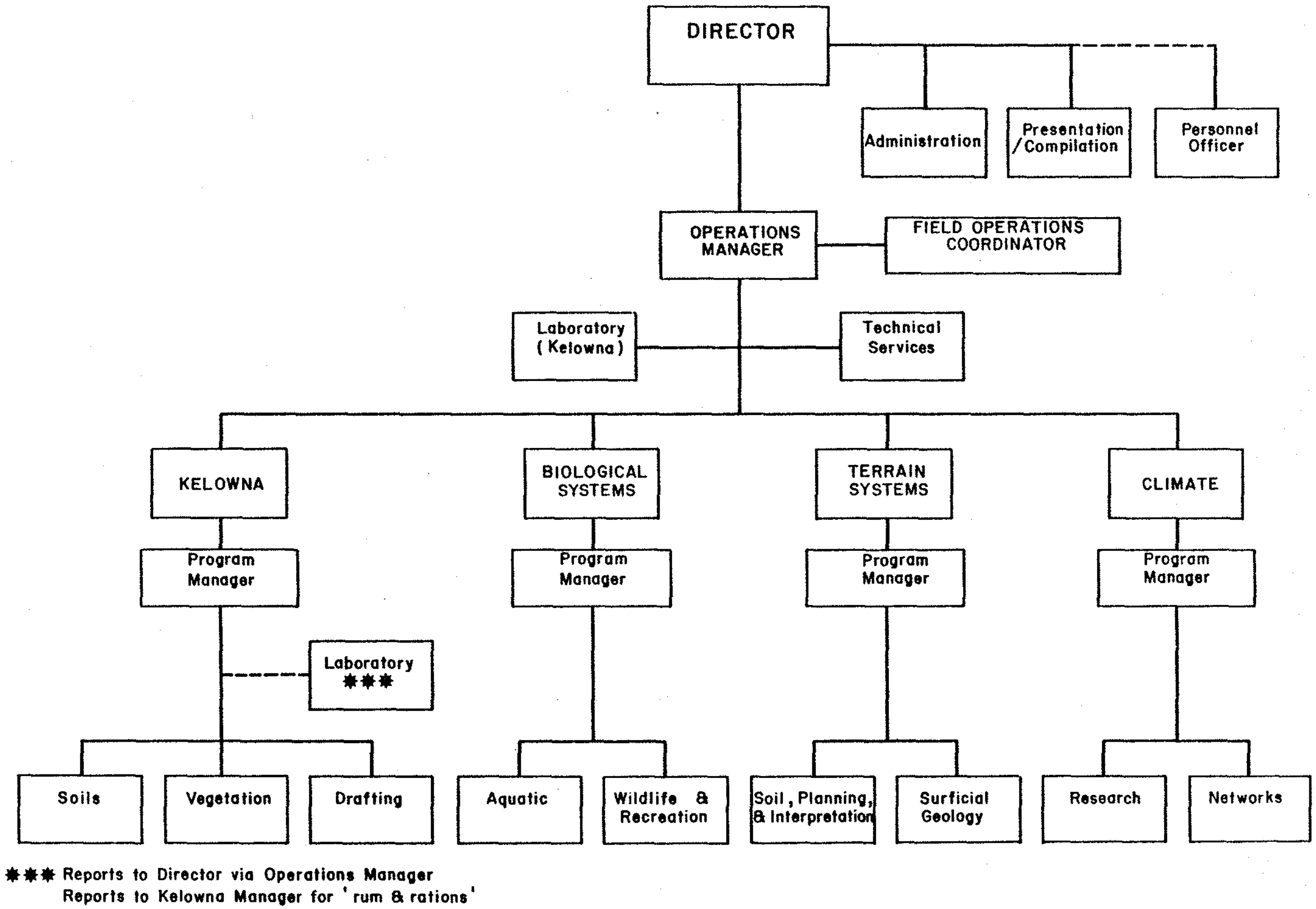


Figure 3. The working level of the Resource Analysis Branch in British Columbia.

biologists. When we get 20 or 30 inches of reports from British Columbia Hydro thrown at us, and they say, evaluate our impact assessment, for example, of damming up the Liard River, it sometimes makes us want to get a little propane torch out because the information is really not intelligible. Who can wade through 150 pages of graphs and figures? To that end on the last half day of the workshop, information on data base and how we manipulate it, how we get to the maps, and what they are used for will be covered.

Another aspect of the biophysical process is the water/land interactions. One example of land systems approaches is Lacate's formal land system classification approach (Lacate 1969). However, now and then you see lakes that are just blank, the river frequently is the boundary line between two land systems, and yet we know we have a three dimensional variable-through-time system that has to be characterized somehow. In Quebec, it was attempted to overcome this by saying that this land area "A" contains so many lakes greater than such and such a size at a specific nutrient status and so many rivers so wide, and so forth. We have found that approach awkward because the users of water information which run the range of interests in fisheries, engineering, chemistry, transportation, aesthetics, recreation, and wildlife really require as much detail about aquatic systems as a soils map would give about soil. If you've seen soils maps you know the legends are quite extensive. You're looking at about 20 or 30 physical, chemical, biological, parameters which describe the particular soil with the classification system that relates the different soils to each other, and to interpretations by management like septic tank suitability and agricultural ratings. Our approach was to assume we should be able to do that for aquatic systems.

Our workshop will primarily focus on rivers. In British Columbia we've done some work with lakes and marine coast lines. Conceptually the approaches to these other types of aquatic systems are similar.

Our approach depends a lot on certain assumptions about aquatic systems and their relationship to the surrounding land systems.

We are involved with a fair number of what you might call fluvial geomorphologists and we are beginning to believe that the properties of the aquatic systems at various scales are related to the properties of the land systems which surround them. There are process linkages between the materials that a stream flows through and the form of a stream, and between the surrounding geology and the chemistry of the stream. A problem stemming from this approach comes in relating streams which flow through land systems and do not take on much change in their properties like the bigger rivers or streams.

So, we have really two systems that we're considering. One is a natural hierarchical drainage basin oriented structure of processes, and the other is land base ecosystem type structure. For example, all of the streams draining the same ridge top will have similar properties (providing the geology and soils, etc. is approximately the same) and yet one set of first order tributaries may be going into the Arctic drainage and the other set may be going into the Pacific drainage. So you have to work with a two-poled approach to that. In other words, the problem is that the process oriented integrators that apply to land may or may not also apply to the river systems. You've got to cover your bases both ways.

In biophysical land classification there is a formal hierarchy of land systems which I'll just mention briefly. The "region", "district", "system", "type" designators have been developed for mapping land systems. The "system" level is the one that we relate most closely to and it's formally defined as a recurring pattern of land forms, soils, and vegetation. Now this doesn't mean that you have homogeneity, but that you have a repetitive pattern. For example, a drumlin field will have little ridges, and swales, and ridges, and swales, but quite different vegetation and soils, whether you are on the drier or wetter portions of the ridges. This can be recognized as a system. A line can be drawn around it. We can talk about similar systems in other areas that will support similar habitats for wildlife. They'll generate similar raw patterns in terms of hydrology. Groupings of systems in which you have sort of characteristic relief and climax vegetation and geology they call land "districts", a level higher than the system level. They then group districts into what they call "regions" in which climate, as expressed by a dominant vegetation type, is the controlling process. Within the systems, "types" are recognized, such as I mentioned, the tops of the drumlins and say the organic terrain between drumlins. Lacate (1969) discusses biophysical land classification in detail.

It is possible to apply a similar conceptual scheme to streams and in fact the word "reach", being the basic mapping unit, is defined exactly analagously to the land "system". A reach is defined as a relatively homogeneous chunk of stream with respect to the occurrence of processes in that particular chunk of river. We will spend a lot of time talking about reaches, how we identify them and what use they are. They are a mapping tool, they are a classification tool, and they are a unit that we apply to management. So when we talk about habitat protection and fisheries management we will usually be couching our discussion in terms of reaches. Most of the airphoto work we will get into toward the end of today and tomorrow morning will be efforts at recognizing reaches on airphotos and at estimating their properties.

Two kinds of hierarchical classification should be distinguished before we go much further. (Everybody likes hierarchical systems because you can pick your level in it, and you can aggregate up or down.) The kinds of hierarchies are mapping and classification hierarchies. I'll give an example from soils mapping. For soils, the orders of soils have a functional classification, for example, podzols, luvisols, regisols, etc. You dig a hole and you can classify the soil. It turns out to be a soil of type "A". Well, there is a pattern of soils across the landscape. The type "A's" aren't all together. The type "A's" may be distributed from here to New Brunswick. We can't draw a line around all the type "A's". So we can classify soils, hierarchically, then by processes which form them in some kind of classification. Analagously we can talk about riffles, say in small streams of relatively low gradient over a certain kind of bedrock. That particular type of stream classification will recur between British Columbia and Newfoundland, and yet can't map it. When you get to mapping hierarchies you have to have spatially related classifications, if you will. A soil series or a watershed is a hierarchical mapping classification that may or may not overlap with your process classification of what you're mapping. This problem emerges when you start building data bases and asking how do you want to sort things, how do you want to enter your data? We'll get into that a little later.

Finally, one difference in aquatic systems that we've had to contend with as a major hangup is time and space variability. River systems contrast markedly with terrestrial systems in this respect. A forest inventory crew can go out there more or less any time of the year and have reasonable confidence that the forest will be standing there to measure heights and diameters of trees. But in fluvial processes we know that such systems go through maybe four orders of magnitude at different times of the year. We know that the populations of animals, all the way from primary producers up, in them also change quite markedly throughout the year. We even know that in terms of their location in space we get change. One flood and all of a sudden the river is on the other side of the valley. When using airphotos from the 1930's, there is quite a difference from what is out there right now. So, we have to deal somehow with this time and space variability. There are implications in terms of inventory in areas of sampling timing, and in some kind of compromise which has to be arrived at in your mapping. You can't map dynamic features. Our cop out, or solution, is to really focus as best we can on those features which control the dynamic features. In other words, for example bedrock outcrops can be mapped. We come up with some conventions on the maps in the data fields to handle the changing features. But it's a different inventory design than you'd design for a vegetation map or for a soils map.

As you may be gathering, when speaking of aquatic habitats, fish are almost a by-product. Now, some disagree with me violently on that, and this is a source of spirited discussions, but I make the emphasis the other way just for balance. In describing these systems in such a way, we are trying to provide usefulness for engineers, for people involved in fisheries habitat, and for people involved in designing recreation. In other words, we are trying to describe this ecosystem in a sufficiently comprehensive manner so anybody who asks a question can get some clues. That may be a bit aggressive in terms of presumptions, but I really believe that's where it's really at, and you don't have to go back and do inventories again and again. I have a certain faith that aquatic systems have an internal order to them and that fish, as users, respond to the same controlling processes and variables that an engineer is concerned about in putting a bridge across the stream.

After a question period I will go into a bit of the structure of the inventory that we do in the Aquatic's grouping in the R.A.B. in British Columbia.

So much for the philosophy of it all. Are there any questions from anyone up to this point. If not, it either means everything is crystal clear or you didn't understand a thing.

1.2 DISCUSSIONS

QUESTION: Referring to your mention about selecting certain characteristics at certain times of the year, how do you make these sorts of selections when you know the differing life forms would have differing responses to these characteristics according to the season? For example, if you took minimum dissolved oxygen at a measure to characterize a stream a certain way, what if there are not fish in that stream because it's the winter time and they all went somewhere else? How do you make choices like this without starting to get interpretive?

CHAMBERLIN: I'd like to answer that question later on in the context of scale. There are some things you can measure once and have them, and some things you must measure throughout the year and that's one of them, obviously. You're not going to come in and just measure dissolved oxygen once and say you understand the system; anymore than you can take one measurement of flow.

QUESTION: Your approach was, as you said, initially designed to provide a service to users. And yet, if you look across Canada there seems to be a great resistance in some user agencies, particularly fish and wildlife groups, to use any kind of standardized classification. This has been evident particularly amongst biologists, perhaps because someone other than biologists invented the system (though I'm not sure). When I was in British Columbia a couple of years ago, there was virtually a total rejection of this kind of approach by the Fish and Wildlife Branch and yet many of them knew very well what you were doing. I think there is a lot of information there that they could have utilized. What's your comment on this resistance?

CHAMBERLIN: Well, two and a half years ago we were six months old and there have been lots of systems around. I think resistance to the imposition of any form of inventory or classification system is initially couched in the fact that people don't understand it, think it's too complicated, or feel it's not relevant to their problems. Those appear to be legitimate reasons for resistance. However, as of this year, in the Fish and Wildlife Branch, most regions and headquarters inventory people will be using our cards, our data storage, and our mapping processes. As well, the Municipal Affairs and Housing Ministry is swamping us with requests for base data for urban suitability analysis. Parks want it. Mines want it, and even consultants are after it. What I believe we have accomplished to make that happen is, firstly, to do it over a wide enough area so that it becomes potentially useful to people with responsibilities in those areas. We've worked in three of our Fish and Wildlife Districts now and the system has proven itself by saving a lot of time in designing more detailed work. Secondly, there is the matter of education. As far as biologists go, many of the biologists I've come in contact with don't know anything about streams.

Sure they know a whole lot about fish, about trophic levels, about nutrient transport, but there are very few biologists that have had any training in hydrology and fluvial geomorphology, and in the relationship betwen land systems and streams. So it is not obvious at first glance to them that these things are related to the welfare of the beasts they are responsible for. I believe such relationships exist and I'll sit down with any biologists and I think I can convince him of this. Thirdly, ours is a cost effective system. It's cheap inventory, I'll get to that when we talk about scale. Incidently Ted and I did a rough calculation and figured that to do the entire AOSERP area at a reconnaisance level would employ somewhere between three and four weeks field time and another six months of office time. In the three years we've been at this, we've finished about 150 1:50 000 map sheets, and a couple of dozen larger scale more detailed studies for particular areas. So, it's not a complicated system to use, and we admit that we're total beginners in terms of applying it to management problems. That will only happen as we get involved with managers and explore the interactions. I mean you have to learn my business and I have to learn your business.

This system had its genesis in a series of about three workshops where I invited every person involved in fish habitat inventory in the province and made them tell me what they thought was useful. It's been through three revisions now; even the data cards were revised this last spring and we think they're fairly good now. Earlier some of the concepts were a bit fuzzy and the manual layout of data cards wasn't as good. It's come a long way.

REPLY: The main reason I raised that point is that there are a number of people representing user agencies or branches at this workshop and also a number of researchers and consultants. It seems to me that if AOSERP is going to proceed with anything of use to clients (and I consider any government department who uses AOSERP information as a client) it would have to get a system agreeable over large areas. This was the point and I'm glad you raised that cost effective bit because it really doesn't matter to me, even though I'm a fish biologist, what fish are in the area. We know the biology of those fish pretty well across Canada. I don't recall any new species being discovered and I would guess that the literature would read pretty well without it anyway. But it's important to us to be able to have the user agencies agree that there is some biophysical way we can classify or characterize large areas so that when there is a development impact we can make some educated guesses as to what will happen.

QUESTION: With regards to cost effectiveness, I consider the AOSERP study area as an arbitrary man-made block, not a natural system set up for any purpose. For an aquatic study of this nature, what value is there in going into a block like this?

CHAMBERLIN: The answer, of course, is that we don't inventory study areas, we inventory watersheds.

2. APPROACH (T. CHAMBERLIN)

2.1 OBJECTIVES

The problem concerning objectives has great bearing in designing the system. We have a whole range of objectives involving questions such as, which quarter of British Columbia should get funding support in terms of regional overviews, down to what are the aberrations of the sex life of the lesser furry polyestermite, which is of particular interest to someone. Therefore, we can't really standardize the problems we're going to face.

2.2 SELECTION OF MAP SCALE

We can't standardize the type of applications right down to the nitty gritty detail, but for conceptual purposes we've come up with four standard scales which form the basis for our inventory design. When we get a problem we try to sit down with the user, and get them to relate to the different scales. When I'm using scale here, I'm talking of a ratio of 1:50 000 being a smaller number than 1:10 000.

We would call 1:250 000 scale inventory a regional reconnaissance. In this kind of inventory or sampling, we generally have little or no ground information, most data being derived from remote sensing and existing management files. At 1:250 000 you may be working with Landsat imagery. The processes you heard about in the AOSERP seminar on remote sensing are examples of the application of information. It's useful for broad scale planning, it's not particularly useful for habitat protection or for management purposes at a detailed level.

We drop down to 1:50 000 in British Columbia, maybe 1:100 000 in the rest of Canada where there is less geological variability, to what we would call standard reconnaissance. At that level of mapping we would obtain some point samples on the ground within our map units. In terms of species we're usually only interested in species present, and distribution of ranges and average properties of the units that we're mapping (reaches). The areas requiring detailed work can be identified, sensitive areas can be flagged and you can usually end up with a rough priorization of your management problems for that kind of mapping. This 1:50 000 reconnaissance level mapping is the scale that I will be discussing in greater detail today.

When we get down to 1:10 000 or 20 000 we're talking about detailed inventory, with extensive sub-sampling of the mapping units so that statistical considerations come into play. We have measurements of the properties of these units as opposed to estimates. In other words, we may do systematic transects every 100 m on a river for bed material, for example. We have management application at the local level, such as evaluating cutting permits or something like that. And finally, we could say if we take it down to 1:5000 to 1:1000, or whatever, we have the design level. Special project inventory, research, whatever you want to call it, involves sampling through time to establish functional relationships dealing with populations or hydrology. We have applications of what we might call the bio-engineering design level, where one is looking at spawning channel design, bridge abutment design, or the layout of settling ponds, with respect to the river flood levels, banks, etc.

You can't gather inventory at one scale level and make decisions at another. Your data just don't match the decision. That single fact probably represents 98% of the problem of getting people to accept inventory designs. For example, when I talked to the Fish and Wildlife biologist he said Canadian Land Inventory is useless. Who cares about ungulate capability if the line is fuzzed out after a quarter of a mile. I need to know where the calving ground is or analagously where the spawning ground is or whatever. There are different levels of inventory, different scales, different objectives. What we're going to do throughout the workshop is try and relate the information that we can pull off the different levels (scales) of photographs, different maps, to the kinds of problems you guys face.

2.2.1 Mapping Reaches

Within these general scales, discussed in Section 2.2, taking them as indicators of our objectives, one is to describe and map a broad range of biophysical properties of relatively homogeneous mappable stream units, called reaches. Homogeneous, relative to what? Relative to the scale that you're interested in, relative to the processes which control those streams. Are they controlled by bed material, are they controlled by fluvial processes, and are they controlled by engineering? They're usually delimited on the basis of such things as discharge, slope, substrate, and the configuration of the valley walls. All of these things interact and none of them are independent. You can't pick one and say this defines a reach. In different portions of the country, muskeg, marine, mountainous, whatever, you're going to have different processes which determine the controlling properties of the reach. So hydrological considerations help considerably in understanding why reaches exist.

One of the most delightful comments I've heard over the last 3 years was from a biologist who said to me one day "My god, reaches are real". We preach that reaches are forever and they are within management time frames, even though they are not within geologic time frames. So we believe it's an extremely useful concept.

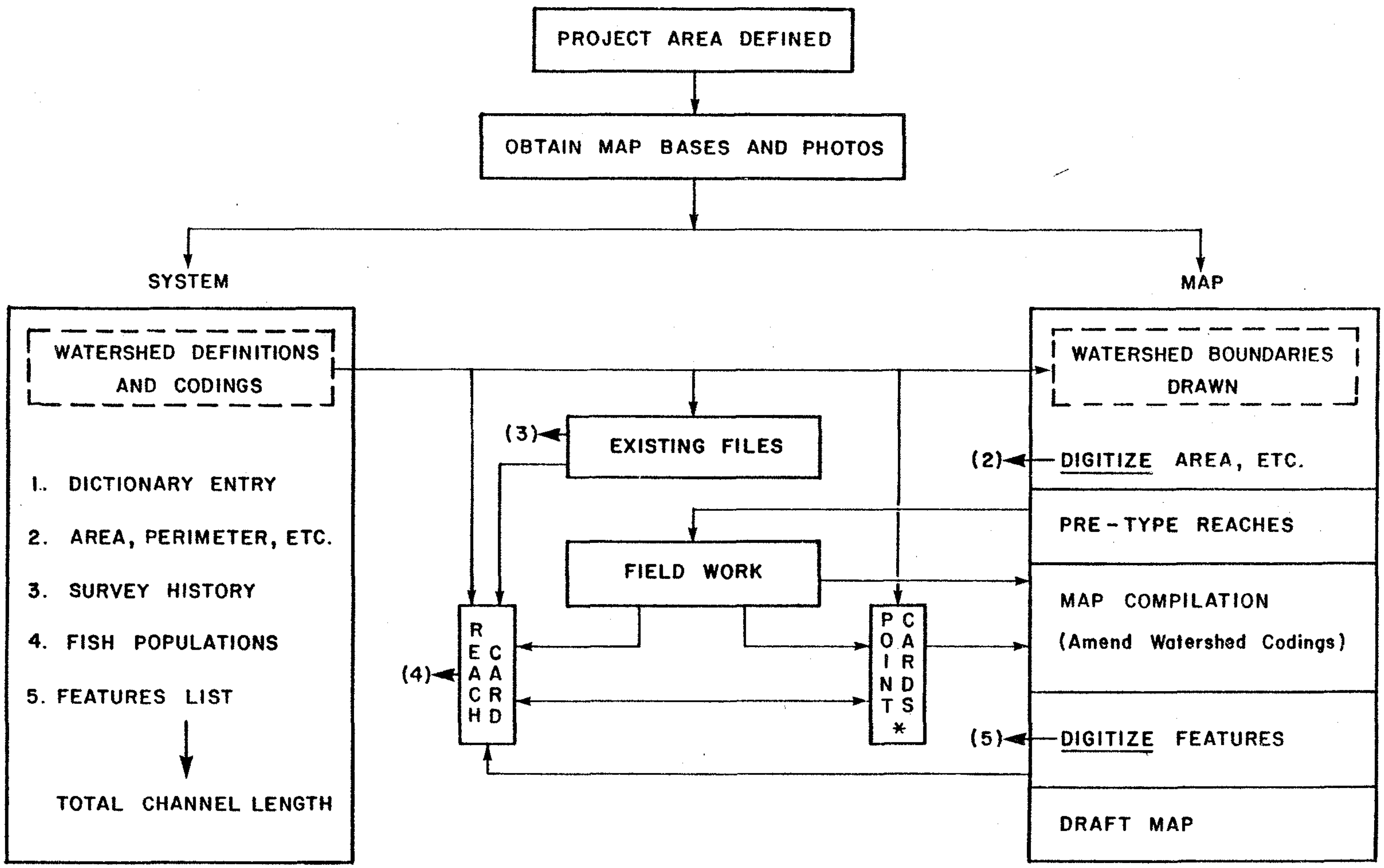
2.3 DATA GATHERING

I'd like to go briefly into the inventory process. I said it's a sampling process. One can look at the scale differentiation, really. We talk about map scales. What we're really talking about is information density. In soils we talk to somebody, and they say well 1:50 000 mapping means 8 pits per map sheet. For streams, it's how many points you are at on the ground gathering real data, and how that relates to your classification and your mapping units. What we're trying to do is produce information in several broad categories. The categories broadly are channel and valley properties. In other words, we are interested in the relationship between the channel and the geomorphic setting; the biota, in as much detail as is relevant to your particular management objectives; the hydraulics of the stream, cross-sections, longitudinal profiles, slopes, substrate, and so forth; and water chemistry. Approximately 20% or less of our inventory process is field time. The other 80% is data compilation, massage, manipulation, mapping, data entry, searching other people's files, and so forth. That does not include writing reports.

The activity flow that we work with in gathering information is shown in Figure 4. This is also found in the handout, dealing with data bases (Appendix 7.2). First of all we have two kinds of flow information that we're after. One is that which goes into the mapping process, and the other is that which goes into the full data system. The map represents six of the 30 or 40 parameters that we gather about a reach. We map some very simple information, mainly fish species present, the nature of the bed material in terms of its texture, and three properties of the channel; its valley to channel ratio, its longitudinal slope, and the mean width of the reach.

2.3.1 Field Preparation

Firstly, we have a project area defined, which entails about a month of discussions with requesting agencies to get to know their objectives. We check bases and photos. I'll discuss map bases at the end of the second day, suffice it to say that we massage the 1:50,000 topographic base so it's a little bit more useful for presenting mapped information or we obtain a different base, if we're working at different scale, but we always work with a topographic base. We define the watershed boundaries. We establish a watershed coding. There's a handout on the watershed coding (Appendix 7.3) that we use. We do some pretyping from the airphotos that represent the project area. We never go into the field without having established what we think are reasonable reach boundaries, so we're not cold when we hit the field.



* DETAILED FISH SAMPLES CHEMISTRY, ETC. REFERENCED TO A POINT CARD.

Figure 4. Information and activity flow for aquatics.

2.3.2 Field Work

The field works consists of two segments, ground checking and aerial observation. Aerial observation is done by helicopter, and if you've really got a good stomach, by fixed wing, following the river with a tape recorder, giving the summary characteristics for each reach as you fly it, describing the location of every feature of significance in the river, the shoots, the falls, the debris jams, the areas of massive slumping banks, etc. This information is then compiled on the reach cards (Figure 5), which eventually go into the data base. That's the structure of the information flow. We also land and do point, cross-sections, flows, fish sampling, water chemistry sampling, ground truthing of the airphoto interpretation, and so forth at as many points as we consider necessary to represent the reaches that we have defined. This is our only chance to get a crack at fish species distribution. We get some real estimates of flow, and take a representative water chemistry sample; we may come back at a different season to obtain replicates --if it's an area that we don't known anything about.

QUESTION: Do you decide on your reaches before you go out in the field from the airphotos?

CHAMERBLIN: Yes, from the initial work. That's critical, otherwise, you're flying up the stream, all of a sudden, "Oh this looks different". "I must be on another reach". We like to be able to say, "O.K., coming around the next corner, it's going to start changing somewhere in there." I'm going to have to pick a spot for the boundary. It's arbitrary. Very seldom is it a hard line. You usually have a transitional zone. It's a little easier in the mountainous terrain than it is in the AOSERP study area. On the Athabasca River there are great long reaches and sub-sampling would be alright.

2.3.3 Field Cards

Now, what we're passing around are three kinds of cards: one is labelled reach (Figure 5), one labelled point (Figure 6), and one labelled fish (Figure 7). These are our basic field cards, and I will be going through each of them briefly.

REACH

Reach No. ______

SYSTEM NAME (or Alias) ______

SYSTEM NO ⌴⌴ ⌴⌴⌴⌴⌴ ⌴⌴⌴⌴ ⌴⌴⌴⌴ ⌴⌴⌴⌴ ⌴⌴⌴⌴ ⌴⌴⌴⌴

Compiling Agency ______ Access ______ NTS Map(s) ______

Field Obs ______ Date ⌴⌴ ⌴⌴ ⌴⌴ (yr mo day) Weather ______

Field Photo Y N Photog. ______ Roll ______ Frames ______

Air Photos Init. ______ Photo # ______ Yr. ______ Photo Scale(s) ______

ACTIVE VALLEY WALL PROCESS		CHANNEL WIDTH (m)	
		BED MATERIAL (%)	
Rock / Soil falls	Nil L M H	Fines: clay silt sand	
Mud / Snow flows	Nil L M H	Gravel (2-64 mm)	
Slumps / Glides	Nil L M H	Large (64 mm+)	
Slides	Nil L M H	Bedrock	
Gullies	Nil L M H		

BAR PRESENCE		CHANNEL COVER		
Side / Point	Nil L M H	Level	% Area	Distr.
Mid Channel	Nil L M H	Crown		
Transverse	Nil L M H	Overhang		
Junction	Nil L M H	RIPARIAN VEG.		
Diamond / Braiding	Nil L M H	Storey	Sp	Distr.
Lee	Nil L M H	Coniferous		
Dunes	Nil L M H	Deciduous		
Islands	Nil L M H	Understorey		
		Ground		

LATERAL CHANNEL MOVEMENT			TOTAL POOLS (%)	
Apparently Stable	Yes No		Bedrock control (%)	
Bar Veg Progressions	Nil L M H		Stage	Dry L M H Fld
Cut-Offs / Ox Bows	Nil L M H		Flow Char	P S R B T
Meander Scars	Nil L M H		Valley: Chan	0-2 2-5 5-10 10+ N/A
Avulsions	Yes No	#	Confinement	Ent Conf Fr Oc Un N/A
Terraces	Yes No	#	Pattern	St Sin Ir Im Rm Tm
Constrictions	Yes No	#	Vert. Stab	Deg ? Agr N/A
Unstable Banks (%)			Side Chan	Nil L M H

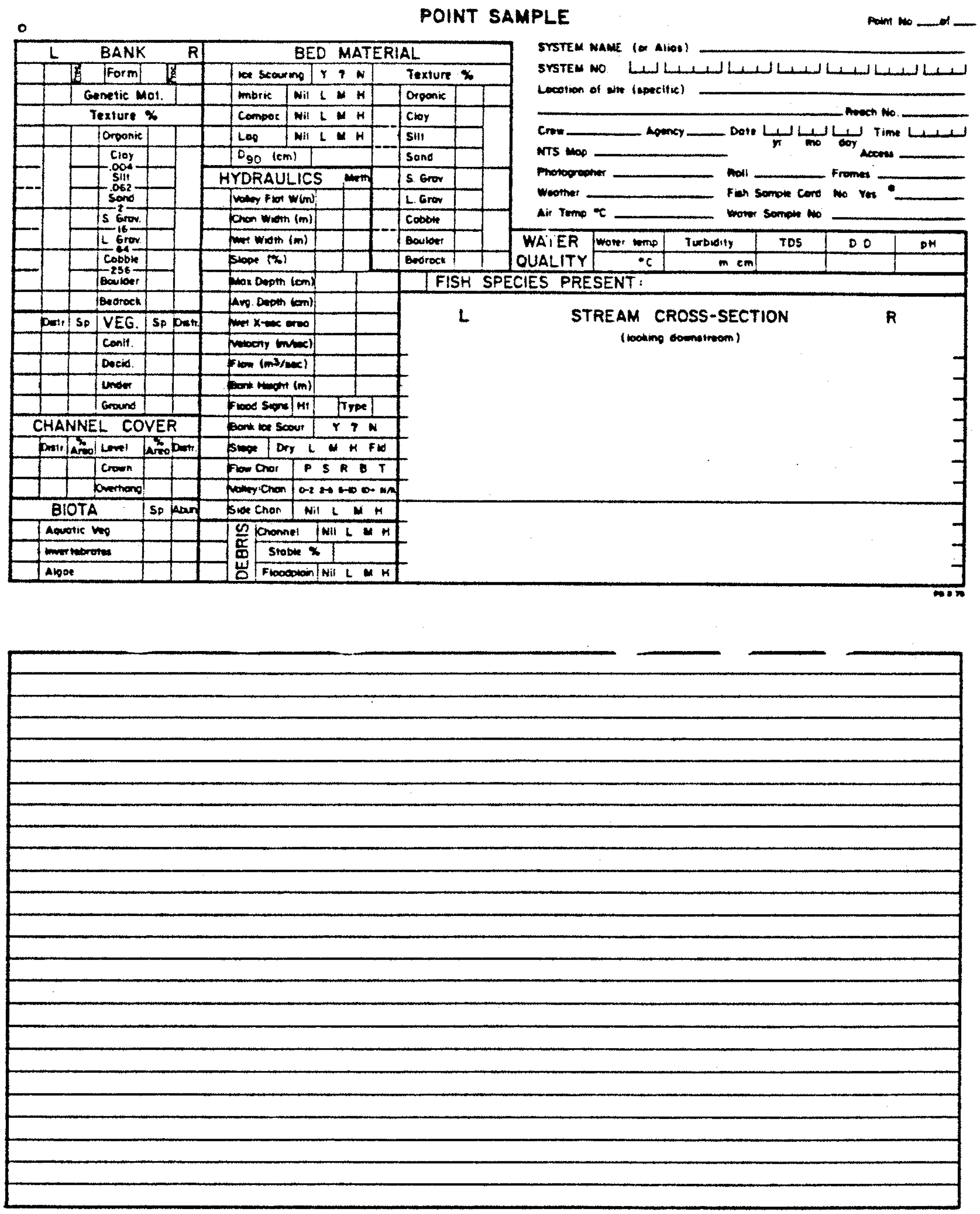
FISH SUMMARY				STREAM FEATURE		
Species	Use	Ref	Map	Type	Ht (m)	Length (m)

Channel Debris	Nil L M H	% Stable Debris	
Floodplain Debris	Nil L M H		

(Fish)

(Width) (Vall: Chan) (Slope) (Bed Material)

Figure 5. Reach tally card.



POINT SAMPLE

Point No ___ of ___

SYSTEM NAME (or Alias) ______

SYSTEM NO

Location of site (specific) ______

Reach No. ______

Crew ______ Agency ______ Date (yr mo day) Time

NTS Map ______ Access ______

Photographer ______ Roll ______ Frames ______

Weather ______ Fish Sample Card No Yes ______

Air Temp °C ______ Water Sample No ______

L	BANK	R
	Form	
	Genetic Mat.	
	Texture %	
	Organic	
	Clay	
	.004	
	Silt	
	.062	
	Sand	
	2	
	S. Grav.	
	16	
	L. Grav	
	64	
	Cobble	
	256	
	Boulder	
	Bedrock	

Distr	Sp	VEG.	Sp	Distr
		Conif.		
		Decid.		
		Under		
		Ground		

CHANNEL COVER

Distr	% Area	Level	% Area	Distr
		Crown		
		Overhang		

BIOTA	Sp	Abun
Aquatic Veg		
Invertebrates		
Algae		

BED MATERIAL

Ice Scouring	Y ? N	
Imbric	Nil L M H	
Compac	Nil L M H	
Log	Nil L M H	
D_{90} (cm)		

Texture %	
Organic	
Clay	
Silt	
Sand	
S. Grav	
L. Grav	
Cobble	
Boulder	
Bedrock	

HYDRAULICS		Meth
Valley Flat W(m)		
Chan Width (m)		
Wet Width (m)		
Slope (%)		
Max Depth (cm)		
Avg. Depth (cm)		
Wet X-sec area		
Velocity (m/sec)		
Flow (m^3/sec)		
Bank Height (m)		
Flood Signs	Ht	Type
Bank Ice Scour	Y ? N	
Stage	Dry L M H Fld	
Flow Char	P S R B T	
Valley Chan	0-2 2-5 5-10 10+ N/A	
Side Chan	Nil L M H	

DEBRIS		
Channel	Nil L M H	
Stable %		
Floodplain	Nil L M H	

WATER QUALITY	Water temp	Turbidity	TDS	D O	pH
	°C	m cm			

FISH SPECIES PRESENT:

L STREAM CROSS-SECTION R

(looking downstream)

Figure 6. Point sample card.

FISH SAMPLE CARD

Point______ FSC No ____ of ____

SYSTEM NAME (or Alias) ____________________

SYSTEM NO ____________________

Location of site (specific) ____________________

____________________ Reach No ____

Date ___ ___ ___ (yr mo day) Time ____ Access ________

Weather ________ NTS Map ________ Agency ________

Photographer ________ Roll ________ Frames ________

Crew ____________________

FISH DATA SUMMARY

Total No	Species	Size Range (cm)	Fish Use	Sampling Length (m)	Sampling Time (sec, min, hr)	# Sets	Diff	Method

WATER QUALITY	Turbidity	Horiz. Visibility
	m cm	m

COMMENTS

INDIVIDUAL FISH DATA

Sampling Method	Sample Type & No(s)	Age	Weight (gm)	Fork Length (cm)	Maturity	Sex	Species	Fish No.

Figure 7. Fish sample card.

I think a little picture (Figure 8) might be useful. Now, this is what we're talking about. We've got a watershed system. We can draw some kind of boundary around that, the land unit for the watershed. Within that watershed we can define maybe two or three reaches, and some sub-watersheds, each tributary represents a system. I'm going to defer talking about how we code those systems until tomorrow afternoon. But this is a reach. We label these on the map Reach 1, Reach 2, and the termination of the survey. Each of these reaches has a symbol, which describes, as I've indicated, fish, width of the channel, the valley to channel ratio, the average slope of the reach, that's filled under some kind of system code, which applies to the whole system; Reach 1, or Reach 2, or whatever it is. The reach card represents the things that we're trying to describe about the reach. Indications of active valley wall processes, of the kinds and abundance of bars in the channel within that reach, of indicators of lateral channel movement, and of the presence of terraces or constriction throughout that reach are noted. All of these can be taken off airphotos. So far we haven't gone to the field. We're interested in the perception of unstable banks in that reach. That requires that we go to the field, because frequently we can't see into the stream with airphotos. I must say that the Athabasca River is beautiful; I didn't see anywhere where you couldn't do most of it with airphotos. There's a lot of streams on the coast the size of the Steepbank River that you can't see. They're just totally obscured by vegetation. In fact, it's even hard to see them with a chopper, unless you go from side to side and look down in. We're interested in the average channel width; a rough breakout of the bed material composition in terms of fines, gravel, large material or bedrock; an indication of the cover of the channel over the wetted areas at the time of the survey (a time variable factor); the general nature of the riparian vegetation back from the stream bank; something about the pools, within that reach; and then a few general indications of relative stage, and the character of the flow. The symbols stand for placid, swirling, rolling, broken, and tumbling. I'll show a few slides to indicate what we mean by that. We found this quite

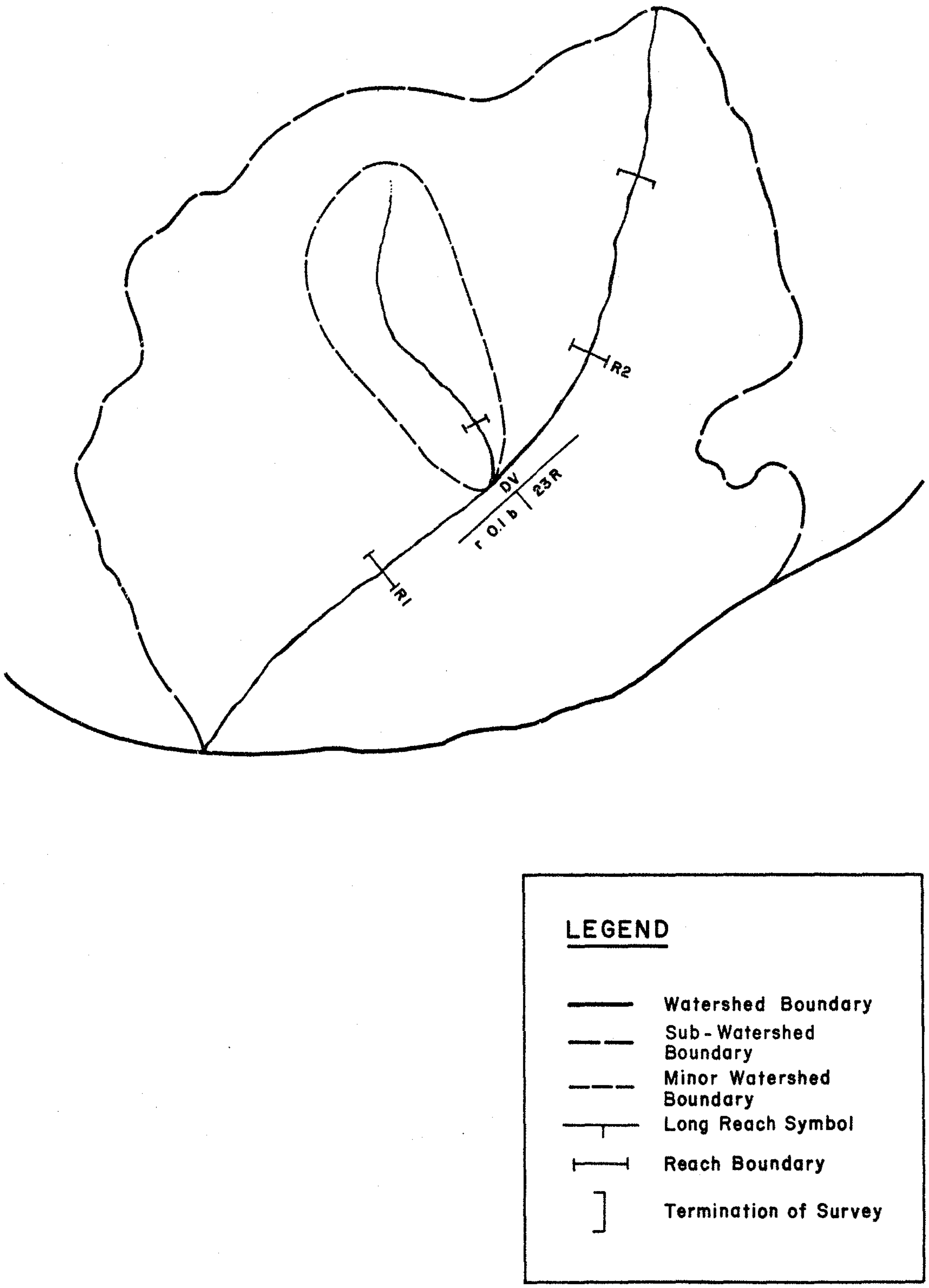


Figure 8. Watershed system.

useful, because frequently you can't get into a river. It's too big, it's turbid. You have no idea really of what's happening, but it turns out that recreationalists are quite interested in the surface character. It's also an indicator of the velocity of flow, depth, size of substrate, and stuff like that. We're interested in what we have for permanent terrestrial vegetation on both sides, not counting aquatic macrophytes. The degree of confinement of meanders by the valley wall is abstracted from Kellerhal's Rivers of Alberta (see Section 6) classification as is the pattern classification in terms of sinuous, irregular, and different kinds of meanders. Indications are of vertical stability of the channels. Channels you know can aggrade, in other words, build-up or degrade, cut down in terrain they're going through. There are signs of this, in terms of bars, in terms of bed transport, in terms of the behaviour of bed material, primarily. Note the relative abundance of side channels from the point of view of rearing habitat for fish. We're after some debris information. Our impression of the AOSERP study area is that, by and large, you don't have a debris transport problem. We would indicate low or nil debris on almost any stream we saw. Now that may be because there was a flood, and everything was swept out, but really you haven't got much wood up there. Frequently we find streams with miles of debris, in fact, on the Finlay where it goes into Williston Lake you can just about map a mile of debris.

Then the symbol on the lower right is the one that goes on the maps, taking some of the material from this card. We have a fish summary which indicates every species that we think uses that reach. This is not just what we've sampled, this also comes out of all the files we've searched, other people's reports, and so forth. We go back to the earliest records. We do code the sources of the data. We talk to some fisherman and he says, "yes, there's all sorts of Rainbow up there". You maybe write "some" on the card. We like to have verification. The stream feature listing is a cross check to what we map. It's also a cross check to out digitzing procedure, for our editing of the data file.

Up on top we have a bunch of administrative stuff to keep track of the system, name, number, compiling agency, how you get there, what maps it's on, who the observers were, date, time, weather, photos, etc., and the airphotos that pertain to that particular reach. We find all of this essential. We're quite picky about the name of the stream, too. We want to make sure it's the gazetted name. There are a whole lot of streams with local names, which we do keep track of as aliases for particular river systems. If you're communicating with somebody in Quebec, or somebody up in Williams Lake, local names can be confusing; you've got to be quite careful about that. Also everything is in metric.

Now these parameters and those that I'll get to on the point card and those on our fish sampling cards are all defined, each and every last one of them in a gloassary of terminology, which is the last bit of the handout (Appendix 7.5). We're not going to go through all the definitions. Learning them, learning how to use them takes at a minimum, something like two weeks of fairly intense field work with people that have been trained in it. What we're really going to just say is, these are the fields, they are described for every reach. Later on in the workshop, if we have interest from participants in particular interpretations, following Ted's work, we can go into some of the problems we have encountered in agreeing on defintions, such as, in getting consistent reporting on field activity and so forth. There's a real training challenge in introducing a relatively standardized system to something like this. There are in Canada something like nine accepted classifications of bed material in terms of textural ranges. We've opted for Wentworth because it's used by geologists and soils people; engineers use a very slightly different classification. The differences are really not too important, since the kind of sampling that we use for bed material is to look at it and kick it and come up with percentage breakouts. So if you want a 12-fold sieve analysis that's fine, but you're going to use up a whole lot of helicopter time hauling your samples back. That's why we settled for a 3-fold breakout, in terms of our overall characterization. Now, when it comes to the point sample, as you'll see, we have allowed for a finer breakout, since you're going to be there on the ground.

On the point card, we have very much the same kind of information, with greater detail in some areas, and the opportunity to distinguish between left and right banks. We also have a section for a stream cross-section which can be blown up, put on the back or whatever, if you're really getting fussy.

We have a fairly long list of hydraulics-related parameters. All of them are interdependent but some of them are derivatives. We have the opportunity for subdivisions within the fines, gravels, and large categories of bed materials. They don't have to be used, but, for example, if you're in a sand bed river, it's nice to indicate that all the fines are sand, so that you're not dealing with silt and clays. Likewise, if you have cobbles only and no boulders, that's of some significance.

The information about banks starts out with a form and process indicator. Our form classification is related to the active equilibrium process on the banks. We're interested in whether they're undercut or steep and stabilized, or whether they're granular and at repose in other words, the sort of normal bank of an alluvial river or whether they're relatively flat and aggrading, like on the inside of most meander banks. We then indicate the genetic material of the banks. The genetic material comes straight out of the terrain classification manul (Section 6) and should be exactly the same stuff as would be mapped by surficial geologists at the same point. Following that, we have texture of the banks, using exactly the same system as we use for the bed material.

Down below that we have vegetation and channel cover, which are defined exactly as they are for the reach, except we're making a distinction between left and right bank, if it's appropriate. Frequently you can't fill in one or the other. You're sitting on one side of a stream that is 100 m wide so you pull out your spotting scope and try to find the texture of the material on the other side, and the biota.

Now, on both cards you'll note that a certain number of the colums are shaded, in fact for every parameter. For example, you have the data entry for the parameter in question as 20% or Type 1 or whatever the particular code happens to be. You may want to say something else. You may be wholly unsatisfied with the pigeon hole we're forcing you to put your answer into. We have what we call a comment sub-file, which is now pretty rigorous. For any parameter or field you can put a comment number, turn the card over where you'll find a whole bunch of lines and you'll write down what you want to say, such as "this is entirely anomalous, the reason there is so much sediment is that a cat just ran across the river 20 minutes ago". That comment will be preserved with the data field. So, if there is a comment it will come out. You are prohibited from writing down anything anywhere else. You may not keep a field book of your own. If you want to write something about the river, if you want to say, "it feels to me like bla bla bla", you put it on these data cards, reference it to the closest parameter or just leave it general, and it will be preserved. One of the biggest problems we've found in dealing with field personnel is that they have a lot of information in their heads of a flight they did 2 years ago. Then they're transferred. We're trying to capture impressions as well as the hard data, but we're trying to separate them. All our people have these cards. If you want to add information, fine. Where you have species entries, for example, invertebrates, you have first of all a density (low-medium-high). These terms are defined at the front of the glossary. You can then start a species sub-file. For example, we found that habitat protection people who are dealing with wildlife frequently want to expand on the riparian vegetation description. All we're interested in regarding the stream is its influence on habitat, and nutrient input, and so forth. If they want to take it back a little further, fine. They build a sub-file, reference it to the riparian vegetation field at that point and then, if somebody asks what's known about anything around that point, you can go to that file and say there was a survey done in 1976 by Renewable Resources. They have a vegetation study in depth for that particular point. So more than just storing field data, this stores the existence of information anywhere. That was one of our objectives.

Finally we have a fish card; our biologists frequently want to record for every fish, length, weight, sample method, or whatever. That's on the back. There is a summary on the front which transfers straight to the reach card. The fish card will be referenced to a point location. You'll see on the upper right of the fish cards it says what point it is so that the data file will say whether or not there was detailed fish sampling done at a particular apoint.

By analogy you could design an invertebrate card, an otter card, or whatever is appropriate for your particular area. But it's referenced to the overall data base. It's not writing to persons who have worked in the area in the past and requesting their reports. That's what we're trying to get away from.

2.4 DATA COMPILATION

We come back from the field, and we get into a map compilation process in which we finalize our watershed coding as our data storage structure. We compile the map according to a whole long string of finicky rules that we have so that the draftsmen will know what we're talking about. Our set of finicky rules for our people is in Appendix 7.4. I'm fairly confident that nobody will want to take it home and start using it, but I thought it might be interesting to see the amount of detail that we have to go through to ensure consistency. In the last 2½ to 3 years we have had some 55 different people mapping internally, not counting outsiders using this system, and there is a real problem in correlation. We spent a lot of time talking about that.

Once the map is compiled (in other words, in a rough form), we digitize a fair bit of information using a Hewlett Packard system 9825 table top mini computer, pulling off what is basically an up-stream chronical of everything we've located the reach boundaries, the intersection of tributaries, the falls, spawning areas, whatever. We code it all. It will be possible then, for example, if you don't have a map on a given creek between 21 and 54 km, to ask are there any Coho, how many gravel beds are there that are suitable for spawning for a particular species, etc? We don't have that on line yet but it might be ready this winter.

Finally having done all that we send the map off to drafting. A mylar copy is made from which paper prints can be reproduced. We've opted for black and white as opposed to color so that they're cheap and easy to reproduce, and easy to update and amend. Being on mylar if you do another survey and change or add to the information on the map sheet it's easy to go in and update it. Right now, we microfilm all out maps and data cards for storage and distribution. Sometime in the future, maybe 6 months, maybe 10 years from now, there will be a way to reproduce them automatically.

In addition to the stream file, we have what we call a features file for the system. We do areas, perimeters, and some long profiles depending upon the interest in the area. We spend a lot of time reading other people's reports, pouring through Fish and Wildlife survey files, looking at the university professor's work, and so forth. It's amazing the amount of information that is available, that nobody knows about. I was in the AOSERP research facility camp talking to one of the researchers a couple of days ago and I asked what species are present in a particular stream. His reply was that he wasn't too sure because another researcher was doing that stream. I hope that when you've finished with the program the question can be answered by reference to some common data base, so that we don't have to look up so and so's AOSERP report on such and such creek on Page 3 of Appendix 3 to find out what fish are in the stream.

All this does is create the data base. From that point on we make an entry into our so-called models of understanding and then we can start discussing capabilities, suitabilities for town sites, mine sites, impacts of relocation of streams and so forth. Now presumably that's where you guys are going with the information you're gathering for AOSERP. That's an embryonic field. The only people I know of who are attempting to get quantitative and hard about it are the people involved in the office of Biological Services in the U.S. Fish and Wildlife Service in Fort Collins. For example, they are talking about how they are to relate the descriptive parameters in stream systems to use by various fish and to theoretical stability of beds.

So this is our sort of information and activity flow. It was drawn up primarily to direct some people who are designing our data system. The system design is being done by B.C. Systems Corporation. They're supposed to be good systems analysts.

2.5 INTERPRETATION

Having established the full range of characteristics of these units of rivers, we then get into interpretations, such as the capabilities for various uses, recreation, fisheries, whatever; the sensitivity to disturbance, bank stability, sensitivity to changes in flow, if you're interested in rerouting rivers and so forth; or present productivity. When we talk about productivity we're working at an incredible cruder scale, I think, than most of the studies I've heard described. We're working at the scale of 1:50 000, mapping data for which we may have one sample at one point in time, not even in every reach, a lot of inference from airphotos, some knowledge of distribution of species, and some theoretical knowledge about habitat preferences of the different species. Again there is a crucial distinction between the biophysical data base and the results interpretation. We're trying to keep the former fairly unambiguous, we're open to all sorts of conjecture, alternate models, hypothesis testing about the interpretations.

We don't write reports, we create a data base, we do a map summary, we do some specific analysis if we come to terms with you as a manager about processes you think are controlling your objectives. We've been forced into writing reports, now and then, and what that does is double the time. The problem with reports is that somebody has to read them, digest them, understand them, and relate them to their particular objective.

2.6 DISCUSSION

QUESTION: What relation do you have with the Canada-wide Limnological Inventory coming out of Winnipeg?

CHAMBERLIN: None.

QUESTION: Do you have any comments about it?

CHAMBERLIN: I'm not aware of a Canada-wide Limnological Inventory. I've been talking about streams so far. We've done some lake inventory, but there is another branch in British Columbia that does lake inventory. We're linking our data files to indicate where lakes have been done. On our maps they're indicated as separate reaches with a different set of summary information mapped such as maximum depth, littoral area, and fish. Specific lakes in British Columbia are inventoried. The stuff that's been done nation wide, we'd be quite interested in linking with. To my knowledge though they haven't approached us and I wasn't aware of them. Frequently nation wide surveys are oblivious to the existence of provincial or regional surveys, and vice versa. I talking about communications. I see the data base as really a communication tool. I see the maps as an effort to communicate. The biggest hangup it seems to me in surveys is letting other people know that the data exist, and the whole effort we're going through to resolve that problem.

QUESTION: When you have a project of the AOSERP type where you want to diagnose change over time, how effective as a diagnostic tool do you see the type of material you normally collect?

CHAMBERLIN: I'll be presenting examples of such diagnoses through time later. In reply to the other aspect of your question, I am not presenting a system for AOSERP. I'm telling you what we do at 1:50 000, for reconnaissance inventory, for streams only, for the non-dynamic properties. Water Survey of Canada and British Columbia Water Resources Service are responsible for hydrometric stations. We don't do any of that.

QUESTION: So with reference to the time-space aspect of the work are you implying you can't say much about dynamics of the system?

CHAMBERLIN: Not spending one hour on one river. If you come back 10 times you can. Your question is a general one we face all the time. Given 3 weeks and 30 000 mi^2 that's what we do. Given the objective of understanding the dynamic properties of the river we would do something quite different. We would come back at least four times. We would attempt to relate what we know about the hydrology of that region, therefore, we come in at high, medium, and low flows. We would get into unit area analysis, etc. None of these stand alone. Having described the point at which measurements are to be taken, you have, if you're a hydrologist, available to you a fairly broad set of theoretical tools ranging from Mannings discussion to bed transport equations. Every time you come back to that point, if you're describing the physical environment, you'll improve the applicability of those tools. That's what we're after. We're also after everybody who goes to that point, getting into a core of physical and biological descriptions which are useful. Biologists may not think channel width measurement is particularly significant whereas, for hydrologists, it is closely correlated with flow levels and that's closely correlated with the stability of the stystem from the point of view of critters. It's the interrelatedness we're trying to get at here.

These parameters were designed for a situation when you're only there once. If you can be there more often or need to be there more often, what we encourage is for you to fill out again the stuff that's most likely to change, particularly water chemistry, biota, etc. We build up, in effect, a file on that point in real space and if we go to other areas within the reach, a much more accurate characterization of the properties of that reach and the variability within it. I'm not implying that this does away with the need for a better sampling.

QUESTION: So you're saying this is a filing system into which you put in any other data collection to any degree of depth that you want?

CHAMBERLIN: Yes.

COMMENT: I think the problem is that you have the reach and the point sample cards extremely detailed for your physiographic type information or hydrometric information or whatever but the "biota card" is relatively limited. Researchers here would like more biota information to go along with the quite detailed reach card.

COMMENT: It's easy to collect, or you are able to collect, physical data on this sort of basis whereas it takes a lot more time to come up with any idea at all of what's happening in a biological system. This would involve you flying back and forth every day on a weekly basis.

CHAMBERLIN: That's an excellent reason for you as a biologist to take the very simple and easy step, filling out the physical data card during your first visit and updating it. What we're really after is some correlation between your knowledge of the biological characteristics of that river and the variables which recur. Presumably they're related.

QUESTION: I came here with something of a misconception that this was a once-over, fly over the river and that was the rubber stamp for your reach and that's all the information you're going to get. It seems that you're not advocating that at all.

CHAMBERLIN: I never have. Also it's a level of skills. We may never look at it. We may only look at an airphoto. Let's go back to where I started in terms of scale and objectives. We do, in fact, fly over once, most of the reaches that we describe. Once only with the tape recorder going and someone describing the scene. That's the data base. If we're really lucky, we find a place to set down and we do some sampling. If it's important we mount a study. But before we start sampling for invertebrates we, as resource analysis people, want to know why we're sampling for the invertebrates. You say we want to understand the biology of the stream. That's not a reason. As a manager I want to say "because if it's this way, I want to mine tar sands one way as opposed to different methods". If I worry about forestry operations, half the size of the clearcut or double the cost of road building. If I'm a town planner I will or won't put a subdivision in that direction. Those are the management decisions we're trying to relate to.

COMMENT: I think there's a comment warranted here. To get back for instance, to a national limnological survey. As far as I'm concerned, for at least 95% of Alberta lakes it would be totally useless because I can tell you they're all 30 feet deep, they've got 450 ppm and they've got the same species of invertebrates. You don't really need to survey many Alberta lakes to know what's going on. What you can do for a quick look at aerial maps is you can determine that 99% of Alberta lakes, on the plains, not in the mountains, are quite different. They represent the richest of the British Columbia lakes for instance. So if you have some experience in limnology you don't have to spend a lot of money to get the information. I think what Tom is saying, I would guess, is if I can look at the cards for a number of stream surveys I can guess pretty well whether we've got a productive stream. The point I'm trying to make here is that AOSERP suffered badly for 3 years up until last year for having no definition of purpose. We studied some things in intense detail with no possible reason at all for the study. We had no objective laid out and so I think you have to be very careful in defining what kind of objectives you have.

CHAMBERLIN: It's interesting that whenever I'm in a roomful of biologists they say that the data base is extraordinarily weak in terms of biological input and whenever I'm in a roomful of engineers they say this is awfully trivial. Surely once you're there you may as well do a decent job of describing the physical habitat. Any biologist who thinks that bed material composition or flow regime is not releveant doesn't know his field. We are doing reconnaissance inventory in British Columbia and this doesn't allow us to get into population sampling. Very few habitat protection biologists in British Columbia are interested in population sizes. They're interested in description of habitat. Habitat, by and large, is physical and chemical so that, you're right, it influences the bias. The other thing is, that's all you can gather in a one-shot survey. Now there's room in the data base for your studies, for the detail on population structure and the variability within units at ever-increasing levels of detail in terms of scale. When you start getting into that level of effort, when you're not talking about inventorying map sheets, you're talking about inventorying a site for a sewer outfall which is sort of a different project objective.

We sample for fish. We pick up rocks. We write down species if we know them and we note densities. We don't preserve rocks because we're picking that rock at the edge of the stream, at one point in time throughout the year. We worried about going too far with that sample. We were even more concerned about invertebrate sampling because of variability diurnally and through the year. About all we can say is the strean bottom seems to be crawling with bugs, the following general orders exist, and categorize or say it's barren. We think we're way ahead because we at least have kept track of where we were and describe the physical characteristics of the sample.

3. APPLICATION (E. HARDING)

3.1 POPULATION-HABITAT RELATIONSHIPS

Over the past 3 years it's been my experience that I'm doing more physical river analysis and less biology. At the moment I work with some fluvial geomorphologists and I sometimes feel like I'm not one of them because I don't know enough geology and I'm not a fisheries biologist anymore because I've stopped really working with fish and doing population studies. So I'm stuck somewhere in between in a no-man's land. But what I hope to accomplish in the long run is to be able to relate physical habitat to fish in a meaningful way. This just hasn't been done in the past. Most people don't want to look at this approach but I don't think it's as difficult as they think. It just takes a little time in that particular field. What I'm going to talk about is how I see the relationship between what we've been doing and fish.

I can basically only talk about coastal situations and a little about my northeastern British Columbia work which is not directly related to the rivers found in the Athabasca area. They're a little bit different in the sense of being foothills streams. So I'll stick with coastal examples almost exclusively.

Bact to the concept of reaches. Tom mentioned we used to think reaches are forever, which is quite true. I'm the one quoted who said reaches are real. After working with them for 3 years, you tend not to think of them as just lines on a map and zones. You think of them as handy units to describe things within. And once you start to look at them for a while you start to discover that there are physical properties that really exist and that there are relationships between fish and other biota and those physical properties that really are there. They're not abstract or pseudo, they're real things.

I'm not sure if I should use the word, but reaches are dynamic. Tom talks about a one-shot survey to describe reaches and rivers and that's one point in time. But those physical parameters you're describing are dynamic.

You talk about a certain type of bar or channel. That's not a fixed channel, that's a dynamic piece of geography. Once you learn what forms it, what the materials on the banks are, and what the flow of the river can do to the material, you start to see the dynamic aspects of those reaches. Suddenly they're no longer statements of what's there. They're statements of what's going on in that reach. They're dynamic to the extent that you don't have to look at them in high and low flow. You can look at the topography, the channel configurations and soils and you'll see what the river has done to that area through all sorts of types of flows. You'll get an appreciation for what the river can do, or is doing.

Fish types are associated with habitat characteristics that are associated with a particular kind of reach. Each reach boundary reflects different fish populations because it reflects different materials and different types of habitat. Those are not artificial, but real, boundaries. If you have the information and you can break the river into different forms, then if you want to see if there is any difference in fish populations you can sample each one of those reaches. Some are harder to sample and some will require different methods but if you want to get a true picture of the habitat of the river you obviously have to sample four or five different areas of that river.

An important sampling procedure, I think, that one should go through for fisheries inventory is to break up a river, to sample the reaches, and to see if, in fact, there are any differences in the fish habitat. If you don't do that initial step you could wind up putting 10 sites on the same reach and your inventory will not be complete for sites up or down river. If you don't have a lot of time and money to conduct sampling it will help you pick the most pertinent points.

3.2 SAMPLING

If you describe reaches they should provide you with information that will help your technical people decide what sampling techniques will work. For example, flow and turbidity information are important as they will influence sampling method.

Relate reach characteristics to the type of sampling. Be prepared for various types of sampling. Try to guess from airphotos which methods will work the best. On one-shot surveys preparation will improve success of the survey. Remember swimming can provide inventory sightings that angling or shocking miss.

An aspect to remember is that a high productivity value in a back channel does not necessarily reflect the value for the reach. If you discover that a bar which you sampled is the only one in a long section, your analysis of the reach capability is reduced. Fish data analysis is associated with sampling the reach. For example, if there are high numbers of fish in the meanders, and the entire reach looks the same, you could conclude there is nothing unusual about the point sample and can extrapolate for the whole reach. It tends to work.

3.3 DESCRIPTORS AND INTERPRETATIONS

I'd like to comment on a few descriptors on the Point Sample Card (Figure 6) and discuss their usefulness. Bed material. Discusses not just classification but what you can do with a particular material. For example, if you know the standard classification you could say sandy gravel versus gravel. You could then break that down to fines, gravels, and larges as percentages. The farther you go, the longer the time required to estimate and you may have to start measuring. So there's a whole range of things you can do with bed material.

Compaction. Range is from low to high. Refers to the amount of fine-grained material in amongst the larger rocks.

Imbrication. Rocks jammed together. Fit side by side, quite tightly. In a sense a compaction without fine material.

Lag material. Refers to material left on surface of stream bed after a major freshet flow. Can look at differences in vertical profile of bed or river channel with respect to amount of area covered by lag or the depth of lag.

D_{50} or D_{90}. Refers to the range of diameter classifications used for substrate. Gives an idea of the top of size classes so is a useful parameter. For example with a D_{90}, if the limit is a 10 cm diameter, 90% will be less than 10 cm and 10% will be greater than 10 cm.

Suspended sediment. This ranges from grab samples to continuous monitoring.

If you have all the mentioned information, you've got several interpretations that can be made. For example, with spawning, grain sizes and species are related. Reach classification with respect to bed material will start to relate to certain species use. Imbrication and compaction reflect the ease with which fish might use the material. For example, rainbow use uncompacted boulders for rearing. Size class of grain size material may be an indicator of presence of species. Suspended sediment will tell which fish will and won't use a particular system. Grain size also gives an idea of what kind of bars will exist. For example, no dunes exist in larger material.

Bed load is hard to measure. It can be related to flow in most of a river bed and will affect fish occurrence on the bed of the river. If you look at the recurrence interval of freshets, you can get a good indication of basic productivity of the river.

Bed material, bed load transport, and gradient are related. In British Columbia these parameters seem to be related to aquatic insects. We can gain information about basic productivity from a fish's point of view. Bed material also gives an indication of flow character and an idea of vertical channel stability.

3.4 SUMMARY (T. CHAMBERLIN)

We have talked about some of the problems of airphoto interpretation. The whole point is to structure the field program in the most efficient manner possible from the prestratification--working with reaches and trying to estimate substrates--to the type of sampling required, etc. We design a helicopter contract so that the flying is usually done in conjunction with soils, geology, wildlife, and whatever so we can get a chance to anticipate some of the interrelations that will hopefully emerge when we are coming up with management recommendations.

4. DATA MANAGEMENT TOPICS (T. CHAMBERLIN AND E. HARDING)

4.1 OVERVIEW

Data management topics are important if you're thinking of getting into systematic inventory of any sort. Many of the things I have to say now don't apply uniquely to work we're doing or to the aquatic inventory structure but to any research design that one gets into.

The material handed out is specific to these concerns.

1. Summary of Aquatic Data Base for Computer System Development (Appendix 7.2). Those of you interested in problems we've faced in designing the data base can look through this paper in detail. An activity flow chart and some standard interpretations we feel are useful and are being supplied at the present time to our management people are included. At the back are standard data summaries. These are the easy things to pull out of any data base that's biophysically oriented. We feel these should be standard reports that come out of any design for a data management system.
2. Watershed System Code Dictionary Users Guide (Appendix 7.3). This handout is intended as an instructive document to those people to whom we provide dictionaries. In British Columbia we have found you have to have a central agency controlling all the coding for all the rivers in the province. We have one person through whom all changes, additions, and deletions are channelled. Our dictionary at the most is about 3 in thick in terms of computer printout. That's about half the province done to the 3rd and 4th order level going upstream from the ocean.

3. Aquatic Mapping Procedures (Appendix 7.4). This handout contains, for those of you who think you want to get into mapping, some of the horrible realities of the precision that is required in terms of editing of maps. Our maps go through four phases of editing before they are at the stage where they are in the library and available for distribution. Before that time you cannot obtain a copy.
4. Glossary (Appendix 7.5). The glossary is an interim document we put together this spring to help people going on to the new cards understand something about the terms we are using.

If you reference any of these handouts please reference them as in manuscript form through our section. Please ask people to contact us for details. We will be putting out a compilation of these and some other methodological documents over the winter as a publication but they will no doubt be different from the present articles.

4.2 OBJECTIVES FOR DATA MANAGEMENT

1. Prevent loss of data. This loss is in terms of accessibility. If you can't get at the data because it's not physically accessible or is in a form that doesn't relate to the analysis you're interested in, I claim it's lost. The problem magnifies when a number of agencies are gathering data related to the same area which has to be used in a planning or management context by a separate group. For example, fisheries management people who don't know how the values for various parameters are collected may require data. It's all well and good to tell them that agencies A, B, and C have the data, and they'll just have to go and get it and look at it. Generally speaking they

either have to hire somebody to do that or sometimes it's more effective to go out and inventory again rather than to look it up.

2. Organize data. There are three fairly standard procedures:
   (a) Standard format retrieval packages. At the back of the data base handout there are certain standard data summaries;
   (b) Integration with other resource data bases; and
   (c) Hypothesis testing.
3. Improve efficiency. Transcribing field data, file assembly, digitizing, map compilation, and information retrieval are areas that will gain from improved efficiency.

Some of these may sound like trivial objectives but without some sort of rationale it's difficult to convince people it's worthwhile systematizing your data base. It comes down to only handling a bit of information once. When the data are brought from the field they should be placed into some format which makes it unnecessary to have to physically look at the data again. If you have to recode your information for every analysis you run, you have another generation of error creeping into the data, not to mention losses of time and efficiency. So it is wiser to contribute to a data base which you can then interrogate systematically for any sort of question in which you're particularly interested.

The three objectives mentioned are our objectives and these and why no one is allowed to take notes on anything other than the field cards. We are trying to reference these notes to a particular topic. That's why the comment columns were developed for these field cards. The cards are more than a means of recording the data in the field, they're also a means of structuring its storage.

4.3 WATERSHED CODING

We anticipated we would want to interrogate data bases primarily by watershed system, asking questions such as what's happening downstream, or upstream of this point within a watershed. We anticipated we would not be asking a lot of questions at the start, for example, on all Coho in British Columbia with respect to a specific activity. That problem may come up in a research mode for which we'd be writing specialized programs for interrogating the data base.

When you design a data base you want to orient it to the most frequently asked questions. That is why we came up with a hierarchical system based on watersheds. The ocean is our base level. On most systems other than the Mackenzie, a second order tributary is the one that the tributary from the ridge flows into.

The way we do it is clearly illustrated in the handout on watershed coding (Appendix 7.3). What we basically have is a set of fields which goes from right to left in terms of hierarchical ordering. We have a three digit number, a four digit number, and a bunch of three digit numbers. The reason was that we were trying to satisfy all users. We're only inventorying, at reconnaissance level, fairly large streams. First of all we subdivided the province, 00 to 99 for the major categories of runoff, everything else being tributary to those. We have 00 to 99 slots for the first tributaries, 00 to 99 tributaries to each tributary, and so on. There are nine slots left over between each of the named tributaries for things we miss. What we're finding is that additional streams may require interpolation. We've never had any trouble fitting things in with this amount of flexibility. If you want to go to smaller rivulets and rills the logical extension is to add more fields. If we wanted to generalize for western Canada and we didn't want to overlay numbers the obvious solution would be to go a letter prefix.

We've made some fudges to arbitrarily split off rivers that give us problems with names, for example the North and South Thompson join to form the Thompson. Frequently rivers change names. We define our way around to avoid confusion. We find this useful not only for computer base storage but for card storage in a manual format. We now have about 15 boxes of these cards. They are all ranked by number. It I have an inquiry about occurrence of steelhead above the bridge on a particular creek, I go to the dictionary, the alphabetical listing, look up the coding for that particular creek, go to the card file, find the number and look at the reach card for the fish summary. It's not really oriented to an in-depth special project oriented summary with a whole lot of data about one point. In that case it would be more reasonable to index the existence as a separate data file about that point in some kind of systematic file of all your rivers or whatever.

QUESTION: Everyone, Canada Land Inventory, British Columbia, etc. seem to have their own system for coding watershed and here we are talking about trying to integrate information so that users can obtain and use it instead of isolating it. Could you comment?

ANSWER: I didn't know Canada Land Inventory had a coding system. I know they've broken out some large regions by watershed. What we're talking about is a coding system which enables you to nail down a bit of information for a particular sub-sub-sub-sub-sub-basin. If somebody else is calling it region 8D, that's fine. It's the first 50 pages of our dictionary and we can indicate that. Our pollution control branch has a water quality storage system which is almost watershed oriented except where administration districts cut watershed boundaries. We tried using it but it only goes down three levels. So we've done a tabular cross-correlation where it can be done. As far as I know there is no other coding system for British Columbia.

The manner in which we get codes if we know we are going to do, for example, the Athabasca is that our central coding person will sit down with an overview map, break out the major basins, and assign codes to them. The field parties would do airphoto pre-typing, field work, and return. They know where they've been on the ground because frequently they've had to modify their inventory strategy during the survey period. They request new code numbers for all the creeks they have touched. Those go in, update the dictionary, and then we have final indexing product.

The system is designed for 1:50 000 scale reconnaissance mapping but if you look at the middle map on the wall it's been used quite nicely at 1:5000. By extending your fields you have the capability in structure, however you want to organize it.

I find I've mentioned quite a bit about the relation of field cards to the files, and I'll emphasize it now. On the field cards each data field is intended as an open file, capable of being expanded so that the structure of things revolves around the system, the reach, the point, as real physical locators. Thinking in terms of georeferencing, the point is in terms of latitude and longitude, the reach in terms of latitude and longitude of boundaries and more importantly the distance upstream of the boundaries of that particular reach. These are the two types of locators we use in our mapping and digitizing. Within this location think of it as a point on ground, as a file within that file where you can put anything you want--physical data, hydrometric flow data, quality, fish, or whatever is relevant to that point in space. Remember the fish card has point and system number.

One problem is the names of streams. In a small study area it's not as much as problem. In extensive data storage you find 75% of the names are not gazetted. There are problems in keeping track of official names versus aliases or common usage names. The maps that are published are usually pretty good but we always cross-reference the printed names to the gazette.

We have a convention for unnamed streams which is kind of useful. If you look in the dictionary, 90% of the streams inventoried don't have names. We enter the information as unnamed, no alias, then we try to give a clue such as, outlet at latitude and longitude, or flows into Schmidt Creek 1 mile below Beaver Lake; it can be found on a map, or can be referenced by somebody that's never heard of the particular area we're in. The real name of these streams becomes the number given to them. This is probably one of the rationales for our getting into systematic numbering. We've backed it all up with microfilm duplication. This includes the maps and data cards. It is cheap. A nickel for 64 data cards. Microfilm enables easy transport. Also we keep the reach cards together and the point cards together.

When numbering, draw an imaginary line up the mainstream, and number tributaries sequentially up as they enter the mainstream. Tributaries to lakes are handled the same way, a line through the lake, and number the tributaries as they enter. It is important to have one agency responsible for all numbering if you cross-correlate information.

4.4 MAPPING

The maps are produced from the field data.

We need a base to plot the map on. When plotted, the information we're interested in should stand out. If we look at an NTS sheet, the information such as the contours stands out. If we were to draft points onto the map it would be terribly confusing. So we get bases screened photographically, at the source. We screen our topographic features about 60% density, cultural features 60-80%, and then stream lines are left full density. So stream lines, stream symbols, and features mapped on the streams stand out over the bases. I think it shows up on 93P3 (Appendix 7.6) and the East Kootenays map (Appendix 7.7). You can see the stuff we've plotted on the map. You have to squint a bit to see the topo lines. That's deliberate. This is a standard trick done for most mapping. It usually takes a long time to prepare the bases, so allow a 2 month lead time to have bases ready to go to the field for mapping. We do our field mapping on regular NTS sheets. When they go in for mapping, the base is on mylar and has been screened so final prints come out looking as they do. Black and white is cheap. Colour is too expensive to reproduce and we'd have to decide what to do with it.

The legend on the side of a map contains everything we're going to put on the map. Examples in the handouts (Appendix 7.6) have the legend. Always ensure a map has a legend.

The sorts of things we have to worry about when we're compiling the maps include map-to-map matching. We spend about 50% of our time worrying about that. Every river that crosses a map boundary has to be correlated with the river on the other side of the boundary. It would be nice if we could get special bases watershed by watershed, but they would be funny shapes and not practical to work on. When we cross the boundary we have to ensure the lines of delineating the watershed is the same kind. We have three kinds of lines which indicate the reach.

The reach symbol is plotted. It contains information about fish, channels, and bed material and has to be doubled up on both sides of a map boundary. The reach numbering has to be consecutive from base level up, which gets you into some problems if you're starting in the middle of a river, as you would be on something like the Mackenzie. The way we solve that is to start at the provincial boundary.

Watershed code numbers have to be put on a map in such a way that you always know what data files to go to for the information. If you look at this little mapping handout (Appendix 7.4) you'll see that most of pages 2 and 3 attempt to tell our mappers how to write the numbers down so they're not confusing. We keep coming up against problems. When we give the map to somebody for outside edit the person asks, "does that number relate to this basin or that basin". It's a simple question but if given to a user that's never heard of a watershed you'd better be sure they'll be looking up the data in the right file.

We do run into the problem of too much data on maps. This is where our system file comes in and where the map becomes just an indexing tool. Where you have several agencies taking samples or transects within a mile of each other, you have a little forest of symbols that's really awkward. That's the point cartographically at which one should cop out and make a reference to another file. What I'm trying to get at is the map is merely a method of communicating information. It doesn't have to show the whole real world. What it does is tell somebody that information exists of a particular sort. Unlike a geology or soils map on which most of the information that's gathered in the field is plotted, our maps are primarily an indexing tool to a data base which contains most of the stored information. It makes no sense to get into this racket unless you have a commitment for a computerized data base of some sort. If you are going to have to do it by hand for the next 5 years you'd be much better off designing a system oriented to manual retrieval, perhaps mapping much more of the information. We did that for a couple of years in federal fisheries on the coast, still using a reach concept but simply numbering reaches and in the legend on the side just matrixing the parameters. We published the data base on the map.

Legends are where flexibility lies. When you're mapping a soils map all the legends are different. Each soil association has all of its properties printed out. They're just getting into a soil data file. There's the Canadian Soil Information System and there's a British Columbia soil data file which links with it and stores that in addition to lab stuff. One could do that for streams and perhaps lakes. (The whole point about a map is that you can go to a meeting with it, talk about your systems, etc.).

You must come to conclusions about pen widths. It is important to achieve some degree of standardization. Otherwise your users will get maps that look different from different areas and you'll confuse them.

One thing we like to do is to indicate exactly the area we know something about and the area we don't know something about. We put a specific termination of survey symbol on our maps which indicates we have data from this point down or up. If we haven't looked at that stream with airphotos or aerial reconnaissance we won't do that. Quite frequently we'll have a road up a valley that cuts many tributaries. We'll stop at each road crossing and throw in a fish sampling point, dig a little gravel, and check out a few invertebrates. We've got a point sample card for each of those points within that system but the system hasn't been surveyed. We wouldn't attempt to break out reaches or imply that we know anything about the whole system. We still use the same framework for storing those almost incidental data. We give them a number and reference points within the system.

We have various devices and conventions for mapping multiple features which are self evident on page 6 of that handout (Appendix 7.4).

We have a concept, a zonal characteristic which is kind of useful. It can be used for any purpose you want. Cartographically, it's almost mandatory. This country doesn't seem to be noted for having cascades and falls every 20 ft but you can get into the situation of having 8 to 10 falls of varying heights. It's entirely arbitrary whether one calls that a cascade or waterfall. Normally we'd bracket the zone, and put many falls there. If you know the 10 m thing in the middle is important you could always pull that out and indicate it within the zone. The mapper has to exercise some kind of judgement to compromise the information and readability. One can always say on the reach card anything one wants to in terms of detail within a given parameter. Given that we put a map together, we have another input to the data file. We consider it likely or at least possible that people will not have the maps accessible to them or will not want to handle 50 pieces of paper but may want to ask questions such as what's happening on the upper 50 mi of a given river. It's awkward to pull out all the maps, tape them together, and so forth. So we got into digitizing. All we do when we digitize is put the map on a table that is gridded electronically and use a cursor to follow the river, plotting every point at which something is located. The machine pulls off the X and Y co-ordinates in terms of inches to the nearest 100th on the table. You write yourself a little program, the output goes through a computer and converts the co-ordinates to a latitude and longitude and because it's sampling quickly you can get a simultaneous printout of distance of every point upstream from the mouth. Those are our two georeferencing inputs. The latitude and longitude allow us to correlate with polygon digitizing systems that are being used by the forest service for their forest cover maps and will be used by Canadian Soil Survey and our soil surveyors for soils and geology maps. We are trying to cross-correlate as much as possible the data bases each of the disciplines are developing. It becomes relevant too when we get into climate data. We would like to get into hydrologic modelling but there are all sorts of problems.

We also input the elevation or reach boundaries prior to actual digitization, interpolating between contour lines as best we can. We then get an average slope calculated for every reach along the river. Then from that, and another program, we can ask for a printout of the profile of that stream. Those will be average slopes.

A separate digitizing program indicating every contour line crossing will provide a better long profile. We have found that fairly useful for some of our work--slopes of long rivers and engineering points. That program is used for our airphoto work as well. We can take a set of airphotos that have river displacement on them through the years, and we can measure accurately with the cursor the lengths of those displacements.

We also take the area perimeter of every basin. This is useful in some of the hydrology type work. Presumably if one were calculating nutrient budgets it would become relevant.

There is a certain flexibility in programming the cursor and overall production is good.

After the map is compiled by the person who did the survey it gets edited once. Then it goes to somebody who was never in the area for an edit. Then it goes to preparing the coding form for the digitizer which is another form of editing, and after the drafting there is another edit.

The biggest problems are trivial ones: numbers in the wrong place, non-consecutive reach numbering, points on cards that don't match points on the map, and points on that map that don't have cards.

If you're designing a data handling system, the only key to avoiding errors is to handle your data as few times as possible. This is preferably once only.

How do you handle systems for which you don't have any information? You have to fit them somehow. Let's say you have a chunk of river that you flew over, you know it's a different reach, but you don't know what is happening there. Maybe it's the last 10 mi of a tributary in the mountains and you don't want to bother flying up because there's no fish in it and there's no development slated for it. We still give it a number. We code it differently in the data file. Keep track of the fact that we don't have any information. We also run into streams that disappear into the ground and re-emerge. We handle that by hypothesizing hydrologic connectiveness between those water systems and the nearest lake or river. It's more a device to keep track of the information than an attempt to say something about reality.

I've nothing against Universal Transverse Mercator (UTM) coordinates. It's the military grid on some published NTS map sheets. It's a good way of telling someone where you are in the field. It's not on all bases yet. Another problem is it's an equal area projection. Every grid is 1 km^2 so as you go north it distorts and it jumps as townships and ranges do. There exist canned programs to convert between UTM and latitude and longitude.

5. DETAILED INTERPRETIVE PROJECTS

We'll present details of two interpretive projects we got into due to base mapping. One project represents a different kind of base mapping but is still connected to aquatic systems. Ted will discuss this. We've looked at airphotos, right down to 1:5000 of the area that he'll talk about.

Following that I will describe some of the detailed aquatic system work we did that doesn't include fish at all but has been very useful in terms of land use planning.

The first project dealt with a new townsite and interpretations for the flood plain. Flood plain analysis is important with respect to road location, sewage plant location, etc.

Flood plain analysis is based on land forms. We looked at flooded areas in the flood plain and classified them according to the value to fish and how fish use them. The classifications were frequently flooded, occasionally, rare, and unlikely. These were based on litter cover, vegetation, terrain height, and terrain unit types.

If you look at all reach breaks on the river it is evident that habitat occurrence varies. You can also analyze movement of meander bends.

The second project presents one kind of detailed aquatic system mapping used on Bowen Island (Appendix 7.8).

The scale had to be large enough to relate to blocks of planner's layout. The reach analysis used a different classification system and the emphasis is different.

We had a base data map, watershed coding, and numbers. This was overlain with the soils and terrain maps.

The units were numbered 1 to 14 and land base units were described in three ways.

A final note is to remember that scale means increased sampling density. Also, a reach boundary, or a land unit boundary represents a transition between two regions. The pen width of the line can represent several hundred metres on the ground.

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7. APPENDIX

7.1 LIST OF PARTICIPANTS AND AGENDA

LIST OF PARTICIPANTS

Michael Kent	-	Schultz International Limited
Akio Masuda	-	Water Quality Control Branch, Alberta Environment
Pat Mitchell	-	Water Quality Control Branch, Alberta Environment
Hal Hamilton	-	Water Quality Control Branch, Alberta Environment
Dave Beliveau	-	Water Quality Control Branch, Alberta Environment
Bill Griffiths	-	Renewable Resources Consulting Service
Brian Hammond	-	Research Secretariat, Alberta Environment
Gary Jenkerson	-	University of Alberta, Department of Botany
Roy Crowther	-	Internal Environmental Consultants
Bill Bond	-	Freshwater Institute
Kaz Machniak	-	Freshwater Institute
Maurice Lock	-	Freshwater Institute
Andy Nimmo	-	Freshwater Institute
Bruce Skirrow	-	James F. MacLaren Limited
Phil Tsui	-	Aquatic Environments Limited
Ken Crutchfield	-	Fisheries Branch, Alberta Recreation, Parks and Wildlife
Dave Berry	-	Fisheries Research, Alberta Recreation, Parks and Wildlife
Stu Smith	-	AOSERP
Ali Khan	-	AOSERP
Av Mann	-	AOSERP
Ev Wrangler	-	AOSERP
Read Seidner	-	AOSERP

AGENDA

Day 1

0900 Introduction to biophysical (ecological) inventory:

- a brief outline of where aquatics inventory relates to other types, the role of inventory in the decision making process, and how the Resource Analysis Branch attempts to do it.

1000 Aquatic inventory structure and parameter overview:

- the component parts and activity flow of aquatics inventory with emphasis on the reconnaissance scale. A rapid slide introduction to parameter definitions.

1100 Workshop: Objectives, scale and data needs:

- participants will produce an objectives - data needs matrix relevant to their own experiences.

1200 Lunch

1330 Uses and limitations of data, or confronting the real world:

- an in-depth review of the potential and limitations of selected inventory parameters with special reference to analyses done in the 93P3 map sheet.

1500 Workshop: Airphoto interpretation:

- an introduction to pattern recognition and practice in reach boundary identification and point sample selection.

1600 Discussion of workshop conflicts.

Day 2

0900 Workshop: Airphoto interpretation (continued):

- parameter estimation, sequential use of increasing scales, review of relation to objectives.

1100 Discussion in expectations from air photos and biophysical inventory design.

1200 Lunch

1330 Data Management topics:

- Field cards in relation to data files.
- Watershed coding as key to the system.
- Maps: bases and compilation procedures.
- Map digitizing objectives and procedures.

1500 Related Aquatic Inventory:

- 1:20 000 and larger scale channel mapping.
- Land use hydrologic interpretations.
- Rapid floodplain analysis techniques and their relationship to aquatic habitat.

7.2 SUMMARY OF AQUATIC DATA BASE FOR COMPUTER SYSTEM DEVELOPMENT

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SUMMARY OF AQUATIC DATA BASE FOR COMPUTER SYSTEM DEVELOPMENT

T.W. Chamberlin
Resource Analysis Branch
September 1977

Introduction

The aquatic system program describes biological and physical attributes of fresh water systems (rivers, lakes, streams, creeks, and marshes, etc.) and analyzes them for the purposes of integrated resource management. It was initiated in 1975 in the absence of any holistic biophysical (ecological) viewpoint of aquatic systems and hence some of its features remain under development. Nevertheless, it exists at the time of writing (September 1977) as the only such continuing program, and has been accepted in principal and in practice by several other agencies.

For a given aquatic system (watershed, basin) data are gathered from all available sources (remote sensing, aerial observation, ground sampling, existing files, interviews) and are compiled as maps, data files, interpretations, and summaries. The methodology for sampling is documented (but under continued revision) and has resulted from two major interagency workshops and a series of field training camps for technicians. The Resource Analysis Branch presently retains responsibility for sampling standards, data handling procedures, and map presentation formats.

The data capture, storage, interpretation, and presentation aspects of the program were originally intended to be assisted by a computer system, but these phases have not kept pace with sampling.

The balance of this report addresses the objectives, existing structure, and applications of system development for the Aquatic program.

Objectives

In the context of the above, the objectives of system development for the Aquatic program are as follows:

1. To prevent loss of data gathered in field programs by R.A.B. or co-operating agencies.
2. To organize the data for:
   a) Convenient retrieval in standard formats;
   b) Integration with other resource data bases; and
   c) Hypothesis testing.
3. To improve efficiency in manual time spent in:
   a) Transcribing from field card formats;
   b) File assembly and review;
   c) Digitizing mapped information;
   d) Co-ordinating map preparation administration;
   e) Map drafting; and
   f) Information retrieval for specific analysis requests.

The three objectives are interdependent, and would presumably be best served by an integrated system design. They are listed separately, however, since each could be accomplished by a more restricted hardware and program development investment.

Present System Structure

The present Aquatics program is oriented to a map and three types of files at the 1:50 000 (detailed reconnaissance) level of sampling intensity. These will be defined before examining the activity and information flow which links them and leads to the user.

Map: The Aquatics map is compiled following airphoto interpretation and field work. It locates significant stream features and all sampling points. Homogeneous sections of streams (reaches are mapped and characterized by seven physical attributes and the fish species present. An additional 17 physical and five biological attributes are compiled on the Reach Tally Card (see below).

The Aquatics map is a limited summary document intended to be understandable by the non-professional. A significant disadvantage of the map is that several 1:50 000 mapsheets may be required to encompass one watershed, making the review of information pertaining to a particular location on a stream awkward.

Point (Plot) File: All field sampling information is recorded on a Point Sample Card. These are numbered and filed by the system code (see below) of the watershed in which the point is located. The point sample assists in characterizing a reach and provides ground measurements of parameters such as flow, water quality, and fish population which cannot be observed from the air. The Point Sample Card presently includes 26 physical and 13 biological descriptions, a list of fish captured, and comments.

At the present time, comparisons between points or groups of points can only be done manually on a card by card basis.

<u>Reach File</u>: Reaches are mapping units, the characteristics of which are <u>inferred</u> from field sampling, aerial observation and remote sensing, and data in existing files. The latter are important since many biological and hydrological stream properties would otherwise require repeated sampling through time. The Reach Tally Card contains 24 physical and seven biological descriptions, a complete list of fish species which may occupy the reach (with a key to their life history types), and comments.

Information organized by reach reflects real physical processes in two ways. First, there is an upstream-downstream relationship; material leaving one reach must enter the next. Second, the sum of reach properties defines some watershed properties such as total fish present of a given species. These functional relationships have no simple analogs in terrestrial ecosystems, and would lead to a variety of resource based analyses if reach data were comparable.

<u>System File</u>: The basic concept of an aquatic system rests on the watershed, or land area, which contributes flow to a water body. Watershed systems have aggregate properties (such as area) which determine their hydrologic behaviour, and populations of animals which may also reflect influences external to the watershed (e.g., a dam). The system file is intended to store these data which do not relate to specific points or reaches.

Watersheds are hierarchically related, and a coding system has been developed for B.C. which reflects this hierarchy through seven levels of tributaries, sub-tributaries, etc. The R.A.B.

currently establishes and maintains the master dictionary of watershed codes for all agencies and private companies gathering data in a similar manner.

In addition to organizing the storage of physical documents (Point Sample Cards, Reach Tally Cards, Maps, existing file documents) the coding system is intended to provide a logical structure for collating data within larger systems, providing comparisons of properties between systems, and facilitating upstream-downstream (e.g., for effluent disposal) analyses.

The system file, at present, also contains a location referenced listing of all mapped physical features and sampling locations. The listing is digitized from the map before drafting and also provides the slope of mapped reaches. A fuller discussion of the digitizing function is given below.

Summary of Existing Data

As of fall 1977, within the R.A.B. there exist approximately 2200 Point Sample Cards, 4500 Reach Tally Cards, and 1200 System Files in rough paper form. Approximately 150 maps (1:50 000 scale) are in the process of being compiled and drafted.

A volume of data totalling about 25% of the above is being generated through co-operative relationships with the Fish and Wildlife Branch and the consultants who have adopted our methodology.

Digitizing

The digitizing procedure is central to several phases of the aquatics program, and is described here as three separate projects. It should be strongly emphasized, however, that the digitizing table and associated calculator represent an extremely versatile measurement tool, the potential of which is only beginning to be developed.

1. The Features Listing: Following map preparation and editing, but before drafting, the location of every mapped feature, sampling station, and map symbol is measured, both in terms of latitude and longitude and distance upstream from the stream mouth. This listing is intended to allow convenient access to the existence of specific features (e.g. waterfalls) in streams which may cross several map sheets, or indeed large regions of the province.

As a spinoff of features digitizing, the average slope of mapped reaches is calculated and added to the map as an explicit reach parameter. The length of each reach and total stream length are also calculated.

These data at present reside in the System File, but could equally logically be stored in the context of the Reach.

2. Area and Perimeter: Each watershed which is digitized for a Features Listing also has its area and perimeter measured. These basic system properties constitute the first mandatory entry to the System File following its code number designation.

Numerous other applications of the area program have developed, including the obvious measurement of other polygon types (e.g., soil or terrain units), lakes, administrative units, present land use patterns, etc.

3. Distance (length): Various applications of length measurements are being explored in pilot projects. These include the measurement of the migration of river meanders on sequential aerial photography, the rates of bank and valley wall slumping, and the photogrametric measurement of channel hydraulic parameters (width, bars, bank heights).

When compiled with contour interval information, length measurements on a topographic map permit longitudinal profiles to be easily plotted.

Future System Developments Involving the Digitizer

The efficiency of present use of the digitizer will be considerably increased with direct input to computer files. At the present time, output is hand transferred to a coding form which will be entered into the System (or other appropriate) File when developed. About 1 to 2 hours per map sheet are required for the coding of the Features Listing alone.

It is also apparent that in tracing the boundary of the watersheds on a map (Area - Perimeter) and the stream line itself (Features Listing), all data necessary for map reproduction can be stored. The possibility of computer assisted map production for arbitrary geographic areas is a next logical step, and would reduce considerably the manpower requirement for data presentation.

Existing Digitizing Time Requirements

The following assumptions are used in this analysis:

1. R.A.B. Aquatics has a backlog of about 100 mapsheets to digitize.
2. R.A.B. Aquatics will complete 50 new mapsheets per year.
3. A mapsheet has an average of 13 watershed systems delineated.
4. Features Listings require 4 hours per mapsheet.
5. Area - perimeters require 2 hours per mapsheet.
5. Outside agency inputs will total 25 mapsheets per year.

Given these assumptions, Table 1 summarizes the best estimate of digitizing time requirements for existing program levels in R.A.B and other agencies.

System Development for Aquatics Program

Over the past 2 years, some system design has taken place, notably during the period of time (pre-BCSC) when the Honeywell computing system was favoured. At that time the basic "nesting" structure of Point, Reach, and System Files was solidified, and the watershed coding system was developed.

Since then, full definitions of all parameters, upper and lower limits required for internal edit checks, and the data capture flow have been established. This process was essentially completed by the spring of 1977.

During 1977, the watershed code dictionary has been put on a computer basis as an intial step toward the creation of System Files, and a correlation made between it and EQUIS for all overlapping stream systems.

TABLE 1

Aquatics Digitizing Needs Related to Aquatic Systems

	R.A.B.	Other Agencies
Feature backlog	56 days	6 days
Area backlog	28 days	3 days
Features 1977-78	28 days	5 days
Area 1977-78	14 days	2 days
Total to 1978	126 days	16 days
Features per year	28 days	9 days
Area per year	14 days	5 days
Non-map users per year	20 days	unknown but large
Total yearly needs	62 days	14+ days

No other progress has been made towards the establishment of Point, Reach, or System Files or in the creation of data input procedures.

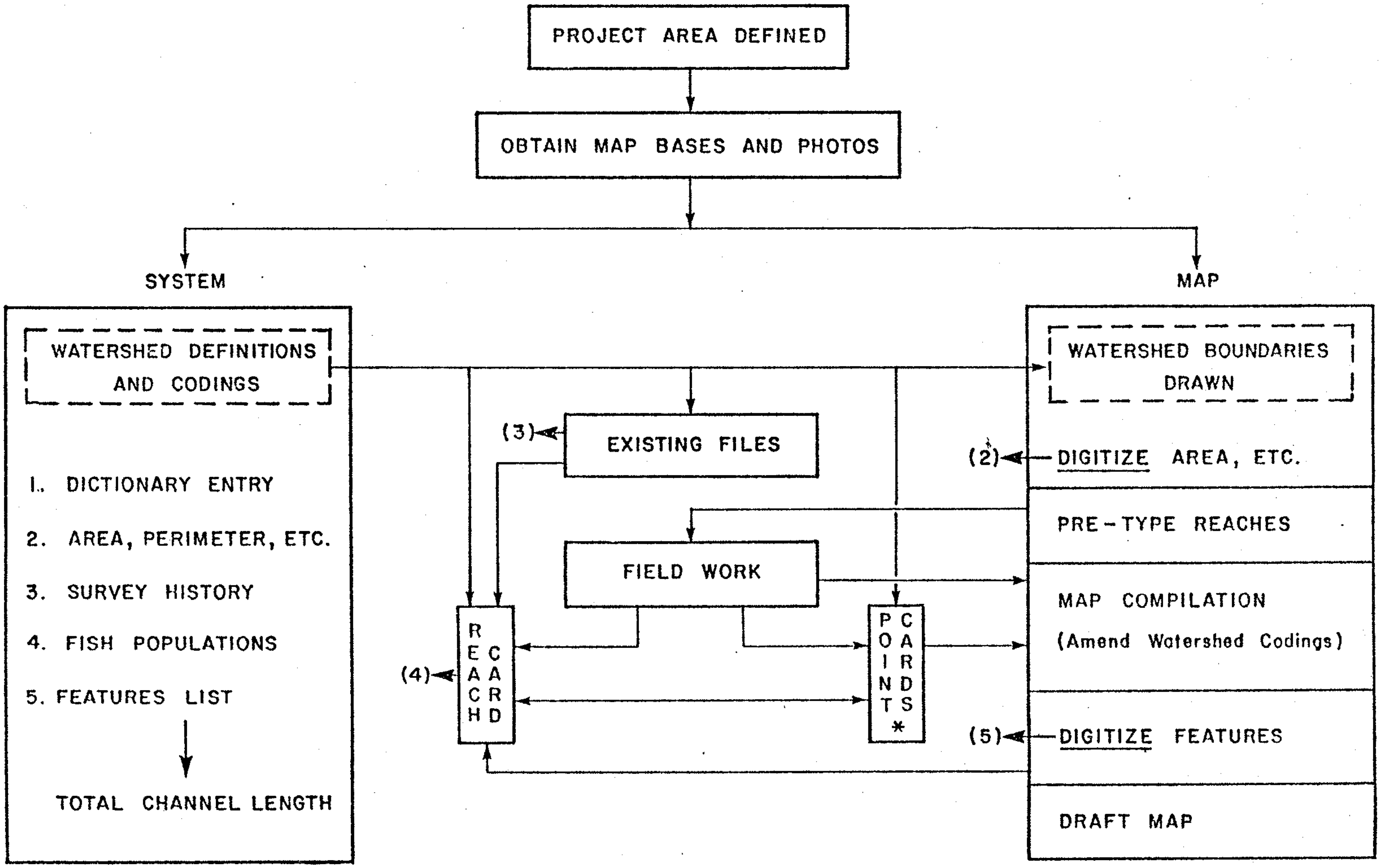
Figure 1 diagramatically illustrates the flow of activities and information to the point of potential data storage. The physical data documents (map, point, reach, system) provide a location for all information gathered, and hence begin to meet objective 1 (cf. p.2). The transfer of such files to machine readable form (tape, disk) has value, however, only in the context of anticipated applications and users.

Aquatics Data Application and Data Management Needs

Aquatics data have been requested by a variety of agencies, Regional Resource Management Committees, private consultants and individuals. At the present time, the requests have been of two general types: summaries and/or interpretations. Requests capable of being met are necessarily simple, since multi-parameter or multi-region comparisons cannot be made with the manual data base.

Typical summaries which have been requested include the following:

1. Flow measurements through time or space;
2. Water quality measurements through time or space;
3. Fish species present in a watershed;
4. The presence of particular types of stream habitat, obstructions, etc. from maps; and
5. Location of stable zones with respect to forest harvesting, road bridge engineering, etc.



* DETAILED FISH SAMPLES CHEMISTRY, ETC. REFERENCED TO A POINT CARD.

Figure 1. Information and activity flow for aquatics.

Interpretations which have been attempted, on a qualitative basis, are generally limited by the capability to sort and compare parameter values from different times and/or locations as well as limitations imposed by the "state of the art". They have included:

1. The timing of fish life histories;
2. The capability of rivers for fish by broad species or life stage groups;
3. The susceptibility of streams to temperature increases;
4. The identification of critical (sensitive, important) habitat areas. (e.g., Environmental Protection Areas);
5. Fish population characteristics where detailed sampling has taken place;
6. Erosion potential of stream banks by reach;
7. Suitability of river for canoeing, campsite development, or other recreational activity;
8. Regional hydrologic analyses based on basin and channel properties;
9. The classification of rivers (and reaches) based on useful combinations of physical and biological attributes; and
10. The relationship between river attributes (e.g., sediment loading) and other resource information (e.g., soils and geology).

For each of the above interpretations, a model relating attributes of the aquatic system to the desired result can be constructed and the data reviewed. Indeed, most specific analysis requests take this general form and are handled by hand.

The time required for a relatively simple request such as a list of what exists (fish, gravel, etc.) in a moderate sized system (e.g., the Sukunka River) takes from 0.5 to 1 day. Hence the data are, for any practical purpose, inaccessible if more than a few data elements (cards, maps) must be consulted.

From the above, some generalizations can be made about the necessary properties of any data management system to be designed for the Aquatics data base.

1. The data management system must be hierarchically organized to permit the aggregation or separation of system properties on a watershed basis.
2. Data will usually be accessed on a watershed basis, with comparisons between watersheds being made following data manipulation within a watershed.
3. There will be a small number of relatively simple listings or summaries based on single reach or system attributes which will be most frequently requested (see Appendix I).
4. The capacity for adding additional data applying to a given point or system must be maintained. The alteration of data, however, is not anticipated. Reach attributes will also likely remain stable.
5. Given data accessibility in Reach and System Files, several models using both physical and biological data will be constructed to test hypotheses about system productivity, stability, capability for various uses, etc. These will not be routinely requested for some time and will form separate projects.

6. A georeferenced comparison of Aquatics data with that of other resource bases (terrain, soils, climate) will be required as a part of (5) above.

7. For frequent data base uses (items 1 to 4 above), the procedures of data input, edit, and retrieval must be interactive. This is predicted on a number of assumptions:

    a) Coding takes time and introduces error;

    b) The transfer of field data to file will require some interpretation (understanding) of field card entries, particularly for qualitative parameters and "comments". Initially, this will be done by Aquatics technicians;

    c) Data will be entered and retrieved from various regional centers as facilities develop; and

    d) The primary objective of putting data in a computer is to <u>encourage its use</u> by making it <u>quick</u> and <u>easy</u> to retrieve.

APPENDIX I

Standard Data Summaries

1. Fish species distribution
    a) Aggregate list for a system.
    b) Limits of upstream - downstream distribution by species and reach boundary location (plotter output).
2. Survey history for a given system.
3. The total lineal distance of the following mapped and digitized features within a system:
    a) Spawning zones (by species); and
    b) Flood and side channels.
4. A listing, for a system, of the location, type, and height of obstructions (falls, chutes, etc.).
5. A listing of arbitrary subsets of reach attributes, by reach, for all or portions of a given system.
6. A listing of the location of specified types of sample points within a given system (e.g. all water quantity sampling stations).

7.3 WATERSHED SYSTEM CODE DICTIONARY USERS GUIDE

WATERSHED SYSTEM CODE DICTIONARY USERS GUIDE

Resource Analysis Branch

Aquatics Section

1978

Users are requested to notify the Aquatics Section (387-5281) in the event of spelling errors, changes or additions.

INTRODUCTION

The watershed coding system was developed to provide a hierarchial storage access number for all streams in British Columbia which appear on 1:50 000 or 1 inch = 1 mile NTS to topographic maps. A unique number can be made available for up to the seventh tributary from a river flowing into the ocean. The number indicates all downstream waters.

<u>All additions, changes, or deletions must be done through the Aquatics Section, Resource Analysis Branch</u>. Dictionaries will be updated periodically and replacement sections distributed.

Detailed numbering has been done only in those areas where extensive surveys have been carried out by the R.A.B. Numbers for other areas will be provided upon request.

Code Number Structure

The watershed number is in the form of a 21 digit number presented as follows:

3	4	0700	110	030	040	020	010
Columbia R.	Lower Kootenay R.	Slocan R.	Little Slocan R.	Koch Creek	Grizzley Creek	Greasybill Ck.	N. Greasybill Ck.

The upstream progression from left to right is apparent. In the example presented, N. Greasybill Creek is a partially intermittent creek draining an area of about 10 km^2. Extensions of the number to smaller gullies, etc., can be made but are not part of the computerized data storage system. Users wishing to store data for more than seventh "order" tributaries are invited to contact the Aquatics Section for some techniques we have found useful.

Unused number groups are dropped in practice (e.g. 34 0700 = Slocan River).

The underlined digits represent open numbers for the insertion of previously unnumbered streams at the various tributary levels.

Within the 3 (or 4) digit groups, streams are numbered sequentially going upstream on the mainstem. For example, 030 (Koch Creek) is further upstream than 020 (Talbott Creek) on the Little Slocan River.

Major Watersheds (Two-Digit Numbers)

Table 1 lists the major (two-digit) tributaries. Departures from a strict hierarchy in the Fraser system have been made in the case of the South and North Thompson rivers, and for the Stuart which is tributary to the Neckako.

The Mackenzie system has been modified considerably to handle rivers entering B.C. at different places. The Hay, Liard, and Peace rivers are all tributary to Great Slave Lake, whose outlet is the Mackenzie. The Chief and the Muskwa are both tributary to the Fort Nelson, as the Wapiti and Kakwa are to the Smokey.

The Upper and Lower Kootenay have been separated for mapping convenience. The 90 series handles other coastal and island rivers as indicated.

Table 1. Major Watersheds in British Columbia

** Indicates completion of sub-watershed coding (with allowance for further additions)

* Indicates partial completion of sub-watershed coding

00	Fraser River**
01	Lillooet-Harrison rivers**
02	Thompson River (From mouth to confluence of North and South Thompson)
03	South Thompson River*
04	North Thompson River*
05	Chilcotin River
06	Quesnel River
07	West Road River
08	Neckako River
09	Stuart River
10	Liard River**
11	Petitot River
12	Fort Nelson River
13	Sikanni Chief River (Tributary to Fort Nelson River)
14	Muskwa River (Tributary to Fort Nelson River)
15	Beaver River
16	Toad River
17	Keckika River
18	Dease River
19	Rancheria River
20	Peace River and Finlay River* (Tributary to Mackenzie River)
21	Kiskatinaw River**
22	Beatton River
23	Pine River**
24	Halfway River
25	Parsnip River ** (And Parsnip Arm)
26	Smoky River**
27	Omineca River**
28	Chinchaga River (Tributary to Hay River)
29	Hay River (Tributary to Mackenzie River)
30	Columbia River**
31	Okanagan River
32	Kettle River
33	Pend Oreille River*
34	Lower Kootenay River**
35	Upper Kootenay River**
36	Illecillewaet River
37	Canoe River
38	Kicking Horse River
39	Spillimacheen River

Table 1. cont'd.

40 Skeena River**
41 Exchamsiks River**
42 Lakelse River**
43 Kitsumkalum River**
44 Zymoetz River** (Alias: "Copper River")
45 Kitsequecla River**
46 Bulkley River**
47 Kispiox River**
48 Babine River*
49 Sustut River**

50 Stikine River
51 Iskut River
52 Chutine River
53 Mess River
54 Tahltan River
55 Tuya River
56 Klastline River
57 Klappan River
58 Pitman River
59 Spatsizi River

60 Yukon River
61 Takhini River
62 Tagish Lake
63 Atlin Lake (Including Atlin River)
64 Gladys River
65 Teslin River
66 Jennings River
67 Swift River

70 Nass River**
71 Ishkheenickh River**
72 Kinskuch River**
73 Cranberry River**
74 White River**
75 Meziadin River - Strohn Creek**
76 Bell-Irving River**
77 Taylor River**
78 Damdochax Creek**
79 Muskaboo Creek** (Alias: "Muckaboo Creek")

Table 1. cont'd.

80 Taku River

90 South Coastal Rivers** (South of Cape Caution)
91 Central Coast Rivers** (Cape Caution north to Lambert Point at mouth of Skeena River)
92 Vancouver Island East**
93 Vancouver Island West**
94 Graham Island**
95 Moresby Island**
96 North Coastal Rivers* (North of Gust Point at mount of Skeena River)

Dictionary Listing

The dictionary listing contains, from left to right, the following entries:

EQUIS : The EQUIS code number for the stream in question. This column is omitted from dictionary copies unless requested.

RAB NUMBER : The watershed code number as described above.

NAME : The officially gazetted name of the stream.

ALIAS : The common name (local useage) of the stream.

BANK : The bank, left or right looking downstream, through which an unnamed stream enters the main stream.

COMMENTS : Verbal comments to assist in locating an unnamed stream.

Other Notes : 1. Unnamed streams which drain named lakes have been given an alias of that lake's name, (e.g. "Sideslip Lake Creek" = 70 3700). In the future such streams will be unnamed, with a comment to indicate their origin.

2. "*" is inserted in the NAME listing to reserve space for a future entry.

3. Rivers which change names (e.g. Courtenay - Puntledge 92 2800) are designated by one watershed code number. (See exceptions under Major Watersheds, above). This may cause confustion where EQUIS gives them separate numbers.

Table 2. Abbreviations used in Watershed Code Dictionary

R	- River	e	- east
C	- Creek	w	- west
I	- Island	s	- south
B	- Brook	Mt	- Mount
L	- Lake	Mtn	- Mountain
S	- Slough	Thru	- Through
HDD	- Headed	Conf(1)	- Confluence
HW	- Headwaters	Trib	- Tributary
nr	- Near	Hbr	- Harbour
n	- north	Pt	- Point
		Gf	- Gulf
		OPP	- Opposite

7.4 AQUATIC MAPPING PROCEDURES

AQUATICS MAPPING PROCEDURES

31 August 1978

Ministry of the Environment

Resource Analysis Branch

Aquatics Section

MAPPING PROCEDURES

The following are conventions which have been adopted as standard mapping procedures of the Aquatics Section.

When a map sheet is about to be used as the MASTER map compilation copy (to be drafted upon completion), it should be stamped with the "MASTER COPY" and "MAP COMPILATION" stamps. The "MAP COMPILATION" stamp should be used once for each major (i.e., 2 digit) watershed that appears on the map. As each stage in map compilation is completed, the appropriate box is to be initialed. The MASTER copy is not to be folded, as this causes errors in digitizing. It is permissible to fold the MASTER copy along the outside border for edge matching, provided this fold is exactly along the border of the map; the person digitizing often needs to make this fold himself and once it has been done slightly incorrectly it is impossible to correct.

Maps and data cards, when not actually being worked on (i.e., when you will be gone more than one day) are to be filed in the map and card files in room 138.

Red ink is used for digitizing preparation only. No red ink is to be drafted.

1. Breaking out Watersheds

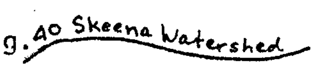
   Breaking out a watershed means drawing the watershed boundary line and watershed code onto the map. Break out a watershed if it contains any of the following:

   - a point sample
   - a long reach symbol (i.e., ‾‾‾‾|‾‾‾‾)
   - more than one short reach symbol (e.g. Ic, IIu)
   - a beaver dam
   - a large or important lake

Do not break out a watershed if it only has slumps on waterfalls mapped. In relatively unmapped areas, large watersheds may be broken out and numbered as references for the distribution of watershed code numbers.

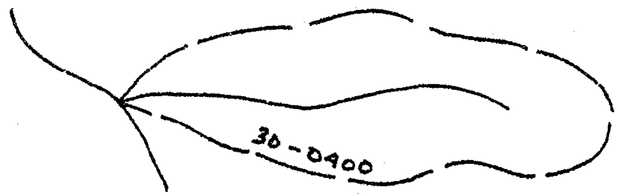
For all watersheds which are broken out, a system file will be created. Initially this will consist of the Map Data File (i.e., Watershed Code, Name, Highest Elevation, Outlet Elevation, Length of Long Axis, Mainstem Azimuth, Area, and Perimeter). The Features Listing sheet will also be made for the stream if the watershed has been broken out.

2. Watershed Boundary Lines

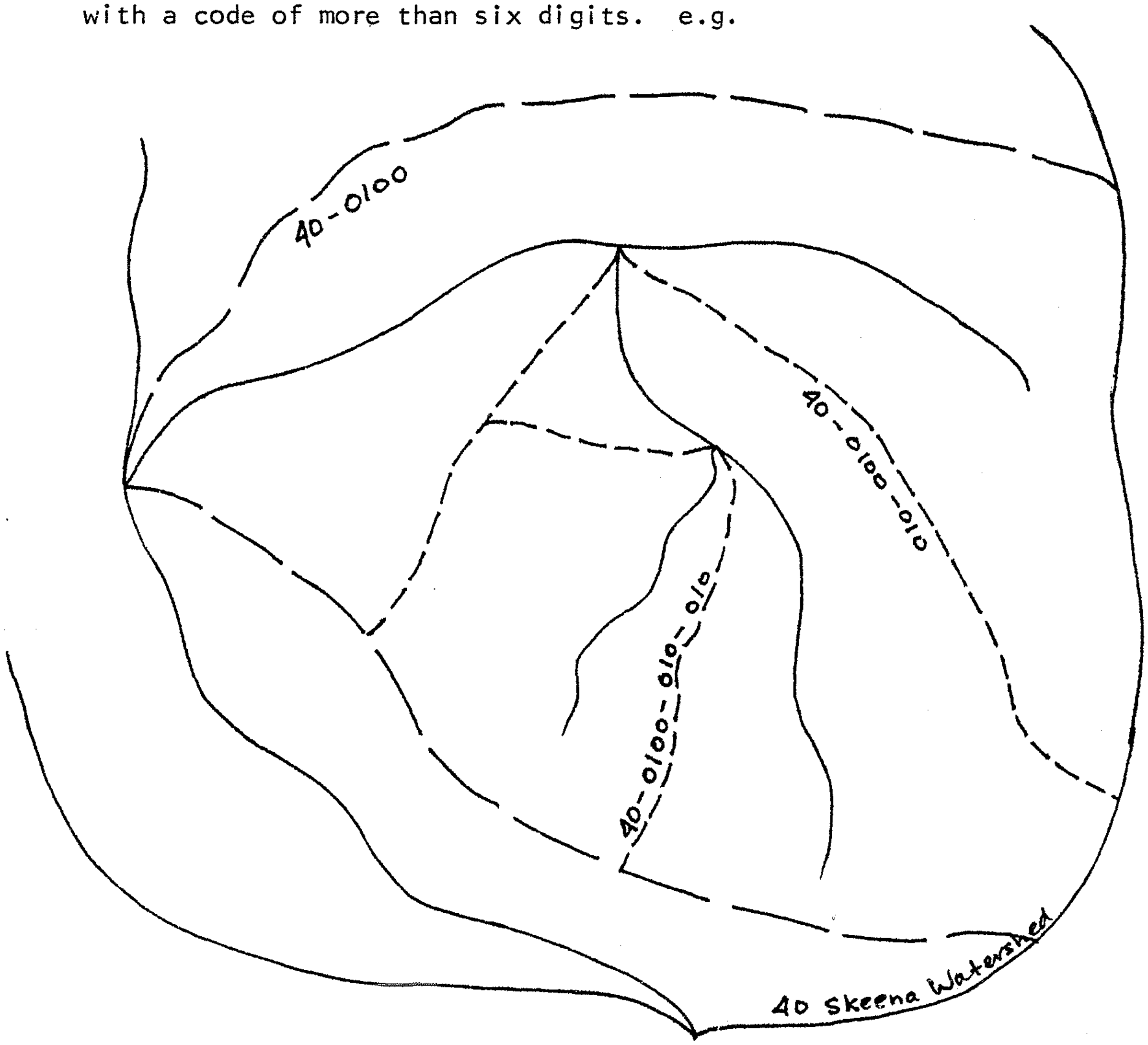
The major watershed boundary  is a solid line which surrounds a watershed with a two digit code. e.g. 

Along this line is usually written the two digit watershed number, followed by the name of the watershed, as in the above example. The only instance where the major code is not written along the line is where the adjacent watershed is actually part of the watershed in question (i.e., the boundary is not the outside boundary of the watershed in question). This occurs with watersheds ending in zero such as 40, adjacent to the boundary of their major tributaries such as 41 to 49. See Placement of Watershed Codes.

The sub-watershed boundary  is made of 1-2 cm line segments which may curve. This boundary surrounds a watershed with a six digit code.



The minor watershed boundary is made of 5 mm straight line segments. This boundary surrounds a watershed with a code of more than six digits. e.g.

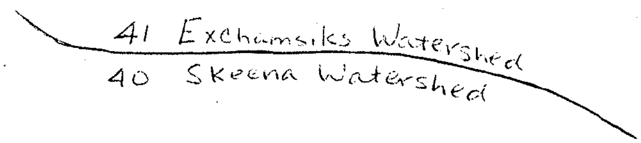


3. Placement of Watershed Codes

The watershed code is to be placed only along boundary lines to which the code directly relates. Thus it must only appear on the outside boundary of the watershed to which it refers.

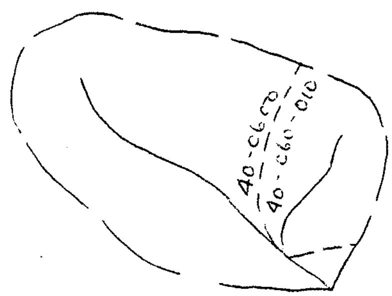
The following examples are done <u>INCORRECTLY</u>:

a)



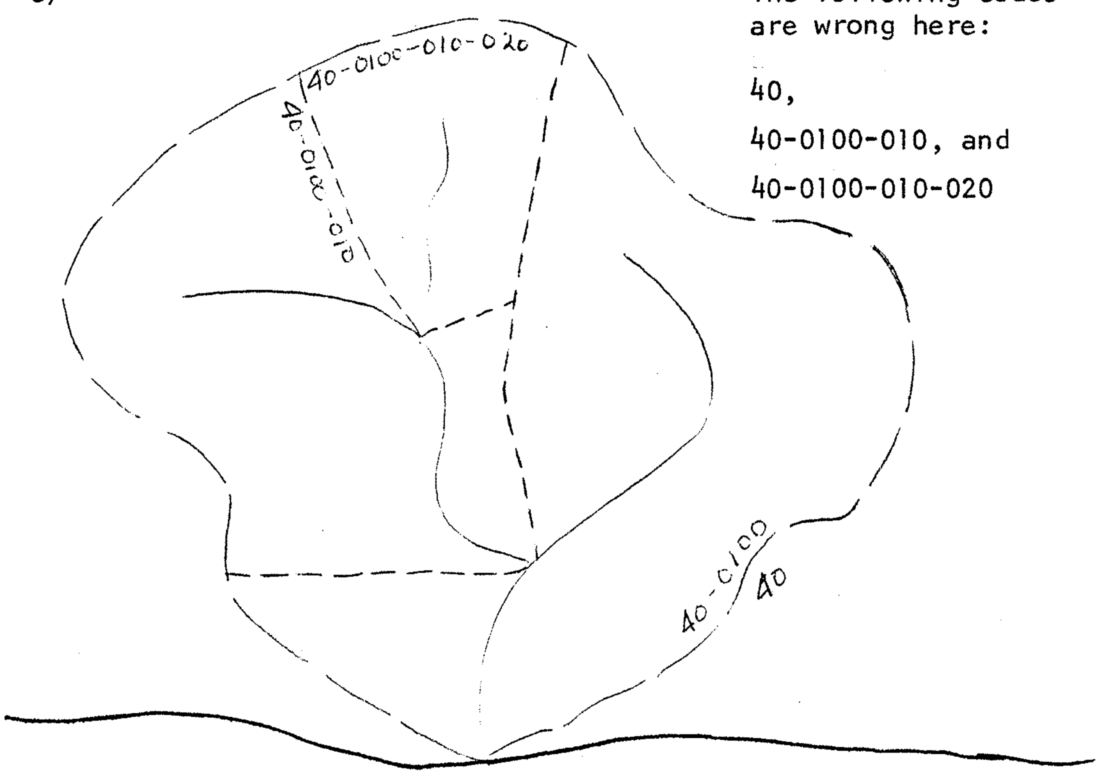
40 is wrong here

b)



40-0600 is wrong here

c)



The following codes are wrong here:

40,

40-0100-010, and

40-0100-010-020

In (c) above, 40 and 40-0100-010 are not the outside boundaries of the watersheds to which they refer. 40-0100-010-020 <u>is</u> on the outside boundary of its watershed. However, it is poor because on this sub-watershed line, it appears that the entire sub-watershed is 40-0100-010-020 which is incorrect.

Where no outside boundary for a watershed appears on the map but the mainstem does appear, write the watershed code inside a rectangular shaped box (not square, as this is used for water quantity) and draw a line from the box to the stream. This convention is most often used for major rivers but it should be used anytime that the watershed code is not cartographically clear. More than one numbering may be used.

Label the major watershed adjacent to the area mapped (i.e., even if the adjacent major watershed has not been surveyed).

Make certain that the correct watershed code is in the watershed code dictionary.

It is sometimes desirable to place codes across watershed boundaries for clarification of watersheds; when codes are mapped across boundaries, they should be drafted as such.

4. Point Samples

Points should be created and plotted on the map if retrievable information is present. When the density of samples becomes too great, a map reference to the system file is made and the points are defined there.

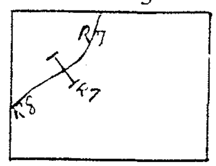
5. Reaches

- All reach boundaries (including implied lower reaches) are labelled along side of the reach symbol.

e.g. DO THIS: NOT THIS:

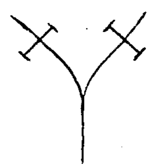
- It may be necessary at the map edge to write the reach number on the stream to clarify which reach is involved and/or which direction the stream is flowing.

  e.g.

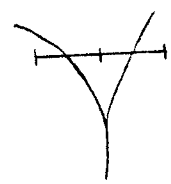


- Reach boundaries are assumed at the inlet and outlet of lakes. However, where a chain of lakes makes the reach numbers difficult to determine, clarify the reach numbers by drawing and labelling a few reach boundaries on the lakes.
- At junctions:

  DO THIS:

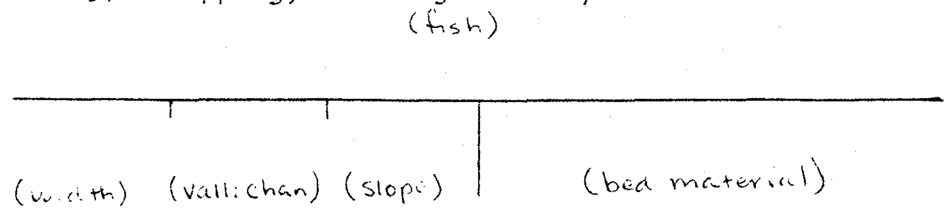


  NOT THIS:



- All reaches delineated on a map must have supporting data mapped and carded, including reaches with only "limited information" (i.e., short reach symbol). Cards need not be completely filled out, and may be only references to some other reach card or other source.
- Information mapped on the upper reach must apply from the last reach boundary to top of the mapped stream. If there is uncertainty about the extent to which the upper reach symbol applies, use a termination of survey symbol.
- Make certain that reach symbols are identical for the same reach on adjoining maps.
- Write short reach symbols on the stream to which they apply rather than on a hillside. Do not use arrows for short reach symbols.

- As of 1978 mapping, the long reach symbol is:



Fish uses the same fish codes as used previously (see map legend).

Do not put commas between the fish species codes.

Bed materials is usually four digits, e.g., 1252 means 10% fines, 20% gravels, 50% larges, and 20% bedrock. Zero is used as a place holder if there is 0 to 5% of a size category. If more than 95% of the bed material in the reach is composed of one size category, F, G, L, or R is used alone. If there is a trace of bedrock (1 to 5%) then indicate this by 145R. Traces of fines, gravels, larges are not indicated in the reach symbol; rather a zero is used as a place holder.

Channel width is given to the nearest metre.

Valley: Channel ratio is coded as A, B, C, D, or E as in the glossary code list.

Slope as derived from digitizing, is indicated to the nearest 0.1% below 3% and to the nearest 1% above 3%.

- All reach breaks must have some kind of reach information mapped downstream of the reach symbol.
- The implied reach symbol is not to be used except in cases of <u>extreme</u> clutter; even if most of the reach symbol is the same

as that of the receiving waters, the slope is usually different. Also, with the implied reach symbol it is not apparent to the user whether or not reach information exists for that reach. If the implied reach symbol is used, the reach number (R1) must still be on the map, the tributary must be broken out, and a card must be made out, referencing the appropriate reach on the receiving waters.

- If none of the data in the reach symbol, except for the reach slope, has been verified

DO THIS:

$$\frac{\text{(DV)}}{\text{(r) 0.1 (b) I (2 3 R)}}$$

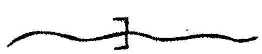
NOT THIS:

$$\frac{\text{DV}}{\text{4 0.1 b I 2 3 R}}$$

OR THIS:

$$\frac{\text{(DV)}}{\text{(r 0.1 b) I (2 3 R)}}$$

6. Termination of Survey

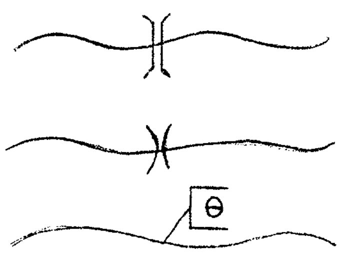
The termination of survey symbol  is not a reach break but indicates that a significant portion of the stream beyond (up or downstream) has not been surveyed. The reach symbol preceding  applies to this portion of the stream up to and possibly further than the termination of survey symbol. This symbol may only be used if reach information is present up or downstream; it is not to be used if there are only isolated point samples or other features on the stream.

7. Creek names

If the gazetted name of a creek is known but not yet printed on the base map, print the name on the MASTER copy and it will be drafted as such. If a creek is unnamed but has a local name (alias), print the name in quotation marks and it will be drafted as such. (Wherever a name is in quotation marks -- whether on data cards, maps, dictionary, etc. -- it is interpreted to be an alias.)

8. Roads and road crossings

Do not map any new roads which do not appear on the base map. Rather, mark only the road crossings. Road crossings take the following form:



Bridge

Ford

Culvert

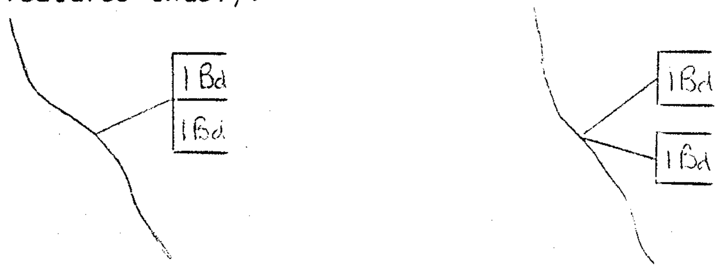
(Note: For features listing sheets, there is also a code for undefined road crossings: RX)

Culverts are to be mapped only when ecologically relevant (e.g., a possible barrier to fish). Culvert height is the outlet drop (as in a falls) and a length is the total length of the pipe.

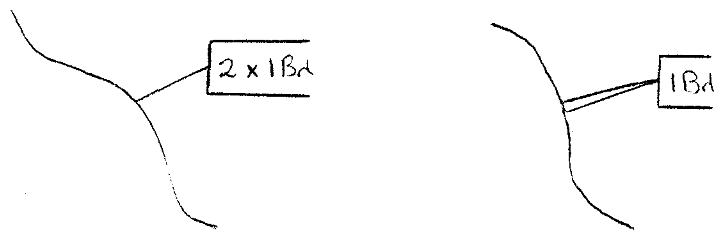
Train bridges should be mapped as bridges and coded as RR on the features listing sheets.

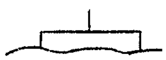
Crossings will not be features listed (and thus not digitized) unless crossing symbols are mapped.

9. Map multiple features thusly:



NOT:

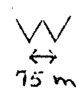


10. Zonal features (i.e. )

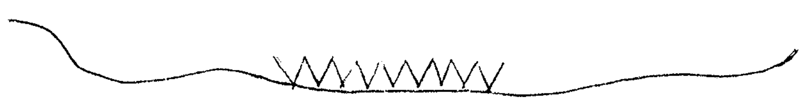
Map all zonal features according to the actual length of the zone, down to a minimum zonal symbol of 100 m (2 mm on a 1:50 000 map). There is not a standard sized zonal symbol. If the zone is smaller than 100 m in length, map the feature at a single point and annotate the length on the map. (e.g. 

).

11. Slumps

The standard drafting symbol for a slump 

measures about 75 m on a 1:50 000 map. Thus, we can distinguish the lengths of slumps if they are greater than 75 m long. Gauge the length of the slump as accurately as possible according to the end-points of the slump symbol which touch the stream.

e.g. 

The symbol will be drafted such that the end-points of the drafted symbol are as close as possible to the end-points of the symbol originally mapped.

12. Falls

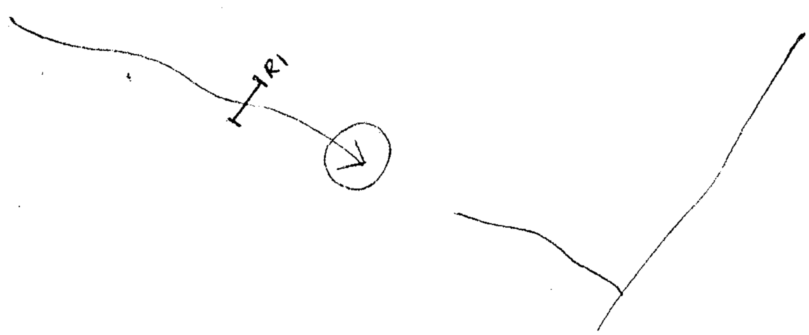
Always try hard to estimate the height of falls.

13. Stream changes

If a stream has changed course, dried up, become intermittent, etc., make the appropriate change to the map with a blue pencil that will easily be noticed by the draftsment. Do not mark a new stream in blue pen as this stream may then go unnoticed. Also, when making any such changes, put an explanatory note in the map margin to the draftsmen.

14. Alluvial sinks

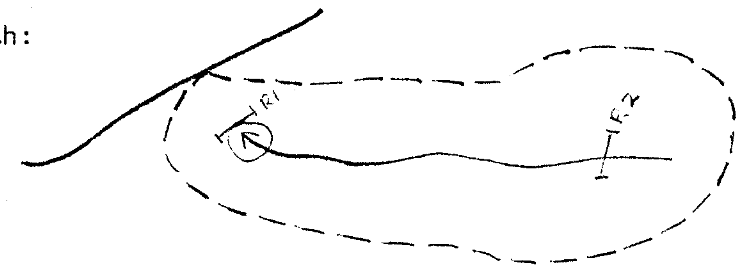
a) Alluvial sinks with surface waters downstream.



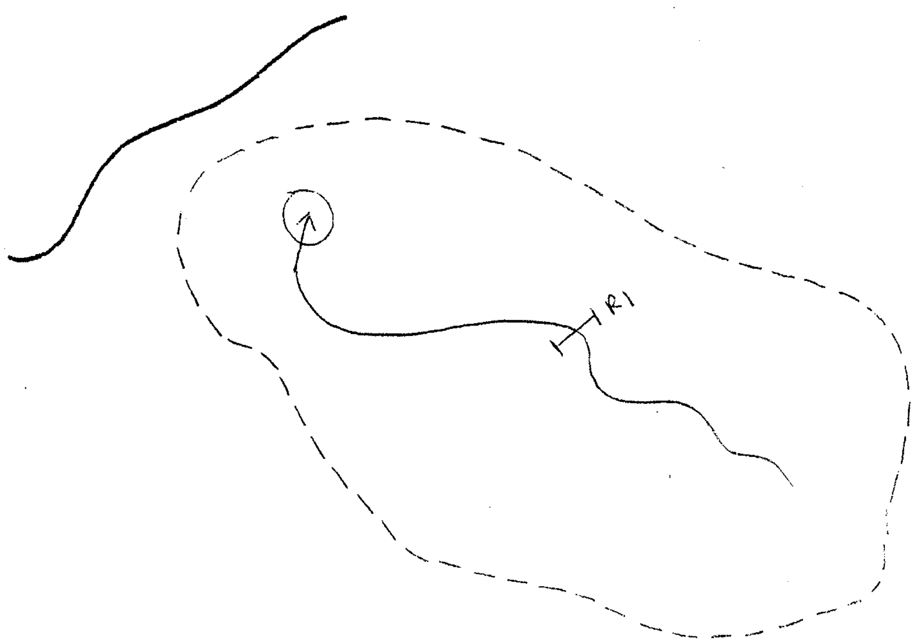
Do not map a spring where water from the alluvial sink returns to the surface, as this point is likely to be seasonally dependent. Instead, draw a red line from the alluvial sink along the most likely route to the point where the water surfaces. The digitizing cursor will be run along this line.

b) Alluvial sinks with no downstream surface waters

(i) If it is assumed that a stream with an alluvial sink flows underground and joins a certain stream (as a tributary), then the underground portion should be reach one and the watershed should be broken out as such:



(ii) If a stream disappears into an alluvial sink and it is not reasonably clear into which stream it eventually drains, its watershed boundary line should not come to a point as it usually does at the mouth of a stream. Instead, it should be rounded around the sink, and the alluvial sink should be called reach zero.



Refer to <u>Making Features Listing Sheets, Jan. 1978</u> for how to alluvial sinks.

15. The mapper is responsible for keeping the map status flow charts

up-to-date.

16. Refer to Making Features Listing Sheets, Jan. 1978 for detailed reference of how the computer data bank will interpret mapped information.

7.5 GLOSSARY

GLOSSARY OF TERMINOLOGY USED IN RESOURCE ANALYSIS BRANCH AQUATICS INVENTORY

AQUATICS SECTION

1978

Introduction

This glossary is designed for users of the aquatic system terminology of the Resource Analysis Branch. It has been compiled, as far as possible, from established sources (see reference list) but is intended to cover all terms used in point, reach, and fish cards, maps, and other data base elements of the R.A.B. aquatic inventory. A summary of parameter classifications (code list) is given at the end of this glossary. Throughout the glossary, the data card in which the term is used is indicated by a letter following the term as follows:

P = point card

R = reach card

F = fish card

M = map

Many of the parameters described are classified in abundance by Nil, Low, Moderate, or High. Where not specifically defined (e.g., stage) these terms should have the following meanings:

Nil - the item is not present, or so seldom as to be irrelevant to any interpretation.

Low - the item is present, but only as a few scattered occurrences or in a single spot.

Moderate - the item occurs in several scattered locations or a few small concentrated zones.

High - the item is frequently present throughout the sample area (reach or point) as a continuous cover or frequent zones of occurrence).

access (P,R) - The means of arriving at the point sample site or of conducting the reach survey. A two character code is used. (See code list.)

active valley wall process (R) - includes all forms of movement of materials on valley walls. (See rock/soil falls, mud/snow flows, slumps/glides, slides, gullies.)

age (F) - age of fish from scale, otolith, fin ray, or other analysis. Normally added to detailed fish sample cards after survey samples. The method of aging must be indicated.

agency (P,R,F) - code of the agency or company that did the point reach or fish sample. A three character code is used. (See code list.)

airphotos (R) - aerial photograph which depicts the reach. Recorded are the following:

- Initials - the person who did the interpretation
- Photo # - the flight line number and individual photo number(s)
- yr. - the year of the photography
- Photo scale - the scale of photo such as 1:15 840, 1:50 000, etc.

air temperature (P) - temperature of the air (°C) taken sheltered from direct sunlight and wind with a dry thermometer.

algae - the relative abundance of non-vascular aquatic plants on rock in the stream at the time survey. Species names are listed in "S" comments; abundance is coded as follows:

nil - most rocks are free from algae and not slippery.

low - some rocks have algal growth, especially on the edges.

medium - most rock faces have a thin layer of algal growth and footing is very slippery.

high - all rock faces have algal growth, much of which is thick and evident.

alias (P,R,F,M) - a locally used, non-gazetted stream name. Written in quotation marks on both data cards and maps.

apparently stable (R) - no obvious signs of lateral channel instability. Described by either yes or no. If yes, neither vegetation progression in bars, cut offs, oxbows, meander scars, or avulsions are apparent in air photos (P,R,F) or in the field.

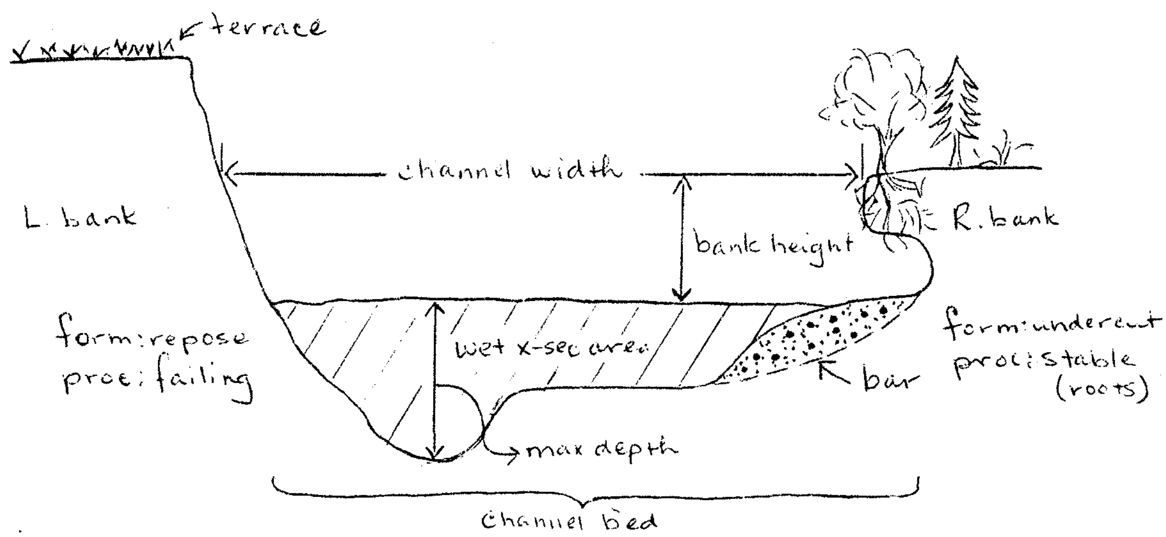
aquatic vegetation (P) - plant life growing in or on the water. Species are listed in "S" comments; abundance is nil, low, moderate, or high. (<u>See</u> comments.)

average depth (P) - the average depth water at a point cross-section. Systematic measurements across the channel width should be made when access and time permits. (<u>See</u> flow.) The method of measurements must be indicated. (<u>See</u> code list.)

avulsion (R) - The abandoned channel resulting from an aggrading stream breaking out of levees or former channel zones. Describe presence by either yes or no and indicate the number of avulsions in the reach.

bank (P) - the rising ground bordering a stream channel below the level of rooted vegetation and above the normal streambed; designated as right or left facing downstream. (See bank form, bank height, bank process, genetic materials and texture.)

Typical Bank and Channel Terms



bank form (P) - the range of bank forms is arbitrarily separated into four classes which reflect the current state of river processes:

F(flat) - the river bed slopes gently to the beginning of rooted vegetation, frequently with overlapping bar deposits.

R(repose) - the bank is eroded at high water levels, but is at the angle of repose of the unconsolidated material (usually 34^{o} - 37^{o}).

S(steep) - the bank is nearly vertical, due to consolidation by cementation, compaction, root structure, or some other agent.

U(undercut) - the bank has an undercut structure caused by erosion. When undercut banks are stabilized by vegetation this should be indicated in the comments.

bank height (P) - the vertical distance from the water level at the time of survey to the top of the bank. If left and right banks are of unequal heights, the lowest is used.

bank ice scour (P) - Bank ice scour is evidenced on the bank or bank vegetation, as bark loss or limb damage; described as either yes, or no or ? (uncertain).

bank process (P) - the current fulvial process the bank is undergoing.

F(failing) - active erosion and slumping is taking place.

S(stable) - the bank is of rock, has very high root density, or is otherwise protected from erosion. Artificially stabilized banks should be noted in the comments.

A(aggrading) - continuous sediment deposition is taking place, causing the river channel to migrate away from the river bank. Common on the inside of meander bends where it may be accompanied by the presence of a range of early to late seral vegetation.

bar (R) - bed materials deposited by streamflow within the stream channel. (See side, point, mid-channel, transverse, junction, and diamond bars; braiding, dunes, islands.)

bar presence (R) - the relative abundance of bars is indicated by the classification nil, low, moderate, or high. (See side point, mid-channel, transverse, junction, diamond, braiding, lee, dunes, islands.)

bar vegetation (R) - seral vegetation sequence growing on aggrading bars, indicating lateral channel migration. Described as nil, low, moderate, or high occurrence.

bed material (P,R) - organic or granular material or rock on the bed of a stream. (See texture, ice scouring, imbrication, compaction, lag, and D_{90}.)

bedrock control % (R) - the percentage of pools in a reach which are formed by the presence of bedrock. These are usually assumed to be permanent and stable.

biota (P) - living plant and animal organisms in the stream. (See aquatic vegetation, vertebrates, algae, fish species).

block, R,M) - angular, boulder sized inorganic material.

bogs (M) - bogs are peat-covered areas of peat-filled depressions with a high water table and a surface carpet of mosses, chiefly *Sphagnum*. The surface bog waters and peat are strongly acid and upper peat layers are extremely in mineral nutrients. They may be treed or treeless, and they are frequently characterized by a layer of Ericaceous shrubs.

braiding (R) - no definite single channel; numerous small channels and bars, particularly diamond bars; characteristic of channels with high rates of bed material transport. Described as nil, low, moderate, or high.

canyon - a deeply entrenched, steep walled valley, frequently in bedrock.

cascade (R,M) - a series of small steps or falls. Total height and length are mapped when available. Listed under stream features on reach cards.

channel (P,R) - a natural or artificial waterway of perceptible extent which periodically or continuously contains moving water. It has definite bed and banks which normally confine the water, and which display evidence of fluvial processes. (See channel width.)

channel cover (P,R) - the vegetation which projects over the water surface at the time of survey. It is divided into two arbitrary levels, crown cover (greater than 1 m above water surface) and overhang cover (less than 1 m above water surface). Described in terms of the projected area of water surface covered (% of width (P) or of reach area (R)) and distribution (distr) along the stream bank. (See distribution.)

channel debris (P,R) - (See debris).

channel width (P,R) - the width of the channel from rooted vegetation to rooted vegetation. Mean annual high water level should be used in the absence of vegetation. The method of measurement must be indicated. If measured by tape, the width should be given to the nearest 0.1 m.

channelization (R,M) - zones of artificially stabilized or diverted channels.

chute (R,M) - a confined section of stream channel usually with bedrock substrate and extremely high velocity flowing water. Total height and length are mapped when available. Listed as a stream feature on the reach card.

clay - (See texture.)

code list - parameter classifications are summarized in a code list at the end of this glossary.

comments - comments are written on the back of point or reach cards, and are referenced to specific parameters in two ways:

1) "C" numbers are placed in the shaded box preceeding every parameter and corresponding comments are numbered on the back. (e.g. C1, C2 . . . . .) Numbers are unique to each card.

2) "S" numbers are put in the box under Sp for BIOTA, VEG, and RIPARIAN VEG and used to reference lists of species on the back of cards or a separate data card if appropriate.

Comments should be provided only for important observations which cannot be accomodated under existing coding (See comment check list.) General (unreferenced) comments may also be written.

comment check list - a list of the types of features, activities, or processes which inventory staff should be thinking about. These include:

aesthetic features

recreation access points or use

significant wildlife use

important vegetation differences

land use activities across the valley flat

the physiographic setting of unique reaches (e.g. deltas, lake beds)

relationships between stream banks and valley wall processes (esp. vis à vis slumping)

left vs. right bank variation

the representativeness of points within reaches

judgements about aquatic habitat (e.g. suitability for spawning for a particular species which the coded data would miss or misrepresent).

compaction (P) - the relative looseness of bed material with respect to fluvial processes. Caused by sedimentation, mineralization, imbrication, or material size. Indicated as nil, low, moderate, or high as determined by the relative ease with which a boot can be worked into stream bed material.

compiling agency (P) - agency which actually describes the reach. Described by a three character code. (See agency code list.)

coniferous (P,R) - (See riparian vegetation.) All larch and tamarack will be excluded from deciduous cover and described only as conifers.

confinement (R) - the degree to which the river channel is limited in its lateral movement by terraces or valley walls. The channel is either:

Ent - entrenched - the stream bank is in continuous contact (coincident with) valley walls. (See entrenched.)

Conf - confined - in continuous or repeated contact at the outside of major meander bends.

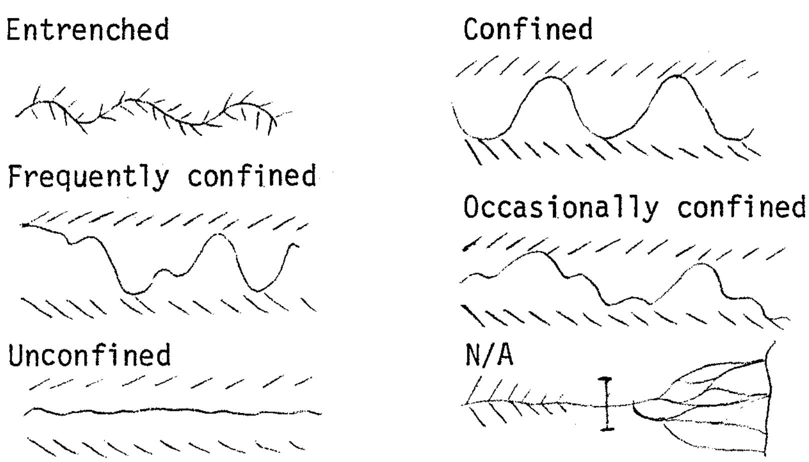
Fr - frequently confined by the valley wall.

Oc - occasionally confined by the valley wall.

Un - unconfined - not touching the valley wall.

N/A - not applicable (e.g. where no valley wall exists).

Confinement Classification



constriction (R) - point where the river channel is constricted (i.e., prevented from any lateral migration) usually by bedrock. Presence is noted by yes or no, and the number in the reach is recorded.

crew (P) - initials of crew member(s) who completed the point sample.

crown (See riparian vegetation.)

cross-section (See wetted x-sec area.)

cut-offs/ox bows (R) - remnant channels, resulting from lateral channel migration. Described as nil, low, moderate, or high

debris (P,R) - organic material deposited either in the floodplain or within the channel. The amount of debris is described as nil, low, moderate, or high. (See stable debris %.)

deciduous (P,R) - (See riparian vegetation) Evergreen broadleaved trees will also be included in this catagory (e.g. *Abutus menzesii*).

diamond bars (R) - an extreme development of mid-channel bars characteristic of braided rivers with sand or gravel beds. Described as having nil, low, moderate, or high occurrence.

difficulty (F) - indicates the relative difficulty of obtaining a representative sample of fish species present within the point location for the indicated sampling method. Described as low, moderate, or high.

low - over the length of stream sampled, most habitats are accessible (to the method used) and no factors (such as high turbidity) limit the effectiveness of the sampling.

moderate - over the length of stream sampled and for the method used, some habitats are inaccessible (e.g. because of depth of water velocity) and/or some factors prevent the sample from accurately representing fish species present in that length of the stream.

high - over the length of stream sampled and for the method used, many portions or segments are inaccessible to the sampler and/or major limiting factors to effectiveness (e.g. high turbidity) are present.

digitize - to locate mapped features and calculate their lat., long., area, length, or other pertinent georeferencing information.

D.O. (P) - dissolved oxygen concentration in mg/L or ppm.

distribution (P,R) - the relative abundance of vegetation in the riparian zone or along a stream bank (See bank cover, vegetation, riparian vegetation.) Vegetation distribuion is coded from 1 to 9 as follows:

1) rare individual plant
2) a few scattered individual plants
3) a single patch of species
4) several scattered individuals
5) a few (small) patches of a species
6) several well-spaced patches of a species
7) continuous cover of well-spaced individuals
8) continuous dense cover with a few openings
9) continuous dense cover uninterrupted

dunes (R) - bed form common in relatively active sand bed channels. The most characteristic feature is an asymetrical profile with a gentle up-stream side and a downstream side at the angle of repose. Described as nil, low, moderate, or high.

D_{90} (P) - the diameter of bed material which is larger than 90% of the remaining material. Measured by length of intermediate axis.

entrenchment (R) - stream channel incision resulting from current fluvial processes. This represents the extreme case of stream confinement. (See confinement.)

ephemeral stream (M) - a stream that dries during periods of low precipitation or runoff for all or part of its length.

features listing - compiled in the digitizing proceudre. Consult R.A.B.

fens (M) - fens are peatlands characterized by surface layers of poorly to moderately decomposed peat, often with well-decomposed peat near the base. They are covered by a dominant component of sedges, although grasses and reeds may be associated in local pools. *Sphagnum* is usually subordinate or absent. The waters and peats are less acid than in bogs of the same area, and sometimes show somewhat alkaline recreations.

field observer (R) - initials of person who compiled information for the reach card.

field photo (P,R) - documentation of photographs taken in the field.

Y N - yes, no; whether photos were taken.

Photog. - name or initials of photographer.

Roll Frames - numbers of each, to facilitate later sorting and indexing.

fines (P,R) - bed or bank material less than 2 mm in diameter; includes clay, silt, and sand. The percentage is estimated to the nearest 10%. (<u>See</u> texture.) For point samples, fines may be subdivided into clay, silt, and sand components such that % clay + % silt + % sands = % fines.

fish sample card (P) - fish sampling data are filed on this card. On point card the existence of a fish sample card is indicated by yes or no and the number of fish sample cards for that point is indicated.

fish species present (P) - list of fish species located at the point; names should be written in full for species without standard map symbols. A numbered comment or a fish sample card can be used to extend the list.

fish summary (R) - a complete summary of fish data for the reach:

use - either spawning S, rearing R, migration ↑, or a combination of these.

ref - the source of the particular identification, usually agency. (See code list.)

map- - used when additional fish information, other than species names, is found on the map. Usually indicates a mapped spawning zone. Indicated with a ✓, and used as an aid in map editing.

species - full common or latin name of fish.

floodplain debris (P,R) - Organic debris deposited by the stream outside the channel. (See debris.)

flood signs (P) - height above the water (m) at which evidence of flooding is found. Type refers to "type of evidence", i.e., (D) debris, (C) old channels, (P) soil profile, (M) mud line, (E) scour or erosion, or (H) historical information.

flow (m^3/sec) (P) - the discharge at the time of survey in cubic metres per second. The method of estimation of water velocity, cross-sectional area, wetted width, and average depth must be indicated.

flow character (P,R) - the surface expression of the water that is determined by water velocity and bed material. It is described at the time of survey as:

P - placid - tranquil, sluggish

s - swirling - eddies, boils, swirls

r - rolling - unbroken wave forms numerous

b - broken - standing waves are broken, rapids, numerous hydraulic jumps.

t - tumbling - cascades, usually over large boulders or rock outcrops.

Two terms may be used to describe flow character. The dominant character is circled and the subordinate underlined. Subordinate components must be at least 25% of the total.

fork length (F) - (*See* length)

form (P) - (*See* bank form)

genetic materials (P) - materials are classified according to their mode of formation. Specific processes of erosion, transportation, deposition, mass wasting, and weathering produce specific types of materials that are characterized chiefly by texture and surface expression. For added detail, consult the Terrain Classification Manual (ELUC - Sec 1976). Subsurface layers are noted in a comment.

Descriptive terminology:

A Anthropogenic - man-made or man-modified materials; including those associated with mineral exploitation and waste disposal, and excluding archaelogical sites.

C colluvial - product of mass wastage; materials that have reached their present position by direct, gravity-induced movement (i.e., no agent of transportation involved). Usually angular and poorly sorted.

E Eolian - materials transported and deposited by wind action. Usually silt or fine sand with thin cross-bedding.

F Fluvial - materials transported and deposited by streams and rivers. Usually rounded, sorted into horizontal layers, and poorly compacted.

I Ice - glacier ice.

L Lacustrine - sediments that have settled from suspension in bodies of standing fresh water or that have accumulated at their margins through wave action. May be fine textured with repetative annual layers (varves).

M Morainal - the material transported beneath, beside, or within and in front of a glacier; deposited directly from the glacier and not modified by an intermediate agent. Usually poorly sorted and angular to sub-angular. May be highly compacted and have significant clay content.

O Organic - materials resulting from vegetative growth, decay and accumulation in and around closed basins or on gentle slopes where the rate of accumulation exceeds that of decay.

R Bedrock - rock outcrop and rock covered by a thin mantle (less than 10 cm) of consolidated materials.

S Saprolite - weathered bedrock, decomposed in situ principally by processes of chemical weathering.

V Volcanic - unconsolidated pyroclastic sediments that occur extensively at the land surface.

W Marine - sediments that have settled from suspension in salt or brackish water bodies or that have accumulated at their margins through shoreline processes such as wave action and longshore drift. Found in coastal areas below 125 m above sea level.

U Undifferentiated - layered sequency of more than three types of genetic material outcropping on a steep, erosional (scarp) slope.

gravel (P,R) - bed material from 2 to 64 mm in diameter. Percentage is estimated to the nearest 10%. (See texture.) Small and large gravel may be differentiated. % small gravel + % large gravel = % gravel.

ground (P,R) - (See riparian vegetation) Moss, grass, and other vegetation growing in close proximity to the ground. Corresponds to "D" layer in vegetation classification.

gullies (R) - parallel and sub-parallel steep-sided and narrow erosional features in either consolidated or unconsolidated materials. Described as having nil, low, moderate, or high occurrence on valley walls.

habitat improvement - a term used on feature listing sheets to describe alterations to channels for fish passage or wildlife habitat.

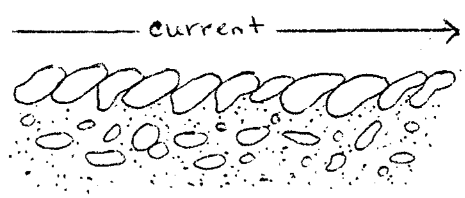
horizontal visibility (F) - (See visibility.)

hydraulics (P) - parameters which relate channel and flow characteristics.

ice scouring (P) (bed material) (P) - evidence of bed materials having been shifted by ice. Normally indicates the location of ice jam accumulations. Either yes, no, or ?.

imbrication (P) - a "shingled" or overlapping orientation of the surface layer of bed material due to running water. Occurence is described as nil, low, moderate, or high.

Imbrication of Bed Material



intermittent stream - a stream which flows only during high rainfall or snowmelt.

invertebrates (P) - aquatic macro-invertebrates. Usually identified are insects and other arthropods, annelid worms, and molluscs. Species or appropriate level of certain identification may be indicated in the "S" comment (See comments) and abundance is nil, low, moderate, or high.

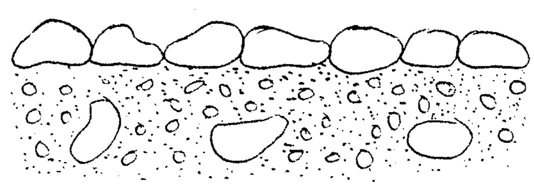
islands (R) - bars of land segments within the stream channel which are relatively stable, usually vegetated, and normally surrounded by water. Described as of nil, low, moderate, or high occurrence in the reach.

junction bar (R) a bar formed at the junction of two streams, usually because sediment transported by a tributary is deposited in the slower moving water of the mainstream. Occurrence in the reach is described as nil, low, moderate, or high.

karst (M) - a comprehensive term applied to limestone or dolomite areas that possess a topography peculiar to and dependent upon underground solution and the diversion of surface waters to underground routes.

lag (P) - the material left on the stream bed surface layer after finer material has been washed away. Characteristically larger and better sorted than underlying bed material. Amount is either nil, low, moderate, or high as determined by presence across the stream section.

Lag Deposits on the Stream Bed



larges (P,R) - bed material 64 mm and larger; percentage is estimated to the nearest 10%. (See texture) On point cards, cobbles and boulders may be differentiated, in which case % cobbles + % boulders = % larges.

lateral channel movement (R) - indicates the relative lateral stability of the reach. (See apparently stable, bar-veg progressions, cutoffs/ox bows, meander scars, avulsions).

lee bar (R) - any bar found in the lee of a large immovable object, most often bedrock or stable debris. Described as of nil, low, moderate, or high occurrence.

length (F) - 1) the length of stream sampled in metres for fish (fish card). The difficulty of sampling that length is indicated. (<u>See</u> difficulty).

2) the fork length of fish, that is, from tip of nose to fork of tail (cm).

level (P,R) - (<u>See</u> channel cover.) Refers to the distinction between crown and overhanging channel cover.

location (P) - a concise but specific description of the location of the point sample. Reference should be made to named creeks, UTM grid, legal lot no's or other features identifiable on 1:50 000 NTS maps.

map (R) - (<u>See</u> fish summary.)

map legend (M) - refer to the Aquatic Legend on published maps. Legends may vary with scale and year of publication.

mainstem azimuth (M) - the angular distance in the horizontal plane from true north of a straight line connecting the head of a stream to its mouth.

marshes (M) - marshes are grassy, herb dominated wet areas, periodically inundated up to a depth of 2 m or less with standing or slowly moving water. Marshes are subject to a gravitational water table, but water remains within the rooting zone of plants during at least part of the growing season. The substratum usually consists of mineral or organic soils with a high mineral content, but there is little peat accumulation. Waters are usually circumneutral to alkaline, and there is a relatively high oxygen saturation. Marshes may be bordered by peripheral bands of trees and shrubs, but the predominant vegetation consists of a variety of emergent non-woody plants such as rushes, sees, reed-grasses, and sedges. Where open water areas occur, a variety of submerged and floating aquatic plants flourish.

maturity (F) - the degree of development of fish through various life history stages. The following descriptions are used on the Fish Sample Cards:

Not obvious - ? - maturity not obvious to the observer.

Alevin - AL - newly hatched with yolk sac, still in nest or inactive on bottom.

Fry - FR - newly hatched, yolk sac gone, actively feeding.

Juvenile - JV - stage prior to maturity, incomplete development.

Mature - MT - fish showing evident diagnostic (M vs F) sexual organs.

Gravid - GV - sexual products are ripe, spawning is taking place.

Spent - SP - spawning is completed, most sexual products gone.

maximum depth (P) - the maximum depth of water in the channel at the sample location used for flow estimation, at the time of survey. Depth measurements should be restricted to the cross-section used for flow calculations. Deep pools nearby may be indicated in the comments.

meander scars (R) - evidence of old channel locations left as a result of lateral channel migration. Described as having nil, low, moderate, or high occurrence.

method - the method of obtaining fish information:

BS - Boat electroshocking

DN - Dip netting

EL - Electroshocking (back pack)

SN - Seining

GN - Gill netting

AG - Angling

TP - Traps

SW - Swimming with face mask

VO - Visual observations from above water

SP - Spearing

CL - Clubbing

HC - Hand capture

PO - Poison

EX - Explosives

method - hydraulic parameters:

E - Estimated

M - Measured (tape or rod)

RF - Range finder

AP - Air photo measurement

CL - Clinometer

TR - Transit

F - Floating chip

C1 - Gurley standard

C2 - Gurley pygmy

Cn - Other current meters

VM - Volumetric measurement

VH - Velocity head rod

En - Equation n (list to be developed as required)

Gn - Gauge n (calibrated according to standard methods)

EC - Echo sounder

? - Method unknown

mid-channel bars (R) - bars found in the mid-channel area transitional between transverse and diamond bars.

mud/snow flows (R) - movement of mud and/or snow like a fluid with high viscosity; slip planes may not be present and movement takes place by continuous deformation. Described as having nil, low, moderate, or high occurrence on the valley walls of the reach. The applicable flow type is circled on the reach card.

N.T.S. map (P,R) - the national topographic system number of the map on which the reach or point is found (e.g. 93P/12 for 1:50 000 scale).

number total (F) - 1) number of fish counted of a given species and size range in the Fish Data Summary.

2) fish number - individual fish specimen number.

obstruction (R,M) - any object of formation that may block or hinder waterflow and/or fish migration. Various types are distinguished such as falls, cascades/chutes, beaver dams culverts, velocity, and manmade dams. Height and length are mapped when available. (See map legend). Barriers are defined as obstructions which may impede upstream fish passage to all species at all flow levels. Obstructions may be listed as stream features on the reach card, and are mapped.

organic (See texture.)

overhang (See channel cover.)

point no. (P) - the field and map no. of a point sample location. Repeated samples at the same location have the same point number. Point sample numbers within a watershed need not be upstream sequential, but must not repeat.

point sample (P) - a sample location on a stream. The point may be defined in any useful manner, such as a very short reach (area visible at a road crossing or helicopter landing site), a particular side channel, a transect, or a single bank (for water sample site, beach seining, etc.). The left and right banks may be described separately for some parameters. The point sample location must be specifically described particularly in distinguishing between line transects and "plots" which average the properties of the stream around a sample location. The latter will normally apply to reconnaissance level inventory.

pong (M) - a small body of still water. (See shallow open water.)

pool - area of low velocity and deep water relative to the main current containing water at all flows. Pools may not be apparent at high flows.

reach (R,M) - the basic biophysical mapping unit for the Aquatic Systems Inventory. It is characterized by relatively homogeneous properties which will vary according to the scale of the survey. These properties should reflect a repetitious sequence of physical processes and habitat types, and are roughly equivalent to the land system in Ecological Land Classification terminology (Environment Canada 1976). Reaches are normally deliniated initially from aerial photographs on the basis of changes in geomorphic indicators such as pattern, surface expression, and the presence of bars. Individual elements (habitat types) of a reach (e.g., pools, riffles, undercut banks) may be mapped at large scales, but should not be called reaches.

pattern (R) - the channel pattern for the reach is described in terms of curvature:

St - straight - very little curvature within the reach.

Sin - sinuous - slight curvature within a belt of less than approximately two channel widths.

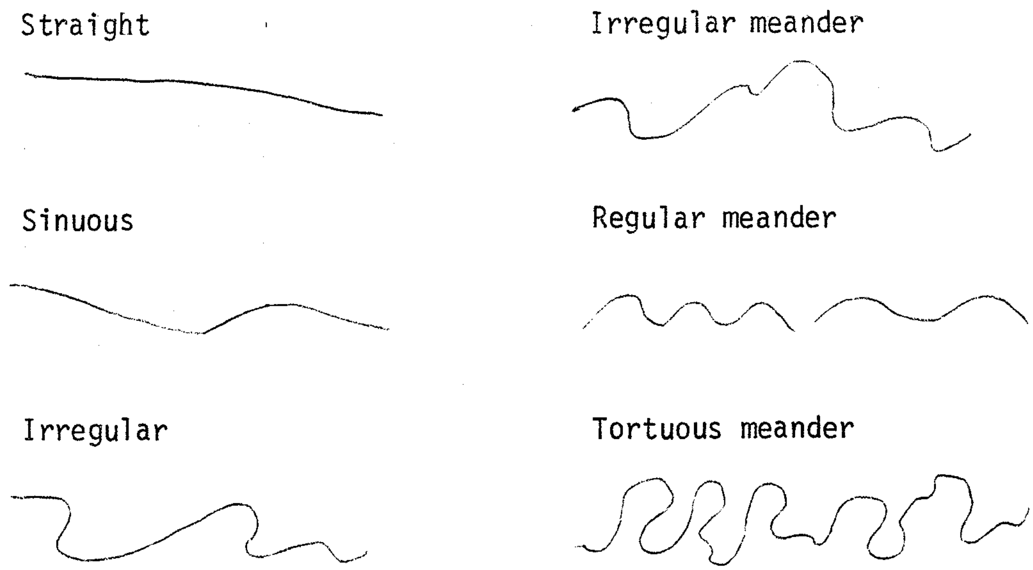
Ir - irregular - no repeatable pattern.

Im - irregular meander - a repeated pattern is vaguely present in the channel plan. The angle between the channel and the general valley trend is less than 90^{o}.

Rm - regular meanders - characterized by a clearly repeated pattern.

Tm - tortuous meanders - a more or less repeated pattern characterized by angles greater than 90^{o}.

Typical Meander Patterns



pH (P) - a rating scale from 0 to 14 which describes acidity or alkalinity of materials (e.g. of water, soil). Measured with Hach kit or pH tape.

photographer (P) - (See field photo.)

point bars (R) - found on the inside of meander bends. May extend to form transverse bars in gravel bed rivers. Described as having nil, low, moderate, or high occurrence.

point card - a listing of the properties of a river at a point sample.

reach number (P,R) - reaches are numbered sequentially upstream from the mouth (1,2,...n). These numbers are mapped at the upstream reach boundary symbol and correlated with data file information. Lakes usually have implied reach boundaries at both ends, in which case the number may not be plotted.

reach card (R) - a compilation of average and summary characteristics of a reach. (See reach.)

riffle - a shallow rapid in a stream, where the water surface is broken into waves by bed material wholly or partially submerged. A riffle may be drowned out at high water. Riffles are frequently caused by the presence of point, junction, transverse, or mid-channel bars.

riparian vegetation (R) or Vegetation(P) - vegetation along the edge of the stream within the influence of the ground water table associated with the stream. Vegetation storeys are divided into coniferous trees, deciduous trees, understorey (i.e., shrubs), and ground (i.e., moss, grass, etc.). Species are listed in "S" comments (see comments) and the species list number referenced in the Sp. column. Distribution (Distr) is coded. (See Distribution.) As a general rule the riparian zone will be extended 20 m back from the stream bank. Tree cover is arbitrarily defined as woody vegetation greater than 3 m high.

rock/soil fall (R) - moving mass of rock or unconsolidated material travelling mostly through the air by leaps and bounds. Especially important in deeply entrenched steep banked rivers. Described as nil, low, moderate, or high on the valley walls of a reach. The applicable fall type is circled (e.g. rock on soil).

sample type (F) - types of fish samples taken.

Fish sample type:

WF - Whole fish

ST - Stomach

SC - Scale

OT - Otolith

FR - Fin ray

TG - Fish tag

HD - Head

EG - Egg

MT - Milt

sampling length (F) - the length of stream sampled for a given method. Portions of the stream for which sampling difficulty is high are included in the sampling length for the method. (See difficulty.)

sampling method (F) - (See method.)

sand - (See texture.)

sets (F) - number of net sets.

sex (F) - sex of fish, either M male, F female, or ? not known.

shallow open water (M) - shallow open water which is locally known as a pond or a slough, is a relatively small body of standing water occupying a transitional stage between lakes and marshes. In contrast to marshes, these waters impart a characteristic open aspect, with proportionately large expanses of permanent surface water that lack emergent cover, except for relatively narrow zones adjoining shorelines. (See pond.)

side bars (R) - bars on the side of a channel, usually associated with slight bends of the river. Described as nil, low, moderate, or high abundance within the reach.

side channel (P,R,M) - a channel connected to the main stream at either low or high water stages. It is characterized by low velocity flows. Spatial frequency within the reach is described as being nil, low, moderate, or high.

silt - (See texture.)

sink (M) - the point at which stream water disappears into bed material.

size range (F) - the range of fork lengths for a given fish species. (See length.)

slides (R) - slope material movement resulting from shear failure along one or several surfaces which are either visible or may reasonably be inferred. Described as either nil, low, moderate, or high occurrence on the valley walls of a reach.

slopes (P,M) - 1) point slope - the slope at a point as read from a clinometer to the nearest 0.5%.

2) reach slope - the length of reach divided by the change in elevation between the downstream and upstream ends of the reach. Derived from topographic maps, it is expressed to the nearest 0.1% between 0% and 3%, and to the nearest 1% above 3%.

slumps/glides (R) - mass movement in which material moves in a single relatively consolidated mass, rather than breaking into smaller pieces. Described as of nil, low, moderate, or high occurrence in the valley walls of a reach.

snow flows (R) - snow avalanches (See mud/snow flows.)

species (P,R) - the common or scientific names of fish, to be written out in full on reach and fish sample cards. On the map and point cards, standard abbreviations may be used. (See fish species present, map legend.)

spring (M) - points of emergence of ground water. May be fresh (f), thermal (t), or saline (s).

stable debris (P,R) - percentage of debris in the river channel which has a low probability of ever being moved by fluvial processes.

stage (P,R) - the relative water level at the time of survey inferred from evidence of flow in bank and bed. The categories used are dry, low, moderate, high, and flood:

Dry - water not present or only as unconnected pools.

Low - water flowing as thred(s) within the channel: most bed material exposed.

Moderate - water flowing throughout the normal bed and in contact with lower portions of banks. Some bars are exposed; sand and small gravel sized bed material is in motion.

High - water filling most of the channel and in contact with middle to upper portions of banks; most bars are submerged; gravel and cobble. Sized bed material is in motion.

Flood - water bank full or over banks and into floodplain; maximum rates of bed material transport.

storey (P,R) - (See riparian vegetation.)

stream cross-section (P) - a drawing of the cross-section at the point sample location with distances labeled, showing such features as bank heights, channel widths, flood levels, bank slopes, etc. Left and right banks are labeled looking downstream.

stream feature (R) - listing of certain mapped stream features such as obstructions or major zones of bank instability. (See map legend.) Heights and lengths are included where applicable.

subsurface flow (M) - flow contained within bed material; not present on the surface except in isolated pools.

swamps (M) - woody plant dominated areas where standing to gently flowing waters occur seasonally or persist for long periods at the surface. Frequently there is an abundance of pools and channels indicating subsurface water flow. The substrate is usually continually waterlogged. Waters are circumneutral to moderately acid in reaction, and show little deficiency in oxygen or in mineral nutrients. The substrate consists of mixtures of transported mineral and organic sediments or peat deposited in situ. The vegetation cover may consist of coniferous or deciduous trees, tall shrubs, herbs, and mosses. In some regions, *Sphagnum* may be abundant.

system (P,R,M) - the watershed catchment area.

system name (P,R) - the official (gazetted) name of the stream which is described on the point, reach, fish sample card, or map. (See alias.)

system number (P,R,M) - code number of the stream system (See Watershed Code Number Users Guide, R.A.B. 1978).

T.D.S. (P) - total dissolved solids, in mg/L.

terrace (R) - a stepped topographic feature (including both the scarp and the flat or gently inclined surface). Presence is described by yes (Y) or no (N) and the number of levels present in a reach are recorded.

texture (P,R) - the assemblage of sizes of material in banks and beds, described according to the following classification after Wentworth. Organic and bedrock components are also recorded.

Organic - (point card only) Any material derived from animals or vegetation.

Fines - clay (less than .004 mm)
- silt (.004 to .062 mm)
- sand (0.62 to 2.0 mm)

Gravel - small (2.0 to 16 mm)
- large (16 to 64 mm)

Large - cobble (64 to 256 mm)
- boulders (greater than 256 mm)

Bedrock

Percentages of size classes are estimated visually to the level appropriate to the point or reach being sampled. Frequently, only the Fine, Gravel, Large, and Bedrock estimation can be made (e.g., for Reach averages). The point sample card allows a combination of the general and detailed classes to be used.

time (sampling) (F) - length of time involved in any particular sampling method. Units must be indicated.

time (survey) (P) - time of day the point sample was done in 24 hour time notation.

total no. - (See number.)

total pool % (R) - the amount of pool area in a reach expressed as a percentage of the reach area. (See bedrock control, pool.)

transverse bar (R) - a bar which runs diagonally across the width of the channel. Occurs mainly in gravel bed rivers, being particularly common in smaller streams. At lower flows, the bar is associated with riffles and the river may cut several channels through the bar. Described as having nil, low, moderate, or high occurrence.

turbidity (P) - measurement of maximum vertical visibility viewed from above the water, without polaroid sunglasses, using a white painted boot toe as the reference surface. Deep pools are estimated. Water clearer than the maximum observable depth should also be described with a verbal comment referenced with a comment number.

type (P,R) - (See stream feature, flood signs.)

understorey (P,R) - (See riparian vegetation.)

unstable banks (R) - banks which are actively failing. Percentage of unstable bank is estimated for the reach.

use - (See fish summary.)

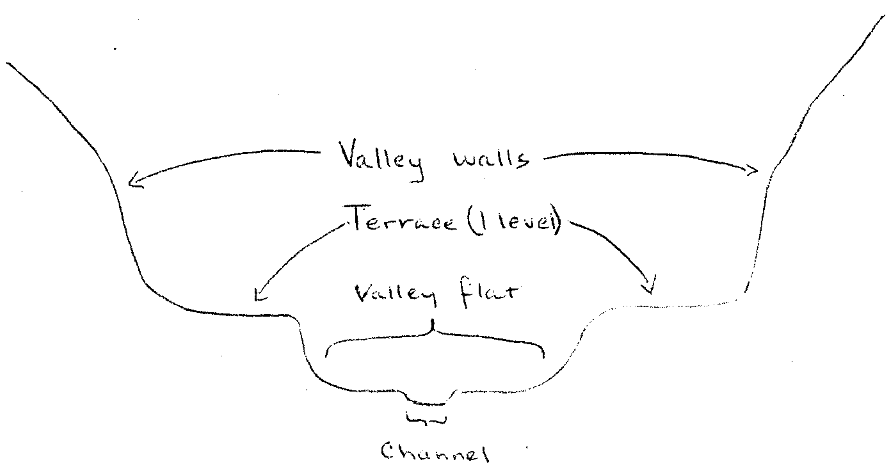
valley:chan - the ratio of the width of the valley flat to the channel width expressed as either 0-2, 2-5, 5-10, 10+, or not applicable, as in a delta where the limits of the valley flat cannot be defined. On the reach symbol these are characterized as A,B,C,D, and E, respectively.

valley flat (P,R) - the area of a valley bottom which may flood, including low terrances. Relic terraces which cannot be flooded by the present river are excluded from the valley flat.

valley flat width (P,R) - width in metres of valley flat.

valley wall (R) - the remainder of the valley slope above the valley flat and relic terraces. In some cases, such as in fans or deltas, there may be no valley wall.

Features in the Valley Cross-section



vegetation (P,R) - (See riparian vegetation, channel cover.)

velocity (P) - the rate of water movement measured in m/s; the distance travelled divided by the time taken to travel that distance. On the point sample card it is the chip or surface velocity unless a current meter is used. Method of measurement must be noted and standard methods followed wherever possible. (See code list under method - hydraulic parameters.)

vertical stability (R) - an indication of the net effect over a long time period of processes of deposition or scour of the stream bed in a reach. Described either as degrading (Deg), aggrading (Agr), not obviously aggrading or degrading (?), and not applicable.

visibility (F) - the distance which a swimmer with face mask can see under water in a horizontal direction. A visual estimate is made to the nearest metre.

water qualtiy (P) - (See water temperature, turbidity, T.D.S., D.O., pH.)

water sample no. (P) - water sample reference number, to be placed on water samples in addition to normal date, time, and location data.

watershed (M) - the area drained by a particular stream or lake. If a watershed boundary is mapped, the watershed has a code number and associated information in the data file. Three watersheds types are differentiated on maps as follows:

———————— Major watershed boundary (e.g. 23 Pine River); two digit watershed code.

———— ———— Sub-watershed boundary (e.g. 23-0400 Sukunka River, tributary to Pine River); six digit watershed code.

------------- Minor watershed boundary (e.g. 23-0400-040 Brunt River, tributary to Sukunka; also 23-0400-040-010 Brazion Creek, tributary to Burnt River); nine to 21 digit watershed code.

<u>See</u> User's Guide to Watershed Code Numbers; R.A.B. 1978.

water temperature - the temperature of the water in degrees Celsius, measured with a handheld thermometer, to the nearest degree near the main channel current.

water (P) - weather conditions at the time of the survey; conditions affecting the quality of the survey should be emphasized (e.g., rain, overcast, cloudy, sun).

weight (F) - weight in grams of whole fish.

wetted width (wet width) (P) - the width of water surface at the point sample cross-section. (<u>See</u> cross-sectional area.)

wetted cross-section area (P) - the cross-section area of water at the wetted width, usually calculated by multiplying wetted width times average depth.

CODE LIST

Agency

B.C. Hydro and Power Authority	BCH
Fisheries Branch (Rec. and Con.)	
Headquarters Inventory	FI
Burnaby	FB
Cranbrook	FC
Kamloops	FK
Nanaimo	FN
Nelson	FNL
Penticton	FP
Prince George	FG
Smithers	FS
Williams Lake	FW
Fisheries and Marine Service	FMS
Parks Branch (Rec. and Con.)	PK
Pollution Control Branch	PCB
Provincial Museum	PMU
Resource Analysis Branch	RAB
Water Investigations Branch	WIB

Consult R.A.B. to obtain code numbers for the following:

Consultant or Company	C##
Private Group	G##
University	U##

ACCESS

Aerial photograph	AP
Boat	B
Fixed wing plane	FW
Float plane	FP
Foot	FT
Helicopter	H
Horse	HS
Motorcyle	M
Vehicle (2-wheel)	V2
Vehicle (4-wheel)	V4

BANK FORM

Flat	F
Repose	R
Steep	S
Undercut	U

BANK PROCESS

Aggrading	A
Failing	F
Stable	S

TYPE OF FLOOD SIGNS

Debris	D
Erosion (Flood Chan. or Bank Scour)	E
Historical Information	H
Mud line	M
Soil profile	P
Topography	T

GENETIC MATERIAL

Anthropogenic	A
Bedrock	R
Colluvial	C
Eolian	E
Fluvial	F
Ice	I
Lacustrine	L
Marine	W
Morainal	M
Organic	O
Saprolite	S
Undifferentiated	U
Volcanic	V

MATURITY (FISH)

Alevin	A
Fry	F
Juvenile	J
Mature	M
Gravid	G
Spent	S
Not Obvious	?

METHOD (FISH SAMPLING)

Angling	AG
Boat electroshocking	BS
Clubbing	CL
Dip netting	DN
Electroshocking (back pack)	EL
Explosives	EX
Gill netting	GN
Hand capture	HC
Poison	PO
Seining	SN
Spearing	SP
Swimming with face mask	SW
Trapping	TP
Visual observations from above water	VO

METHOD (HYDRAULIC PARAMETERS)

Air photo measurement	AP
Clinometer	CL
Echo sounder	EC
Equation #	E#
Estimate	E
Floating chip	F
Gauge #	G#
Gurley standard	C1
Gurley pygmy	C2
Other current meters	C#
Measured (tape or rod)	M
Range finder	RF
Transit	TR
Unknown method	?
Velocity head rod	VH
Volumetric measurement	VM

SAMPLE TYPE (FISH)

Egg	EG
Fin ray	FR
Fish tag	TG
Head	HD
Otolith	OT
Scale	SC
Stomach	ST
Whole fish	WF
Milt	MT

VALLEY:CHANNEL RATIO
(For Map Symbol Only)

0-2	A
2-5	B
5-10	C
10+	D
N.A.	E

8. AOSERP RESEARCH REPORTS

1.		AOSERP First Annual Report, 1975
2.	AF 4.1.1	Walleye and Goldeye Fisheries Investigations in the Peace-Athabasca Delta--1975
3.	HE 1.1.1	Structure of a Traditional Baseline Data System
4.	VE 2.2	A Preliminary Vegetation Survey of the Alberta Oil Sands Environmental Research Program Study Area
5.	HY 3.1	The Evaluation of Wastewaters from an Oil Sand Extraction Plant
6.		Housing for the North--The Stackwall System
7.	AF 3.1.1	A Synopsis of the Physical and Biological Limnology and Fisheries Programs whithin the Alberta Oil Sands Area
8.	AF 1.2.1	The Impact of Saline Waters upon Freshwater Biota (A Literature Review and Bibliography)
9.	ME 3.3	Preliminary Investigations into the Magnitude of Fog Occurrence and Associated Problems in the Oil Sands Area
10.	HE 2.1	Development of a Research Design Related to Archaeological Studies in the Athabasca Oil Sands Area
11.	AF 2.2.1	Life Cycles of Some Common Aquatic Insects of the Athabasca River, Alberta
12.	ME 1.7	Very High Resolution Meteorological Satellite Study of Oil Sands Weather: "A Feasibility Study"
13.	ME 2.3.1	Plume Dispersion Measurements from an Oil Sands Extraction Plant, March 1976
14.		
15.	ME 3.4	A Climatology of Low Level Air Trajectories in the Alberta Oil Sands Area
16.	ME 1.6	The Feasibility of a Weather Radar near Fort McMurray, Alberta
17.	AF 2.1.1	A Survey of Baseline Levels of Contaminants in Aquatic Biota of the AOSERP Study Area
18.	HY 1.1	Interim Compilation of Stream Gauging Data to December 1976 for the Alberta Oil Sands Environmental Research Program
19.	ME 4.1	Calculations of Annual Averaged Sulphur Dioxide Concentrations at Ground Level in the AOSERP Study Area
20.	HY 3.1.1	Characterization of Organic Constituents in Waters and Wastewaters of the Athabasca Oil Sands Mining Area
21.		AOSERP Second Annual Report, 1976-77
22.		Alberta Oil Sands Environmental Research Program Interim Report to 1978 covering the period April 1975 to November 1978
23.	AF 1.1.2	Acute Lethality of Mine Depressurization Water on Trout Perch and Rainbow Trout
24.	ME 1.5.2	Air System Winter Field Study in the AOSERP Study Area, February 1977.
25.	ME 3.5.1	Review of Pollutant Transformation Processes Relevant to the Alberta Oil Sands Area

26.	AF 4.5.1	Interim Report on an Intensive Study of the Fish Fauna of the Muskeg River Watershed of Northeastern Alberta
27.	ME 1.5.1	Meteorology and Air Quality Winter Field Study in the AOSERP Study Area, March 1976
28.	VE 2.1	Interim Report on a Soils Inventory in the Athabasca Oil Sands Area
29.	ME 2.2	An Inventory System for Atmospheric Emissions in the AOSERP Study Area
30.	ME 2.1	Ambient Air Quality in the AOSERP Study Area, 1977
31.	VE 2.3	Ecological Habitat Mapping of the AOSERP Study Area: Phase I
32.		AOSERP Third Annual Report, 1977-78
33.	TF 1.2	Relationships Between Habitats, Forages, and Carrying Capacity of Moose Range in northern Alberta. Part I: Moose Preferences for Habitat Strata and Forages.
34.	HY 2.4	Heavy Metals in Bottom Sediments of the Mainstem Athabasca River System in the AOSERP Study Area
35.	AF 4.9.1	The Effects of Sedimentation on the Aquatic Biota
36.	AF 4.8.1	Fall Fisheries Investigations in the Athabasca and Clearwater Rivers Upstream of Fort McMurray: Volume I
37.	HE 2.2.2	Community Studies: Fort McMurray, Anzac, Fort MacKay
38.	VE 7.1.1	Techniques for the Control of Small Mammals: A Review
39.	ME 1.0	The Climatology of the Alberta Oil Sands Environmental Research Program Study Area
40.	WS 3.3	Mixing Characteristics of the Athabasca River below Fort McMurray - Winter Conditions
41.	AF 3.5.1	Acute and Chronic Toxicity of Vanadium to Fish
42.	TF 1.1.4	Analysis of Fur Production Records for Registered Traplines in the AOSERP Study Area, 1970-75
43.	TF 6.1	A Socioeconomic Evaluation of the Recreational Fish and Wildlife Resources in Alberta, with Particular Reference to the AOSERP Study Area. Volume I: Summary and Conclusions
44.	VE 3.1	Interim Report on Symptomology and Threshold Levels of Air Pollutant Injury to Vegetation, 1975 to 1978
45.	VE 3.3	Interim Report on Physiology and Mechanisms of Air-Borne Pollutant Injury to Vegetation, 1975 to 1978
46.	VE 3.4	Interim Report on Ecological Benchmarking and Biomonitoring for Detection of Air-Borne Pollutant Effects on Vegetation and Soils, 1975 to 1978.
47.	TF 1.1.1	A Visibility Bias Model for Aerial Surveys for Moose on the AOSERP Study Area
48.	HG 1.1	Interim Report on a Hydrogeological Investigation of the Muskeg River Basin, Alberta
49.	WS 1.3.3	The Ecology of Macrobenthic Invertebrate Communities in Hartley Creek, Northeastern Alberta
50.	ME 3.6	Literature Review on Pollution Deposition Processes
51.	HY 1.3	Interim Compilation of 1976 Suspended Sediment Date in the AOSERP Study Area
52.	ME 2.3.2	Plume Dispersion Measurements from an Oil Sands Extraction Plan, June 1977

53.	HY 3.1.2	Baseline States of Organic Constituents in the Athabasca River System Upstream of Fort McMurray
54.	WS 2.3	A Preliminary Study of Chemical and Microbial Characteristics of the Athabasca River in the Athabasca Oil Sands Area of Northeastern Alberta
55.	HY 2.6	Microbial Populations in the Athabasca River
56.	AF 3.2.1	The Acute Toxicity of Saline Groundwater and of Vanadium to Fish and Aquatic Invertebrates
57.	LS 2.3.1	Ecological Habitat Mapping of the AOSERP Study Area (Supplement): Phase I
58.	AF 2.0.2	Interim Report on Ecological Studies on the Lower Trophic Levels of Muskeg Rivers Within the Alberta Oil Sands Environmental Research Program Study Area
59.	TF 3.1	Semi-Aquatic Mammals: Annotated Bibliography
60.	WS 1.1.1	Synthesis of Surface Water Hydrology
61.	AF 4.5.2	An Intensive Study of the Fish Fauna of the Steepbank River Watershed of Northeastern Alberta
62.	TF 5.1	Amphibians and Reptiles in the AOSERP Study Area
63.		Calculate Sigma Data for the Alberta Oil Sands Environmental Research Program Study Area.
64.	LS 21.6.1	A Review of the Baseline Data Relevant to the Impacts of Oil Sands Development on Large Mammals in the AOSERP Study Area
65.	LS 21.6.2	A Review of the Baseline Data Relevant to the Impacts of Oil Sands Development on Black Bears in the AOSERP Study Area
66.	AS 4.3.2	An Assessment of the Models LIRAQ and ADPIC for Application to the Athabasca Oil Sands Area
67.	WS 1.3.2	Aquatic Biological Investigations of the Muskeg River Watershed
68.	AS 1.5.3 AS 3.5.2	Air System Summer Field Study in the AOSERP Study Area, June 1977
69.	HS 40.1	Native Employment Patterns in Alberta's Athabasca Oil Sands Region
70.	LS 28.1.2	An Interim Report on the Insectivorous Animals in the AOSERP Study Area
71.	HY 2.2	Lake Acidification Potential in the Alberta Oil Sands Environmental Research Program Study Area
72.	LS 7.1.2	The Ecology of Five Major Species of Small Mammals in the AOSERP Study Area: A Review
73.	LS 23.2	Distribution, Abundance and Habitat Associations of Beavers, Muskrats, Mink and River Otters in the AOSERP Study Area, Northeastern Alberta
-	--	Interim Report to 1978
74.	AS 4.5	Air Quality Modelling and User Needs
75.	WS 1.3.4	Interim report on a comparative study of benthic algal primary productivity in the AOSERP study area

76. ‾ish Fauna of the
heastern Alberta

7 .velopment in the
since 1961.
Management of Terrestrial
berta.
of Vanadium, Nickel, and

nent of Peregrine Falcons
anatum) in Northeastern Alberta.

These reports are not available upon request. For further information about availability and location of depositories, please contact:

Alberta Oil Sands Environmental Research Program
15th Floor, Oxbridge Place
9820 - 106 Street
Edmonton, Alberta
T5K 2J6

76. AF 4.5.1 An Intensive Study of the Fish Fauna of the Muskeg River Watershed of Northeastern Alberta

77. HS 20.1 Overview of Local Economic Development in the Athabasca Oil Sands Region Since 1961.

78. LS 22.1.1 Habitat Relationships and Management of Terrestrial Birds in Northeastern Alberta.

79. AF 3.6.1 The Multiple Toxicity of Vanadium, Nickel, and Phenol to Fish.

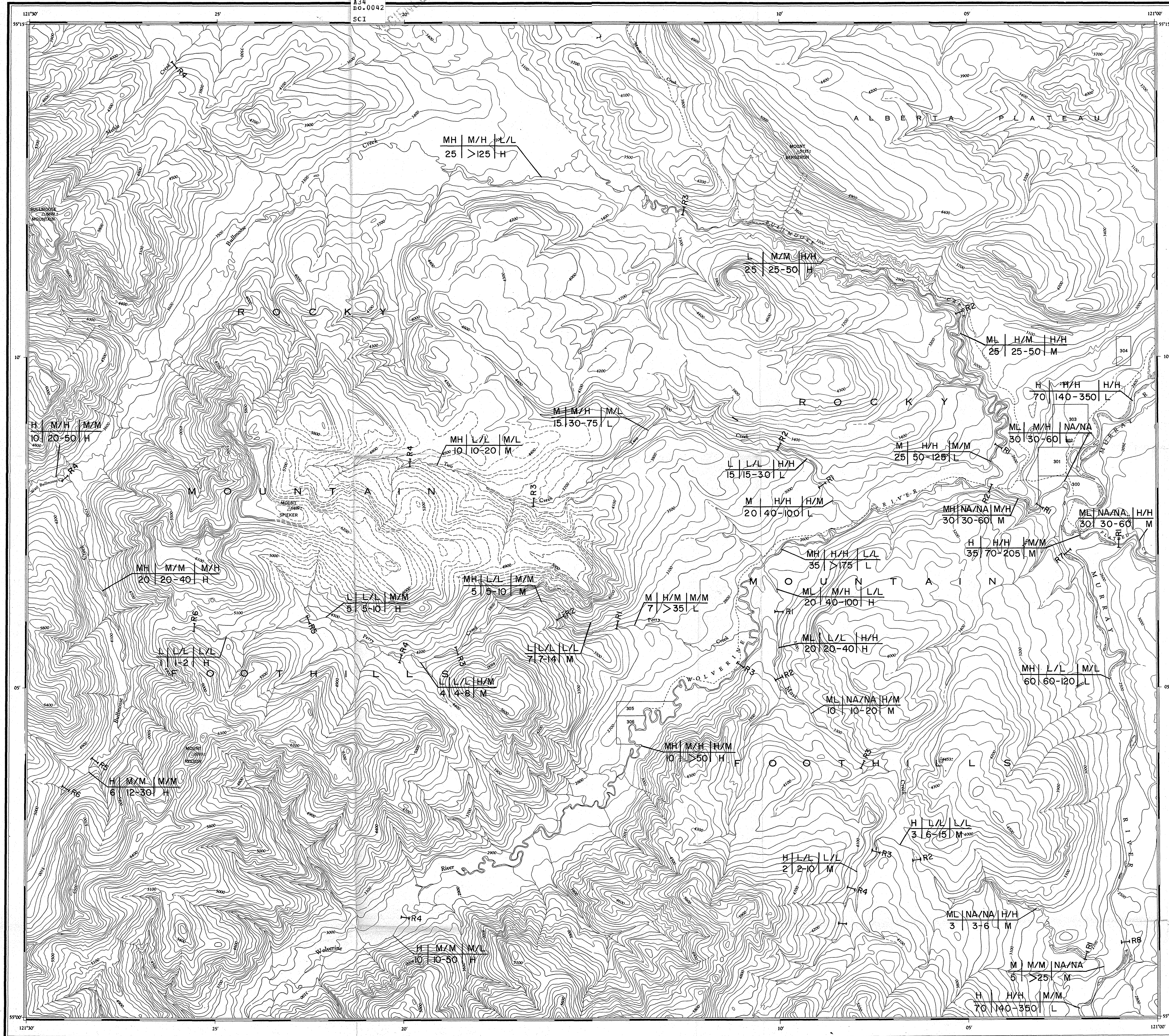
80. LS 22.3.1 Biology and Management of Peregrine Falcons (_Falco peregrinus anatum_) in Northeastern Alberta.

These reports are not available upon request. For further information about availability and location of depositories, please contact:

Alberta Oil Sands Environmental Research Program
15th Floor, Oxbridge Place

STREAM REACH EVALUATION

NO. 12 93P/3



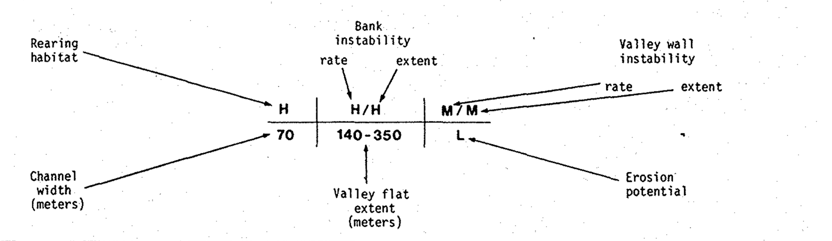
Scale 1:50,000

LEGEND

Explanation of Map Symbols

The stream reach evaluations presented on this map have been derived by the use of the AQUATICS BIOPHYSICAL BASE MAP (No. 11) and take two forms. Aquatic interpretations are presented in tabular form for each stream reach (see Data Sheet for Stream Reach Evaluation below).

Interpretations are also presented using map symbols as follows:



Data Sheet For Stream Reach Evaluation

	REACH BASE DATA							REACH SYMBOL VALUES							
Stream	Reach No.	Flood/ Side	Debris	Pool	Banks	Canopy	Over hang	Rear-ing Habi-tat	Lateral Bank Instability Rate	Lateral Bank Instability Extent	Valley Wall Instability Rate	Valley Wall Instability Extent	Channel Width (Meters)	Valley Flat Extent (Meters)	Erosion Potential
Flatbed	1	H	M	M	M	L	H	H	H	H	M	M	35	70-205	M
	2	L	L	L	H	L	L	M/L	N/A	N/A	H	H	30	30-60	M
Wolverine	1	L	M	L	L	L	L	M/L	M	H	N/A	N/A	30	30-60	L
	2	L	L	M	H	-	-	M/H	N/A	N/A	M	H	30	50-125	M
	3	M	M	L	M	L	M	M/H	H	H	L	L	35	> 175	L
	4	L	L	M	M	L	H	M/H	M	H	H	M	10	> 50	H
	5	M	M	H	M	L	H	H	M	M	M	L	10	10- 50	H
Bullmoose	1	H	M	0	H	0	0	M	H	H	M	M	25	50-125	L
	2	L	L	M	H	0	0	M/L	H	M	H	H	25	25-50	M
	3	L	L	M	-	0	0	L	M	M	H	H	25	25-50	H
	4	H	M	-	H	0	M	M/H	M	H	L	L	25	> 125	H
	5	M	M	M	M	L	L	M/H	M	M	M	H	20	20-40	H
	6	L	H	-	H	-	-	H	M	M	M	M	6	12-30	H
W. Bull-moose	1	M	M	M	H	L	H	H	M	H	M	M	10	20-50	H
Two Creek	1	M	M	0	L	L	H	M	H	H	H	M	20	40-100	L
	2	0	L	-	-	-	-	L	L	L	H	H	15	15-30	L
	3	M	M	M	L	L	-	M	M	H	M	L	15	30-75	L
	4	-	M	L	H	-	-	M/H	L	L	M	L	10	10-20	M
Mast	1	H	L	0	L	L	L	M/L	M	H	L	L	20	40-100	H
	2	0	L	M	H	L	L	M/L	L	L	H	H	20	20-40	H
	3	L	L	L	H	0	0	M/L	N/A	N/A	H	M	10	10-20	M
Perry	1	M	M	L	L	0	M	M	H	M	M	M	7	> 35	L
	2	0	L	0	0	-	-	L	L	L	L	L	7	7-14	M
	3	L	M	0	H	L	M	M/H	L	L	M	M	5	5-10	M
	4	0	M	0	H	L	M	L	L	L	H	M	4	4-8	M
	5	0	M	0	-	M	M	L	L	L	M	M	5	5-10	H
	6	0	L	0	L	L	H	L	L	L	L	L	1	1-2	H
Murray	7	H	M	H	H	0	L	H	H	H	H	H	70	140-350	L
	8	L	L	H	H	-	-	M/H	L	L	M	L	60	60-120	L
	9	H	M	H	H	0	M	H	H	H	M	M	70	140-350	L
Trib. to Murray -118	1	M	M	L	M	0	L	M	M	M	N/A	N/A	5	< 25	M
	2	0	M	-	H	0	L	M/L	N/A	N/A	H	H	3	3-6	M
	3	L	L	H	H	L	H	H	L	L	L	L	3	6-15	M
	4	0	H	H	M	L	H	H	L	L	L	L	2	2-10	M

Key To Stream Reach Evaluation

REARING HABITAT

An overall assessment of the first 6 parameters, by averaging them out and coming out with a rating for the amount of rearing habitat present.

The number value for the various feature values is shown below:

Value	Number Value
0	0
Low	1
Moderate	2
High	3

The calculation was as follows:

Value of Flood/Slide
+ Value of Debris
+ Value of Pools
+ Value of Banks
+ the higher value of canopy or overhang

Range of calculated values:

0 to 1.0	Low	L
1.1 to 1.5	Moderate-Low	ML
1.6	Moderate	M
1.7 to 2.0	Moderate-High	MH
2.1 to 3.0	High	H

Explanation of values:

Low - some rearing habitat available but of limited use

Moderate - suitable habitat available for rearing but with usually two or more low values

High - substantial amount of rearing habitat available with at least two "high" features and only one "low" feature

FLOOD/SIDE CHANNELS

Channels connected to the main Channel, either at high flows (flood) or normal flows (side). These channels are usually characterized by low velocity water. (found on reach card)

	Value
Nil	0
Low	Low
Mod	Mod
High	High

DEBRIS

Organic materials deposited within the flood plain. Described as to abundance and to whether it is being transported or is stable. (found on reach card)

	Value
None	0
Low-unstable	Low
Mod-unstable) High- ") Low-stable)	Moderate
Mod-stable High-stable	High

POOL (found on reach card)

	Value
None	0
< 10%	Low
11% - 30%	Mod
31% - 50%	High
>50%	Mod

BANK HABITAT (sloping banks)

The amount of bank that is greater than 45^{o}, from the % sloping bank parameter on the reach card.

% sloping bank - The estimated length of banks that slope less than 45^{o} expressed as a percentage of total bank lengths.

	Value
71% - 100% sloping banks	Low
51% - 70% "	Mod
0% - 50% "	High

CANOPY COVER (closure)

The closure over a stream created by overstory vegetation. It is expressed as a percentage of the channel area so covered. (found on each reach card)

	Value
None	0
10% - 20%	Low
11% - 20%	Mod
>20%	High

RATE OF LATERAL BANK INSTABILITY (1)

This assessment is made by air photo interpretation and attempts to describe the relative rate of movement of points on the channel across the valley flat.

N/A Non-applicable. The channel is confined by the valley wall

Low The channel appears to be stable or migrating very slowly

Mod Small point bars and a pattern of vegetation succession are apparent

High Large unvegetated point bars are present and the pattern of vegetation succession is distinct

EXTENT OF LATERAL BANK INSTABILITY (1)

This is an attempt to indicate the amount of the channel which has the above indicated rate of movement

N/A Non-applicable. The channel is confined by valley walls

Low Most of the meander bends appear stable

Mod Moderate - some of the bends are unstable

High Most or all of the meander bends are actively eroding.

RATE OF VALLEY WALL INSTABILITY(1)

Done by airphoto interpretation. This attempts to describe how active any given slump is.

N/A Not applicable - no obvious valley wall

Low The valley appears stable or nearly stable

Mod Moderate. Noticeable erosion of the valley is occuring through hydraulic erosion small scale mass failures, or gullying

High The valley wall is being actively undercut by the river or large scale mass failures are present

EXTENT OF VALLEY WALL INSTABILITY(1)

This describes the number of instability features in a reach.

N/A Not applicable. The stream does not have a vally wall

Low The valley walls are stable or nearly stable

Mod Moderate. Instability features occur in locally susceptible locations, such as where a meandering river is occasionally confined by a valley wall.

High Numerous instability features occur within the study reach

CHANNEL WIDTH

The figure is in meters taken from the visual estimate on the reach card.

EXTENT OF VALLEY FLAT

Taken from the section of the reach card called cross-section.

Valley flat is defined (2) as an area of relatively flat surface on the valley floor, subject to flooding, and consisting of low terraces and flood-plain.

confined - the valley flat is less than two times the channel width

bounded - the valley flat is 2 to 5 times the channel width

unconfined - the valley flat is greater than 5 times the channel width

EROSION POTENTIAL

This information comes from the erosion potential interpretive map based on the soils and landform maps. The aquatics interpretation is made by estimating the percentage of high erosion potential land which is found within the drainage area of a given reach.

Low 10% or less of the reach drainage area has high erosion potential

Mod Moderate. 10% to 30% of the reach drainage area has high erosion potential

High Over 30% of the reach drainage area has high erosion potential

OVERHANG CLOSURE

The closure over a stream created by understory vegetation within one meter of normal water surface. Expressed as a percentage of the channel area. (found on reach card)

	Value
None	0
<10%	Low
11% - 20%	Mod
>20%	High

FOOTNOTES:

(1) Environmental Impact Assessment of The Proposed Yukon Pipeline (B. C. Section). 1976. Prepared for Westcoast Transmissions Co. Ltd., by C. D. Schultz Co. Ltd.

(2) Classification and Analysis of River Processes. 1976. By R. Kellerhals, M. Church and D. Bray. Journal of The Hydraulics Division, ASCE, Vol. 102, No. HYF, Proceedings paper 12232, pages 813 - 829.

References

Aquatic System Units in the Northeast Coal Study Area, 1978. Prepared by E. Harding, Resource Analysis Branch, B. C. Ministry of Environment, Victoria, B. C. In preparation.

Credits

Mapped by - E. Harding, Resource Analysis Branch, B. C. Ministry of Environment

Date of mapping - 1978

Drafted by - Cartographic Section, Resource Analysis Branch

Topographic base map provided by - Surveys and Mapping Branch, B. C. Ministry of Environment

AQUATICS BIOPHYSICAL

NO. 11 93P/3

LEGEND

Explanation of Map Symbols

REACH SYMBOLS

GENERAL: FISH SPECIES / CHANNEL | SUBSTRATE

Example (reach with complex cross-section and substrate)

Rb Ch↑ (Co) / s 1 c/b | (02R3) / 12

- Rainbow trout (present)
- Chinook (migration)
- Coho (probable)
- inferred substrate referring to confined portion (0% fines, 20% gravels, 30% bedrock, 50% larges)
- stepped profile
- 1% slope
- repeated pattern of confined and bounded cross-section types
- substrate referring to bounded portion (10% fines, 20% gravels, 70% larges)

Note: 1) where the channel or substrate component is man-made, the symbol is underlined.

2) where channel or substrate data has not been verified the symbol is placed in parentheses

Fish Species

1. Sport and Commercial abbreviations

Symbol	Species	Symbol	Species
Ch	Chinook salmon	LT	Lake trout
Co	Coho salmon	GB	German Brown trout
Cm	Chum salmon	MW	Mountain Whitefish
Pk	Pink salmon	LW	Lake Whitefish
Sk	Sockeye salmon	Gr	Grayling
Ko	Kokanee salmon	LMB	Largemouth bass
Rb	Rainbow trout	SMB	Smallmouth bass
St	Steelhead trout	NP	Northern pike
Ct	Cutthroat trout (Coastal)	WP	Walleye pike (Pickerel)
		YP	Yellow perch
YCt	Yellowstone Cutthroat trout	Sg	Sturgeon
		Bb	Ling (Burbot)
EB	Eastern Brook trout	Cp	Carp
		WF	Whitefish
DV	Dolly Varden Char		

2. OS - indicates known but non-sport or non-commercial species, data bank must be consulted for complete species list.
3. Sp - indicates fish observed but not indentified.
4. Ø - indicates fish not detected at time and place of sampling.
5. Absence of any fish species symbol indicates that no sampling information was available.
6. (Co) - indicates probable but unconfirmed presence.
7. Sk↑ - indicates reach used by species for migration only, no resident population.
8. Note: no specific symbol exists for a barren stream. When such a condition is suspected, it may be indicated by (Ø) which is an inference that *if* sampling took place, fish would not be detected.

Channel

1. Longitudinal Profile:
   - s - stepped — repetitious sequence of slopes or forms
   - r - regular — homogeneous or continuous profile
2. Slope: % (elevation gain/reach length)
   - > 3% measured to nearest percent
   - < 3% measured to nearest tenth percent
3. Cross-section
   - c - confined (channel is entrenched or lateral movement is controlled by banks)
   - b - bounded (channel movement is limited by valley walls near the edge of the floodplain)
   - u - unconfined (channel is not bounded by valley wall and much lateral movement or flooding is possible at high flows)

Substrate Materials

Fines, gravels and bedrock are listed in sequence to nearest 10%, expressed as an integer. Larges are inferred. (see example)

1. fines - materials in 0-2 mm size class
   gravels - materials in 2-100 mm size class
   larges - materials greater than 100 mm in size
2. Bedrock percentage indicated by Rn, where integer n represents percentage. R without integer implies 0-10%.
3. F, G, L or R used alone indicates 90-100% of a reach is in one category size; fines, gravels, larges or rock respectively.

STREAM REACHES WITH LIMITED INFORMATION

1. Slope
   - I > 5%
   - II < 5%
2. Cross-section
   - c: confined
   - u- unconfined
3. Wetland Class
   - m - marsh
   - s - swamp
   - b - bog
   - p - pond
   - f - fen

eg. Ic(b) - a steeply sloping confined channel, probably through an alpine bog.

Note: slope and cross-section may be used alone.

LAKES

General: Fish Species / Max. depth | T.D.S. / % Littoral area

1. Fish species: sames as streams
2. T.D.S.: total dissolved solids, if available
3. Maximum depth: measured to nearest meter.
4. Littoral area: measurement or visual estimate of % of total area < 6m. When estimate is made, parenthesis will be used.

SITE SPECIFIC STREAM SYMBOLS

3R — Obstructions are symbolized as follows:

R (Rock)	Bd (Beaver dam)
L (Logs)	θ (Culvert)
B (Blocks)	V (Velocity)
D (Man-made dam)	C (Cascade/Chute)
Chan(Channelized)	Canyon
Dyke	F (Type unknown)

Heights (m) may be indicated as numbers before symbols (e.g. 3R = 3m rock falls); lengths (m) as numbers after symbols (e.g. C50 = 50m long chute/cascade)

C — Zones of the above types (plus subsurface flow) may also be indicated with or without height and length information (e.g. zone of chute or cascade)

5R200 — A 5m high and 200m long rock cascade

Ch — Clear evidence (e.g.: persistent redds or observed spawning adults) of spawning by the indicated species in the indicated zone

A general zone of flood and side channels

A persistent debris accumulation

A bridge

Ford

2 — A site (point) number with biophysical data available

4 — A water quality sampling site number

7 — A water quantity sampling site number

R3 — A reach boundary. Reach number on upstream reach boundary

20R — A reach boundary which is also an obstruction

A major bank or valley side wall slump zone

An alluvial sink hole without surface effluent

Spring unclassified

f — Spring f fresh, t thermal, s saline

Termination of survey; indicates reach information available

K — A karst pothole

Persistent snow or ice

Major watershed boundary
Sub-watershed boundary
Minor watershed boundary

23-0400-020-010 indicates watershed system code number

References

Aquatic System Units in the Northeast Coal Study Area - 1978

Prepared by E. Harding, Resource Analysis Branch, B.C. Ministry of Environment, Victoria, B.C. In preparation.

Aquatic System: Inventory and Analysis - 1977

Resource Analysis Branch, B.C. Ministry of Environment, Victoria, B.C. 39 pp. plus appendices.

Credits

Mapped by - Aquatics Section, Resource Analysis Branch, B.C. Ministry of Environment

Date of mapping - 1977

Drafted by Cartographic Section, Resource Analysis Branch.

Topographic base provided by - Surveys and Mapping Branch, B.C. Ministry of Environment

Scale 1:20,000

Metres 500 400 300 200 100 0 500 1000 1500 2000 Metres

Feet 1000 0 1000 2000 3000 4000 5000 6000 7000 8000 Feet

Part of 82 G/10,15 From Crowsnest Industries Sheets 1,4

SPARWOOD — AQUATIC ANALYSIS

Unit No.	General Description	URBAN SUITABILITY INTERPRETATIONS: Flood Hazard*	Other Hydrologic Constraints Of Terrain Units	Fish Utilization
1.	Steep alpine and subalpine slope with a high density of avalanche tracks or gullies; source area for flow on lower slopes; ephemeral surface flow, mainly during seasonal snowmelt.	H	$L^{3,4}$	H
2.	Coalescing colluvial fans at base of steep slopes; receiving area for avalanches, mudflows and surface drainage; locally, surface flow and seepage, mainly during seasonal snowmelt.	H	$L^{3}_{4,5}$	H
3.	Till covered lower valley slopes and knolls; subsurface flow predominant with some surface flow and seepage zones locally.	H	$M_{5,6}$	H
4.	Till and colluvium covered lower valley slopes; subsurface flow predominant; some avalanching locally; evidence of active and inactive gullying; local surface flow and seepage.	H	L^{5}_{6}	H
5.	Valley floor fluvial terraces; deep groundwater and subsurface flow predominant; little or no surface flow, minor local seepage.	H	H	H
6.	Valley floor lacustrine terraces; subsurface flow predominant, particularly along impermeable strata; high water tables and seepage locally in surface hollows; active gullying along edges; some well defined surface channels (mapped separately as unit 12).	H	M^{5}_{6}	H
7.	Valley floor lacustrine terraces; subsurface flow predominant, particularly along impermeable strata; active gullying and frequent surface channels dissect this unit.	M_3	L^{6}_{5}	H
8.	Man-made terraces and mining spoil piles; subsurface flow predominant with active surface gullying on steep slopes.	H	M_6	H
9.	Lower valley slope ice contact deposit; subsurface flow predominant; little or no evidence of surface flow except gullying locally on steep slopes.	H	M_6	H
10.	Escarpment unit; frequent active and inactive gullying; seepage emerging locally along impermeable strata.	H	L^{6}_{5}	H
11.	Undifferentiated shallow till and colluvium covered bedrock slopes; frequent entrenched surface flow channels, but unit less dissected than unit No. 1; no avalanche tracks present.	H L_3 locally along gullies	L^{5}_{6}	H
The Following Units are Surface Channel Reach Types.**				
12.	Ravine; channel entrenched in deep surficial deposits with no valley flat.	L^3	L^{4}_{6}	H
13.	Canyon; channel entrenched in bedrock with no valley flat.	L^3	H	H
14.	Bounded; channel on a narrow valley flat bounded by terraces; channel may shift over the valley flat.			
	a) Cummings Creek; considerable shifting of channel in recent past.	$L^{1,2}$	H	M_8
	b) Michel Creek; channel formerly active; no shifting of channel in recent past; Creek has been channelized by artificial terraces of mine spoils.	L^1	H	M_8
15.	Fluvial fan; channel unconfined but presently stabilized by vegetation; shallow subsurface flow and local surface seepage in remainder of unit.	L^{3}_{2}	M_5	H
16.	Flood plain (inactive); valley flat subject to occasional inundation and channel migration.	L^{1}_{2}	H	H
17.	Flood plain (active); present and recent active channel subject to frequent inundation and channel migration.			
	a) Elk River unstable channel; evidence of channel diversion and active migration.	$L^{1,2}$	H	L^7
	b) Elk River stable channel; slight confinement by low terraces and rock outcrops; some minor migration in reach south of Sparwood, none in reach north of Sparwood.	L^1	H	L^7
	c) Michel Creek, unstable channel; evidence of active migration and channel diversion.	$L^{1,2}$	H	M_8
18.	Seepage zone; high water table; ephemeral surface flow in hollows; poorly defined channel.	M_1	L^{5}_{6}	H
19.	Seepage zone (earth flow); active earth flow with high water table; seepage, ponding, and surface flow in poorly defined channels.	M_1	$L^{4}_{5,6}$	H
20.	Wetland (tailings pond); tailings pond of coal mine.	L^1	H	H
21.	Slough; (Elk River and Michel Creek flood plain); channel on flood plain or low terraces with a substantial portion of flow derived from emergent groundwater originating on valley slope.	L^1	H	L^7
22.	Unconfined channel. Stabilized by vegetation.	L^1	L^2	H

*The flood hazard rating is based on historic, geomorphic, soil, and vegetation evidence of the type and relative frequency of flooding indicated; it is not a water stage-frequency prediction. Reference should be made to Water Investigation Branch flood plain mapping of the Elk River valley for 25 and 200 year flood plain levels.

**Boundaries delineated around stream reaches smaller than the Elk River are not necessarily accurate at the scale of mapping. Their purpose is to show the existence of a Unit with indicated limitations for Urban Development.

**** The **HIGH MEDIUM LOW SYSTEM.** Used to Rate Aquatic Units and Hydrologic Factors of Terrain Units for Various Interpretations Related to Urban Suitability Potential.

H HIGH POTENTIAL - no limitations concerning the factor indicated.

- severe Limiting Factor

M # # MEDIUM POTENTIAL - some limitations concerning the factor indicated; these limitations need to be recognized, but can be overcome with good management and design.

- moderate Limiting Factor.

- severe Limiting Factor

L # # LOW POTENTIAL - enough limitations to make use questionable. However, with careful planning and management, the limitations may be overcome, but economic feasibility may then become limiting.

- moderate Limiting Factor.

EXAMPLE: $L^{1,2}_{3}$ This represents a Unit having a selected interpretation severely limited by overbank inundation and channel instability and having moderate limitation due to possible flash floods.

Note that the interpretative is for urban suitability, so that, for example, a High rating under the flood hazard column indicates a hydrologically suitable area for urban land uses.

Limitations to Use

A. Flood Hazard
1. Overbank Inundation
2. Channel Instability
3. Flash Floods

B. Other Hydrologic Constraints
(Potential Changes to Surface Drainage Characteristics)
4. Mass Movements (muds flows and avalanches)
5. Surface Interception of Subsurface Flow
6. Gullying of Exposed Surfaces

C. Fish Utilization
7. Fish Population Viable Under Sustained Angling Pressure
8. Fish Present but Population Not Viable Under Sustained Angling Pressure; Children's Fishery and Educational Values in Urban Areas.

MAP SYMBOLS

Study Area Boundary

defined – approx. – assumed Unit Boundary

SURVEYS AND MAPPING BRANCH
MINISTRY OF THE ENVIRONMENT
VICTORIA, B.C.

U.T.M. Grid – Zone 10 (1975)
Date of Photos: July 1976
Control by: 1:50 000 Mapping
Contour Interval: 10 Metre

Triangulation Station with elevation: △
Horizontal Control Point with elevation: □
Bench Mark: →
Vertical Control Point: —•—
Air Photo Centre: ○

AQUATIC ANALYSIS : BASE DATA

BOWEN ISLAND

SCALE 1:10000

77-104T-O

Sheet 1 of 2

REACH SYMBOLS

GENERAL: FISH SPECIES / CHANNEL | SUBSTRATE

Fish Species

1. Sport and Commercial abbreviations:

Symbol	Species	Symbol	Species
Ch	Chinook salmon	GB	German Brown trout
Co	Coho salmon	MW	Mountain Whitefish
Cm	Chum salmon	LW	Lake Whitefish
Pk	Pink salmon	Gr	Grayling
Sk	Sockeye salmon	LMB	Largemouth bass
Ko	Kokanee salmon	SMB	Smallmouth bass
Rb	Rainbow trout	NP	Northern pike
St	Steelhead trout	WP	Walleye pike (Pickerel)
Ct	Cutthroat trout (Coastal)	YP	Yellow perch
YCt	Yellowstone Cutthroat trout	Sg	Sturgeon
EB	Eastern Brook trout	Bb	Ling (Burbot)
DV	Dolly Varden Char	Cp	Carp
LT	Lake trout		

2. OS - indicates known but non-sport or non-commercial species, data bank must be consulted for complete species list.
3. Sp - indicates fish observed but not identified.
4. Ø - indicates fish not detected at time and place of sampling.
5. Absence of any fish species symbol indicates that no sampling information was available.
6. (Co)- indicates probable but unconfirmed presence.
7. Sk↑ - indicates reach used by species for migration only, no resident population.
8. Note: no specific symbol exists for a barren stream. When such a condition is suspected, it may be indicated by (Ø) which is an inference that if sampling took place, fish would not be detected.

Channel

1. Cross Section
   - C - a degrading channel entrenched in bedrock (canyon).
   - V - a degrading channel entrenched in deep unconsolidated material without bedrock exposures (ravine).
   - Vc - a degrading channel entrenched in deep unconsolidated material with bedrock exposures along the channel.
   - W - a gully on a bedrock slope.
   - Wg - a gully on a slope of unconsolidated material.
   - F - an unconfined channel on a fluvial fan.
   - A - an unconfined channel on a floodplain.
   - B - a channel with constricted lateral movement on a narrow floodplain.
2. Slope: % (elevation gain/reach length)
   - < 3% measured to nearest tenth percent.
   - 3-10% measured to nearest percent.
   - > 10% measured to nearest 5%.
3. Lateral Stability
   - s - single channel, laterally stable (implied for reach cross section types C, V and Vc).
   - p - single channel showing meander development; channel may shift laterally by progression and cutoff at meander bends.
   - b - single channel without definite meander development; channel may shift by avulsion (blockage and diversion).
   - d - single main channel divided by islands; side channels are present; channel may shift laterally by blockage and diversion.

Substrate Materials

Fines, gravels and bedrock are listed in sequence to nearest 10%, expressed as an integer. Larges are inferred. (see example)

1. fines - materials in 0-2 mm size class.
   gravels - materials in 2-100 mm size class.
   larges - materials greater than 100 mm in size.
2. Bedrock percentage indicated by Rn, where integer n represents percentage. R without integer implies 0-10%.
3. F, G, L or R used alone indicates 90-100% of a reach is in one category size; fines, gravels, larges or rock respectively.
4. D90 (diameter of 90th percentile to nearest cm.

Example

Rb Cht(Co)
B2.5d | (02 R1-30)

- Rainbow trout (present)
- Chinook (migration)
- Coho (probable)
- a channel on a narrow floodplain with constricted lateral movement
- 2.5% slope
- main channel divided by an island; channel may shift laterally by blockage and diversion
- inferred D90 of 30 centimeters
- inferred substrate (0% fines, 20% gravels, 10% bedrock, 70% larges)

Note:
1) where the channel or substrate component is man-made, the symbol is underlined. Parentheses indicate the former state.
2) where channel or substrate data has not been verified the symbol is placed in parentheses.
3) a blank implies that no data is available.

STREAM REACHES WITH LIMITED INFORMATION

Substrate and fish species are omitted from small channels which have not been ground checked. Only the channel cross section, slope, and lateral stability are shown.

Example: V15 - a channel with a slope of 15% entrenched in unconsolidated surficial materials

LAKES AND WETLANDS

GENERAL (Lakes): FISH SPECIES | T.D.S. / MAX. DEPTH | % LITTORAL AREA

1. Fish species: sames as streams
2. T.D.S.: total dissolved solids, if available
3. Maximum depth: measured to nearest meter
4. Littoral area: measurement or visual estimate of % of total area <6 m. When estimate is made, parenthesis will be used.

Wetlands are indicated by the symbol "D", followed by class symbols:

m	marsh	s	swamp
b	bog	p	pond
f	fen	h	seepage hollow

SITE SPECIFIC STREAM SYMBOLS

- 3R — An obstruction 3 m high of the following types: R (Rock), L (Logs), B (Blocks), D (Man-made), Bd (Beaver dam), F (Type unknown), V (Velocity), C (Cascade or Chute)
- 5R50 — A chute or cascade 5 m high and 50 m long of the above types
- C — A chute or cascade with details unknown; obstruction type symbols used when possible
- Bd — A sequence of beaver dams
- Ch — Clear evidence (e.g. persistent redds or observed spawning adults) of spawning by the indicated species
- Specific location of flood and side channels
- A persistent debris accumulation
- A bridge (Chan = a channelized channel)
- (2) — A site (point) number with biophysical data available
- △4 — A water quality sampling site number
- □7 — A water quantity sampling site number
- R3 — A reach boundary. Reach number on upstream reach boundary (not numbered when watershed boundary not shown)
- 20R — A reach boundary which is also an obstruction. The obstruction height is not to be included in either adjacent reach for the purposes of reach slope calculation
- A major zone of bank or valley side wall instability
- A sink on an influent stream
- Unclassified spring or resurgent stream
- (fc) — Spring: f fresh, t thermal, m mineral; r spring in bedrock fault, fissure or fracture; c spring along a bedrock contact; s seepage spring along an intersected water table
- Major culvert or flume. Θ or V indicates obstruction due to protruding entrance or velocity respectively
- Diversion channel
- Ephemeral channel or seepage zone
- Permanent channel
- Major watershed boundary
- Sub-watershed boundary
- Minor watershed boundary

23-0400-020-010 indicates watershed system code number

Definitions and methods are available from Resource Analysis Branch, Ministry of the Environment.

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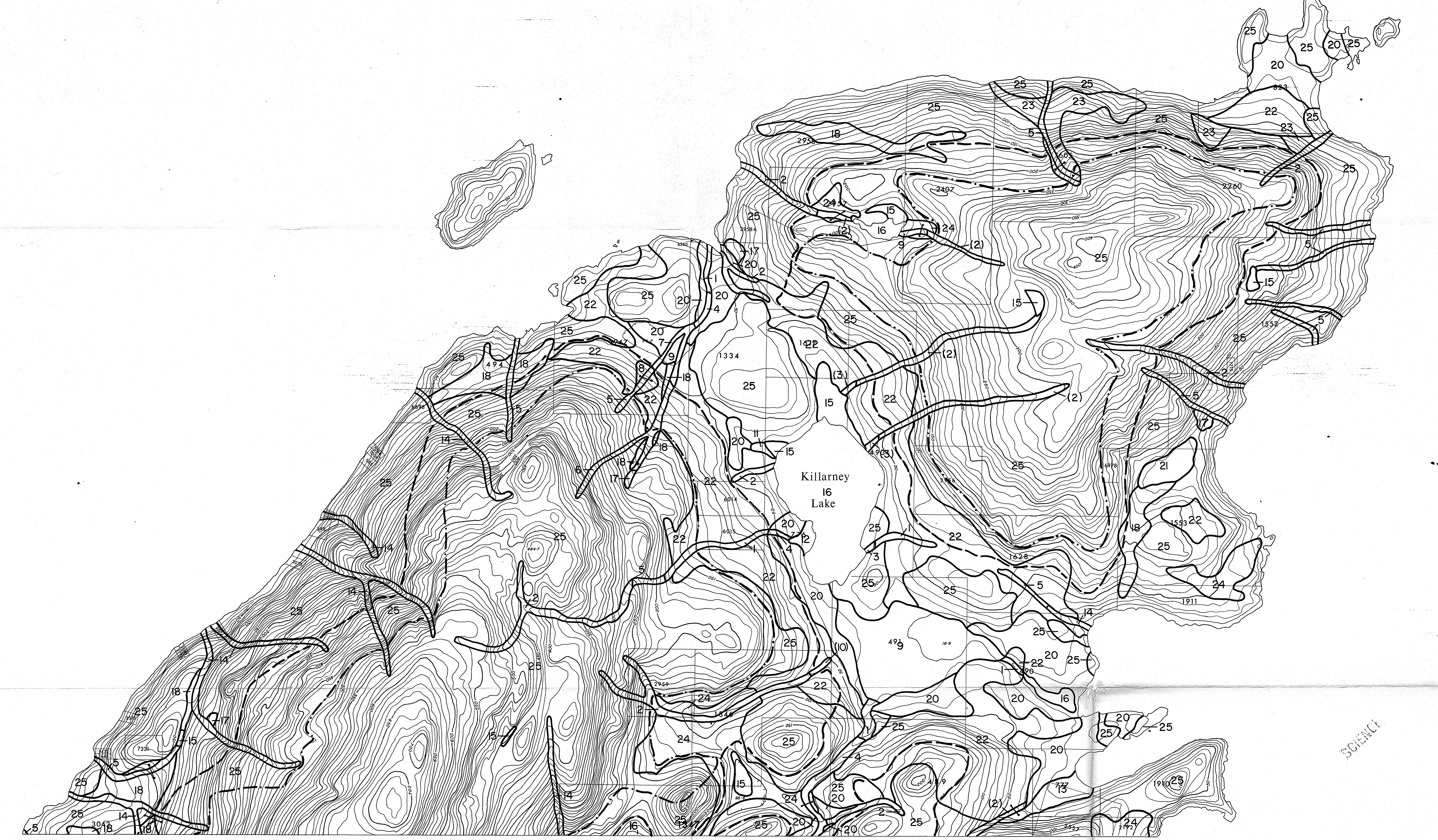

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AQUATIC ANALYSIS : INTERPRETIVE

BOWEN ISLAND
SCALE 1:10 000
77-104T-O
Sheet 1 of 2

Units 1 - 14 enclose areas which are subject to flooding, and fall within the zone to which flood control requirements of Water Investigations Branch apply, and to which the environmental buffer zone concept of the Fish and Wildlife Branch should apply. These units are unsuitable locations for dwellings.

			Channel Process		
Unit No.	Salmonid Rearing and Spawning	Salmonid Migration	Debris and Bedload Storage	Lateral Channel Movement	Floodplain width
1	M	L	M/L	L	L
2	L	L	L/M	L	L
3	H	H	L/M	L	L
4	M	L/M	M/H	L	L
5	L	L	L/M	L/M	L
6	H	H	M	L	M
7	M	M	M	L/M	M
8	H	H	M	M	H
9	M	M	M	L/M	H
10	L	L	M	L	H
11	M	M	L/M	L/M	H
12	H	H	H	M	H
13	H	H	L	L	H
14	L	L	M/H	L	L

Variables rated low - L along a stream reach are not considered important in the design of structures along the channel.
Guidelines for variables rated medium - M along a stream reach should be included in the design of structures along the channel.
Variables rated high - H along a stream reach indicate extreme or severe hazard or unwanted impact if not considered in the design of structures along the channel.

Units 15 and 16 are permanent wetlands and lakes. The wetlands should not be disturbed or filled in for development because of their value in alleviating critical low flow conditions present during the summer on many Bowen Island streams.

AQUATIC INTERPRETIVE UNIT FOR SETTLEMENT DESIGN

Unit No.	Generalized terrain description*	Runoff processes and hydrology	Settlement design sensitivity
17	Small inactive fluvial fans and pockets of fluvial materials deposited on slopes and in depressions around the base of slopes.	The fluvial materials are shallow but highly permeable, with rapid rainfall percolation; the impermeable underlying materials cause the formation of a perched local groundwater table. Seepage springs may occur at the base of the unit. The slope above the unit or entrenched streams which may run through the unit are major sources of groundwater.	Sensitive to: impermeable surface area changes and sewage disposal. The groundwater supply may be sensitive to changes in surface permeability (asphalt, roofs, etc.) if the major groundwater source is through surface infiltration. Changes in water quality may occur if sewage is by means of septic tanks.
18	Fluvial benches along present day streams. Deposits have varying textures and thicknesses.	Generally similar to unit 17. Deeper and larger pockets along Terminal Creek valley may contain more substantial aquifers.	Sensitivities similar to Unit 17.
19	Coastal benches of fluvial and marine origin. Thick fluvial gravels overlying marine sediments or till.	The fluvial materials are highly permeable, resulting in rapid rainfall percolation. The underlying marine deposits or till are generally impervious, resulting in formation of a groundwater table, or subsurface seepage at the base of the fluvial strata.	Sensitivities similar to Unit 17.
20	Sandy marine sediments overlying compact till on coastal and interior valley benches.	Generally similar to Unit 19.	Sensitivities similar to Unit 17.
21	Silty and clayey marine sediments overlying compact till on coastal and interior valley benches.	This unit has slow natural drainage, generally as subsurface seepage along the till or unweathered marine strata. Surface ponding which is not connected to surface channels is characteristic of this unit.	Sensitive to: drainage ditches and surface disturbance associated with development. Runoff process is speeded up by drainage ditches. This unit has high siltation potential for any adjacent stream channels from surface disturbance.
22	Thick lowland till deposits, on lower slopes and benches of valleys.	The surface capping of coarse textured fluvial or marine materials, or weathered or reworked till is highly permeable. Subsurface flow occurs on the underlying impermeable till, and surface ponding may occur in local depressions.	Sensitive to: drainage ditches associated with development. Runoff process is speeded up by the drainage ditches.
23	Thick colluvial deposits (fans and blankets) on steep slopes (in depressions and at the base of gullies).	Surface is highly permeable, with rapid rainfall percolation. This unit characteristically has subsurface flow or a perched groundwater table along the contact with underlying impermeable bedrock.	Sensitivity similar to Unit 17: the major effect on the runoff process occurs from changes in impermeable surface area: the groundwater supply or subsurface flow is only affected if infiltration from the surface of the unit is the main source.
24	Thick till deposits on slopes and uplands, underlain at depth by bedrock.	The surface capping of weathered or reworked materials is highly permeable. Subsurface flow occurs on the underlying impermeable till; surface ponding may occur locally in depressions.	Sensitive to: roads and associated drainage ditches. A major effect on the runoff process occurs from interception of the subsurface flow along roads.
25	Bedrock covered by veneers and pockets of deeper colluvial and morainal deposits on slopes and uplands.	The surface capping is generally highly permeable. Subsurface flow occurs on the underlying impermeable bedrock. Surface ponding may occur locally in depressions, and some groundwater percolation occurs in joints and faults in the bedrock.	Sensitive to: roads and associated drainage ditches. Similar to Unit 24.

*Information on surficial geology provided by terrain base map; for definitions of geologic terms refer to Terrain Classification System (Resource Analysis Branch, 1976). Aquatic terminology and methods of inventory are described in the Aquatic Systems Inventory Manual (Resource Analysis Branch, 1976). The methods of interpretation are also discussed in a report 'Resource Analysis For Urban Suitability: Vancouver's Northshore Area' (Resource Analysis Branch, 1977).

SLOPE

In general, potential for surface erosion and interception of subsurface flow, and the difficulty of building roads and associated drainage systems increases with slope. As a rough guideline, the low (<15%), moderate (15-30%), high (>30%) classes of slope suitability apply to the sensitivity of the runoff process to development.

LOCATION OF DEVELOPMENT WITHIN WATERSHEDS

Location of development within a watershed affects the intensity and extent of changes in stream discharge. In general, the upper watershed of basins in which low summer flows, water quality and storm peakflows are water management concerns have low suitability for settlement development. To facilitate definition of upper watershed areas, the lower quartile (upper elevation of lowest 25% of basin area) and median elevations of Bowen Island watersheds are shown on the aquatic interpretive map.

CRITERIA FOR LOW, MEDIUM AND HIGH RATINGS

1. Salmonid Spawning and rearing

Low - Salmonids not known to be present.
Medium - Utilization by sea run or lake resident salmonids.

2. Salmonid migration

Low - Salmonids not known to be present, or stream has frequent obstructions thought to be barriers to upstream passage of fish.
Medium - No obstructions to upstream passage, and stream utilized by stream resident salmonids.
High - No obstructions to upstream passage, and utilized by stream or sea run salmonids.

3. Bedload and debris storage

Low - Accumulations of debris not present, and bed material consists of large, stable lag boulders without gravel accumulations, and bedrock.
Medium - Debris accumulations consist of individual lags along the channel; channel rooted width is less than two times the width of the low flow netted width.
High - Debris accumulating in larger aggregations; channel rooted width is greater than two times the width of the low flow wetted width.

4. Lateral channel migration

Low - No lateral channel migration observed.
Medium - Occasional islands and meanders (definition of "occasional" follows usage by Kellerhals, Bray and Church, 1975.)
High - Frequent islands and meanders with evidence of meander cutoff and channel avulsion (this rating category is not present on Bowen Island).

5. Floodplain width

Low - Floodplain width less than two times the rooted channel width.
Medium - Floodplain width two to five times the rooted channel width.
High - Floodplain width more than five times the rooted channel width.

MAP SYMBOLS FOR WATERSHEDS

———— Unit Boundary
—·—·— Mean Watershed Elevation
— — — First Quartile Water Elevation
( ) Inferred

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