Erosion and Sediment Transport Monitoring Programmes in River Basins (Proceedings of the Oslo Symposium, August 1992). IAHS Publ. no. 210, 1992.

Network evaluation and planning: Canada's sediment monitoring program

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ABSTRACT Environment Canada manages the major Canadian program for monitoring sediment transport. Its almost 30 year investment has produced an active network of about 250 stations and over 600 discontinued stations. In attempting to improve the management of active stations, and to extract the information content of both active and discontinued stations, a network evaluation and planning (NEP) strategy was developed with these general objectives: ensuring reliable data; matching station objectives to needs; producing interpretations of data, particularly for issue analysis; and developing and managing basin/regional/national plans. There are three elements to this strategy: (1) network descriptions such as station profiles which document objectives, data types, clients and other basic information; (2) technical assessments of the data from systematic annual assessment through to regional analyses; and (3) network plans to guide decision making. This strategy, where implemented properly, has improved management control and field operational design -important gains as managers must guide network shifts from long term to short term records and respond to the rapidly emerging importance of environmental issues such as toxics transport. This strategy has also increased the demand for good technical expertise and decision making. A wide range of information products relating to sediment transport are being generated.

INTRODUCTION

The network evaluation and planning (NEP) function of any major data collection agency has long been recognized as important for both effective operational and strategic management. NEP is the process by which network activities are planned and measured against objectives, where network evolution (size, perspective, etc.) is managed, and where the information content is developed. The sediment monitoring activities of Environment Canada present no exception to this view, yet an enormous amount of effort has been, and is still, required to bring an intelligent and pragmatic approach to NEP.

These sediment monitoring activities evolved as an adjunct to the much larger hydrometric program managed by the Water Resources Branch of Environment Canada. Original program objectives focused on providing data for specific operational needs, such as navigational dredging, and on providing documentation of geophysical and anthropogenic impacts primarily along the main stems of Canadian river systems. As a consequence of this approach (detailed, long term sampling of suspended sediments) by the early 1980's the program had generated substantial data sets on many rivers, yet in many cases evaluations identified a series of concerns relating to too much and or little data, and a continuing

narrow focus on water resource engineering needs, while environmental issues were being identified as increasingly important. One consequence to this insensitivity to correctly addressing data needs was a diminishing of management support for the sediment program. The program had stalled at about 200 active stations across the country.

The challenge to bring order and sensitivity to this program was significant, for example:

(a) there were approximately 800 station data sets which had undergone little if any analysis,
(b) there was the current responsibility to give direction to the existing 200 stations,
(c) there were few, if any, current network development plans guiding decisions across Canada,
(d) there was the interesting spectre of the role and importance of fluvial sediments in environmental issue resolution, and
(e) there was an organizational setting where little interpretive expertise existed as the tradition was to collect not interpret data, and the organizational structure and management style worked to prevent, rather than promote change and cross-sectoral activities like quantity and quality sediment work.

This paper presents an outline of the NEP process developed to provide a systematic approach to network management, provides examples of interpretive work which is its key element, and sets out a future strategic, issue orientation for evolving the NEP process.

SEDIMENT PROGRAM NEP FRAMEWORK

The institutionalization of any process requires a systematic approach. Developing the appropriate science and technology is always challenging, but for major organizations, building the support for implementation is often a far more challenging task. In recognizing such organizational challenges, this NEP framework was constructed around examples and based on simple steps, integrated where possible with other Water Resource Branch activities.

The framework is structured around objectives and goals, and four strategies: network descriptions, operational planning, assessments, and network planning.

Objectives and Goals

The basic objectives of the framework are: (1) to ensure that appropriate data are available in sufficient type and amount for client needs; and (2) to provide information on fluvial transport. While the data delivery aspect is the traditional responsibility, the challenge now is to provide data for both water resource engineering and environmental applications. The basic transport data have general applicability to both needs but some environmental quality issues require different sampling strategies and compatible methodologies and equipment, for example.

The "new" demand for NEP is to provide the ability to generate information, particularly with respect to the transfer, fate and effect of contaminants within fluvial systems, and to assess the effect of natural (e.g. climate change, floods) and human (dams and diversions) impacts. Designing and managing sediment networks for information generation is a different challenge requiring considerable extra effort and expertise.

The goals of the framework can be specified as: (1) providing reliable data; (2) matching station objectives and operation design to the need; (3) developing reliable interpretations of the data; (4)

providing information to address issues; (5) ensuring network overviews are available on appropriate scales (basins, regional, national); and (6) having current plans to guide decision making on network evolution.

Network Descriptions

The framework strategy is to develop and use descriptions which give such essential information as station location, objectives, required products, clients, etc. These facts provide a snapshot of the station and must be updated as, for example, when client demands change or objectives are met. This strategy produces a station profile.

Operational Planning

Collection of discrete data sets, such as suspended sediment concentration, requires special attention to when and how many samples are taken. Sediment data need not, and cost-wise should not, be collected in large numbers. The Canadian program began by collecting several hundred samples per year, the "daily" sampling strategy. As many studies have shown (e.g. Kellerhals et al., 1974) the same information in many applications, can be derived from concentration - flow discharge rating curves. The new emphasis in the program is now on small data sets collected over shorter periods (3-7 years depending upon the hydrologic regime). While saving field time and laboratory analysis costs, this approach creates the need for closer management of the field program.

Our solution has been to develop station management plans (SMP) for each active station. The SMP's contain basic procedures, such as concentration-discharge plots, to track the new annual data. As this relationship is completed by targeting annual data collections to fill in the gaps of the rating relationship, the objectives of the station are met. Other tools such as flow duration curves are used to assess the completeness and representativity of the concentration data set. The SMP process is discussed in more detail by Herrington et al. (1991).

The real strength of the SMP process lies in its potential empowerment of the field staff not only to make decisions on field sampling design, but to be involved in the associated data analysis. This benefits the individual and hence the program, as it generates ownership through involvement and understanding of how the data are used and what it can tell about the river. Besides giving operational instructions, this annual process provides a first level of interpretation.

Assessments

Sediment monitoring programs cannot be managed effectively if decisions are not guided by data assessments. While clients are expected to use the data as their application requires, the program managers must be in a position to understand what the data can tell about the behaviour of the river, and in reverse, what this understanding can tell about the data collection program itself. Management concerns exist on three scales - single stations, basins and regions (meaning in Canada either a province or provinces).

The single station analysis approach is an extension of the SMP process, but is much more comprehensive. These analysis are undertaken either at major decision points, such as planning for a dam, or after a station has been terminated (based on SMP decisions). Numerous examples now exist, such as Ashmore (1990) and Glavic et al. (1988).

The resulting reports provide a good basis for any further studies in the vicinity of the stations. Attempts have been made (e.g. Hydrcon Engineering, 1987a) to incorporate water quality concerns into these analyses but no consistent integration presently exists.

Basin analysis report (such as Ashmore, 1986; Hydrocon Engineering, 1987b; Carson and Associates, 1990) also are built on the same basic approach used in the SMP's and the station analysis, but the real focus is on how the station data sets support one another in documenting the transport of sediments through the basin. As program managers seek to address environmental quality issues this basin approach is much preferred as the associated resource management questions exist at reach, river system and basin scales.

Regional data analyses form the third scale of assessment. These analyses are obviously demanding in resources but can provide program managers with insights into regional patterns of fluvial processes and sediment transport. Examples by Church et al. (1989), Dickinson & Green (1987) and Hudson & Niekus (1990) provide such information for the provinces of British Columbia, Ontario, and Alberta, respectively. More such assessments need to be either commissioned or completed by program staff.

Network Planning

Network planning needs exist at three levels: (1) management responsibility - i.e. provincial and or territorial scales as these are the size of the administrative units; (2) basin scales - these are natural unit which generally reflect the scale at which most resource and environmental issues must be addressed; and (3) need specific - this could mean either for specific objectives such as navigation dredging or for specific issues such as sediment related toxics.

The central planning challenge is to maximize the use of the varied interests driving the network. Even stations with very specific objectives can be used to supplement basin or regional knowledge. Program managers must meet client obligations in the most efficient manner while also using program (and client) resources to further develop an understanding of fluvial sediment characteristics and issues in their jurisdiction.

An example of a provincial scale network plan is the Yuzyk & Penner (1988) exercise in Manitoba. The authors reviewed each existing station assessed its progress, developed specific monitoring instructions for activities (sampling strategy, bed material, etc.), reviewed new program requirements, and set out priorities for shifting resources from terminated stations to new sites. The reorientation of a major component of the Ontario sediment monitoring network to address Great Lake tributary transport of contaminants is another example of how provincial scale planning can be successful (Smith, 1991).

Basin scale planning approaches have taken several forms. For example, Carson and Associates' (1988) review of the Mackenzie River Basin assessed the various potential client needs and proposed a renewed sampling program for the main portion of the Mackenzie River and some of its key tributaries. Hudson's (1990) assessment of the suitability of the existing sediment monitoring program in the South Saskatchewan River Basin found, for example, that little information of plains area basins existed yet these areas were responsible for additions to the sediment load and were important sources of sediment associated contaminants, nor did the present program provide much information on the sources of sediment, and their pathways and fate - critical requirements for environmental quality management.

These basin planning exercises emphasize the need to take a

systematic and more holistic approach. While this appears rather obvious, it presents significant management challenges as client requests tend to be narrowly focused and the sediment program managers themselves do not have sufficient resources to create the bigger picture.

Planning to meet the needs of specific client requests is rather straight forward, and there must always be effort made to respond to these needs in a boarder context.

Planning to meet the needs of issues, such as climate change, marine environmental quality and sediment associated toxic transport, force new perspectives onto the program. While the output of the monitoring program will still be physical attributes of the transport, these must be collected and interpreted to meet special needs such as aesthetics and fish habitat management. Successful planning demands an expanded expertise base to understand the application and to design the network response. Integrated approaches at the planning, field operational, and analysis stages are essential. Actual network expressions arising from these issues are varied, with their spatial and temporal characteristics shaped by the substance, species or perspective of importance.

STATUS OF THE NEP STRATEGY

The tight organizational setting for these sediment activities (e.g. decreasing resources, few experienced interpretive and planning staff, and higher Branch priorities) has led to a relatively low keyed approach. Having developed the NEP strategy, with appropriate supporting examples, the intent is to implement the elements where local management support exists, and to attempt to strike a balance amongst controlling of the current network, extracting the information content and responding to the ever increasing departmental concern over environmental issues. Focusing on only one aspect is fatal as the overall NEP objectives soon tend to be forgotten. Also, programs can survive in the relatively volatile organizational setting only by being relevant, which requires a concerted effort to look ahead.

The real status of the sediment program's NEP strategy remains very mixed, and nowhere yet fully in place and functional. There are some notible successes as well, including a systematic shift from long to short term stations, an increasing issue focus (e.g. Smith, 1991) and a larger 400 station network (including special event sampling stations).

FUTURE CONSIDERATIONS

The future for sediment program network evaluation and planning clearly lies in integrating this need into those of other surface water network designs. It is no longer possible, nor for a long time appropriate, to design and manage a sediment network in isolation of, or in lesser importance to, water quantity and quality networks. The management questions, whether resource or environmental (and the two are rapidly becoming intertwined), simply demand an integrated organization response. Depending upon the issue at hand, integration can occur at the planning, data collection and/or interpretation stage. Whatever the need and solution required, organizations must set about their broad NEP responsibilities with an integrative perspective.

Recent examples of an issue oriented, integrated network planning are Hudson and Kowalchuk (1991) and WMO (1991). The former is a broadly based management framework which serves to focus network managers on strategic information requirements rather than operational needs. The WMO initiative recommends an "Integrated Network Design Framework" for the design of water resources data networks for multipurpose hydrological

information needs. These two frameworks link institutional needs, data users/uses, priority setting, state-of-network information, and network design techniques.

Future sediment networks in Canada will continue to address operational and baseline data needs, but the real challenge and emphasis will lie in designing and managing network responses to environmental issues, such as the transport of contaminants to the Great Lakes, and cumulative impact studies of pulp mill effluent along the Athabasca River in Alberta. These require integrated approaches in both science and organizational dimensions.

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