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Project Summary

A Prototype Computer-Interactive Groundwater Monitoring Methodology: An Example for Sedimentation Ponds

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This report describes a prototype computer-interactive system that enables the development of a groundwater monitoring program for sedimentation ponds at coal strip mines. The system is an eight-step procedure derived from the fifteen-step methodology developed for the U.S. Environmental Protection Agency (Monitoring Groundwater Quality: Monitoring Methodology, EPA-600/4-76-026) for monitoring coal strip mine operations which constitute a major potential source of groundwater degradation. While this report addresses the monitoring of sedimentation ponds, the system presented consists of a set of instructions applicable to monitoring any specific groundwater pollution source.

The instructions enable the user to select from a large amount of text information those portions appropriate to be written into his own file. Of the several approaches that can be used, the approach described in this system is one that breaks the text into segments or frames numbered consecutively and stored in a sequential file. The information contained in the frames offers various alternative methods for building components of a mine surface and subsurface water monitoring design plan. The user constructs his own monitoring design file by selecting from the methods presented those applicable to his specific mine. For each step and objective the user is presented with a description of the principle involved in each of the alternative methods, the advantages and disadvantages of each, and the associated cost.

This Project Summary was developed by EPA's Environmental Monitoring Systems Laboratory, Las Vegas, NV, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

As part of its program to protect the environment from the adverse effects of the rapidly increasing industrial development of Western U.S. coal reserves, the U.S. Environmental Protection Agency (EPA) conducted a project to identify, quantify, and priority rank the important sources of groundwater quality degradation within a given coal strip mine area. The resulting report, "Groundwater Quality Monitoring of Western Coal Strip Mining: Identification and Priority Ranking of Potential Pollution Sources" (EPA-600/7-79-024) identifies coal strip mining in the Western U.S. as a major potential source of groundwater quality degradation and describes the following specific sources of potential pollution within this major classification:

1. Spoils
2. Pit Water
3. Sedimentation ponds
4. Explosives
5. Mine Solid Waste and Liquid Shop Wastes
6. Sanitary Waste
7. Spills
8. Leaks
9. Stockpiles
   a. topsoil
   b. overburden
   c. coal
   d. coal refuse
   e. partings
10. Reclamation Aids
11. Solid Waste from Road Construction

These sources are listed in a priority order or in relative order of the magnitudes of water quality impacts that they cause in typical coal strip mining environments. Some or all of these potential sources of contaminants may be found at any given coal strip mine in the West.

The computer-interactive monitoring system presented in this report uses an eight-step methodology derived from the fifteen-step methodology. This structured, cost-effective methodology enables the design and implementation of a groundwater quality monitoring program for any manmade source under any hydrogeologic regime and could be used by government and industry as the basis for developing all Western coal strip mine and oil shale groundwater monitoring guidelines.

In addition, this monitoring methodology shows that a finite number of monitoring techniques are available to assess the problem and design the monitoring program; that the design, implementation, operation and maintenance costs can be reasonably estimated by formula; and that pump size, screen size, pumping rates and other factors all behaved according to fundamental relationships. These capabilities of the methodology prompted the work described in this report and the resultant construction of the computer interactive system that enables a nontechnical person to design a monitoring program for a coal strip mine sedimentation pond. The following eight-step procedure forms the basis for the computer interactive system:

1. Select the area for monitoring.
2. Inventory potential pollution sources.
3. Identify potential pollutants and methods of disposal.
4. Identify groundwater usage.
5. Evaluate infiltration potential.
6. Evaluate pollutant mobility in the vadose zone.
7. Evaluate pollutant mobility in the saturated zone.
8. Priority rank the sources:
   a. Potential pollutant amounts and concentrations
   b. Amounts infiltrating
   c. Mobility of infiltrating pollutants in the vadose zone
   d. Mobility of pollutants reaching the saturated zone

A coal mine operator or other person planning to use the monitoring methodology would select those potential sources found on his mine site. He would then develop an appropriate monitoring program for each source by applying Steps 3 through 7 of the eight-step methodology to each source in order of its priority or importance at that particular mine site. A primary goal in developing a monitoring program is to evaluate existing monitoring effectiveness and related monitoring gaps for each of the existing sources and to determine the potential for groundwater contamination by each source according to its preliminary priority rank (Step 8). This computer interactive system serves to develop the monitoring plan.

For each type of source, the program discusses Steps 3 through 7 of the eight-step methodology under the following headings:

1. General monitoring objectives

   Specific monitoring objectives

2. Alternative monitoring approaches for achieving objectives including:
   a. Advantages and disadvantages of each alternative method
   b. Sampling frequencies needed for each method
   c. Analytical methods
   d. Costs
3. Recommended monitoring approach (including costs)

The report from which this summary is derived addresses the monitoring of sedimentation ponds. However, by following the preceding format, (Step 3 through 7 applied to each source), a user of the interactive system can develop a monitoring program tailored to meet the needs of specific sources at the site under investigation.

To operate the system a user requires a standard electric wall plug inlet (110-120 VAC), a telephone, and a portable computer terminal, which cost about $2,600 in 1980. The system requires less than 60K words of memory. Daily operating costs are approximately $25 to $100, depending upon the kind of monitoring methods selected.

Computer Program Description

The computer program presented in this report addresses methods of delivering a large amount of text from which the user can select those portions appropriate to be written into his own file. Several approaches may be used on such a problem. In the approach selected for discussion, the text information is broken into a number of segments or frames.

A logic record is stored in each frame. The system uses this to determine the correct frame to branch to in response to queries about material in the frame itself. This dispersal of logic into the frames themselves allows a complex frame-branching to occur, without cluttering the main computer program with branching information for each frame.

In this approach, the frames are numbered consecutively and stored in a sequential file (Figure 1). As the program operates, specific frames are retrieved from the file and the information contained in them is presented to the user. The information includes various alternative methods of building components of a mine surface and subsurface water monitoring design plan. The user selects the appropriate methods for his specific mine and loads these into his own monitoring design file, which is compiled as the program progresses.

The program is interactive and tutorial in nature. During the execution, the user is presented material from a frame and then queried as to whether he is currently using some of this material in his monitoring operations; would like to use some of this information in his own specific monitoring design file; or would like to introduce comments into his monitoring design file (MDF).

User responses are analyzed by the computer for possible errors as well as for the occurrence of control words. These control words require the program to override the current operation and allow for various other functions to be executed. Other functions may range from stopping work on a specific step in the monitoring design methodology to having printed what has already been loaded into the MDF.

The computer program allows the user to go through portions of the steps in the monitoring design methodology and he is not required to finish any one step before he may work on another. This allows the steps to be done in any selected order and allows a given step to be broken off and then continued from that point at some later time. Such an interruption in a step may be due to the need for data analysis, consultation with others, or the end of work period.

The computer program is designed to be used with either a standard or portable computer terminal. The text material is formatted so that it may be presented on a small portable terminal with only 80 columns available for output. A typical terminal of this nature is the Texas Instruments 700 series, which may be easily carried and connected to any telephone. The program is operated by dialing a host computer and, when a carrier signal is obtained, attaching the telephone handset to the computer terminal. Thus, the computer terminal may be operated at any location having an electrical outlet and a telephone.

The primary text file is formatted in such a fashion that it may be constructed by persons with little if any previous exposure to a computer. The provided text file (TEXT.DAT) suffices for mines in the West. The computer program presented was developed on a DEC-20 computer through the use of mostly ANSI FORTRAN IV so that its movement to other computers should be straightforward.

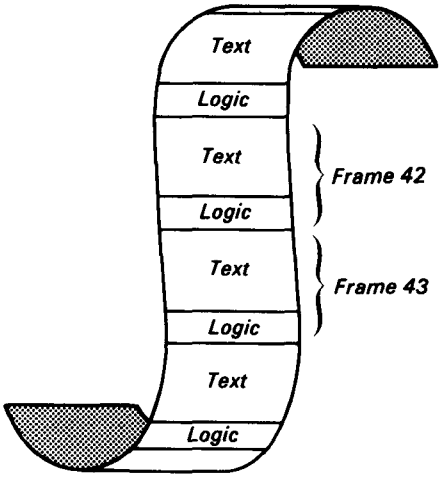

Figure 1. Typical structure of TEXT.DAT file.

The parent report describes a small version of the TEXT.DAT file constructed to show how the program operates. In this example, various options and abilities of the program are exercised to show the reader what is available and how it may be used. A basic system for program execution is illustrated in Figure 2.

The main driver component of the total program is used to respond to the user's request as to what is to be done for a given lease (Figure 3). It determines whether a new or old monitoring design file (MDF) is to be utilized (i.e., is this a continuation of work on an existing mine MDF or is a new file to be built?). It then asks the user which step he is interested in addressing. Text material relative to that step is presented from TEXT.DAT to the user, who selects appropriate items from it and, in so doing, enters material into his MDF. This continues for as long as the user wishes to operate the program.

The main driver assigns device channel numbers and opens the three files which are used by the program (Figure 2). Channels are paths of information flow between the main program and the supporting files. As these numbers are assigned at the beginning of the main program, this capability allows for easy modification, if required, for another computer or configuration on a given computer. File names are also assigned to the three files. For the present case, the names are TEXT.DAT; MDF30.DAT; and MDF30.TEM. These are the stored text files containing all text material that is presented to the user; the monitoring design file being built specifically for the user's mine site; and a temporary file used to insert material into the monitoring design file, respectively.

The program begins with the user being informed what the program is and what it does. He is then asked if this is a new or existing lease. This question refers to whether the mine has been addressed previously by the program. If it has, components of the monitoring design file for this mine already exist in the MDF30.DAT file and will be linked into the system and expanded by the current operation of the program.

If the user states that it is a new mine, the program asks again if that is the case and informs him that all information in any existing monitoring design file for that mine will be destroyed and to input again if it is a new mine. Given that it is indeed a new mine location, the program begins to build a new MDF. (Figure 3).

To identify the mine data set, the lease number of the mine and the name of the mine are requested of the user and stored as the first items in the monitoring design file for that mine. The program then builds the rest of the file by setting up areas in which to load information relative to the several steps in the eight-step methodology. Associated with each step is a frame number in the TEXT.DAT file. This is the beginning frame of the sequence of frames containing text material for possible loading into the MDF.

If an existing monitoring design file is to be expanded, it is first linked into the system. The user is asked if he would like to examine its contents. In the event he does, he may look at all material stored in the MDF for a given step. This may be repeated for as many steps as he wishes. In case the step has not been addressed before, and is empty, the user is so informed. He is also informed if the step was terminated early and does not contain all information that it might. In a similar vein, the user is informed if the step has been totally covered and the material for that step is complete. By examining the material contained in the MDF in this fashion, the user may determine the state of completion of the MDF and where he should begin for a particular session.

From either path, (the initialization of a new MDF or the use of an existing MDF), the user is next presented a menu of steps in the eight-step methodology and asked which step he wishes to address. When the user selects a given step, the program passes operation to one or more of the other program modules.

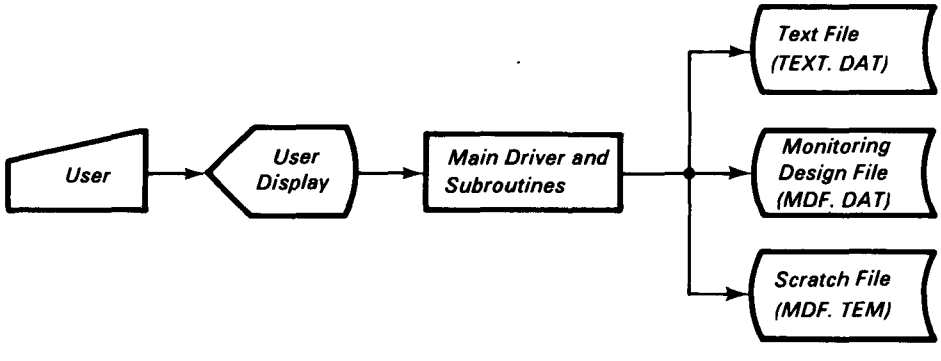

Figure 2. Basic system for program execution.

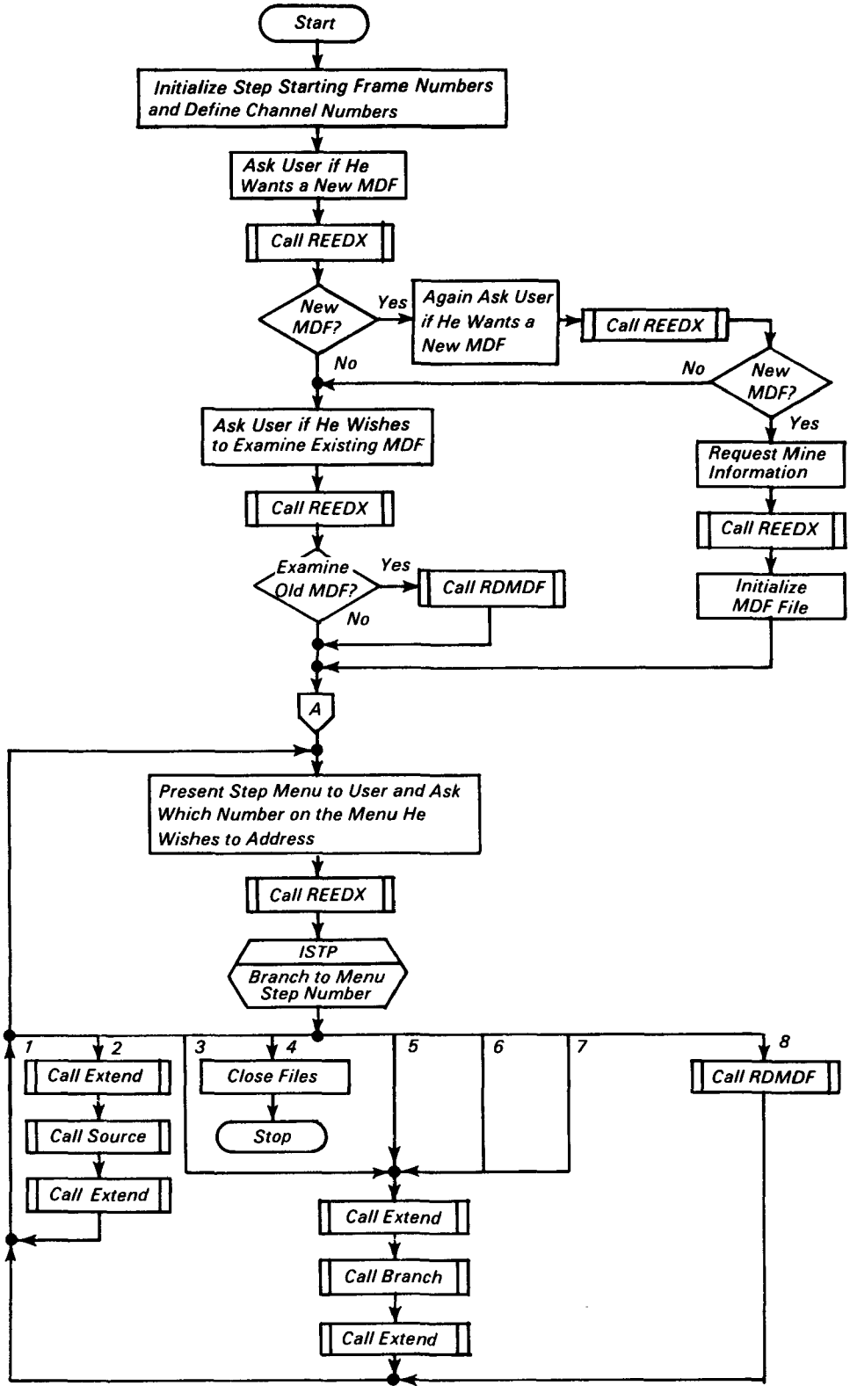

Figure 3. *Flowchart of main driver.*

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The complete report, entitled "A Prototype Computer-Interactive Groundwater Monitoring Methodology: An Example for Sedimentation Ponds," (Order No. PB 83-200 600; Cost: $17.50, subject to change) will be available only from:
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