PNL-SA--19002

DE91 008745

REMEDIAL ACTION ASSESSMENT SYSTEM -- A COMPUTER-BASED METHODOLOGY FOR CONDUCTING FEASIBILITY STUDIES

February 1991

M. K. White
J. L. Buelt
J. A. Stottlemyre

Presented at the
Waste Management '91
February 24-28, 1991
Tucson, Arizona

Work supported by the
U. S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

Remedial Action Assessment System - A Computer-Based Methodology for Conducting Feasibility Studies

Michael K. White
James L. Buelt
James A. Stottlemyre
Pacific Northwest Laboratory[1]
Richland, Washington

ABSTRACT

Because of the great complexity and large number of potential waste sites facing the U.S. Department of Energy (DOE) for potential cleanup, the DOE is supporting the development of a computer-based methodology to streamline the remedial investigation/feasibility study process required for DOE operable units. Consequently, Pacific Northwest Laboratory (PNL) is developing the Remedial Action Assessment System (RAAS), which can be used for screening, linking, and evaluating established technology process options in support of conducting feasibility studies under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). It is also intended to do the same in support of corrective measures studies required by the Resource Conservation and Recovery Act (RCRA).

The RAAS methodology computer interface with the user is being designed to be friendly, intuitive, and interactive. Consequently, the user interface employs menus, windows, help features, and graphical information while RAAS is in operation. Object-oriented programming is used to link unit processes into sets of compatible processes that form appropriate remedial alternatives. Once the remedial alternatives are formed, the RAAS methodology can evaluate them in terms of effectiveness, implementability, and cost. RAAS will access a user-selected risk assessment code to determine the reduction of

---

[1] Operated for the U.S. Department of Energy by Battelle Memorial Institute under Contract DE-AC06-76RLO 1830

risk after remedial action by each recommended alternative. The methodology will also help determine the implementability of the remedial alternatives at a site and access cost estimating tools to provide estimates of capital, operating, and maintenance costs.

This paper presents the characteristics of two RAAS prototypes currently being developed. These include the RAAS Technology Information System, which accesses graphical, tabular and textual information about technologies, and the main RAAS methodology, which screens, links, and evaluates remedial technologies.

INTRODUCTION

The U.S. Department of Energy (DOE) is facing the major task of cleaning up hundreds of waste sites at its facilities across the nation, which will necessitate completing remedial investigations and feasibility studies (RI/FSs) or facility investigations and corrective measures studies for each of these sites . For example, DOE has 330 proposed operable units on the National Priorities List alone. The first 67 of these waste sites are tentatively scheduled for RI/FS completion in the 1992 to 1997 time frame with implementation of remediation technologies to commence subsequently (U.S. Department of Energy 1989 and U.S. Environmental Protection Agency 1989). The RI/FSs for the remaining 263 operable units will be done over the next 10 to 20 years. The initial sources of contamination for these operable units may have been ponds, drain fields, trenches, cribs, leaky tanks, or pipes and these waste sites may contain mixed radioactive and hazardous chemical wastes in groundwater, deep and shallow soils with interstitial (pore) waters, surface waters, sediments, sludges, and buried wastes. The large number of sites and the diversity of contamination types, sources and contaminated media make DOE's RI/FS requirements very complex.

The intent of each RI/FS is to characterize the waste problems and environmental conditions at the operable unit(s), segment the waste remediation problems into manageable media-specific and contaminant-specific pieces, define the remediation objectives, and identify general response actions to meet these objectives (U.S. Environmental Protection Agency 1988). These general response actions typically involve various combinations of: a) no action; b) institutional controls; c) waste stabilization and containment; d) waste recovery and treatment; and e) in situ treatment. The RI/FS team must then identify and evaluate various combinations of technologies and associated processes that might be employed to meet the remediation objectives. Furthermore, it must provide defensible rationale why other combinations of technologies and processes are not as effective, implementable, cost competitive, or acceptable.

Feasibility study analyses are conducted in at least three different stages of the RI/FS process. First, a feasibility study analysis can be conducted, in an exploratory screening mode using "engineering judgement" site information, early in the site characterization process to focus site remedial investigation activities. The feasibility study analysis can be repeated later in the process to help design treatability studies and determine second phase site characterization requirements. Finally, the feasibility study analysis should be again performed at a later date to conduct the detailed evaluation of the remaining alternatives upon which a cleanup strategy can be negotiated with regulators.

To streamline this entire process and make it more defensible, Pacific Northwest Laboratory (PNL) is developing the Remediation Action

Assessment System (RAAS). RAAS is a computer-based methodology that provides a discrete, useful product at each of these stages of the RI/FS process. Figure 1 shows graphically how RAAS contributes to the various stages of the RI/FS process.

CHARACTERISTICS OF THE REMEDIAL ACTION ASSESSMENT SYSTEM

RAAS is currently being developed for the DOE's Office of Technology Development. In terms of directly supporting the technology development program, RAAS 1) provides a vehicle for collecting and sharing detailed information on technologies and regulations, 2) helps implement newly developed technologies as they emerge from demonstration, testing, and evaluation, 3) compares newly developed technologies with more established alternatives, and 4) can be used to support the selection and evaluation process for integrated demonstrations of existing and newly developed technologies.

In supporting the RI/FS process, RAAS is being designed to be a complementary member of an RI/FS team. As such, it provides 1) a comprehensive information source and broad-based expert advisor to the team; 2) a vehicle for documenting (archiving) the computer's and the RI/FS team's assumptions, data selections, and decisions; 3) a mechanism for identifying site and technology data collection requirements early in the RI/FS process; 4) a mechanism for identifying treatability study procedures; 5) a tool for preparing RI/FS technology descriptions and RI/FS tables documenting the rationale for selecting the technologies to be included in the Record of Decision and the reasons why the remaining technologies were excluded from further consideration; and 6) a vehicle for capturing an RI/FS team's experiences and transmitting this information to other teams across DOE.

RAAS will also permit sensitivity (i.e., what if) studies and thus prompt an RI/FS team to consider innovative and potentially less costly solutions. Those experienced in performing RI/FS studies indicate that human experts often subliminally select technology combinations that they know the most about and with which they have grown comfortable. Since the overall costs of the DOE for environmental restoration may be in the range of many tens of billions of dollars, prompting users to consider innovative, less costly technologies (such as those emerging from DOE's demonstration, testing, and evaluation programs) may ultimately prove to be one of RAAS's greatest contributions. RAAS is also expected to reduce RI/FS costs by reducing the time and effort required to do (and redo) RI/FSs. RAAS may also decrease challenges to the results of many feasibility studies, since the computer methodology will allow for a much broader array of potential alternatives to be explored, and will facilitate the documentation of why these alternatives were or were not selected.

RAAS TECHNOLOGY INFORMATION SYSTEM

The RAAS Technology Information System provides the user with graphical, tabular, and textual information about the technologies that are included in the main RAAS methodology. It is a stand-alone, personal computer-based system that identifies and sorts remedial technology information. To date, approximately 100 technologies have been identified for inclusion in the RAAS Technology Information System. These are listed in Table 1. Various process options for each technology will be included. For example, the rotary kiln, controlled air, and fluidized bed incinerators will be described as process options within the incineration technology entry.

Information for a technology is accessed through a computer screen such as that shown in Figure 2. The cursor is simply clicked on the appropriate menu block to access to one of the following types of information:

- a graphical depiction or flow diagram of the process
- a brief narrative description of the process
- engineering parameters such as power and space requirements
- applicability information (contaminant and media types for which the technology is applicable)
- regulatory constraints such as compliance with air, water, and solid waste discharge regulations
- limiting technical constraints such as pH or particulate loading limits on feed materials to a unit process
- identification of technologies that are generally combined with the selected technology (pretreatment processes or processes for treatment of residual waste streams)
- a list of sites where the technology has been considered or implemented in the past
- a list of key technical references.

The technology information has been derived primarily from existing databases (attained via subcontract with private industry), technology reports, and past feasibility studies. The contents of new technology databases are evaluated as they emerge and, to the extent practicable, technology information is adapted for the RAAS Technology Information System.

Development of the user-friendly personal computer program for accessing the technology information is being conducted in parallel with the development of the technology information. The computer system selected was the MacIntosh IIc▮ series personal computer using Supercard▮ software for its user interface and an ORACLE▮ database for storing and sorting technology information. The user interface relies on a mouse with pull-down menus to eliminate the necessity of keyboard entries. The first demonstration prototype model (containing information for 10 technologies) completed in September 1990, has been shown to numerous potential user groups with great acceptance of the tool. The first operational version is expected to be ready for field testing in April 1991.

Aside from providing an early, usable product, the RAAS Technology Information System will be linked with the main RAAS methodology as a user help feature. A user of RAAS will be able to access explanations of technologies or specific information that was used to formulate object modules of technologies considered by the main RAAS methodology. This feature is critical in gaining acceptance of the RAAS methodology by the user community.

MAIN RAAS METHODOLOGY

Another key accomplishment for the RAAS project has been the completion of the demonstration prototype of the main RAAS methodology. This part of the RAAS project is developing the product that selects, screens, links, and evaluates remedial alternatives in support of the feasibility studies required for every DOE operable unit. Some of the methodology's features include

- screening and linking of technology unit processes into remedial alternatives
- comparative evaluation of technologies and remedial alternatives in terms of established EPA criteria
- documentation of assumptions and decisions made by the user, for use in defending the recommended alternative for each waste site
- identification of treatability tests and site characterization requirements for streamlining the remedial investigation portion of the RI/FS process
- upgrade mechanisms for maintaining current technology information

- internal consistency checks to ensure data inputs by the user are consistent with previous data entries and results

- an internal risk assessment model for back calculating cleanup objectives from health-based risk criteria and a data gate for accessing user-selected technology risk assessment models.

The main RAAS methodology is based on object-oriented programming. For each technology unit process, an "object" module is developed for RAAS to describe the controlling characteristics, including the inputs, outputs, and the processing rules and constraints. For example, final concentrations of a contaminant exiting an ion exchange treatment process might be related to the input concentration specified by a pretreatment air-stripping process through direct internal communication among technology objects within the software. Each technology object module will have its input and output specifications and its own set of internal operating or process rules and local data.

The object-oriented computer programming will allow the RAAS user to identify the "most likely" remedial action treatment trains for a site. In the object-oriented approach, a unit process or technology is represented by an object, and the objects can send messages and ask questions of each other or request more information (Thomas 1989). For example, a particular treatment object may "know" that it is good at handling non-volatile organic contaminants as long as the waste stream it receives does not also contain excess quantities of heavy metals and radionuclides. If such waste constituents are present, the technology object module may send out a request message to all other waste separation and/or treatment objects asking if any of them can remove the heavy metals and/or organics prior to the waste stream being delivered to the organic treatment process. This concept is illustrated in Figure 3. Since all other unit processes (objects) presumably contain local information and rules about what they can and cannot do, return messages will only be received from viable candidate processes. In this manner, groups of technologies will be linked to form complete treatment trains.

It is important to understand that the human user can and should interact frequently with this process by sending his or her own messages and asking questions of the system. Inversely, the computer program must be able to solicit additional or clarifying information from the user and expect the user to make certain decisions along the way. A RAAS methodology user is an integral, interactive part of the analysis methodology. The object-oriented computational approach facilitates this function and minimizes the number of "hard-coded" connections that are built into the computer model.

CONCLUSIONS

Development of the two RAAS prototypes has been successful in accomplishing three goals during the project's first year of development. The prototypes have:

- provided a tool for users to comment on the functionalities and user interface features for development of the first operable version of RAAS.
- provided a vehicle for gaining acceptance of the RAAS methodology from the regulatory and technical community.
- demonstrated to the development team that object-oriented programming can be used to determine whether technologies are applicable for specific waste site conditions and to effectively construct remediation trains.

REFERENCES

Thomas, D. 1989. "What Is an Object?" Byte March 1989.

U.S. Department of Energy. 1989. Hanford Federal Facility Agreement and Consent Order. U.S. Department of Energy, Richland, Washington.

U.S. Environmental Protection Agency. 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. EPA/540/G-89/004, Washington, D.C.

U.S. Environmental Protection Agency. 1989. Rocky Flats Federal Facility Agreement and Consent Order, CERCLA/RCRA. U.S. Environmental Protection Agency, Region 8, Denver, Colorado.

CAPTIONS

Figure 1. RAAS Contributions to the Remedial Investigation/Feasibility Study Process

Figure 2. Screen for Accessing Technology Information in the RAAS Technology Information System

Figure 3. Object-Oriented Programming Allows Technology Objects to Communicate with Each Other to Form Remedial Alternatives (treatment trains)

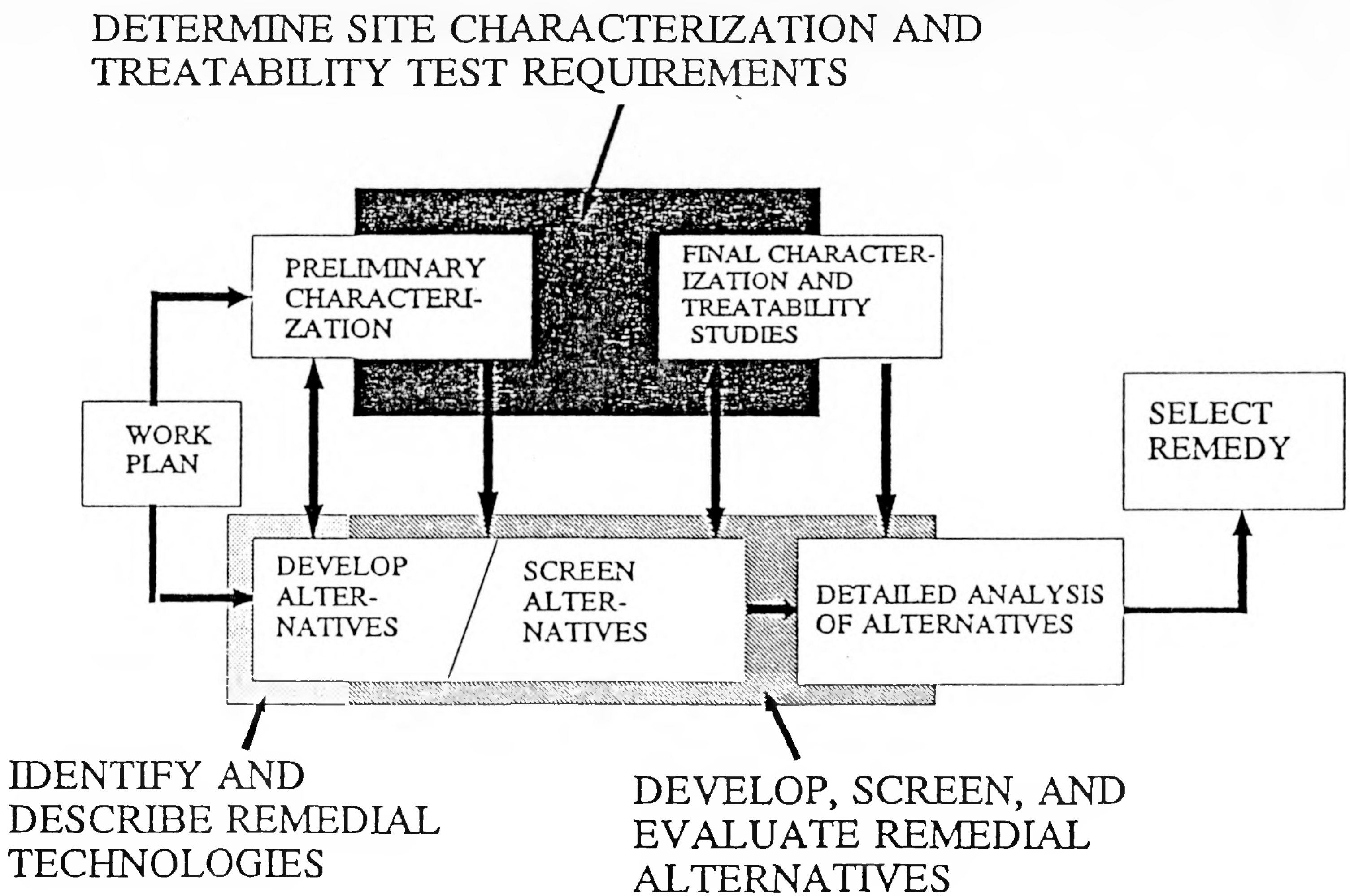

FIGURE 1. RAAS Contributions to the Remedial Investigation/Feasibility Study Process

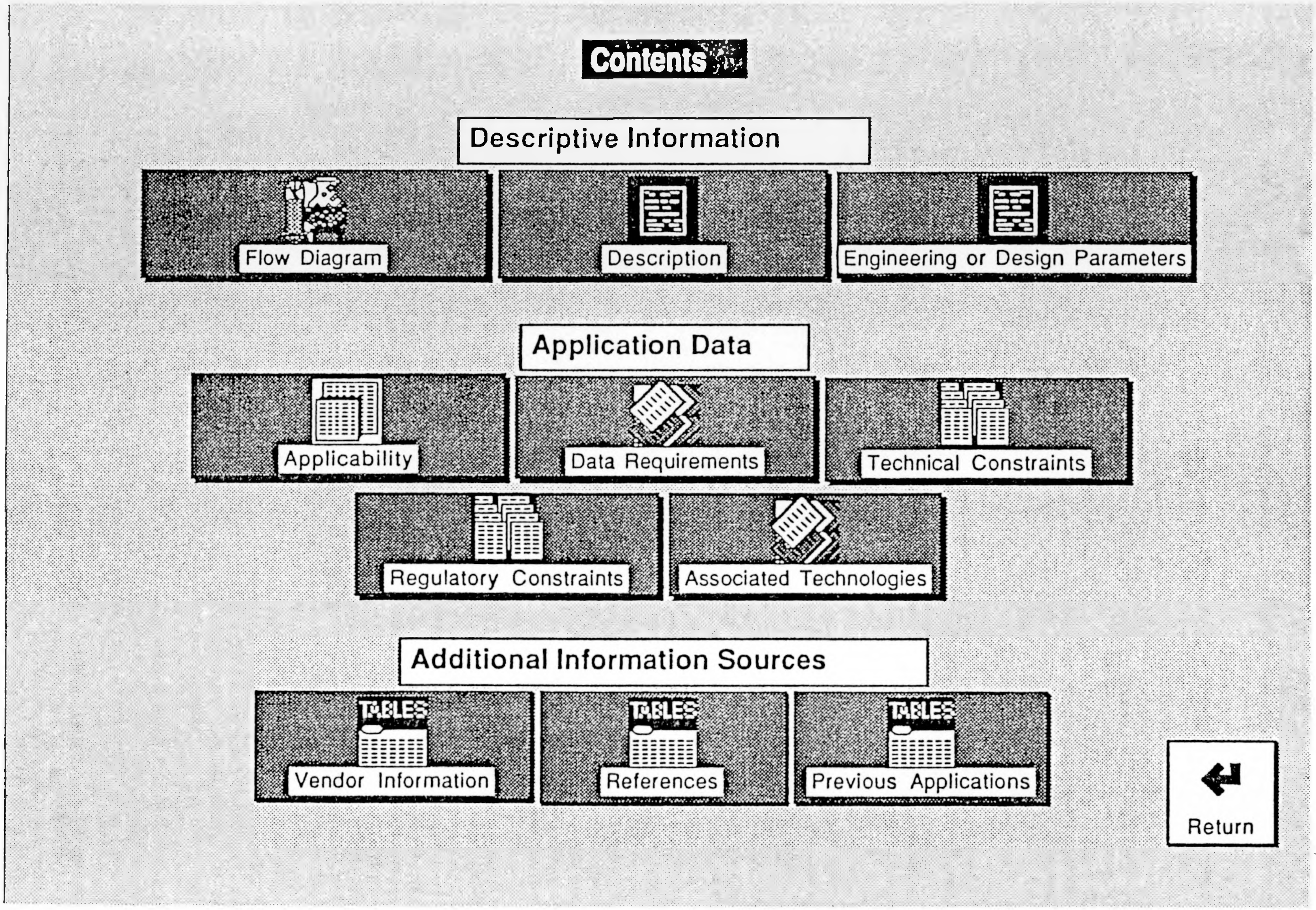

FIGURE 2. Screen for Assessing Technology Information in the RAAS Technology Information System

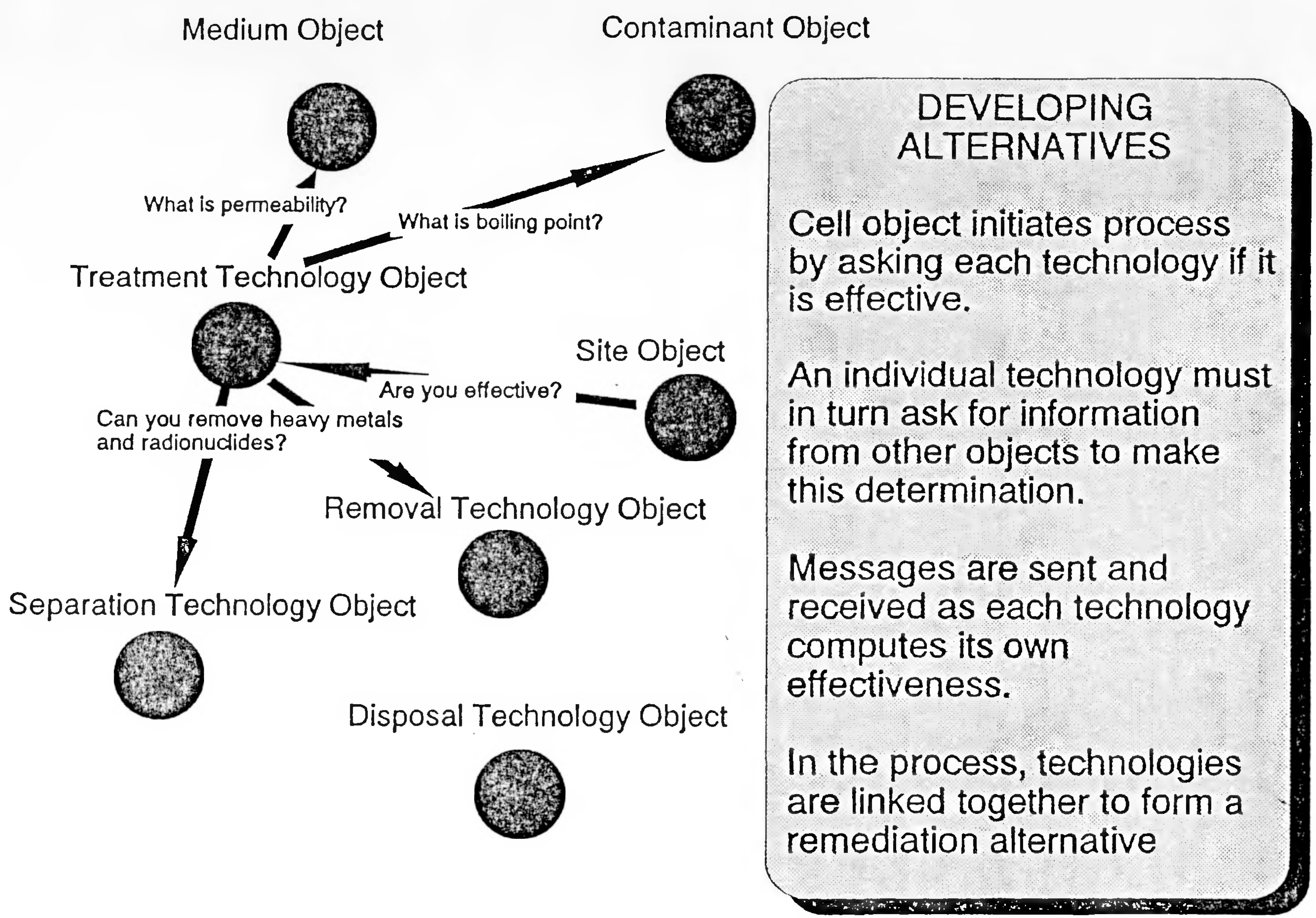

FIGURE 3. Object-Oriented Programming Allows Technology Objects to Communicate with Each Other to Form Remedial Alternatives (treatment trains)

Table 1. Technologies Planned for Inclusion in the RAAS Technology Information System

INSTITUTIONAL ACTIONS

access controls
flora/fauna monitoring
groundwater monitoring
land use restrictions
new water supply
relocate water intake
soil gas monitoring
surface water monitoring
water use restrictions

CONTAINMENT

capping
extraction/injection wells
ground freezing
membranes or tarps
prefabricated liners or barriers
run-off diversion systems
site-constructed barriers
subsurface drains
surface sealants or stabilizers
surface grading
surface water collection
surface revegetation
wind barriers

RECOVERY OR REMOVAL

dredging
excavation
extraction wells
springwater collection
subsurface drains
vacuuming (surface soil)

VOLUME REDUCTION

air stripping
beneficiation
bioaccumulation

VOLUME REDUCTION (cont)

coagulation/flocculation
crystallization
dewatering
dissolution or leaching
electrokinetic separation
freeze crystallization
gas adsorption
gas particulate filtration
ion exchange
liquid phase particulate filtration
liquid absorption
membrane separation
oil/water separation
precipitation
soil gas extraction
soil flushing
soil heating
soil washing
solvent extraction
steam stripping
thermal stripping
vegetative uptake

TOXICITY REDUCTION

acid digestion
catalytic destruction
chlorinolysis
dehalogenation
ex situ biochemical degradation
ex situ hydrolysis
ex situ oxidation
ex situ reduction
ex situ neutralization
gas phase plasma destruction
in situ biodegradation
in situ vitrification
in situ chemical reduction/oxidation

TOXICITY REDUCTION (cont)

in situ hydrolysis
in situ neutralization
incineration
molten solid encapsulation
photolysis
precipitation
roasting/calcining

MOBILITY REDUCTION

chemical precipitation (in situ)
in situ vitrification
in situ stabilization
macroencapsulation
microencapsulation
molten solid encapsulation
polymerization

DISPOSAL

discharge to surface
discharge to POTW
gas venting
geologic repository
injection wells
low level waste burial
mixed waste landfill
on site infiltration
open air evaporation
RCRA landfill
recycle
TRU disposal