

Development of A Prioritization Tool for Multimedia Enforcement

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ABSTRACT

This paper describes a decision support system developed for the Environmental Protection Agency that assists their staff in the prioritization of resources for the enforcement of multi-media dischargers. The paper describes the development of the system, its major components, and its use.

INTRODUCTION

Since its creation, the Environmental Protection Agency (EPA) has been responsible for identifying industrial and municipal dischargers and limiting the deleterious effects of their discharges to the environment. This process involves the development of discharge permits, the monitoring of dischargers to ensure that the permits are being met, and the use of enforcement actions if the permits are violated. These actions have been conducted by specific programs in EPA that reflect congressional mandates, such as the Clean Water Act, the Clean Air Act, and Resource Conservation and Recovery Act (RCRA). Recently, however, EPA has become interested in developing a more comprehensive perspective of the total impacts to all media from a discharger. The phrase "multimedia dischargers" has been coined to describe those facilities whose discharge impact more than one media.

Several Regional EPA offices are currently sponsoring multimedia enforcement pilot projects to examine the potential of multimedia enforcement as a comprehensive and effective approach to achieve compliance of point source dischargers. This task has proven difficult because EPA uses independent tracking and compliance procedures for each media. For example, each program has its own permitting system, inspection schedules, compliance databases, and enforcement strategies. Currently, a facility discharging to more than one media, such as both water and air, is separately regulated by all applicable EPA programs. EPA wishes to identify those facilities which are violating permits in more than one media and target enforcement resources efficiently to minimize risk to human health and the environment. The development of a decision support system (DSS) to guide management through the enforcement prioritization process was identified as one means of approaching this goal.

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APPROACH

DSS are defined here as any computerized procedure with the purpose of providing information, decision structure, or requirements tracing ability that can improve or enhance a decision making process (Holsapple et al, 1987). Our DSS was developed in two distinct phases. First, a series of interviews were conducted to identify and characterize the major requirements for the decision support system. Then available computer technology was reviewed and appropriate tools were selected for the prototype. The initial interviews conducted with EPA Region X enforcement and management staff were designed to: 1) Obtain background information on the permitting, compliance, and enforcement procedures used at Region X in each of the three media programs water, air, and hazardous waste, 2) Determine what data is generated through these procedures and how this data is stored, accessed, and used in these processes, and 3) Identify tools that would be needed to facilitate a multimedia enforcement approach.

EPA compliance staff representing each of the media programs (water, air, and hazardous waste) were interviewed. Staff in areas such as the DOCKET database, the TRI database, and GIS, as well as people currently involved in multimedia inspections and database integration were also interviewed.

PROGRAM NEEDS

These interviews generated a number of requirements for the multimedia enforcement process. It was determined that a framework for prioritization should be established to make the ranking process reproducible. This framework, when supplied in the form of a DSS, should ideally be interactive, helpful and user-friendly. Thus, the DSS should allow the user to make selections and enter data as needed. In addition, supplemental information including requirements for user input, relevant information on enforcement, and system procedures and logic, should be presented in an easy to understand format. Furthermore, the system should be relatively versatile, allowing the user to select alternate management schemes and to analyze their impacts on the ranking of multimedia dischargers.

DSS COMPONENTS

Based upon the variety of concerns that were identified in the interview process and the needs outlined above, three management and computer technologies were selected for the prototype DSS: an expert system (Maher, 1987), a database management system (Clark, 1980), and a multiobjective ranking tool to rank facilities (Holden and Palmer, 1990). The contribution of each component to the prioritization process is discussed in detail below.

A significant problem faced by EPA is the rate at which employees either move within the agency or leave the agency and the void of experience this causes. Several individuals reported that there is little time to train new personnel. Furthermore, no mentoring system exists to provide them with a clear understanding of their job and how their jobs relate to other programs within EPA. It is anticipated that the expert system component of the DSS will decrease the difficulties encountered by new staff, by providing a training tool that conveys the goals and the methodology of the multimedia enforcement approach. An expert system can also provide an interactive, user friendly environment for the decision-maker.

The interviews indicated that a considerable amount of effort and resources are devoted to the development and maintenance of databases. However, it appears that the needs of the staff are not being met completely and that many people do not take full advantage of the database

resources that do exist. The reasons most commonly given were the lack of access to the databases, the fact that they are often found to be incomplete or not current, and that they did not contain information required to achieve specific enforcement objectives. In any successful multimedia approach, the supporting database must provide information across media and programs in such a way as to facilitate a broad perspective of the problem. This constraint requires the development of a multimedia specific database that draws from existing EPA databases but which is composed only of data that is directly related to multimedia problems.

The problem of multimedia enforcement is inherently a multiobjective problem. One must evaluate the allocation of enforcement resources among a number of dischargers based upon specified criteria. These criteria are likely not to be of equal importance, that is some criteria will naturally be more important than others. This does not imply that only the most important criteria should be considered, but rather an approach that can weight each criteria relative to its importance must be created. Any tool developed should guide EPA staff in defining appropriate criteria for specific media and provide a multiobjective analysis approach to examine the impacts of alternative weighting schemes on the ranking of facilities for enforcement.

Evaluation Criteria

In any multimedia enforcement program, the number of impacts are large and the criteria by which these impacts are measured can be very different. In multimedia problems, it is likely that EPA will be concerned with both human health and ecological impacts. A careful and accurate listing of relevant criteria is necessary as the point of departure for developing prioritization of the criteria. Such a prioritization must be based upon site specific conditions as well as state and national considerations.

Weighting Schemes

The multiobjective nature of this problem is exhibited in a number of ways. EPA's primary interest is in establishing rankings of facilities due to the impacts of their discharges to all media (Halfon, 1989). However, it is likely that the importance of the media will vary among individuals for different situations. In addition, although a number of criteria can be used to characterize both the impacts of a discharge on a media and the compliance history of a facility, the importance of these criteria are not always of equal value in ranking the facilities. Thus, schemes that allow the user to conveniently and descriptively demonstrate the relative importance of media, criteria, and compliance and to integrate these into an acceptable ranking of facilities are needed.

PROTOTYPE DEVELOPMENT

In response to the needs identified above, a customized prototype DSS was developed using LEVEL5 Object, an expert system shell. The development of this DSS was an iterative process. The system was repeatedly modified to provide a tool for demonstration that would be useful and realistic. Additional EPA staff interviews were conducted to identify evaluation criteria for each media, pertinent database parameters to assist with evaluation, and general guidelines for the evaluation process. As these components of the system were developed, opportunity was given for Region X staff review and their comments were incorporated whenever possible into the system.

USE OF THE PROTOTYPE DSS

The first phase of the evaluation process is the scoring of each discharger on the basis of established evaluation criteria for each media. The criteria that are used in the prototype DSS

were chosen based on the input gathered from EPA Region X compliance officers in each division. The criteria chosen are not necessarily unique for each media, but in each case reflect those considerations that were consistently viewed as most important for evaluation purposes. An example of such criteria for the three primary medias are: Water; Magnitude of Violation, Compliance History, Human Health Impacts, and Ecological Impacts; Air; Source Type, Violation Severity, Human Health Impacts, and Ecological Impacts; RCRA; Type of Facility, Violation Severity, Impact on Groundwater, Impact on Drinking Water, Human Health Impacts, and Ecological Impacts.

The user is asked to enter a score between 1 (best) and 9 (worst) to reflect each discharger's performance with respect to the selected criteria. The output of this process is a decision matrix summarizing all of the input scores. The user is given the option of viewing this completed decision matrix and making any modifications needed before selecting a ranking method.

As a starting point for evaluation, the user may request that the system calculate default scores for each discharger based on the information currently in the database. These default scores are calculated by a series of IF THEN rules which are incorporated into the LEVEL5 knowledge base. These rules were developed to emulate the evaluation process as described by EPA compliance staff. These default schemes are intended to provide an example or initial point, particularly for the novice user. All of these scores can be replaced as warranted by the best professional judgement of the user and their interpretation of database and/or other supplemental information.

During the scoring process, the user can obtain simultaneous summaries of compliance information for each discharger which are formulated through an interface with a customized multimedia database. The information included in this database for each discharger is reflective of the types of information that can be accessed with existing EPA databases; however, only the information identified as most important is presented to the user. The types of information provided relate specifically to the criteria for each media, and are dependent on the type of multi media discharger being evaluated. If more information is desired, the user has the option of leaving the knowledge base to interact directly with the database, which contains more comprehensive information. Help files also provide suggestions for potential in-house sources of information.

Once the evaluation matrix has been completed, the user has the option of selecting from three basic ranking approaches which may be run with or without weighting factors: total score, rank order score, and threshold ranking. A choice of methods is provided to enhance the types of information provided to the decision-maker. For example, a non-weighted, total score may be appropriate when the relative importance of criteria is equal and the value given to media are equal. A weighted scheme is more appropriate when the relative importance of criteria is different. A rank order score is appropriate when ranking, rather than the average value of a discharge is of importance.

When a weighted ranking method is selected, the user is prompted to enter the relative weighting factors for each media as well as for the criteria within each media. The weighting factors are then incorporated into the formulation of a final ranking score for each multimedia discharger.

Once a particular ranking method is selected, the system determines an overall ranking score for each multimedia discharger by first calculating a normalized score for each media according to the selected ranking method and then multiplying this score by the weighting factor associated with each media. The sum of the weighted media scores is the final ranking score. The dischargers are then ordinally ranked on the basis of this final ranking score. The final output of the session is the ranking of the multimedia dischargers accompanied by their associated ranking scores. Inclusion of the ranking scores allows the decision maker to group the multimedia dischargers according to high, medium, and low resource priorities.

At this point in the session, the user is given several options. The ranking method may be changed while keeping all scores and weighting factors fixed, or alternatively the impact of different weighting schemes on a single ranking method can be examined. Such options allow the user to analyze the sensitivity of the final ranking to changes in management priorities reflected by the weighting factors or ranking schemes.

CONCLUSIONS

This prototype DSS was developed to facilitate a multimedia prioritization approach for enforcement. This system provides a framework for multiobjective analysis which produces a consistent and reproducible methodology for the ranking process. The prototype also has potential for use as a training tool for new personnel. Currently, the system is being applied to a case study area within EPA Region X. Areas for improvement include expansion of the existing rule base to provide more comprehensive scoring heuristics, and increasing the flexibility of the system by allowing the user to add or select specific evaluation criteria or to modify the list of multimedia dischargers considered for evaluation.

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