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An Innovative Approach to Multimedia Waste Reduction: Measuring Performance for Environmental Cleanup Projects

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Oak Ridge National Laboratory
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Paducah Gaseous Diffusion Plant
Portsmouth Gaseous Diffusion Plant
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EXECUTIVE SUMMARY

One of the greatest challenges we now face in environmental cleanup is measuring the progress of minimizing multimedia transfer releases and achieving waste reduction. Briefly, multimedia transfer refers to the air, land, and water where pollution is not controlled, concentrated, and moved from one medium to another. An example of multimedia transfer would be heavy metals in wastewater sludges moved from water to land disposal. Over $2 billion has been budgeted for environmental restoration site cleanups by the Department of Energy (DOE) for FY 1994. Unless we reduce the huge waste volumes projected to be generated in the near future, then we will devote more and more resources to the management and disposal of these wastes.

To minimize multimedia transfers and reduce waste for significant amounts of contaminated soil, sediments, and groundwater, two things have to happen.

1. We need to develop a better understanding of how to collect good trend data from various phase projects that reduce waste and releases.

2. We need to evaluate how accurate the trend data are by some quantitative measurement of each generator's ability to prevent or minimize waste, thus establishing performance measures.

Reliable data that exhibit where and how much waste is reduced would aid the pollution prevention cause. It would provide trend data to show generators, managers, and regulators where pollution prevention is needed most. It would show where to focus our efforts, taking into consideration factors such as potential exposure and public concerns. It would identify successful pollution prevention projects that would be prioritized for technology transfer. The data would establish the basis for performance measures for individual generators and programs.

Unfortunately, there are several constraints on the collection of good data for environmental cleanup programs, which, when combined with the Environmental Protection Agency enforcement of multimedia-specific requirements via the integrated permit, waste reduction becomes a monumental task. An integrated permit coordinates various media-specific requirements for releases to air, water, and land to minimize cross-medial transfers of pollutants. Such a permit would be based on an assessment of all releases from that plant. It becomes apparent that environmental cleanup activities have a high potential for varied releases from all media, placing even more emphasis on collecting good trend data.

To meet this challenge, the Martin Marietta Energy Systems, Inc., Oak Ridge Environmental Restoration (ER) Program has explored the value of a multimedia approach by designing an innovative Pollution Prevention Life-Cycle Model. The model consists of several fundamental elements (Fig. 1) and addresses the two major objectives of data gathering and establishing performance measures. Because the majority of projects are in the remedial investigation phase, the focus is on the prevention of unnecessary generation of investigation-derived waste and multimedia transfers at the source. A state-of-the-art tool developed to support the life-cycle model for meeting these objectives is the Numerical Scoring System (NSS), which is a computerized, user-friendly data base system for information management, designed to measure the effectiveness of pollution prevention activities in each phase of the ER Program.

This report contains a discussion of the development of the Pollution Prevention Life-Cycle Model and the role the NSS will play in the pollution prevention programs in the remedial investigation phase of the ER Program at facilities managed by Energy Systems for DOE.

1. INTRODUCTION

The Martin Marietta Energy Systems, Inc., Oak Ridge Environmental Restoration (ER) Program, involving federal facilities in Oak Ridge, Tennessee, Paducah, Kentucky, and Piketon, Ohio, is conducting remedial action and decontamination and decommissioning (D&D) activities. Among the ER Program activities that will generate wastes are site characterization studies; contaminated soil, sediment, and structural removal; groundwater remediation; and treatability studies. In general, the magnitude of expected ER Program waste-generation activities is enormous, with over 1.1 billion ft^3 of waste estimated over the life of the ER Program. Both the solid and liquid waste totals represent waste management activities equivalent to or greater than the existing operating plants' waste management programs. The most significant contributing factors to this large volume of waste are the assumed use of groundwater collection and treatment options and the expected demand for excavation of contaminated soils and sediments from a number of large area sites/projects. Therefore, the benefits that can be derived from implementation of an effective pollution prevention program early in the process are obvious.

In response to the regulatory issues and economic considerations, ER management is committed to enforcing pollution prevention policies in Energy Systems programs for the decontamination of former waste sites, management of wastes generated, and minimization of risks to human health and the environment. The ER Program established a formal pollution prevention program in March 1991. The program's mission is to implement and integrate pollution prevention into RA and D&D site program activities. Success of the mission will result in the reduction of the volume and/or hazard level of the waste generated.

2. POLLUTION PREVENTION PERFORMANCE MEASUREMENT

Clearly, to understand and appreciate innovation in performance measurement for multimedia waste reduction during site cleanups, we need to determine what, if any, pollution prevention techniques were used throughout the Department of Energy (DOE) and in private industry.

The ER Program performed a literature search to determine what performance measurement techniques for pollution prevention are being used in the United States and what their potential application might be to ER activities at Oak Ridge. Sites from the DOE complex, along with private vendors, were contacted and solicited for information about their pollution prevention measurement techniques. Various other sources were also contacted for any information they may have on this subject.

It was determined that there are, on average, three common methods to measure pollution prevention: comparison of volume produced to a baseline established or previous volume produced; comparison of the weight of the waste to an established baseline or previous weight measured; and measurement of the cost benefit that pollution prevention has produced. Both in the literature search performed and in the numerous telephone interviews conducted, it was found that well-established performance measures for pollution prevention in ER activities are very hard to find. Major obstacles to developing ER Program performance measures for pollution prevention include variability and uncertainty in waste generation data, numerous and varying waste streams, and a lack of life-cycle cost data. Because these three common performance measurements have significant variance and uncertainty in RA and D&D activities, it was recommended that the ER Program establish a performance measure that is not solely dependant upon volume, weight, or cost.

The Pollution Prevention Performance Measure Project was undertaken to examine pollution prevention programs across the United States and determine if an accurate and feasible method for measuring pollution prevention existed which would be applicable to the ER Program at Oak Ridge. The scope of this project included sites in the DOE complex and conventional hazardous waste generators in the private sector.

To become more familiar with the subject of pollution prevention, materials from the Oak Ridge National Laboratory (ORNL) library were accumulated and reviewed. A list of waste minimization contacts for the DOE complex was obtained from the Hazardous Waste Remedial Actions Program (HAZWRAP), and a list of private vendors was acquired from the Environmental Protection Agency (EPA). After these materials were analyzed, a comprehensive effort was undertaken to contact as many people as possible within the 6-week time frame.

In preparation for this project, much material was gathered that contained listings of various contacts both in the DOE complex and the private sector. Table 1 presents in a matrical listing of the sites contacted and the information acquired.

Table 1. Sites contacted

DOE sites and private vendors	Measure by volume	Measure by weight	Other method of measure
	Albuquerque Field Office		
Kansas City plant	Yes	No	No
Pantex plant	Yes	Yes	No
Sandia National laboratory Livermore	Yes	Yes	No
	Chicago Field Office		
Battelle Columbus laboratories	Yes	No	No
Combined laboratories	[a]	[a]	[a]
	Fernald Site Office		
Feed Materials Production Center	Yes	No	No
	Idaho Field Office		
Grand Junction Project Office	Yes	No	No
Idaho National Engineering Laboratory	Yes	Yes	No
West Valley Demonstration Project Office	Yes	Yes	No
	Nevada Field Office		
Nevada Test Site	Yes	Yes	Yes. Sometimes a cost benefit is used.
	Oak Ridge Field Office		
Oak Ridge K-25 Site	Yes	Yes	Yes. Sometimes a cost benefit and a cost avoidance are used.
Oak Ridge National Laboratory	Yes	Yes	Yes. Sometimes a cost benefit and a cost avoidance are used.
Oak Ridge Y-12 Plant	Yes	Yes	No
	Richland Field Office		
Hanford Site Office	Yes	Yes	Yes. Sometimes a cost benefit and a cost avoidance are used.

Table 1. (continued)

DOE sites and private vendors	Measure by volume	Measure by weight	Other method of measure
		Rocky Flats Field Office	
Rocky Flats Site Office	Yes	No	No
		San Francisco Field Office	
Stanford Linear Accelerator Center	No	Yes	No
		Savannah River Field Office	
Savannah River Site Office	Yes	Yes	Yes. Sometimes a cost benefit and a cost avoidance are used.
		Private Vendors	
International Remediation Corporation	[a]	[a]	[a]
Groundwater Technology, Inc.	[a]	[a]	[a]
Geo-Microbial Technologies, Inc.	Yes	Yes	Yes. Sometimes a cost-benefit analysis is used.
3-M Corporation	Yes	No	No
Remediation Technologies	[a]	[a]	[a]
Biogee International, Inc.	No	No	Yes. Levels of contamination before and after treatment.
Ensite, Inc.	[a]	[a]	[a]
CTC	Yes	No	No
Bryson Industrial Services	[a]	[a]	[a]
OHM Corporation	Yes	No	Yes. Sometimes a cost-benefit analysis is used.
Riedel Environmental Technologies	[a]	[a]	[a]
Dix and Associated Hazardous Materials Corporation	[a]	[a]	[a]
Delta Environmental	[a]	[a]	[a]
Praxair	No	No	Yes. Calculations regarding evaporated waste are used.
Horsehead Resource and Development Co., Inc.	No	No	No

Some of the problems associated with measuring pollution prevention are listed and discussed. This list is by no means comprehensive, but it gives a good picture of the general problems being faced.

- Many environmental cleanup programs are in the start-up or infancy stages.
- Published sources of information on source reduction and recycling technologies for remediation programs are limited. Source reduction is hard to quantify; when you stop generating waste, there is no waste to measure.
- Quantifying pollution prevention is simpler for facility manufacturing of a product than for decontamination of a manufacturing facility with a history of several waste streams. No historical production rate data can be applied.
- There are multiple sites, multiple programs, and many players. Project schedules and targets are uncertain, making it difficult to project a waste baseline.
- Published guidance from DOE (i.e., goal setting, waste assessments) was not designed for remediation implementation.
- A recent literature search yielded a lack of available information on ER performance measures.
- Application of common performance measures to ER activities will not accurately monitor ER's pollution prevention performance.

The Oak Ridge ER Program is designing an innovative Pollution Prevention Life-Cycle Model for measuring the effectiveness of management and implementation of site-wide pollution prevention programs. The model consists of several fundamental elements (Fig. 1) and addresses two major objectives. The first objective is to develop pollution prevention/waste minimization techniques that focus on investigative-derived wastes (IDW) from remedial investigation (RI) activities. To meet this objective, data are collected to determine what deficiencies exist in the pollution prevention/waste minimization program, and guidelines are introduced in the form of a checklist for the generators so that the concept of pollution prevention will originate during the planning stages of the RI. The second objective is to then evaluate the success of implementing pollution prevention techniques early in the RI phase by some quantitative measurement of each generator's ability to prevent and/or minimize IDW. Comparisons can then be made between the various ER Program sites and incentive awards given to those with the highest scores during self assessment. A state-of-the-art tool developed for meeting these objectives is the NSS, which is a computerized, user-friendly data base system for information management, designed to measure the effectiveness of pollution prevention activities in each phase of the ER Program. The NSS will enable waste generators to establish performance measures and set numerical goals for pollution prevention and will provide the waste generator/manager a guide for implementation of pollution prevention techniques for all projects. The NSS is a checklist approach to the development and integration of all the elements in the Pollution Prevention Life-Cycle Model. When incorporated into the planning stage of a project, the NSS will become a powerful tool in the prevention of unnecessary IDW at the generation source and will minimize multimedia transfers.

3. APPROACH

The ER pollution prevention program assessed the existing planning techniques and practices. The major weakness found was the flowdown of pollution prevention planning/ practices into individual projects and tasks. to overcome the weaknesses and obstacles previously cited, an innovative approach is needed in implementing pollution prevention in all ER projects for all media. Those needs are as follows:

- Development of a life-cycle model to aid in understanding how data are collected from various ER project phases;
- Brainstorming to conduct process waste assessments (PWAs) and establish quantitative performance measures;
- Utilization of life-cycle costs developed from ER treatment, storage, and disposal modeling efforts to provide foundation for cost-benefit analysis; and
- Use of computerized tools for generators to provide consistency in documentation of pollution prevention and planning strategies.

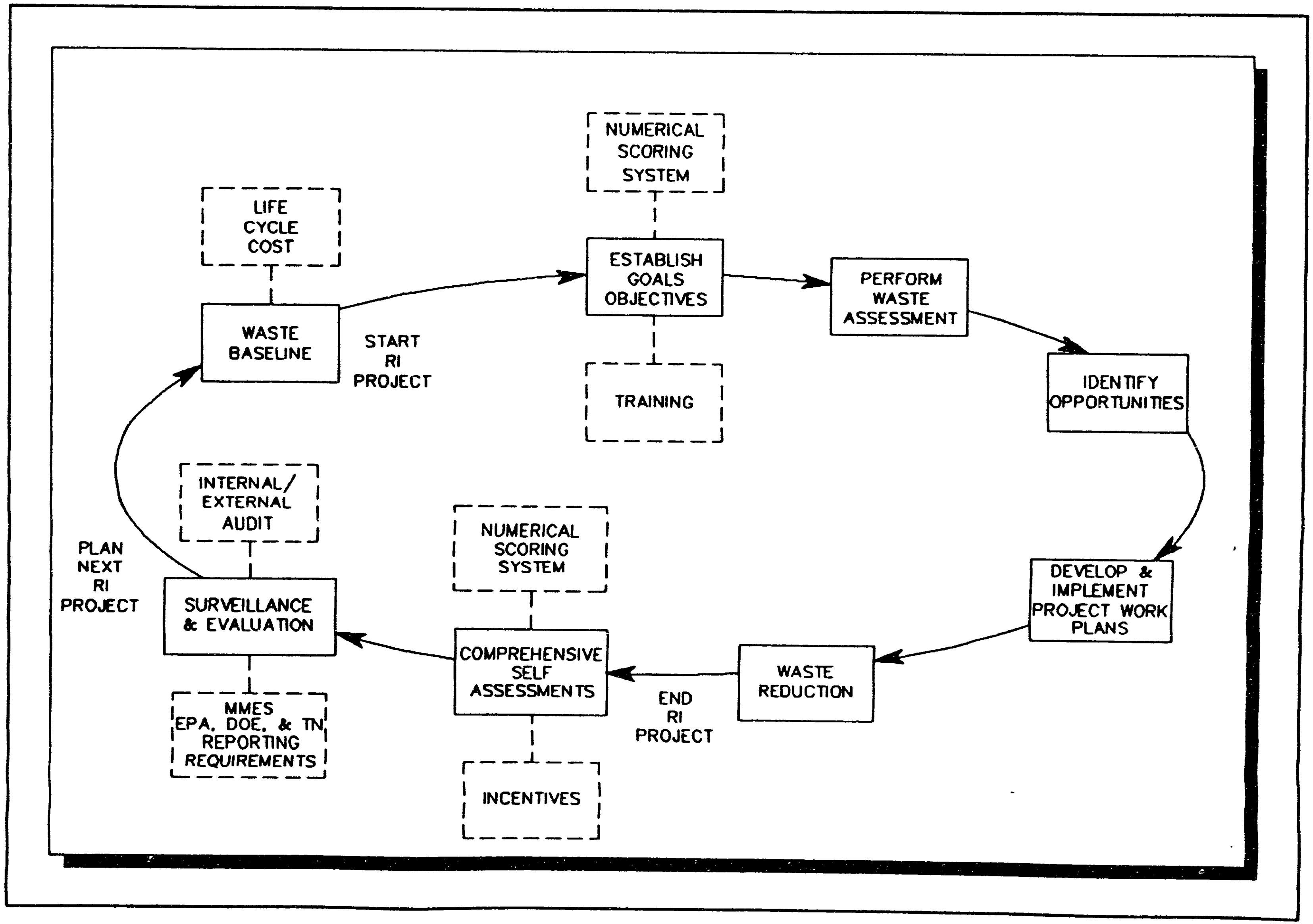

Fig. 1. Pollution prevention life-cycle model.

4. POLLUTION PREVENTION LIFE-CYCLE MODEL

The pollution prevention program is a cyclic process with the objective of continuing to improve on previous results. The initial stage in the pollution prevention program requires assurances that pollution prevention plans are in place and that the development of a waste stream baseline has been initiated. The waste stream baseline, usually supported by a computer data base, involves determinations of types of waste, volumes, toxicity, and other information for the various waste streams that will be generated. In the early stages of the model, a life-cycle approach has been integrated into the planning stages. Life-cycle costs are all costs associated with managing, treating, and disposing of any wastes or contaminants. These life-cycle costs are housed in a computer data base. By using the NSS, waste generators can easily see what pollution prevention techniques to use and what goals and objectives should be established. Opportunities identified during the waste assessment are then documented in the RI work plan. This is a very important step in the life cycle, because it is the only way to ensure that subcontractors performing RI work implement waste reduction techniques. The NSS is then used again to establish opportunities to minimize waste generation. Examples of opportunities for waste minimization during the typical RI include

- obtaining information through noninvasive techniques,
- reducing the number and size of bore holes,
- recycling decontamination water,
- reusing personal protective equipment (PPE),
- optimizing monitor-well locations, and
- implementing groundwater sampling procedures that minimize the volume of purge water.

The strengths and weaknesses of a pollution program are identified during the waste assessment stage. Strengths can include a well-conceived pollution prevention plan and a strong management commitment to minimize waste production, thereby reducing the volume of waste generated during site investigations. Weaknesses may include insufficient attention to planning and failure to effectively implement the pollution prevention techniques in the field. The RI work plan is compared to a generator checklist to make sure D&D pollution prevention techniques are listed. The work plan is then implemented in the field by the subcontractor. After the RI project has been completed, the self-assessment program will determine whether the reduction techniques employed are sufficient to meet the program goals by confirming actual versus planned estimates of production. These estimates can be further verified by program audits, and the information can be used to update the waste stream baseline. This life cycle of self-assessment and baseline updating is shown in Fig. 1 for those generators with the highest scores. A formal, documented assessment program to monitor the pollution prevention activities is considered an essential element of a successful pollution prevention program.

The assessment system developed to support waste minimization for the ER Program is the NSS. The NSS can be effectively used to establish goals and objectives and also to monitor and rank pollution prevention activities.

5. NUMERICAL SCORING SYSTEM

The NSS is a computerized user-friendly information management system consisting of two tiers. The first tier is the data base portion of the system, which is designed to maintain baseline data for the pollution prevention program. The data is collected from input from waste generators. The data base contains the facility-specific information and lists the waste-generating activities. The facility-specific information includes hazard characterization, regulatory status, volume, and project management costs for the various wastes at the subject facility. The waste-generating activities information includes the type and volume of wastes from these activities, the distribution of these wastes by regulatory status, and total costs.

The second tier includes the system of algorithms for computing the individual indexes and the composite indexes for all the waste streams. These indexes are designed to measure the effectiveness of different areas such as pollution prevention general practice, waste volume reduction, cost, and pollution prevention in the ER Program. The system design allows revision of the algorithmic parameters as data from implementing pollution prevention techniques are assembled. The input-information tier consists of specific waste streams, waste minimization techniques implemented, volumetric reductions achieved, and cost information. The output from this tier consists of the generator evaluation score (GES), a volume reduction index, a cost-benefit index, and a relative ranking index.

5.1 DEVELOPMENT OF POLLUTION PREVENTION TECHNIQUES FOR IDW FOR REMEDIAL INVESTIGATION

A planning checklist was developed to identify elements that should be considered for pollution prevention in the ER Program. The questions on the checklist are divided into two sections. The first section consists of general questions that apply to every phase of the program. These questions will be developed from the combination of the required elements in the pollution prevention program and the elements of the Nuclear Quality Assurance document NQA-1 which are relevant to waste minimization.

- Does the waste generator have a pollution prevention plan incorporated in the RI work plan?
- Is the area of contamination (AOC) clearly defined?
- Are the contaminants identified?
- What are the levels of contaminants?
- What waste streams will be generated?

After completing the assembly of general information, the waste generator is presented with a set of examples of remedial initiatives from which the waste generator picks the example that best illustrates the project of interest. The waste generator is then asked a series of yes or no questions dealing with specific elements of the generator's pollution prevention program.

The second set of questions are phase specific and are developed from waste reduction techniques for specific waste streams associated with the RI phase. These streams include soils, sediments, sludges, groundwater, decontamination liquids, and PPE. These questions are primarily used to collect waste-stream data and will be used to determine the total numerical score for the waste generator. The main purpose for these questions is to encourage the waste generator to (1) use the checklist to properly plan the project and (2) select appropriate pollution prevention techniques during the planning effort.

The waste stream questions were put into the EPA data quality objectives (DQO) format to facilitate compliance with regulatory reporting requirements.

5.2 DEVELOPMENT OF POLLUTION PREVENTION TECHNIQUES ON IDW FOR FEASIBILITY STUDIES, D&D, AND SURVEILLANCE AND MAINTENANCE

As has been done previously for the RI phase, NSS questions will also be developed to evaluate the pollution prevention plans for ER Program feasibility study (FS), D&D, and surveillance and maintenance (S&M) activities.

Questions on these new checklists will be divided into two sections. The first section will consist of general questions that apply to all phases of the ER Program. These questions will be based on the required elements in the ER pollution prevention program and those elements of NQA-1 that are relevant to pollution prevention. The second section will be the waste-stream-specific section for each phase. These questions will be developed from the from waste reduction techniques specifically used for different types of waste streams and will be specifically designed for FS, S&M, and D&D activities.

5.3 EVALUATION OF THE EFFECTIVENESS OF POLLUTION PREVENTION ACTIVITIES

Presently, evaluation of the pollution prevention activities for the ER Program is focused only on the RI projects in FYs 1993–1994 at the following DOE facilities: the Oak Ridge Y-12 Plant, the Oak Ridge K-25 Site, the Oak Ridge National Laboratory, the Paducah Gaseous Diffusion Plant, and the Portsmouth Gaseous Diffusion Plant.

GESs, volume reduction indexes, cost-benefit indexes, and relative ranking indexes, as described in the following sections, are being used to evaluate various aspects of pollution prevention activities specific to the RI projects at these facilities.

5.4 GENERATOR EVALUATION SCORE

The GES component of the NSS system is an interactive, computer screen-based questionnaire derived from applicable NQA-1 elements, DQOs, and successful pollution prevention programs. The questionnaire is designed to provide guidance to the user concerning incorporation of the necessary waste reduction elements during the implementation of projects. This component of the system will consist of a set of inquiries derived from the 18 elements of NQA-1 and 8 EPA elements. Figure 2 is an illustration of the correlation of waste minimization program requirements and those NQA-1 elements applicable to the ER Program phases.

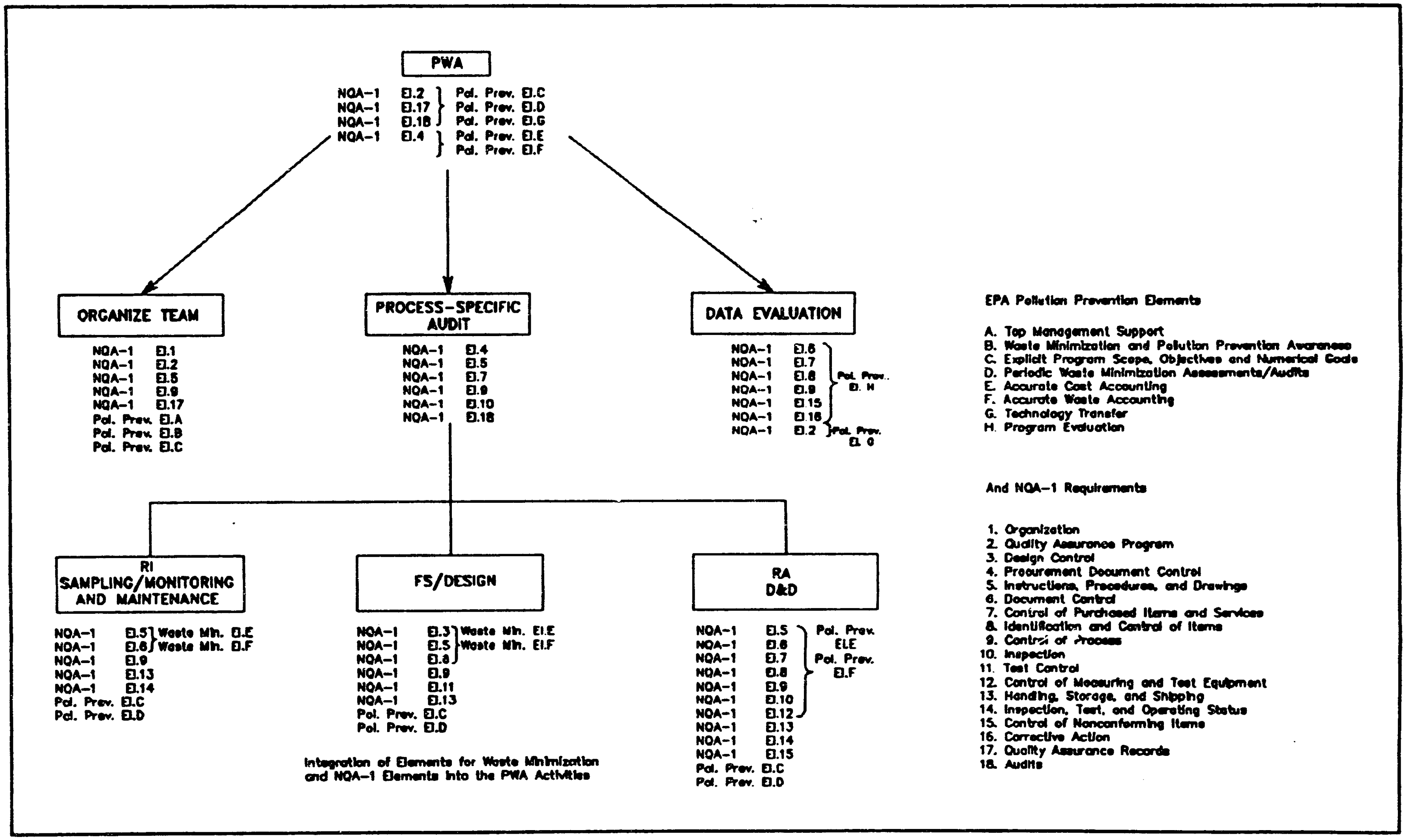

Fig. 2. Environmental Protection Agency Pollution prevention elements and NQA-1 requirements.

5.5 VOLUME REDUCTION INDEX

The volume reduction index is intended to measure the effectiveness of the waste generator's efforts to achieve significant volume reduction. A numerical index, S, is defined as the effectiveness of the pollution prevention efforts for volume reduction. The value of S is determined through a comparison of the actual volume reduction achieved to the potential reduction that could be achieved. For a given waste stream, j, the mathematical representation of S_j is:

$$S_j = \frac{A_j}{R_j} , \quad (1)$$

where S_j is a numerical index that measures the effectiveness of waste minimization efforts as related to volume reduction for waste stream j, A_j is the actual volume reduction index for waste stream j, and R_j is the potential reduction index for waste stream j (details of indexes A_j and R_j will be described in later sections).

It is likely that during early implementation of the NSS cases will occur in which the value of the ratio will exceed 1.0 as a result of techniques or gains not considered in the initial development stage. Therefore, data concerning these situations will be used to interactively refine the parameters used to calculate the potential reduction index.

The actual volume reduction index, A_j, is the ratio of the actual volume reduction achieved by the implementation of waste minimization techniques to the total volume that would have resulted without waste minimization efforts. This is mathematically represented as:

$$A_j = 10 \times \frac{(V_{jp} - V_{ja})}{V_{jp}} , \quad (2)$$

where V_{jp} is the volume of waste stream j that would be generated without implementing any waste minimization techniques, V_{ja} is the volume of waste with the implementation of waste minimization efforts, and A_j is the volume reduction index for waste stream j (A_j would have a value in the range of 0 to 10).

The potential reduction index, R_j, is designed to measure the theoretical volume or toxicity reduction achieved by a given waste minimization technique. The potential reduction index, V_{ij}, for a waste stream j and reduction technique i is:

$$r_{ij} = \frac{e_{ij} \times P_{ij}}{10} , \quad (3)$$

where r_{ij} is the reduction index for waste stream j using the reduction technique i (maximum value of 10), the value e_{ij} is the effectiveness of reduction technique i on waste stream j

(range of 0 to 10), and P_{ij} is an adjusted value of the probability of reduction technique i being implemented for waste stream j.

Estimation of the effectiveness and probability parameters will be developed for each target waste stream and reduction technique by doing literature searches and using best engineering judgment.

After determining the potential reduction index for each waste stream and reduction technique combination, the composite potential reduction index, R_j, for waste stream j will be calculated. It is considered unlikely that the entire range of reduction techniques could be applied to a given waste stream. Therefore, the composite reduction index for the waste stream will be based on only those techniques that are considered to be most favorable.

5.6 COST-BENEFIT INDEX

The cost-benefit index provides a cost-benefit factor that will enable the waste generator to assess the economic effectiveness of a particular waste minimization technique. The cost-benefit index is the ratio of the overall cost saving from implementing waste minimization to the overall cost of managing the waste without minimization efforts. This cost-benefit index for a waste stream j can be represented as:

$$C_{ja} = \frac{C_j - C_{jm}}{C_j} , \qquad (4)$$

where C_{ja} is the cost-benefit index for waste stream j (maximum value of 1), C_j is the overall cost of managing the waste without waste minimization, and C_{jm} is the cost of managing the waste with minimization of waste stream j.

5.7 RELATIVE RANKING INDEX

The relative ranking index is a measure of the desirability of the implemented minimization efforts relative to the pollution prevention hierarchy. The relative ranking index for a given technique and waste stream may be defined by the pollution prevention hierarchy factor, Z_{ij}, in conjunction with the effectiveness factor, e_{ij}, as represented by the following equation:

$$h_{ij} = \frac{e_{ij} Z_{ij}}{10} , \qquad (5)$$

where e_{ij} is the effectiveness of reduction technique i on waste stream j (maximum value of 10), Z_{ij} is the pollution prevention hierarchy of reduction technique i being implemented for waste stream j (value range from 0 to 10), and the parameter h_{ij} is the relative ranking index of reduction technique i on waste stream j.

The pollution prevention hierarchy Z_{ij} will be developed for each target waste stream and reduction technique by using best engineering judgment coupled with a relative ranking of the waste minimization technique. The pollution prevention hierarchy may generally be assigned in the following order:

- procedural alterations,
- material substitutions,
- process elimination,
- technology alteration,
- direct reuse,
- reclamation, and
- end-of-pipe treatment.

The composite relative ranking index for each target waste stream, H_j, will be defined as the sum of the Equation (5) products of the effectiveness and position parameters for each of the reduction techniques.

5.8 FUTURE SCORING MECHANISM

A periodic re-evaluation of the pollution prevention activities in the ER Program will be very beneficial. It will not only give a better picture of how well each individual generator and the overall program are doing but will also facilitate feedback of the necessary information to the NSS, which is by nature a dynamic process.

Some indexes, such as the volume reduction index and the relative ranking index, will greatly benefit from a frequent reevaluation because these indexes are designed for long-term self refinement. Parameters used in the calculations will need a series of iterations to improve accuracy. The cost-benefit evaluation will also improve with the maturity of the pollution prevention activities in the ER Program. The breakdown in cost accounting will get better, and, in turn, more detailed cost information will become available. This will result in a more accurate definition of the cost-benefit index.

The waste generator will also be provided with outputs for documenting all performance indexes which include their GES answers, volume reductions, cost benefits, and relative ranking.

5.9 SCORING FOR FS, D&D, AND S&M PHASES

The initial stage of development of the FS, D&D, and S&M checklist questionnaires has just begun. The preliminary questionnaires will serve as the pilot stage of the evaluation of the pollution prevention activities in the FS, D&D, and S&M phases. Eventually, a full-scale scoring mechanism will be developed to serve as an evaluative tool for waste generators in these phases. It is likely that the scoring mechanism and index already developed for the RI phase in the NSS, with some adjustment to accommodate the different nature of FS, D&D, and S&M phases, will be used as an evaluative tool for these three phases.

6. RECOMMENDATIONS AND CONCLUSIONS

After reviewing the information obtained in this report, it can be concluded that the area of multimedia waste reduction performance measurement is very complex. In observing sites within the DOE complex and those of various private vendors, it was discovered that most generators are trying to measure waste reduction after generating the waste. This may be the "normal" method of measuring waste minimization, but it does not give accurate results in all cases, especially for remedial or restoration activities.

Until accurate waste generation and life-cycle cost data are available, use of common pollution prevention measures such as percentage goals for ER would not yield meaningful results. Pollution prevention is a high priority because of regulatory drivers and cost benefits; therefore, it is logical to apply meaningful performance measures.

In conclusion, a multimedia approach to performance measures which accurately reflects pollution prevention to minimize multimedia transfers and reduce waste is essential to the ER Program. One of the first steps in this approach is the application of the Pollution Prevention Life-Cycle Model. The model is based on a cyclic process and has as its objective the collection of trend data from the various phase projects to be measured. The next step is to utilize the NSS, which scores a waste generator on how well the generator is implementing the best available methods to maximize pollution prevention.

Although the NSS is in the premature stages of development, Energy Systems and other environmental cleanup site managers will be able to realize the benefits of pollution prevention in every aspect of remedial action planning and project implementation. The benefits are as follows:

- Limited dollars will be needed to implement, because personal computers are readily available;
- Performance indexes for pollution prevention activities will be established;
- Cost savings result as waste generators train and assess themselves, thereby eliminating expensive PWAs and audit teams;
- Consistency and communication will be improved among top management, technical support, and waste generators;
- Reporting requirements are improved, because all pollution prevention activities are documented by the NSS; and
- Healthy competition between site programs will be promoted as top performers are recognized through incentive programs.

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