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A FOUNDATION TO PRIORITIZE COAST GUARD AtoN BATTERY DISPOSAL SITES FOR CHARACTERIZATION AND TREATMENT

by

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Introduction

The logical basis for prioritizing Coast Guard AtoN battery disposal sites for characterization and treatment rests with values. The question is, "what does the Coast Guard wish to achieve by cleaning up these sites?" Four separate meetings with Coast Guard personnel concerned with AtoN battery sites were held to discuss their values for cleanup operations. This report presents the results of those discussions in the Appendix. For each of those discussions, we converted the list of values stated into objectives useful for appraising possible cleanup programs.

The objectives representing the values of Coast Guard personnel are divided into four types. These are referred to as fundamental objectives, means objectives, process objectives, and broader Coast Guard objectives. The specific objectives in each class are organized as indicated respectively in Tables 1 through 4. The relationships of these classes of objectives are indicated in Figure 1. Let me discuss the relationships between the different classes of objectives.

The fundamental objectives indicate what one wishes to achieve by any cleanup of AtoN battery sites. These fundamental objectives provide the basis for any prioritization of sites for potential cleanup operations. It is also the case that the control that the Coast Guard has with respect to cleanup is in terms of how well they meet these fundamental objectives.

There are a number of means objectives that contribute to the achievement of the fundamental objectives. That is to say, if one does better in terms of the means objectives, it should be the case that the fundamental objectives are better achieved. For example, a means objective is to minimize concentrations of mercury in the aquatic environment including sediments and water near AtoN battery sites. If mercury levels are reduced, this would naturally lead to better achievement of the fundamental objectives of reducing environmental impacts. Specifically, environmental impacts due to high mercury levels would naturally be lower.

A third type of objective is the process objective. Process objectives refer to what one would like from the process by which decisions are made about any potential cleanup of AtoN battery sites. For instance, process objectives concern issues such as whether the decisionmaking process is open and understandable and whether the process contributes to credibility with the regulatory community. Per se, the process objectives do no contribute directly to the achievement of the fundamental objectives. However, when the process is going smoothly, it may be much easier for the Coast Guard to concentrate on the substance of the cleanup programs and better address the achievement of the fundamental objectives.

The Coast Guard's treatment of any environmental problem reflects upon its overall public image. Hence, the decisions about AtoN battery sites may have an impact on achievement of broader Coast Guard objectives. These broader objectives concern the public image of the Coast Guard and whether the Coast Guard solves the AtoN battery contamination problem once and for all. Both how well and the public's perception of how well the Coast Guard addresses the AtoN battery problem is important.

Process to Identify and Organize Objectives

Discussions were held to determine the values that Coast Guard personnel think are appropriate for evaluating AtoN battery cleanup operations. The intent was to promote a comprehensive list of anything and all things that are important to this class of decisions. These things that are important are what I refer to as values. To develop a comprehensive listing, I pursue both the reasoning for and the meaning of any mentioned value. To promote thought, after an open discussion, I ask individuals to separately think about possible values in different categories such as environmental, social, safety, health, economic, and political.

Once a list of values is obtained from a discussion, I convert each item on the list to an objective. An objective is defined by an object and direction of preference in the context of the battery cleanup. For example, if it is mentioned that time of cleanup is important, this is converted to the objective "minimize the time needed for cleanup."

Next, the objectives are each organized into the objective classes. The objectives related only to cleanup operations are either means objectives or fundamental objectives. For each of these, we use the "why is it important" test to identify whether it is a means or a fundamental objective. The means objectives are those that are important only because of their impact on another objectives. The fundamental objectives are important because they essentially describe the reason AtoN battery cleanup is an issue.

Objectives not related directly to cleanup operations are classified as process objectives or broader Coast Guard objectives. The process objectives refer to how the decisions are made and communicated, rather than the consequences of those decisions. Broader Coast Guard objectives are meant to be contributed to by the fundamental objectives, means objectives, and process objectives.

Once the objectives are organized for each discussion, they are combined by category. This increases the breadth of values covered. In combining objectives, sometimes two objectives with essentially the same meaning are expressed as a single objective. Also, it is useful to structure the objectives hierarchically with lower level objectives helping to define the meaning of higher level objectives.

The results of this process are the lists of objectives in Tables 1 through 4. The lists are not intended to indicate any prioritization based on their order. In interpreting any of the objectives, it is important to recognize that this work is preliminary. Indeed, one important purpose is to provide a basis for constructive comment, modification, and improvement.

Objectives for Prioritizing Characterization and Treatment

The fundamental objectives in Table 1 provide the basis for prioritizing both characterization and treatment of AtoN battery sites. The objectives regarding environmental, social, and health impacts are those that should be the foundation for characterization. Based on the expected consequences of a site in terms of these objectives, we would have an indication of the potential seriousness of the contamination of the site. This should provide a reasonable basis for prioritizing the order of sites to be considered for cleanup.

In the consideration of how one might clean up this site, one needs to add the costs objective as an additional consideration. Also, one must be careful to consider the possible negative implications in terms of the environment, social impacts, and the health and safety impacts of the cleanup activities themselves. For instance, it may be that the possible environmental impact of batteries in a coral area leads to a particular site having a high prioritization for considering cleanup. However, in considering the options for that cleanup, it may be discovered that there may be more damage to the coral done by the cleanup itself than simply letting the site remain unbothered by additional cleanup efforts.

Measures to Evaluate the Fundamental Objectives

A system is required to quickly and efficiently evaluate the relative damage that may be caused at AtoN sites. To do this, it is necessary to describe the sites in terms of how they might measure up on the fundamental objectives that are influenced by any possible pollution. This requires selecting measures for which data on AtoN sites is readily available or soon can be made available.

Table 5 lists a set of selected measures and their corresponding fundamental objectives. The measures in regular type are suggested for characterization. The additional measures in italics should be added to evaluate any proposed cleanup strategies, including no cleanup. Selection of these measures was partially based on the aforementioned Coast Guard discussion and discussions with Dr. Sherry Borener of the U.S. Department of Transportation Volpe Center, who works with the Coast Guard on AtoN issues.

To prioritize sites for possible cleanup action, one uses the five measures in Table 5. However, these need to be appropriately weighted relative to each other. In this regard, note that whether an area is used for recreational diving or fishing is significant for both social and health reasons.

Weighting Objectives Using Value Tradeoffs

When objectives are weighted, it is necessary to be clear about how much of each objective is being considered. This is done by clearly defining ranges for the measures, as indicated in Table 6. Then what we need to do is assign relative values to each item in Table 6 to provide the weights for a prioritization system. For this purpose, based upon worst-case experience with the numbers of batteries found in different locations, it was assumed that a recreational diving or fishing area in salt water has 200 batteries and that a drinking source has 50 batteries. For the measures of total mercury in sediment and percent of total mercury in methylmercury used to indicate environmental impacts, data to date suggests there is not a strong correlation between them, so both are treated independently.

Prior to actual weighting, one should rank the relative seriousness of seven situations in Table 6. The ranks listed are based on discussions with Dr. Sherry Borener. These imply that the potential health implications of having 50 batteries in a water source should be of more concern than the social implications of 200 batteries in a recreational diving area, which are of more concern than the health implications of those 200 batteries in the recreational diving area. The environmental implications of 10 ppm of total mercury in sediment in an area is of less concern than the potential health implications of 200 batteries in a fishing area.

The next step is to weight (i.e., rate) the seven situations in Table 6. The weights shown in Table 6 are consistent with the rankings and based partially on the same discussion with Dr. Borener. First, it was agreed that ten batteries in a source of drinking water was one-fifth as significant as 50 batteries in that source. Dr. Borener felt that the health implication of 10 to 15 batteries in a drinking source was about equally as significant as either 200 batteries in a recreational diving area or in a fishing area. This set the relative ratings for the three health situations in Table 6 of 1:1:4. Clearly the two environmental situations would each have the same rating since they were equally ranked. The same situation applied to the two social situations.

To compare across different categories of objectives, the same discussion suggested that the social implications of 200 batteries in a recreational area were about 1.5 times as important as the health implication of that situation. Also, the environmental implication of a site with 10 ppm mercury in sediment that all (100 percent) showed up as methylmercury was about equivalent to the health implications of 200 batteries in a recreational area. Using these value judgments leads to the weights in Table 6 which were scaled to total to 100. The logic for calculating these weights is summarized in Table 7.

A System to Prioritize Sites for Characterization

The various objectives in Table 6 need to be combined logically to create a prioritization system for sites. Because whether an area is used for recreational diving is relevant to both social and health effects, note that the total weight on this measure is 25 from Table 6. For this same reason, the total weight for whether an area is used for fishing is 25.

Suppose we describe a site for potential cleanup by the vector $(x_1, x_2, x_3, x_4, x_5)$, where

x_1 = ppm of mercury in sediment,
x_2 = percent of total mercury in methylmercury,
x_3 = number of batteries in a recreational diving area,
x_4 = number of batteries in a fishing area, and
x_5 = number of batteries in a source of drinking water.

Then the priority P of a site for consideration for cleanup can be evaluated as

$$P(x_1,x_2,x_3,x_4,x_5) = 5\left(\frac{x_1}{10}\right) + 5\left(\frac{x_2}{100}\right) + 25\left(\frac{x_3}{200}\right) + 25\left(\frac{x_4}{200}\right) + 40\left(\frac{x_5}{50}\right). \qquad (1)$$

Note from (1) that it is reasonable to interpolate between levels of measures in the prioritization of sites. Also, if no information is available on the number of batteries at a site requested by x_3, x_4, and x_5, then one should set the variable to 0 if it is not used for diving, fishing, or drinking water, respectively. If it is used for a specific purpose, set the variable to the standard amount of $x_3 = 200$, $x_4 = 200$, and $x_5 = 50$ as indicated in Table 6. Table 8 illustrates two examples using the prioritization system in (1).

A System to Evaluate Cleanup Alternatives

A system for evaluating cleanup alternatives, including do nothing, at a site would require combining additional variables of the impact of cleanup operations with those variables in (1). To illustrate, suppose weights were determined for the specified changes in measures as indicated in Table 9. These weights are scaled to be consistent with the weights in Table 6. In this illustration, since 1 is the weight on $1,000 and 40 is the weight on 50 batteries in a drinking water source, the value judgment implied is that it is worth $40,000 if the batteries could disappear from that source.

Let us define the following levels of measures from Table 9:

x_6 = 0, if no damage to a coral community, and x_6 = 1 if damage,
x_7 = 0, if no removal of fish habitat, and x_7 = 1 if removal during sensitive time,
x_8 = 0, if no removal of fish habitat, and x_8 = 1 if removal during other time,
x_9 = square meters where diving is prohibited,
x_{10} = square meters where fishing is prohibited,
x_{11} = person-days of scuba diving,
x_{12} = person-days of diving with surface air supply, and
x_{13} = thousands of dollars for cleanup.

Combining these with x_1 - x_5, we can describe a site after any alternative to address AtoN batteries was implemented by a vector (x_1, x_2, ..., x_{13}). Consistent with (1) and the weights in Table 9, the relative desirability D of alternatives could be evaluated by

$$D(x_1,x_2,\ldots,x_{13}) = 5\left(\frac{x_1}{10}\right) + 5\left(\frac{x_2}{100}\right) + 25\left(\frac{x_3}{200}\right) + 25\left(\frac{x_4}{200}\right) + 40\left(\frac{x_5}{50}\right)$$

$$+10(x_6) + 50(x_7) + 10(x_8) + 10\left(\frac{x_9}{10000}\right) + 10\left(\frac{x_{10}}{10}\right)$$

$$+ 1\left(\frac{x_{11}}{100}\right) + 0.5\left(\frac{x_{12}}{100}\right) + 1(x_{13}). \qquad (2)$$

Using (2), the alternative with the lowest level of D is the preferred alternative.

As an illustration, suppose that you could clean up Site A in Table 8 completely for $5,000 and two person-days of scuba diving. For this alternative, suppose no coral or fishing habitat is disrupted, so after cleanup,

$$x_1 = 0,\ x_2 = 0,\ \ldots,\ x_{10} = 0,\ x_{11} = 2,\ x_{12} = 0, \text{ and } x_{13} = 5.$$

Substituting into (2)

$$D(x_{11} = 2,\ x_{13} = 5,\ \textit{other } x_i = 0) = 1\left(\frac{2}{100}\right) + 1(5) = 5.02.$$

The alternative of no cleanup is the site remains as described in Table 8 so D = 32.5. Hence, the cleanup is preferred.

A Comment on Implementation

To implement the prioritization and evaluation systems, it would be worthwhile to review the relative weights in Tables 6 and 9 and ensure that they are logically consistent. Specifically, value judgments of Coast Guard personnel and interested parties would be appropriate to use in place of the illustrative value judgments provided by Dr. Borener. Then, the system can easily be put into a spread sheet program for use. When implementing, it would be useful to conduct sensitivity analyses of the prioritization of sites and the evaluation of alternatives to the weights assigned and to the descriptions of sites in terms of the x-vectors.

Table 1. Fundamental Objectives

1. Minimize damage to the marine environment
    - Minimize impacts on estuaries and other sensitive environments
        - Minimize impacts on shellfish
        - Minimize impacts on other fish
        - Minimize impacts on plant life
    - Minimize impacts on coral communities

2. Minimize social impacts
    - Minimize detrimental impacts on the quality of sport diving
        - Minimize aesthetic impacts
        - Minimize area where diving is prohibited
    - Minimize impacts on fisheries
    - Minimize impacts on eating habits

3. Minimize health and safety impacts
    - Minimize health impacts due to batteries
        - Minimize health impacts due to exposure while diving
        - Minimize health impacts from eating contaminated fish
        - Minimize health impacts from drinking contaminated water
    - Maximize safety of any cleanup activities

4. Minimize costs of cleanup activities
    - Minimize administration costs
    - Minimize operations costs
    - Minimize disposal costs

Table 2. Means Objectives

1. Minimize contamination of the water
   - Minimize mercury levels
   - Minimize lead levels
   - Minimize acidity due to batteries
   - Minimize sediment pollution

2. Minimize the difficulty of cleanup operations
   - Maximize the probability of detection of batteries
   - Minimize the ease of getting to batteries
   - Minimize travel between sites during cleanup

3. Minimize disturbance of cleanup operations
   - Minimize disturbance of animals
   - Minimize disturbance of plant life
   - Minimize degradation of drinking water
   - Comply with all water standards

4. Minimize the time necessary for cleanup operations
   - Retrieve batteries as soon as possible

5. Meet regulations
   - Be consistent with CERCLA process
   - Meet state regulations
   - Meet district/field intergovernmental regulations

6. Utilize Coast Guard resources efficiently
   - Be sustainable within limits of EC&R funds for AtoN batteries
   - Be flexible to annual funding fluctuations

Table 3. Process Objectives

1. Ensure a quality process for decisionmaking
   - Provide for verification
   - Provide for transparency of the process
   - Keep the process open
   - Disclose all aspects of the process

2. Enhance the perception of the quality of the process
   - Ensure credibility with regular communication
   - Ensure defensibility of the model and actions

3. Act consistently with local customs and procedures
   - Meet all permitting concerns

4. Ensure acceptability of the model
   - Ensure acceptability to the public
   - Ensure acceptability to regulators

5. Minimize negative publicity about the process

Table 4. Broader Coast Guard Objectives

1. Enhance the public image of the Coast Guard
   Preserve positive image as a maritime environmental enforcement agency

2. Ensure no further remediation is needed after site cleanup

Table 5. Measures Selected for the Characterization of AtoN Sites

Objectives Potentially Affected by Batteries	Measures
Environmental	
Minimize impacts on estuaries and other sensitive environments	Total mercury in sediment (ppm)
	Percent of total mercury as methyl-mercury
	Elimination of fish habitat (removal of habitat during sensitive time, removal of habitat during other time, no removal of habitat)
Minimize impacts on coral communities	*Damage to coral communities (yes/no)*
Social	
Minimize detrimental impacts on the quality of sport diving	Whether area is used for recreational diving (yes/no)
	Area zoned off for diving (square meters)
Minimize impacts on fisheries	Whether area is used for fishing (yes/no)
Minimize impacts on eating habits	*Area zoned off for fishing (square meters)*
Health	
Minimize health impacts due to exposure while diving	Whether area is used for recreational diving (yes/no)
	Number of batteries in diving area
Minimize health impacts from eating contaminated fish	Whether area is used for fishing (yes/no)
	Number of batteries in fishing area
Minimize health impacts from drinking contaminated water	Whether area is source of drinking water (yes/no)
	Number of batteries in drinking water source
Maximize safety of any cleanup activities	*Person-days of scuba diving*
	Person-days diving with surface air supply
Cost	
Minimize costs of cleanup activities	*Economic costs ($1,000s)*

Table 6. Levels of Measure for Prioritization

Measure

Environmental	Best	Worst	Rank	Relative Ranking Within Objective Category	Weight
Total mercury in sediment (ppm)	0	10	6	1	5
Percent of total mercury as methylmercury	0	100	6	1	5
Social					
Whether area with 200 batteries is used for recreational diving	No	Yes	2	1	15
Whether area with 200 batteries is used for recreational fishing	No	Yes	2	1	15
Health					
Whether area with 200 batteries is used for recreation and diving	No	Yes	4	1	10
Whether area with 200 batteries is used for fishing	No	Yes	4	1	10
Whether area with 50 batteries is a source of drinking water	No	Yes	1	4	40

Table 7. Examples of Prioritizing Sites for Possible Cleanup

Site A: $x_1 = 10$, $x_2 = 50$, $x_3 = 0$ since not used by recreational divers,
$x_4 = 200$ since site used for fishing but unknown how many batteries,
$x_5 = 0$ since site A is not a drinking water source.

$$P(10,50,0,200,0) = 5\left(\frac{10}{10}\right) + 5\left(\frac{50}{100}\right) + 25\left(\frac{0}{200}\right) + 25\left(\frac{200}{200}\right) + 40\left(\frac{0}{50}\right)$$

$$= 5 + 2.5 + 0 + 25 + 0$$

$$= 32.5$$

Site B: $x_1 = 1$, $x_2 = 50$, $x_3 = 100$, $x_4 = 100$, $x_5 = 0$ since Site B is not a drinking water source.

$$P(1,50,100,100,0) = 5\left(\frac{1}{10}\right) + 5\left(\frac{50}{100}\right) + 25\left(\frac{100}{200}\right) + 25\left(\frac{100}{200}\right) + 40\left(\frac{0}{50}\right)$$

$$= 0.5 + 2.5 + 12.5 + 12.5 + 0$$

$$= 28$$

Table 8. Level of Measures for Evaluating Cleanup Alternatives

Variable	Measure	Best	Worst	Weight
6.	Damage to coral community	No	Yes	10
7.	Removal of fish habitat during sensitive time	No	Yes	50
8.	Removal of fish habitat during other time	No	Yes	10
	Social			
9.	Area prohibited for diving (square meters)	0	10,000	10
10.	Area prohibited for fishing (square meters)	0	100	10
	Safety			
11.	Person-days of scuba diving	0	100	1
12.	Person-days of diving with surface air supply	0	100	0.5
	Cost			
13.	Dollars in thousands	0	1,000	1

Appendix

The following is a summary of the objectives identified in the discussions held with members of the Coast Guard and individuals working with the Coast Guard on AtoN battery sites.

Summary of a Discussion with Ed Wandelt, Mike Bee, and Chris Hart

The following objectives were developed based on values mentioned in the discussion.

Fundamental Objectives

- Minimize environmental risk
- Minimize aesthetic impact of the batteries (e.g., visual impact on recreational divers)
- Minimize cost of the cleanup
- Minimize health effects due to the food chain or to any acute effect of divers
- Minimize damage to the environment of the cleanup operations

Means Objectives

- Minimize exposure of the public to contamination

Process Objectives

- Ensure the decision process is palatable to internal stakeholders and the Coast Guard (e.g., district level operations)
- Ensure the decision process is palatable to external stakeholders (e.g., states)

Broader Coast Guard Objectives

- Minimize negative publicity about the AtoN battery sites issue
- Minimize any tainting of the Coast Guard's image
- Reduce the likelihood of any necessary future remediation at sites

Summary of a Discussion with Art Wittich, Ron Weston, and Tom Hayes

The following objectives were developed based on values mentioned in the discussion.

Fundamental Objectives

- Minimize the cost of cleanup
- Minimize the environmental impacts
- Minimize impacts on species of concern
- Minimize impacts on the fishing industry
- Minimize any social implications

Means Objectives

- Minimize lead contamination
- Minimize acid contamination
- Minimize contamination of the sediment
- Fully comply with any water standards
- Minimize the time needed for cleanup
- Meet all state requirements and regulations

Process Objectives

- Ensure acceptability of the model to external parties
- Ensure credibility with the regulatory community
- Ensure that the decisions are defensible
- Be consistent with the NPL hazard ranking scoring system
- Be consistent with all local permitting concerns and process requirements
- Ensure decisionmaking process is transparent and open
- Ensure disclosure of information
- Ensure the decisionmaking process can be verified
- Be able to address local differences in values
- Ensure public acceptability

Broader Coast Guard Objectives

- Ensure that no further remediation is needed after the cleanup

Summary of a Discussion with Dan Stuhlmann, Leo Black, and Chuck Mosher

The following objectives were developed based on values mentioned in the discussion.

Fundamental Objectives

- Minimize cost of the cleanup
- Minimize environmental impacts
- Minimize visual impacts to divers

Means Objectives

- Maximize the ease of getting to batteries for cleanup
- Minimize the time required for cleanup
- Minimize environmental sensitivity of the cleanup
- Minimize travel costs between cleanup of different sites
- Minimize level of difficulty of cleanup
- Maximize the probability of detecting disposed batteries

Process Objectives

- Enhance likelihood of public acceptability of the process
- Ensure good public perception of the cleanup process

Broader Coast Guard Objectives

- Do not degrade public image

Summary of a Discussion with Bill Davis

The following objectives were developed based on values mentioned in the discussion:

Fundamental Objectives

- Minimize environmental impacts
  - To shellfish
  - To non-mammal animal life
- Minimize visual implications
- Minimize impacts on fisheries
- Minimize impacts on coral
- Minimize health impacts due to drinking water
- Minimize degradation on the quality of sport diving
- Minimize any necessary changes in eating habits
- Minimize the cost of cleanup, including administration cost

Means Objectives

- Minimize mercury pollution in water
- Minimize lead pollution in water
- Minimize acid levels in water
- Ensure a high probability of finding batteries
- Minimize disturbance to living creatures and plants during cleanup

Broader Coast Guard Objectives

- Enhance public image of the Coast Guard

Summary of a Discussion with Bill Davis

The following objectives were developed based on values mentioned in the discussion:

Fundamental Objectives

- Minimize environmental impacts
  - To shellfish
  - To non-mammal animal life
- Minimize visual implications
- Minimize impacts on fisheries
- Minimize impacts on coral
- Minimize health impacts due to drinking water
- Minimize degradation on the quality of sport diving
- Minimize any necessary changes in eating habits
- Minimize the cost of cleanup, including administration cost

Means Objectives

- Minimize mercury pollution in water
- Minimize lead pollution in water
- Minimize acid levels in water
- Ensure a high probability of finding batteries
- Minimize disturbance to living creatures and plants during cleanup

Broader Coast Guard Objectives

- Enhance public image of the Coast Guard