On-Site Disposition of Concrete During Decommissioning and Decontamination: A Data Quality Objective-Based Approach – 8457

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ABSTRACT

On-site disposition of concrete derived during decommissioning and demolition (D&D) of buildings at industrial sites is a cost-effective, waste minimization alternative to off-site disposal. Because the concrete is to be left on-site it becomes part of the solid matrix of the site and is subject to the compositional constraints governing site soils. In addition, the concrete and its contained-in materials may be subject to physical constraints such as size and shape which do not apply to soils. When considering on-site disposition of concrete, the data quality objective (DQO) process should be used to determine the compositional and physical constraints on the concrete and for developing the characterization approach to determine whether those constraints have been met. The information inputs to the compositional and physical constraints on the concrete constitute the concrete acceptance criteria (CAC) which become the basis for developing decision rules – the yes/no statements that unequivocally state the compositional and physical conditions under which concrete may be left on site.

An important DQO boundary concept is concrete classification. The cost of concrete characterization can be minimized with a thorough data gap assessment by focusing resources on the concrete most in need of characterization. Concrete for which a yes/no decision can be made with reasonable certainty based on a comparison of existing data to the CAC receives a lesser amount of characterization scrutiny than does concrete for which existing data is non-existent or ambiguous relative to the CAC.

INTRODUCTION

Decommissioning and decontamination (D&D) during closure of industrial sites can generate substantial waste in the form of uncontaminated concrete and contained-in solids such as rebar, tile, brick, and mortar. A cost reduction and waste minimization alternative to transport and disposal of the concrete is to

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leave the uncontaminated concrete on site. Several site-specific alternatives exist for on-site disposition of concrete. One alternative is to use concrete rubble derived from demolition of walls and floors as basement fill material. Regardless of the site-specific use of the concrete, by leaving concrete on site it becomes part of the solid matrix of the site just like soil and evaluation of the concrete mirrors the methods used to evaluate soil. The only real difference from an evaluation point of view is that the physical character of the concrete and contained-in solids must be considered. In considering concrete for on-site disposition, the data quality objective (DQO) process (1) is an important tool for defining acceptance criteria for low-level chemical and radiological contaminated or uncontaminated concrete and for developing a characterization approach.

The characterization approach is the process of gathering new data that is sufficient to support the decision for on-site disposition of concrete. For the purposes of this paper, the term “data” is defined as any type of pertinent information but especially includes records, observations, field survey results, and analytical data, where analytical data are quantitative results, presented in concentration units, from laboratory analyses of samples. Conducting characterization will incur costs, primarily for sampling and analysis, but these costs are minimal when compared to the cost of transportation and off-site disposal. Nonetheless, it is an imprudent waste of funds to address all concrete with the same level of scrutiny within the characterization approach. In fact, review of historical data often shows that there is concrete with sufficient associated historical data to make a contaminated/not contaminated decision and by recognizing and using these data to meet data sufficiency requirements, the magnitude of the characterization program can be greatly reduced to focus on the concrete mass for which there are insufficient data to make that decision. Thus an important part of the DQO process presented here is development of a concrete classification approach. In asking the question, “Where are data needed?” an important role of the DQO process as a data gap assessment is highlighted.

An important parameter in the DQO process is the action level (AL), the criterion, or criteria, against which data are compared in order to make the decision. The AL plays heavily in the DQO process. On the one hand, the purpose of the DQO process may be to develop the AL(s) for some potential action or set of actions. On the other hand, the AL(s) may already exist and the purpose of the DQO process is to develop a systematic approach toward making AL-based decisions and obtaining the data necessary for making the decisions. Here, the latter approach is taken. That is, it is assumed that the ALs already exist and the DQO process is one of developing a systematic approach for evaluating concrete against them.

What follows is a summary of the DQO process that was developed to address on-site disposition of concrete during D&D of a former nuclear facility in Oak Ridge, Tennessee (2). Because this paper is a summary of what was done and is not a reiteration of the DQO process, the presentation of the seven DQO steps that were followed has been simplified and condensed into three main sections. As a roadmap, section titles contain reference to the DQO steps being addressed.

PRINCIPAL STUDY QUESTIONS – DQO STEPS 1 AND 2

To begin the DQO process for on-site disposition of concrete a simple problem statement is developed which states that on-site disposition of concrete is the intent and which broadly captures the criteria for acceptance of the concrete for on-site disposition and the types of data that will be needed. The acceptance criteria will be largely determined by the allowable compositional end state of the site. It may also be necessary to address the acceptance criteria for the physical state of the concrete and its contained-in materials as dictated by the end state decision or by waste disposal regulations. The data needs are the types of information which will be used to evaluate the concrete against the acceptance criteria. It is important at this point in the process not to be specific about criteria or data; these will be specified later. Beginning the process with broad generalities enhances flexibility in the process during later stages. Quite simply, the essence of the problem is that, in order to leave concrete derived during D&D on site, the compositional and physical acceptance criteria for on-site disposition must be established and data must be obtained in order to determine whether the concrete meets the acceptance criteria.

Elaboration of the problem statement leads to development of the decisions that will have to be made. Each decision is composed of two parts: the principal study question and the alternative actions. The principal study question combines the acceptance criteria and the data needs from the problem statement. The alternative actions specify possible alternatives in response to the principal study questions. Inspection of the problem reveals that there are two principal study questions – one regarding the composition of the concrete and the other regarding the concrete's physical attributes. Furthermore, there are two alternative actions to each principal study question – either the concrete is suitable for on-site disposition or it is not. The principal study questions and their alternative actions are presented in Table I. Note that the Principal Study Questions in Table I refer in a general sense to acceptance criteria and that the acceptance criteria themselves are not stated specifically. These will be stated later. They are not stated here because the logic of the DQO process requires a systematic expansion of specificity so that each new step can build on previous steps.

Table I. Principal Study Questions and Alternative Actions for On-site Disposition of Concrete

Principal Study Questions	Alternative Actions
Does the concrete composition meet the compositional acceptance criteria for on-site disposition?	Yes – then the concrete may be left on site providing the physical acceptance criteria have also been met.
	No – then the concrete may not be left on site.
Does the physical state of the concrete meet the physical acceptance criteria for on-site disposition?	Yes – then the concrete may be left on site providing the compositional acceptance criteria have also been met.
	No – then the concrete may not be left on site.

The two different alternative actions presented in Table I are the simplest and most universal. There are additional possible alternative actions which could be added to one or both Principal Study Questions and when developing DQOs for on-site disposition of concrete all possible alternative actions should be considered.

DATA NEEDS AND USES – DQO STEPS 3, 4, AND 5

This section describes the data that are needed in order to make the decision for on-site disposition of concrete and the different ways in which data are used to develop the decision and streamline the characterization approach for obtaining new data. The section begins with a description of the concrete acceptance criteria (CAC). The CAC begins to add specificity to the Principal Study Questions. The CAC is a list of the acceptance criteria which must be met in order for the concrete to be left on site and the data inputs which (1) quantitatively define the criteria, and (2) will be needed in order to evaluate the concrete against the criteria. This is followed by a discussion of concrete classification. Classification is a boundary consideration that addresses the compositional question of the Principal Study Questions. Classification uses the results of a data gap assessment of existing data to classify concrete so that characterization to obtain new data can be focused on the concrete most in need of new data. Finally in this section, the CAC and the Principal Study Questions are combined to form decision rules, the unequivocal statements of the circumstances under which concrete may be left on site.

An integral part of the process of developing acceptance criteria is to not only identify what will be acceptable but, also, to whom it must be acceptable and who will pass judgment on and agree to accept the concrete for on-site disposition. For the DQO process to work as intended all the key decision makers must be identified and included in development and finalization of the acceptability determination. Their input, from the formulation of the basic problem statement to the final decision rules, and their ultimate concurrence and approval is what will generate a functional set of acceptance criteria to support the on-site disposition of concrete.

The decision to leave concrete on site is supported by a set of decision inputs called the concrete acceptance criteria (CAC). In order to fully support the decision, the CAC should define the broad term “acceptance criteria”, which is referenced in the Principal Study Questions, and present the data needs for each acceptance criterion in order to make the decision. As presented in the Principal Study Questions, the decision for on-site disposition of concrete at any site will likely be dictated by compositional and physical acceptance criteria. Therefore, every site will likely have a set of Compositional CAC and a set of Physical CAC. An example of the CAC is presented in Table II. The acceptance criteria are defined in Table II in the column labeled “CAC Inputs”. The data needs are listed in the column labeled as “Data Inputs”. Furthermore, there are two types of data being input to the CAC. The first type is “Defining Data” which quantitatively define the CAC. The second type is “Evaluation Data” which are used to compare concrete to the CAC Input in order to make the decision. Some of the Evaluation Data inputs, i.e., site history and historical data, are available at this point whereas development of the new data input will be addressed during the DQO process. Table II is subdivided into Compositional CAC and Physical CAC but it is possible that site-specific requirements may necessitate additional CAC.

In the Table II example, the Compositional CAC Input is a generic statement regarding the compositional limits placed on the concrete. When developing a set of Compositional CAC for real-world application, the generic CAC Input in Table II should be replaced by a specific description of the compositional limits. The source for the compositional limits may be decision documents, regulations, or other promulgated decrees. For example, if the acceptable lead concentration has been promulgated in a record of decision (ROD) as 800 mg/kg then the CAC Input should say, “The lead concentration may not exceed the limit imposed by the ROD” and the value of the concentration limit should be stated as the Defining Data Input (see below). In most cases there will be more than one CAC Input. For example, there may be risk-based compositional limits that apply over a specified area of the site, maximum concentration limits, or surface radiation limits. Each should be listed as a separate CAC Input along with its Data Inputs because development of decision rules later in the DQO process will be founded on the individual CAC Inputs. If a site undergoing D&D already has promulgated compositional limits on soils it stands to reason that the

Table II. Example Concrete Acceptance Criteria

CAC Inputs	Data Inputs	
	Defining Data	Evaluation Data
Compositional CAC		
The concentrations of chemicals and radionuclides cannot exceed limits established in *source*	Established concentration limits from *source*	1. Site history 2. Historical data of acceptable quality to address the CAC Input 3. New data of acceptable quality to address the CAC Input
Physical CAC		
The physical nature of the concrete (e.g., size, shape) and the types and physical natures of contained-in materials must meet established criteria in *source*	Established physical criteria from *source*	Visual inspection and/or physical measurements

concrete to be left on site should be subject to the same compositional limits as the soils. In fact, addressing all solid media in one decision, instead of addressing soils and concrete separately, is an efficiency which should be considered during planning if soils are to be addressed and on-site disposition of concrete is intended. However, because concrete is a man-made material, it has a considerably different composition than soil and it may have a significantly different impact on the immediate local environment. Being composed of calcium carbonate, concrete has a high pH and, in some circumstances, can affect the solubility and secondary transport of metal ions. For this reason, conditions at the receiving site should be considered when developing the acceptance criteria. For example, acceptance criteria may be different for disposition of concrete above the water table and disposition below the water table.

The Data Inputs for the Compositional CAC include the compositional limits themselves as the Defining Data. The compositional limits should either be stated specifically here or, at a minimum, they should be referenced; they will need to be known in order to develop the decision rules. Using the lead example in the previous paragraph, the general language for the Defining Data Input in Table II should be replaced with the 800 mg/kg concentration limit promulgated in the ROD. Site history and historical data are Evaluation Data Inputs for the Compositional CAC. These inputs will be compared against the compositional limits during decision making. Because of the probable large volume of information, these two inputs should not be presented in the CAC table. Instead, the site history and historical data should be summarized separately as part of a data gap assessment. A data gap assessment is a summary of what is known about the site and what is not known. The information developed during the data gap assessment is also used for classification, a key component in the sampling approach design; classification is described below. The new data inputs will be used to fill data gaps and minimize decision uncertainty.

It should not be expected that all of the Evaluation Data Inputs for the Compositional CAC will be available. For example, there may be no historical data for a structure undergoing D&D. In this case, the new data inputs take on extra importance. Conversely, historical data may be sufficient to make a decision regarding on-site disposition of the concrete and, in this case, new data will not be needed or data gathering may be limited to confirmatory sampling only. This mutual concession of one type of data for another is a key aspect of classification, which is discussed below.

Under CAC Inputs for the Physical CAC in Table II a statement is presented about the allowable size and shape of the concrete and the types and physical natures of contained-in materials. When developing CAC, this general statement should be replaced with a statement describing the specific criterion. There may be more than one CAC Input for the Physical CAC. For example, allowable size of concrete rubble and allowable length of exposed rebar may be separate CAC Inputs. Just as with the concentration limits in the Compositional CAC, the Defining Data should be stated explicitly in the CAC table or their source(s) should be referenced. The Evaluation Data Input for the Physical CAC in Table II is visual inspection and/or physical measurements. These inputs will likely serve at most sites because it is generally the visually observable and measureable physical nature of the concrete that is being considered under the Physical CAC. However, it is conceivable that other physical attributes of concrete and its contained-in material may be governed by criteria which are not verifiable by visual inspection or physical measurement.

Boundaries are another type of data input to the DQOs. Boundary information places the spatial and temporal limits on what is being addressed during the DQO process. Certain boundaries are site-specific. For example, it may be that all structures on a site are being addressed or only a portion of the site is being addressed and the temporal boundary may be the planned closure date of the site. These are important boundaries that should be stated during DQO development. However, because these types of boundaries are site-specific, they are not addressed here. Instead, the boundary discussion here focuses on a spatial boundary, concrete classification, which determines the manner in which characterization will be conducted.

Classification is a system of grouping entities based on similarities. For concrete classification the similarities by which groupings are made are how concrete compositions compare to the Compositional CAC. Concrete classification is an important, generally applicable, boundary concept that relies on the results of the data gap assessment conducted earlier in the DQO process. The primary reason for classifying concrete is to minimize characterization costs. Sampling and analysis of concrete to address the constraints of the Compositional CAC can be a time-consuming and expensive endeavor if all concrete is addressed by a characterization program whose goal is to produce sufficient data of adequate quality to make the decision on the disposition of the concrete. However, with judicious use of existing data, characterization efforts can be focused on the concrete identified in the data gap assessment as most in need of compositional information. Because concrete classification is based on compositional criteria, it does not apply to the Physical CAC.

As a simple example of the utility of classification, consider two buildings on a former nuclear site. One building has been dedicated to office space throughout its history on the site and the other building has been used for cleaning equipment which has come into contact with radionuclides. Both buildings have undergone routine radiation surveys in the interest of worker safety and several areas in the equipment cleaning building have been demarcated as being contaminated by radionuclides. No analytical data exist for either building. It is clear in this simple example that a rigorous program of sampling and analysis at the office building would be an imprudent waste of resources. On the other hand, there is clear reason to suspect that portions of the equipment cleaning facility are contaminated and sampling and analysis is needed to fill the data gaps so that the Compositional CAC can be addressed. This simple example demonstrates the emerging structure of concrete classification and, by asking the question “Where are analytical data needed?”, highlights the important role played by data gap assessments in the DQO process. The example focuses on two buildings but in applying concrete classification, portions of the same building can be classified differently if the historical data, or lack of it, support separate classifications. In practice, different classifications within the same building do not create a problem larger than the act of demolishing the building during D&D. Different classifications within the same facility will result in different levels of scrutiny, which is generally conducted before the facility is demolished. Then during demolition, the portions of the facility meeting the Compositional CAC for on-site disposition are segregated from the portions of the facility failing the Compositional CAC.

Three concrete classifications that will be applicable at almost any site are presented in Table III. It is apparent from the classification definitions in Table III that different characterization activities will be appropriate for each classification. Note that the definitions in Table III are of primary importance and have little flexibility whereas the numerical classification assignments are of little importance and highly flexible. The rationale for ordering the classifications as they are presented in Table III is that the concrete is ordered as contaminated, may be contaminated, not contaminated. Other logical orderings of numerical classification assignments are possible.

Table III. Concrete Classifications

Classification	Definition
Class 1	High degree of certainty to fail the constraints of the Compositional CAC
Class 2	High degree of uncertainty as to whether the constraints of the Compositional CAC will be met
Class 3	High degree of certainty to meet the constraints of the Compositional CAC

It is important during classification to look ahead in the DQO process in order to appreciate the implications of the three classifications. By classifying concrete as either Class 1 or Class 3 the decision for on-site disposition has essentially been made and little or no additional characterization will be required. Class 2 concrete, on the other hand, is defined by where the data gaps occur and therefore the bulk of the characterization effort and budget will be spent on Class 2 concrete. At this point in the DQO process conflict often arises between those stakeholders responsible for the budget and those responsible for public protection. For example, budget-minded stakeholders will likely look on Class 3 as the preferred classification whereas stakeholders vested with the goal of public protection will prefer Class 1 and Class 2 classifications. This is not to say that neither group recognizes the importance of the other group’s primary point of view. Instead, it should be recognized by all parties in the DQO process that historical data can be highly tractable especially when a large part of those data consist of written records, and that the classifications presented in Table III are generic enough to allow a large degree of flexibility in data interpretations. Therefore, it is important to conduct a thorough data gap assessment and to present the rationale for assigning concrete to one of the classifications in order to reach consensus among the stakeholders. In addition, each group should be aware that confirmation of Class 1 and Class 3 designations will be built into the DQOs as part of minimizing decision error.

The decision for on-site disposition will be made for all concrete, regardless of classification, based on a set of decision rules. Decision rules are matter-of-fact, if/then statements which say under what set of circumstances the concrete may be deposited on site. The decision rules for on-site disposition of concrete are built on the CAC.

In order to develop decision rules it is necessary to know at least two decision rule parameters and the relationships between those parameters; both parameters have been specified in separate, preceding steps of the DQOs and are brought together in the decision rules. The first parameter consists of one or more action levels ALs. The ALs are the Defining Data of the Data Inputs to both the Compositional and the Physical CAC (Table II). The second necessary decision rule parameter is the set of alternative actions to the principal study questions presented in Table I.

In addition to the AL and alternative action decision rule parameters, there may be other, site-specific decision rule parameters which need to be specified. For example, the unit of decision-making may need to be specified. The unit of decision-making is the area or volume over which the ALs are applied and is often included as part of the ALs. For example, risk-based soil concentration limits are typically promulgated over an area and a depth. However, if the unit of decision-making is not embedded in the AL then it needs to be stated in the corresponding decision rule.

Because the decision rules are built on the CAC, there will be a set of decision rules which address the Compositional CAC and a set which address the Physical CAC. The number of decision rules will be determined by the number of CAC Inputs; there is a one-to-one correspondence between CAC Inputs and decision rules. Following are two example decision rules, one compositional and one physical. At this point in the DQO process it is important to be very specific because decision rules are the final statements of what is acceptable for on-site disposition of concrete. After developing the decision rules the DQOs will no longer address the criteria for decision making.

Example compositional decision rule:

If the concentration of a particular chemical or radionuclide, or group of chemicals or radionuclides, does not exceed a particular value, then the concrete is acceptable for on-site disposition providing it is also acceptable under all other decision rules, otherwise, the concrete may not be left on site.

Example physical decision rule:

If a physical attribute of the concrete or its contained-in material does not exceed the limit placed on that attribute, then the concrete is acceptable for on-site disposition providing it is also acceptable under all other decision rules, otherwise the concrete may not be left on site.

In the two preceding examples several general references are made which must be replaced by specific inputs from the CAC (Table II). In the example compositional decision rule, “the concentration of a particular chemical or radionuclide, or group of chemicals or radionuclides” should be replaced with a specific CAC Input (Table II) and the general term “particular value” should be replaced with the corresponding Defining Data Input (Table II). Similar specificity should be used in all decision rules. It is important to keep in mind that it is the acceptance, concurrence, and approval of these decision rules by the decision-makers that is the primary goal of the DQO process. Through the systematic development of these rules and through the consideration of all pertinent criteria, the process yields yes/no statements which cannot be altered or ignored once the costly process of site remedial action begins.

Given the importance placed on concrete classification earlier in this section, it is interesting to note that classification is ignored in the decision rules. This is because the decision rules are applied to all concrete regardless of classification. Concrete classification reenters the DQOs in the next section where it becomes the basis around which characterization is designed for obtaining new data.

CHARACTERIZATION TO OBTAIN NEW DATA – DQO STEPS 6 AND 7

Characterization to address the Physical CAC decision rules is generally a matter of visual observation to ensure that the physical parameters of the concrete rubble and the nature and physical parameters of the contained-in materials are acceptable for on-site disposition. For the most part, characterization to address the Physical CAC decision rules can be accomplished during D&D by means of the mechanical processes by which a concrete facility is demolished and the various components of the facility are sorted for disposition. Uncertainty in the decision for on-site disposition based on the Physical CAC decision rules is of little concern because the determination of the physical parameters of the concrete is under human control.

There are two ways in which the decision for on-site disposition of concrete can be in error when addressing the Compositional CAC. The first is that uncontaminated concrete can be erroneously determined to be contaminated and sent off-site for disposition. The second way in which a decision can be in error is that contaminated concrete can be erroneously determined to be uncontaminated and left on site. In the first situation the severity of the consequences for the decision error is relatively small. There are additional sampling and analysis expenses that would not have been incurred had there been no decision error. In addition, there is a small increase in the possibility of an accident resulting from transportation and off-site disposition of concrete which in fact satisfied the CAC requirements for on-site disposition. In the second situation, on the other hand, the severity of the consequences for the decision error is potentially greater. In this case, the public may be exposed to potentially hazardous chemicals or radionuclides because concrete was determined to be acceptable for on-site disposition under the CAC when in fact it was not acceptable.

A two-tiered approach is taken toward minimizing decision error when addressing the Compositional CAC. The first tier is classification. As described above, classification is the product of a data gap assessment. During classification, evaluation of historical data identifies where existing data are reasonably sufficient to make the decision for or against on-site disposition of concrete and where data gaps must be filled in order to make the decision. Because classification is part of the DQO process, all stakeholders are provided with the historical data supporting a particular classification and have the opportunity to concur with the classification.

The second tier is characterization. Characterization activities are classification-specific therefore characterization is conducted both to fill data gaps and to support classifications which rely on existing data. Thus, three types of characterization activities, summarized in Table IV, fall out of concrete classification.

Table IV. Classification-Based Characterization Activities

Concrete Classification	Characterization Activities
Class 1	Contaminated concrete confirmation sampling and analysis and boundary definition determination if needed
Class 2	Systematic sampling and analysis to fill data gaps
Class 3	Visual inspections, field surveys, and biased sampling and analysis if needed

By virtue of its classification, it has been decided that Class 1 concrete is not suitable for on-site disposition. The severity of the consequences for an error in this decision is small and the extent of the characterization activities should also be relatively small. If the stakeholders have confidence that the data which led to the Class 1 classification were sufficient to define the nature and extent of the contamination there may be no need for additional characterization. If their confidence is not so great, then sampling and analysis to confirm the presence of contamination should be conducted followed by, or in conjunction with, characterization to define the boundaries of the contamination. Boundary definition is an important activity for minimizing the amount of concrete that needs to be sent off-site. An example of boundary definition characterization is compositing and analyzing concrete samples collected from outside the perimeter of the area of contamination to verify that the CAC ALs are not exceeded and that the concrete outside the area of contamination is acceptable for on-site disposition under the decision rules. Alternatively, if the contamination is radiological then a radiation walkover survey may be sufficient characterization for confirmation and boundary definition.

For Class 2 concrete, characterization activities are conducted to fill the identified data gaps. Unlike Class 1 and Class 3, the Class 2 classification does nothing to minimize decision error. Instead, it is left to characterization to provide the certainty that the correct decision has been made. The manner in which this is accomplished is to develop a statistically-based sampling approach which incorporates the decision error the stakeholders are willing to accept. Class 2 characterization results become the data upon which it is decided that concrete meets the constraints of the Compositional CAC and is acceptable for on-site disposition under the decision rules. Thus, based on characterization results, concrete which had originally been classified as Class 2 will be essentially reclassified as Class 1 or Class 3 or both; by the end of characterization activities there should be no more Class 2 concrete. Follow-on characterization activities may be necessary to address residual uncertainty in the new Class 1 and Class 3 concrete. However, if a proper Class 2 characterization approach is developed in the first place, there should be little decision uncertainty and follow-on characterization should not be necessary.

The Class 3 classification entails the severest consequences if an error was made during classification. Thus, the data gap analysis performed during classification must be thorough. If the classification was made based on existing data that meets the requirements of a Class 2 characterization approach then there will be little need for additional characterization. On the other hand, if the classification was based solely on records, for example, then a characterization approach designed to verify the classification would be prudent. However, because even records provide a degree of certainty, the characterization approach can usually be scaled down considerably from a Class 2 characterization. Calling on an example used earlier, if records indicate that a facility, or portion of a facility, had been devoted to office space during the lifetime of the facility then a characterization program consisting of visual inspection, radiation surveys, and biased sampling at visual and radiological anomalies is a reasonable approach to obtaining an acceptable level of certainty.

CONCLUSION

Developing acceptance criteria for the on-site disposition of concrete through the DQO process provides a systematic methodology for determining and documenting what decisions will be made and what information is necessary to support those decisions. At each step in the process, input from all individuals or organizations that have a role in making the ultimate decision must be invited. The primary goal of the DQO process is the development of a clear and defensible set of decision rules that are acceptable, unanimously agreed upon, and approved by all decision makers. By conducting the DQO process in an analytical and systematic manner, unexpected and, perhaps, costly changes to an operational program resulting from last minute second-guessing can be prevented.

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