Using the Conceptual Site Model Approach to Characterize Groundwater Quality

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ABSTRACT

To understand groundwater quality, the first step is to develop a conceptual site model (CSM) that describes the site history, describes the geology and the hydrogeology of the site, identifies potential release areas or sources, and evaluates the fate and transport of site related compounds. After the physical site setting is understood and potential release areas are identified, appropriate and representative groundwater monitoring wells may be used to evaluate groundwater quality at a site and provide a network to assess impacts from potential future releases.

To develop the CSM, the first step to understand the different requirements from each of the regulatory stakeholders. Each regulatory agency may have different approaches to site characterization and closure (i.e., different groundwater and soil remediation criteria). For example, the United States Environmental Protection Agency (EPA) and state governments have published guidance documents that proscribe the required steps and information needed to develop a CSM. The Nuclear Regulatory Commission (NRC) has a proscriptive model for the Historical Site Assessment under the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), and contains requirements for developing a conceptual site model in NUREG 1757. Federal and state agencies may also have different closure criteria for potential contaminants of concern. Understanding these differences before starting a groundwater monitoring program is important because the minimum detectable activity (MDA), lowest limit detection (LLD), and sample quantitation limit (SQL) must be low enough so that data may be evaluated under each of the programs.

After a Historical Site Assessment is completed a work plan is developed and executed to not only collect physical data that describes the geology and hydrogeology, but to also characterize the soil, groundwater, sediments, and surface water quality of each potentially impacted areas. Although the primary purpose from operations management may be to address radionuclides in groundwater, the same steps are used to assess other potential contaminates of concern. Based on past experiences, each agency (and in turn the public interest groups) appreciate the initiative of an integrated approach. Use and coordination of the file search and investigative effort to understand potential impacts from all environmental impacts (radiological and chemical) will introduce cost savings and reduce the overall schedule for future projects. Be proactive and combine the initial programs to analyze samples for all appropriate chemical and radiological constituents.

Because of the differences between the agencies, it is critical that there are ongoing discussions with all of the regulators. By developing a cohesive CSM, working together, sharing data, and being transparent during each step of the CSM development, there will

be more trust, more public support and an easier and more efficient closure process if contaminated media are identified.

The benefits of this approach include:

- Trust with the regulators and the public.
- EPA, state and NRC accepted base line evaluation.
- Representative groundwater monitoring network.
- Reduced number of points needed for long term monitoring.

This paper discusses the process of using the CSM approach for groundwater contamination with examples from a variety of NRC licensed sites.

INTRODUCTION

Characterizing groundwater quality at a site is not a simple process, but employing the Conceptual Site Model (CSM) approach provides a logical way to accomplish the task. The CSM approach uses an iterative process to compile known site history and couple it with an interpretation of available site-specific and regional data to form a picture of a site to address the following questions:

- What activities have been conducted at the Site?
- How releases have or may have occurred?
- What contaminants have or may have been released?
- What is the fate and transport of contaminants in the environment?
- What are the impacts that contaminants have or may have on human health and the environment?

The CSM approach relies on developing an understanding of the entire site picture. This includes identifying and evaluating:

- Physical site features;
- Geology;
- Hydrogeology;
- Source areas and contaminants; and
- Contaminant fate and transport.

A CSM needs to address the physical site setting, historical operations, potential migration pathways, potential receptors, and extent of impacted media. Because each site is unique, each site will have a unique CSM.

CONCEPTUAL SITE MODEL APPROACH

The CSM approach uses a logical process to develop an understanding of the site including the characterization of geology, hydrogeology and how they impact groundwater flow. The following steps comprise the CSM approach:

1. Identify stakeholders and their requirements.
2. Conduct a Historical Site Assessment (HSA).
3. Develop the initial CSM and identify data gaps.
4. Develop and implement the Characterization Work Plan.
5. Refine the CSM and identify data gaps.
6. Develop and implement Supplemental Work Plans and conduct additional site investigation (as needed) to address data gaps.
7. Validate the CSM.

Although sites may share similar designs, their unique physical setting and operating histories require unique CSMs. Application of the CSM approach is an iterative process. Each step in the process provides additional data but may introduce new data gaps. Each iteration of the CSM process provides additional building blocks to refine the CSM. By approaching the CSM systematically, the potential for misinterpreting hydrogeologic data is minimized, saving time and money.

STEP 1: IDENTIFY STAKEHOLDERS AND THEIR REQUIREMENTS

The first step in the CSM approach is to identify stakeholders and their investigation and remediation requirements. There is typically at least one regulatory agency whose requirements are the drivers to site characterization and remediation. However, in many instances multiple regulatory agencies (e.g., United States Environmental Protection Agency [USEPA], Nuclear Regulatory Commission [NRC] and state agencies) have interest in sites. Each agency may have unique cleanup criteria and different sampling approaches and/or monitoring frequencies. Other stakeholders may also have requirements that need to be considered.

It is imperative to identify the stakeholders and their requirements to make certain that the site characterization, and ultimately site remediation, that is conducted meets all the stakeholder requirements. When multiple regulatory agencies are involved, the CSM must identify each agency's characterization, remediation, and monitoring requirements to ensure that the CSM approach incorporates the requirements into each iterative step of the CSM process. This is the first step in identifying the Data Quality Objectives (DQOs). It is very important to communicate with stakeholders early in the CSM process to build a sense of teaming and a strong sense of trust and confidence between all parties.

STEP 2: CONDUCT A HISTORICAL SITE ASSESSMENT (HSA)

Perhaps one of the most important steps in the CSM process is conducting a Historical Site Assessment (HSA). The HSA includes the collection, evaluation, and documentation of existing information concerning the site and its surroundings. The HSA will begin to from the foundation of the CSM.

Activities to support completing an HSA should include (at a minimum) the following components:

- Review information on regional geology and hydrogeology.
- Review existing files and documents.
- Conduct interviews with current and past employees.
- Review historic and current operations.
- Review regulatory files (FOIA).
- Review aerial photographs and historic maps.

The HSA Report documents historic and current operations and identifies areas of known and/or potential releases of site related material to the environment; such as leaking tanks, or underground utilities.

STEP 3: DEVELOP THE INITIAL CSM AND IDENTIFY DATA GAPS

Using the information obtained during the HSA, the initial CSM is developed. The level of detail in the initial CSM is dependent upon the amount of information obtained during the HSA. The effort in this step is focused on identifying the areas of concern (AOCs); the known and potential release areas (or potential contaminant sources [PCSs]) in each AOC, and the contaminants of potential concern (CPOCs). The initial evaluation of the physical site data (water bodies, buildings, and paved areas), geology, hydrogeology, and meteorology is also completed in this step to begin for form the conceptual model of site.

Each PCS identified needs to be evaluated by considering the physical site data to begin to formulate an understanding of fate and transport of CPOCs in the environment, and the potential impacts on human health and the environment. Once the initial CSM is developed, it needs to be scrutinized to determine what data gaps exist, and how those data gaps will be addressed during Step 4.

STEP 4: DEVELOP AND IMPLEMENT THE CHARACTERIZATION WORK PLAN

Using HSA and initial CSM information the next step is to develop the Characterization Work Plan to collect data to fill the data gaps identified. The Characterization Work Plan should be focused on collecting physical (geology and hydrogeology) and characterization (soil, groundwater, surface water, and sediment) data to build the CSM. The Characterization Work Plan needs to be developed to address data gaps. This typically includes identifying the groundwater flow regimes and determining the nature and extent of contamination at each PCS.

Once the Characterization Work Plan is prepared, it should be provided to the stakeholders for review and comment prior to implementation. Including and involving the stakeholders throughout the CSM process will encourage a sense of teaming and encourage “buy-in” of the CSM.

STEP 5: REFINE THE CSM AND IDENTIFY DATA GAPS

Step 5 includes incorporating the data collected during Step 4 and completing a critical review of the CSM to identify any new data gaps. Steps 5 through 7 form the iterative steps of the CSM approach. This iterative approach allows for building blocks to be collected to complete the CSM, and enables the investigation to be focused on filling data gaps and collecting data that meets the DQOs (i.e. refine the list of analytes and the sampling locations). The CSM approach provides a logical process for collecting data to define the site conditions.

STEP 6: DEVELOP AND IMPLEMENT SUPPLEMENTAL WORK PLANS AND CONDUCT ADDITIONAL SITE INVESTIGATIONS (AS NEEDED) TO ADDRESS DATA GAPS

Step 6 is conducted as needed to address data gaps any identified in the CSM. Supplemental Work Plans are developed that focus on collecting site-specific data to provide additional building blocks to complete and strengthen the CSM, and provide a solid foundation for all stakeholders to support. Throughout the iterative CSM approach, it is important to continually involve and communicate results with stakeholders to build the team concept and address concerns as early as possible.

STEP 7: VALIDATE THE CSM

This step of the CSM approach is used to determine if the CSM accurately presents:

- The geology of the site and surroundings;
- The hydrogeology of the site and surrounds;
- The site's operating history and the extent of source areas and contaminants; and
- The fate and transport of site contaminants in the environment.

Key questions to be asked during the validation of the CSM include:

- Are the data gaps filled?
- Does the CSM make sense?
- Do the stakeholders concur with the CSM?

If the answer to these questions is yes, then the CSM is complete for the site and remedial decisions can be made.

SUMMARY

The CSM approach uses a logical process to develop an understanding of the site including the characterization of groundwater. This approach uses an iterative process to compile and document site history and couple it with an interpretation of available site-specific and regional data to form a picture of a site.

The steps of the CSM approach include:

1. Identify stakeholders and their requirements.
2. Conduct a Historical Site Assessment (HSA).

3. Develop the initial CSM and identify data gaps.
4. Develop and implement the Characterization Work Plan.
5. Refine the CSM and identify data gaps.
6. Develop and implement Supplemental Work Plans and conduct additional site investigation (as needed) to address data gaps.
7. Validate the CSM.

Including and involving the stakeholders in the CSM process will encourage a sense of teaming and encourage regulatory "buy-in" of the CSM. Documentation of the CSM process builds trust with stakeholders, and allows data gaps and question to be addressed during the process, streamlining the schedule, and reducing costs.