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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JUL 20 1993

OFFICE OF
SOLID WASTE AND EMERGENCY RESPONSE

MEMORANDUM

SUBJECT: Waste Management Area and Supplemental Well Guidance

FROM: Dev Barnes, Director
Permits and State Programs Division, OSW

Susan Bromm, Director
RCRA Enforcement Division, OWPE

TO: RCRA Branch Chiefs,
Regions I-X

Attached is the June, 1993 "Waste Management Area (WMA) and Supplemental Well (SPW) Guidance." This document is intended to provide guidance to regulators regarding the implementation of the WMA and SPW approaches of the proposed Ground-Water Amendments Rule (53 FR 28160, July 26, 1988) prior to promulgation of the final rule. We appreciate your earlier thoughtful reviews of this document.

The proposed Amendments Rule is designed to increase flexibility in the RCRA ground-water monitoring program so that monitoring systems may be tailored to site-specific conditions and designed to foster the early detection of contaminant releases. We believe that the WMA and SPW approaches will provide greater protection of human health and the environment, and that EPA can immediately implement the approaches in individual facility permits and orders under the authority of the RCRA omnibus provision (RCRA §3005(c)(3) and 40 CFR 270.32(b)(2)).

We have also included an unbound copy of the guidance so that you can easily make additional copies. If you have any questions about this guidance or the Amendment's Rule, please contact Hugh Davis at (703) 308-8633.

Attachment

cc: Dave Fagan, OSW
Ken Gigliello, OWPE
Mimi Newton, OE
Larry Starfield, OGC

WASTE MANAGEMENT AREA (WMA)

and

SUPPLEMENTAL WELL (SPW)

GUIDANCE

United States Environmental Protection Agency
Office of Solid Waste
401 M Street, S.W.
Washington, D.C. 20460

FINAL

June 1993

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OVERVIEW

EPA proposed Amendments to the RCRA Subtitle C ground-water monitoring regulations on July 26, 1988. The Agency presently is evaluating comments received from the public on the proposed rule and is developing the final rule. The proposed rule contains several provisions, including the waste management area (WMA) and the supplemental well (SPW) provisions, that are intended to increase flexibility in the RCRA ground-water monitoring program so that monitoring systems may be better tailored to site-specific conditions and designed to foster the early detection of contaminant releases. EPA believes that the WMA and SPW provisions of the proposed rule would provide greater protection of human health and the environment, and that EPA can immediately implement the WMA and SPW approaches in individual facility permits under the authority of the RCRA omnibus provision (RCRA §3005 (c)(3); 40 CFR 270.32(b)(2)). The purpose of this document is to provide guidance to RCRA permit writers and other interested parties regarding the implementation of these approaches prior to promulgation of the final rule.[1]

[1] The policies and procedures established in this document are intended solely as guidance and are not intended and cannot be relied upon to create any rights, substantive or procedural, that are enforceable by any party in litigation with the United States. EPA reserves the right to act at variance with these policies and procedures and to change them at any time without public notice.

CHAPTER 1

INTRODUCTION

1.1 Background and History of the Ground-Water Amendments Rule

The Environmental Protection Agency (EPA) first promulgated regulations governing ground-water monitoring at hazardous waste management units on July 26, 1982, under Subtitle C of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976 (RCRA), and the Hazardous and Solid Waste Amendments of 1984 (HSWA). Under these regulations (40 CFR Part 264, Subpart F), facility owners or operators are required to install ground-water monitoring systems and to sample ground water to determine whether there is a release of hazardous constituents from the facility and contamination of ground water. If contamination exceeds statistically significant levels, the owner or operator must perform compliance monitoring or implement a corrective action program in accordance with §§264.99 and 264.100.

EPA proposed Amendments to the Subpart F regulations (hereafter referred to as the "proposed rule" or "proposed Amendments Rule") on July 26, 1988. The Agency presently is evaluating comments received from the public on the proposed rule and is developing the final rule. The proposed rule is intended to increase flexibility in the RCRA ground-water monitoring program so that monitoring systems may be tailored to site-specific conditions and designed to foster the early detection of contaminant releases. The proposed Amendments Rule contains a number of provisions, including the waste management area (WMA), the supplemental well (SPW), and the unsaturated zone (USZ) provisions. The SPW and WMA provisions are the subjects of this guidance document. The Agency plans to implement these provisions in the context of individual permit decisions pursuant to the authority of the RCRA omnibus provision (RCRA §3005 (c)(3) and 40 CFR 270.32(b)(2)) prior to promulgation of the final Amendments Rule. The Office of Solid Waste currently is developing a companion guidance document for the implementation of the USZ provision.

1.2 Summary of the Multiple Waste Management Area (WMA) and Supplemental Well (SPW) Approaches

The proposed Amendments Rule contains a provision that allows for the establishment of multiple WMAs at a facility. The intent of this provision is to provide for protective point of compliance (POC) ground-water monitoring systems that can detect releases earlier, or in some cases, detect releases that may otherwise bypass a single POC monitoring system. This provision also would allow for a separate monitoring program or corrective action for each WMA at a site, thereby more efficiently focusing resources on areas with releases. The designation of a specific area within a facility as a WMA for purposes of a ground-water monitoring or corrective action program does not limit or otherwise affect EPA's corrective action authority under RCRA §§3004(u) and 3008(h), which extends to all contiguous property under the owner or operator's control.

The proposed Amendments Rule also contains the SPW provision that would allow the Regional Administrator (RA) to require the installation of wells to supplement the POC system. The intent of this provision is to allow installation of additional wells where complicated site conditions caused by hydrogeologic or contaminant characteristics could allow contaminants to migrate past or away from the POC without being detected. SPWs may function as standard ground-water monitoring wells, piezometers, or as monitoring wells designed to monitor specific hydrogeologic or contaminant conditions such as perched water tables, fractured bedrock, or nonaqueous phase liquids (NAPLs). SPWs may be necessary to improve the performance of the facility's POC ground-water monitoring system.

1.3 Overlap of the Waste Management Area and Supplemental Well Approaches

The authorities of the proposed SPW and WMA provisions may overlap in certain site-specific cases. This overlap may occur because both proposed provisions allow for extra wells in cases where releases might not be detected by conventional POC monitoring systems that are required under §264.91. [The proposed WMA provision also is intended to promote earlier detection of releases that would be detected otherwise]. In general, however, there are several distinctions between the use of the two approaches. Where only a few additional wells are necessary, or where conditions that warrant additional wells (e.g., reversal of ground-water flow caused by extreme storm surges) are infrequent, SPWs may be more appropriate. SPWs may include wells, such as piezometers, that perform functions other than standard ground-water monitoring, as would be conducted at the POC of a WMA. In cases where a large number of additional wells are needed to detect a potential release, such as from a multi-acre unit overlying complex hydrogeology, forming a WMA with an individualized monitoring program around the unit would be preferred over designating multiple SPWs. Chapters 2 and 3 of this document give additional examples of the uses of the two approaches.

1.4 Purpose of this Document

The purpose of this document is to provide guidance to RCRA permit writers and other interested parties regarding the implementation of the WMA and SPW approaches of the proposed Amendments Rule. This document will assist permit writers in defining single or multiple WMAs, and includes a description of the proposed criteria to be considered when defining WMAs. The document also provides guidance for identifying the need for SPWs, describes the difference between SPWs and POC wells, and explains the use of SPWs for corrective action. Throughout the document, real and hypothetical sites are presented as examples.

Although EPA has not yet finalized the proposed Amendments Rule, the WMA and SPW provisions of the proposed rule ensure greater protection of human health and the environment, and EPA will immediately implement these approaches in the context of individual permit decisions under the authority of the RCRA omnibus provision (§3005(c)(3) and 40 CFR 270.32(b)(2)). The final Amendments Rule, if adopted in a form similar to that proposed, would make the multiple WMA and SPW requirements more explicit and the provisions more readily implementable.

1.5 Organization of this Document

The remainder of this guidance document is organized as follows:

- Chapter 2 provides a detailed discussion of the multiple WMA approach and discusses each of the factors that should be considered when designating WMAs. Chapter 2 also describes those situations where a single WMA might be appropriate.

- Chapter 3 provides a detailed discussion of the SPW approach and describes some of the hydrogeologic settings and waste characteristics that may warrant implementation of the SPW approach. Chapter 3 also discusses the relationship between SPWs and POC wells, and discusses the use of SPWs for interim measures and corrective action.

- Chapter 4 concludes this guidance document by describing how to implement the WMA and SPW approaches.

Appendix I to this guidance document contains proposed modifications to the model permit language to be used in implementing the WMA and SPW approaches. Appendix II compares and contrasts the objectives and uses of WMAs and corrective action management units (CAMUs).

CHAPTER 2

THE MULTIPLE WASTE MANAGEMENT AREA APPROACH

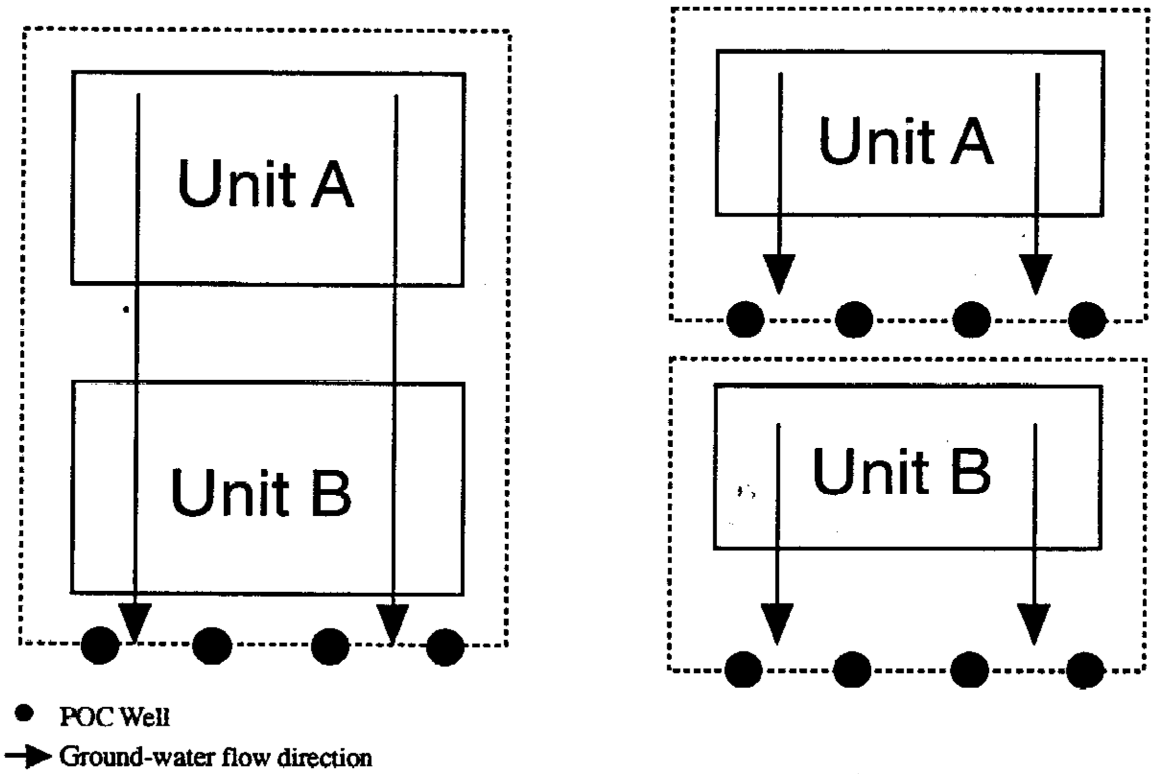
2.1 Description and Intent of the Multiple Waste Management Area Approach

For facilities that contain more than one regulated hazardous waste management unit, §264.95(b)(2) currently states that the WMA is described by an imaginary line circumscribing all of the regulated units. A point of compliance (POC) ground-water monitoring system is located at the downgradient margin of the WMA. The POC is the point at which both the ground-water protection standard must be met and monitoring must be conducted. [The POC is defined as a vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated units.] However, the current regulations establishing a single WMA for the entire facility may prevent the early detection of ground-water contamination in certain circumstances. For example, if a contaminant release occurred at the upgradient edge of a WMA, ground-water contamination would not be detected until the release migrated to a POC well. Such a scenario could result in extensive contamination of the uppermost aquifer prior to detection of the release. The WMA provision of the proposed Amendments Rule (§264.95(b)(3)) and its implementation in individual permits through the omnibus provision, is intended to provide an additional margin of safety above that provided by the existing regulations in such cases.

As depicted schematically in the following diagram, §264.95(b)(3) of the proposed Amendments Rule would allow the Regional Administrator (RA) to designate the WMA in individual permits as: (1) an imaginary line circumscribing a number of waste management units, and/or (2) imaginary lines circumscribing individual waste management units. Similarly, permit writers may require such provisions in individual permits where deemed necessary to protect human health and environment based on the omnibus authority. The multiple WMA approach would allow individual monitoring requirements to be defined at each WMA to: (1) promote ground-water monitoring and phased corrective action strategies that correspond to the magnitude of the contamination in each waste management area (e.g., one portion of the facility could be in corrective action while another portion is in detection monitoring), (2) eliminate the potential for a required response action at one unit to unnecessarily trigger a response action for all units, (3) minimize the time from when a release occurs to when it is detected, and (4) minimize the volume of aquifer potentially contaminated prior to detection of a release. The multiple WMA approach will ensure greater protection of human health and the environment and eliminate unnecessary monitoring programs or remediation measures.

Case 1: WMA is designated by an imaginary line circumscribing more than one waste management unit.

Case 2: WMAs are designated by imaginary lines circumscribing individual waste management units.



Waste management areas (WMAs) and corrective action management units (CAMUs) which are authorized by §264.552 of Subpart S, both circumscribe areas or units containing hazardous wastes or constituents. The two designations are made for different purposes, however, and are independent of one another from a regulatory standpoint. A comparison of WMAs and CAMUs is given in Appendix II of this document.

2.2 Criteria for Defining Waste Management Areas

To determine whether it is appropriate to define single or multiple WMAs, the permit writer should consider the following five factors:

1) number, spacing, and orientation of units;

2) waste types handled;

3) hydrogeologic setting;

4) site history; and

5) engineering design of units.

These criteria are summarized in Table 2-1 and are discussed in the following sections.

To select a WMA configuration that is protective of human health and the environment, the five factors should be assessed as to how they affect:

- Early detection or lack of detection of releases from the unit(s); and
- Ease or difficulty of corrective action.

2.2.1 Number, Spacing, and Orientation of Units

The number, spacing, and orientation of the waste management units may significantly affect the designation of WMAs and monitoring programs. The spatial relationship between units must be considered in conjunction with other factors such as hydrogeology and waste characteristics. The distance between regulated units may be sufficient such that releases go undetected, or are not detected promptly with a single WMA. Example 1 demonstrates how a release from an isolated waste management unit located within a larger WMA may not be detected until extensive contamination has taken place.

When the regulated units within a WMA are closely spaced, it usually will not be necessary to establish separate ground-water monitoring systems for each unit. However, in some cases, closely-spaced units should be designated as separate WMAs. For example, if the contaminants of concern are not highly mobile, the designation of separate WMAs for individual units will better provide for early detection of contaminant releases.

Table 2-1

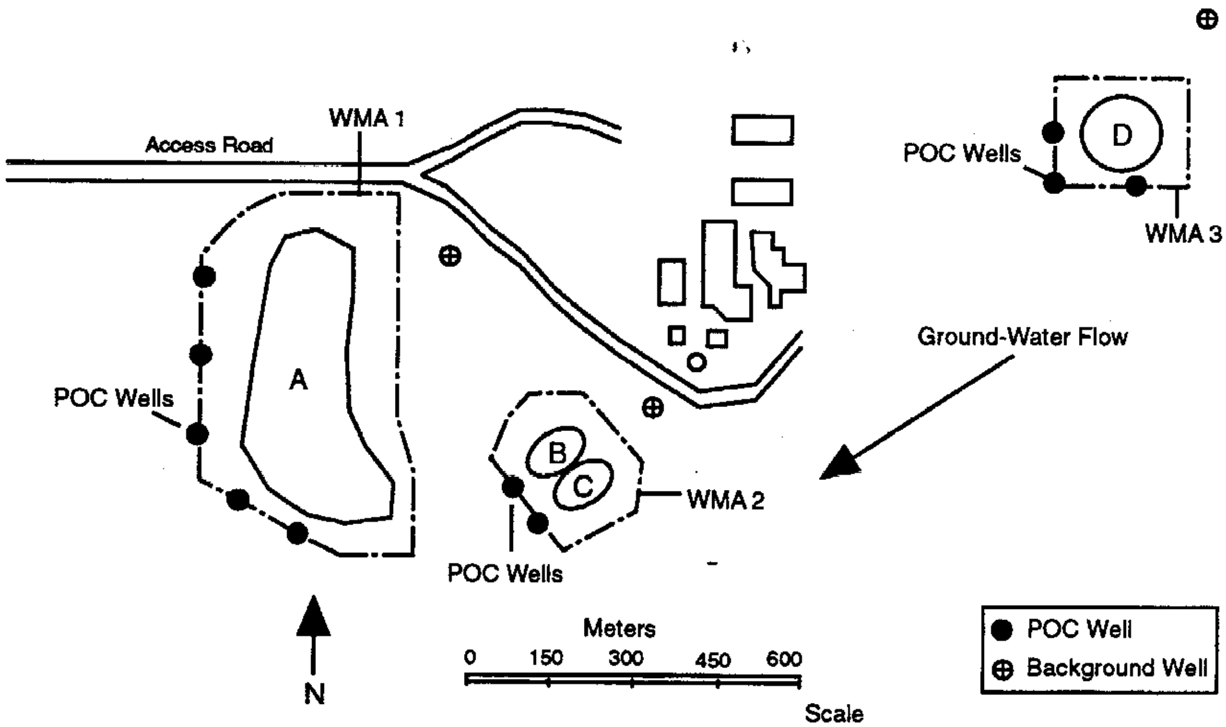
Criteria Influencing Designation of Multiple Waste Management Areas

Factor	Multiple WMAs may be appropriate if:
- Number - Spacing - Orientation of Units	● There is more than one regulated unit. ● There are great distances between units. ● Closely-spaced units are oriented such that a monitoring system for one unit may not detect releases from the other unit(s), or the source of a release cannot be distinguished.
Waste Type	● Wastes are not highly mobile. ● Wastes managed in closely-spaced units are identical. ● Nonaqueous Phase Liquids (NAPLs) are present.
Hydrogeologic Setting	● There is a ground-water divide between units. ● There is a change in geology between units that influences ground-water flow (e.g., due to stratigraphy, structure, fractures, faults, solution channels, etc.). ● A surface water body influences the hydrogeology (e.g., tidal influences, gaining/losing streams). ● Perched water zones or other preferred contaminant migration pathways are present. ● There are natural or human-induced fluctuations in ground-water flow direction
Site History	● Waste type has changed over time. ● Regulated units are located near solid waste management units (SWMUs). ● A unit has been subject to compliance monitoring or corrective action in the past.
Engineering Design	● There are buried pipes, utility trenches, etc., where a point source leak might occur. ● Type of unit is different than adjacent units. ● A unit is poorly constructed or has a high potential for failure or leakage.

WMA Example 1

Designation of Multiple Waste Management Areas Due to Significant Distance Between Units

An automotive parts assembly plant is located in the glaciated central region of the United States. The water table is approximately 30 feet below ground surface. A WMA comprised of three waste management units (Units A, B, and C) is located in the southwest portion of the site. An isolated waste management unit, Unit D, is located greater than 1,000 meters upgradient from Units A, B, and C. If all four units were included in one WMA, a release from Unit D would travel a significant distance beneath the WMA prior to detection at the POC wells. If the resulting contamination were to remain undetected for a substantial period of time, the potential for exposure to contaminants would be greater and the remediation more complex and expensive. Alternatively, the release might not migrate along a straight path towards the POC wells and might miss the POC wells and go undetected. A more protective strategy would be to designate three WMAs (WMA 1, WMA 2, and WMA 3), each with its own background well(s) to better differentiate sources of contamination, as shown in the figure below.



Finally, the orientation of the units may affect the designation of WMAs. Example 2 shows a large facility with a series of regulated units whose long axis is approximately parallel to the direction of ground-water flow. In this example, a release from the most upgradient unit would not be detected until it had migrated the entire length of the WMA. In this situation, it may be appropriate to break the WMA into two or more WMAs and to install additional POC wells to ensure more immediate detection of a release. Alternatively, supplemental monitoring wells (SPWs, discussed in Chapter 3) may be used to assure detection of a release from the upgradient regulated units. SPWs are intended to supplement POC systems that might not adequately detect releases. If only two or three wells are needed to assure the detection of a release, SPWs might be a better option than designating multiple WMAs. However, if larger numbers of wells are needed, or if corrective action of any unit is triggered, subdividing the WMA into multiple WMAs could direct resources more efficiently for monitoring and cleanup purposes.

2.2.2 Waste Type Handled

The type of waste that each unit contains or has contained in the past can affect chemical fate and transport or the likelihood of a release. These factors can influence whether units should be monitored as a single WMA, whether different types of waste require different monitoring systems or programs, or whether units or groups of units containing wastes with distinctive properties are appropriate candidates for multiple WMAs. Two of the most important factors to consider with regard to waste type include the physical state of the waste (liquid (including presence of light and dense nonaqueous phase liquids (LNAPLs and DNAPLs)), solid, sludge) and waste chemistry, including such factors as toxicity, mobility, solubility, and pH.

The physical state of the waste may influence the likelihood of a release. For example, if the a liquid waste is managed in the unit, a leak or structural failure of the unit may result in an immediate release to ground water or the unsaturated zone. Structural failure of a unit containing solid wastes may not result in contamination of ground water until infiltrating rain water mobilizes the contaminants.

WMA Example 2

Designation of Multiple WMAs Due to Orientation of Waste Management Units

A large facility located in the Atlantic Coastal Plain operates a series of surface impoundments that have been designated as a single WMA, as shown below in Figure A. The long axis of this single WMA is parallel to the direction of ground-water flow. If a release from the most upgradient impoundment occurred, the release would not be detected until it had migrated the entire length of the WMA to the POC wells. In addition, small changes in the ground-water flow direction might cause a release to remain undetected as it migrated to the side of the POC wells. In this situation, dividing the existing WMA into two or more WMAs as indicated in Figure B would have been more protective of human health and the environment.

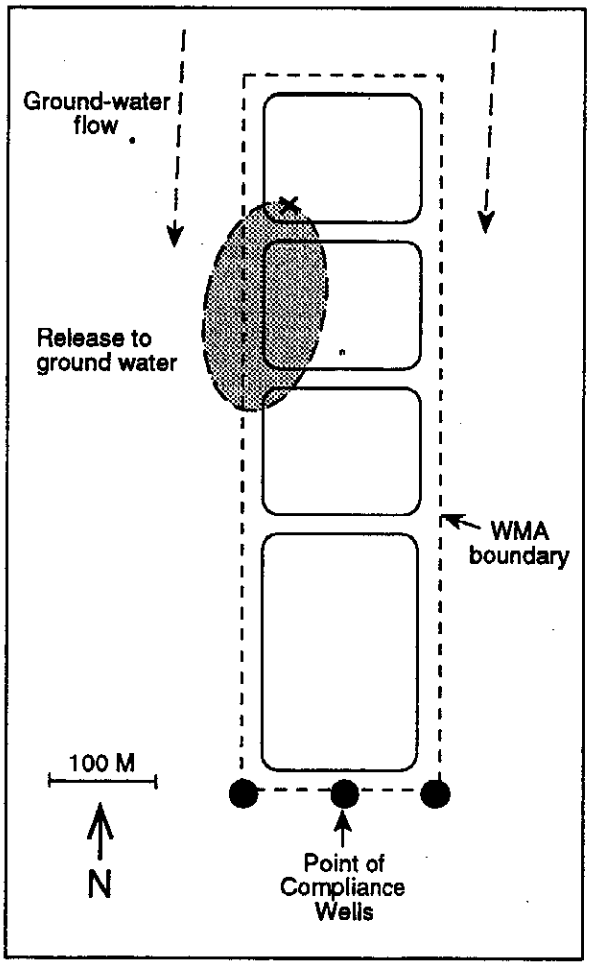


Figure A

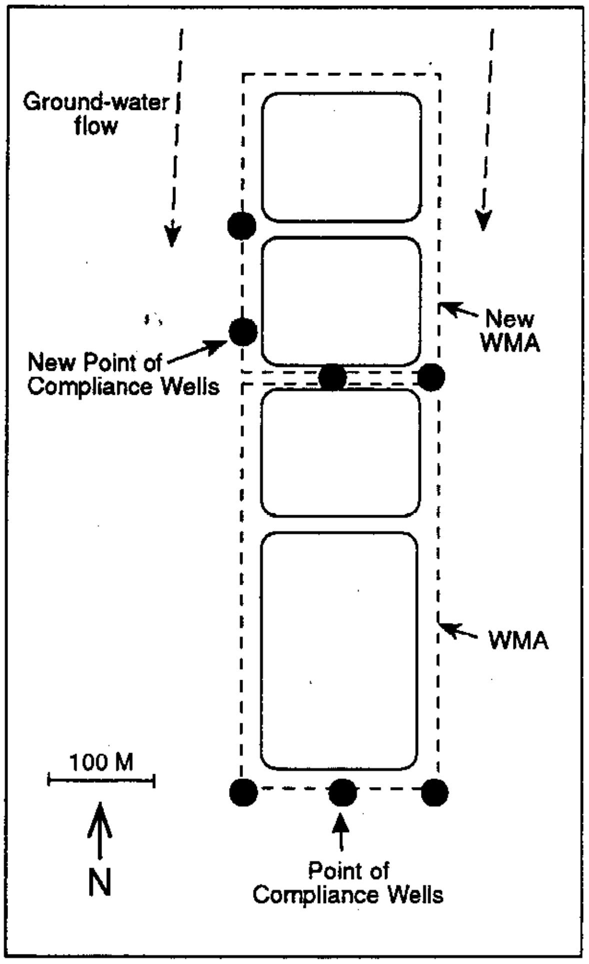


Figure B

Waste chemistry also should be considered in designating WMAs. For example, highly soluble or mobile contaminants might be readily detected with a single ground-water monitoring system monitoring a multi-unit WMA, whereas less mobile contaminants may be released into the subsurface for a long period of time before they are detected. Thus, at sites where there are multiple units containing relatively immobile constituents, a multiple WMA designation may facilitate the detection of a release prior to extensive subsurface contamination. Factors such as pH, hardness of ground water, and organic matter content can affect the mobility of certain metals. For example, at high pH and in oxidizing conditions, trivalent chromium can convert to hexavalent chromium, which is a more mobile and toxic form.

LNAPLs and DNAPLs are particularly difficult to remediate and may require unique monitoring systems. Units with the potential to release LNAPLs or DNAPLs should be considered candidates for designation as single WMAs so that a sufficiently protective ground-water monitoring program can be implemented. NAPLs are discussed further in Section 3.4 of this document.

It may be possible to differentiate between releases from multiple units within a single WMA if waste types differ significantly among units. In such a situation, multiple WMAs may not be needed, since a release may be readily attributable to the unit containing the constituents present in the release.

2.2.3 Hydrogeologic Setting

The hydrogeologic setting of a facility strongly influences the potential transport and migration of contaminants once a release has occurred. The permit writer should evaluate flow net and conceptual geologic/hydrogeologic models to determine if appropriate zones are being monitored and if the horizontal and vertical placement of the wells is sufficiently protective. If different or complex hydrogeologic settings exist at a facility, it might be more protective to establish multiple WMAs at the facility. Key elements of the hydrogeologic setting that may influence the need to designate multiple WMAs include:

- Depth to ground water;
- Perched water tables;
- Lateral and vertical changes in natural water chemistry;
- Geologic structures;
- Ground-water flow directions, gradients, and rates; and
- Waste management unit effects.

The SPW approach (discussed in Chapter 3 of this document) also may be applied at sites with varied or complex hydrogeologic settings. The SPW approach is intended to allow for the placement of additional wells when the existing POC wells might not detect releases. SPWs can be used for the same purposes as POC wells, or may be specialized wells (e.g., for monitoring intermittent perched water tables) or simple piezometers. If few additional wells are needed, SPWs may be an appropriate complement to the POC well system. However, if a large number of additional wells are needed, the designation of an additional WMA with its own monitoring program may be the most appropriate response.

Ground-Water Flow Directions, Gradients, and Rates

Ground-water flow directions, gradients, and rates may be the most significant hydrogeologic factors affecting the designation of multiple waste management units. The permit writer should evaluate flow nets and potentiometric surface maps submitted by the owner/operator to assess the presence of ground-water divides, the potential effects of nearby surface water bodies (e.g., ponds, lakes, gaining or losing streams, oceans), seasonal or tidal affects on the water table elevations and hydraulic gradients, effects of pumping of nearby water supply wells (e.g., local public, facility, or agricultural supply wells), and the presence of steep downward or upward hydraulic gradients, or other gradients, such as radial flow from human-made ponds. In certain cases, potentiometric surface maps must be constructed from measurements made during periods of potential change in ground-water flow direction, such as during seasonal agricultural pumping or during high or low tides, in order to detect complex or variable flow directions.

Example 3 shows how the presence of a ground-water divide at a facility may affect the designation of WMAs. Example 4 shows how the presence of a surface water body at a facility can affect the designation of WMAs. Example 5 demonstrates how the use of multiple WMAs may enhance detection of releases at a site with strong downward hydraulic gradients.

Depth to Ground Water

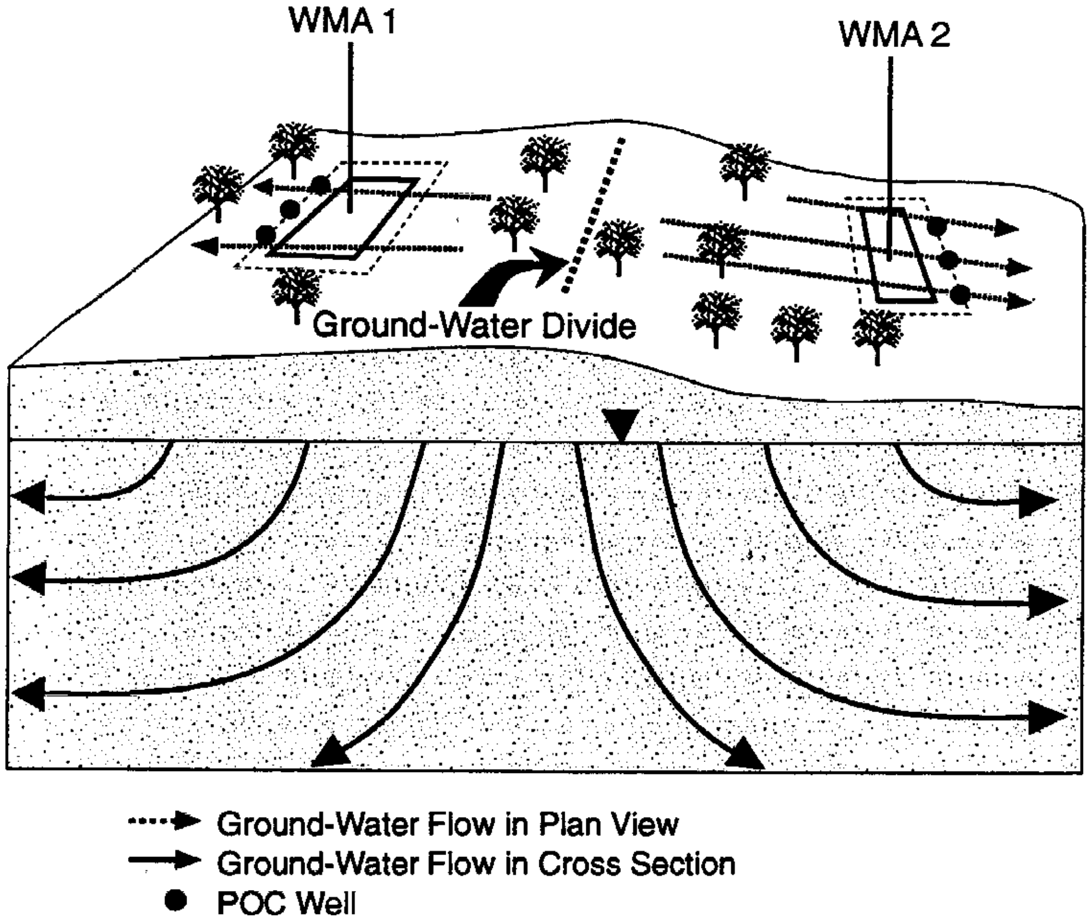
Depth to the saturated zone, when considered with the characteristics of the geologic material beneath the regulated units, can have a substantial influence on the potential migration of contaminants released to ground water. The thickness and transport characteristics of the unsaturated zone (used synonymously with "vadose zone" in this document), as well as the contaminant characteristics, influence the potential for contaminant migration to ground water. If depth to ground water is shallow, a release from the unit may result in an immediate release to ground water. However, even with great depths to the saturated zone, contaminants released in sufficient quantity also can migrate to the water table. In certain situations, such as when depth to the saturated zone is great, monitoring of the unsaturated zone may enable detection of releases prior to extensive contamination of the subsurface. The proposed Amendments Rule contains a provision to allow for unsaturated zone monitoring at hazardous waste sites. The Office of Solid Waste currently is developing a document to provide guidance on the design and implementation of unsaturated zone monitoring systems. Additional information and guidance on unsaturated zone characterization and monitoring can be found in Permit Guidance Manual on Unsaturated Zone Monitoring for Hazardous Waste Land Treatment Units (USEPA, 1986) and Monitoring In the Vadose Zone: A Review of Technical Elements and Methods (USEPA, 1980).

If depth to ground water is great, the permit writer should evaluate the potential for monitoring perched water tables. The importance of monitoring perched water is discussed in the following subsection.

WMA Example 3

Designation of WMAs in the Vicinity of a Ground-Water Divide

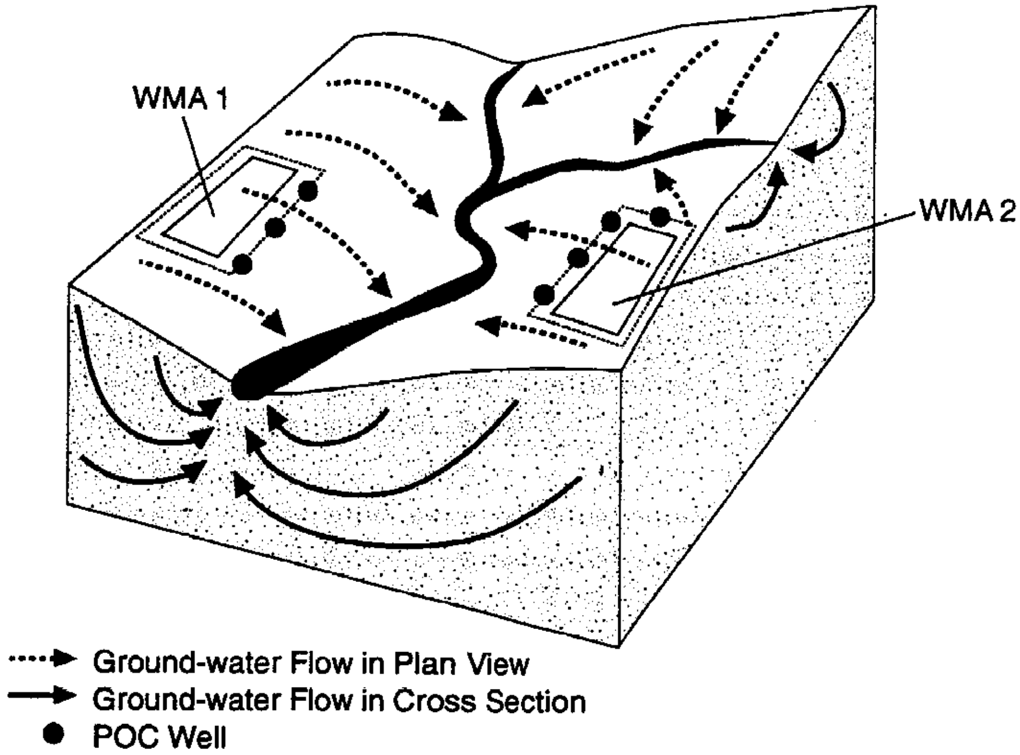
A facility located in the nonglaciated central region of the U.S. is positioned over a ground-water divide as shown in the figure below. In this example, the presence of the ground-water divide affects the appropriate designation of WMAs. Although closely-spaced, WMA 1 requires POC wells located on the west side of the WMA, while WMA 2 requires POC wells located on the east side of the WMA.



WMA Example 4

Effect of Surface Water Body and Ground-Water Flow Direction on Designation of WMAs

A pesticide manufacturing facility manages sludge in two waste management units. Ground-water flow in the uppermost aquifer at the facility is towards a stream, which bisects the site. The waste management units are located on either side of the stream. In this situation, it is appropriate to designate two WMAs as shown in the figure below to detect releases from each waste management unit.

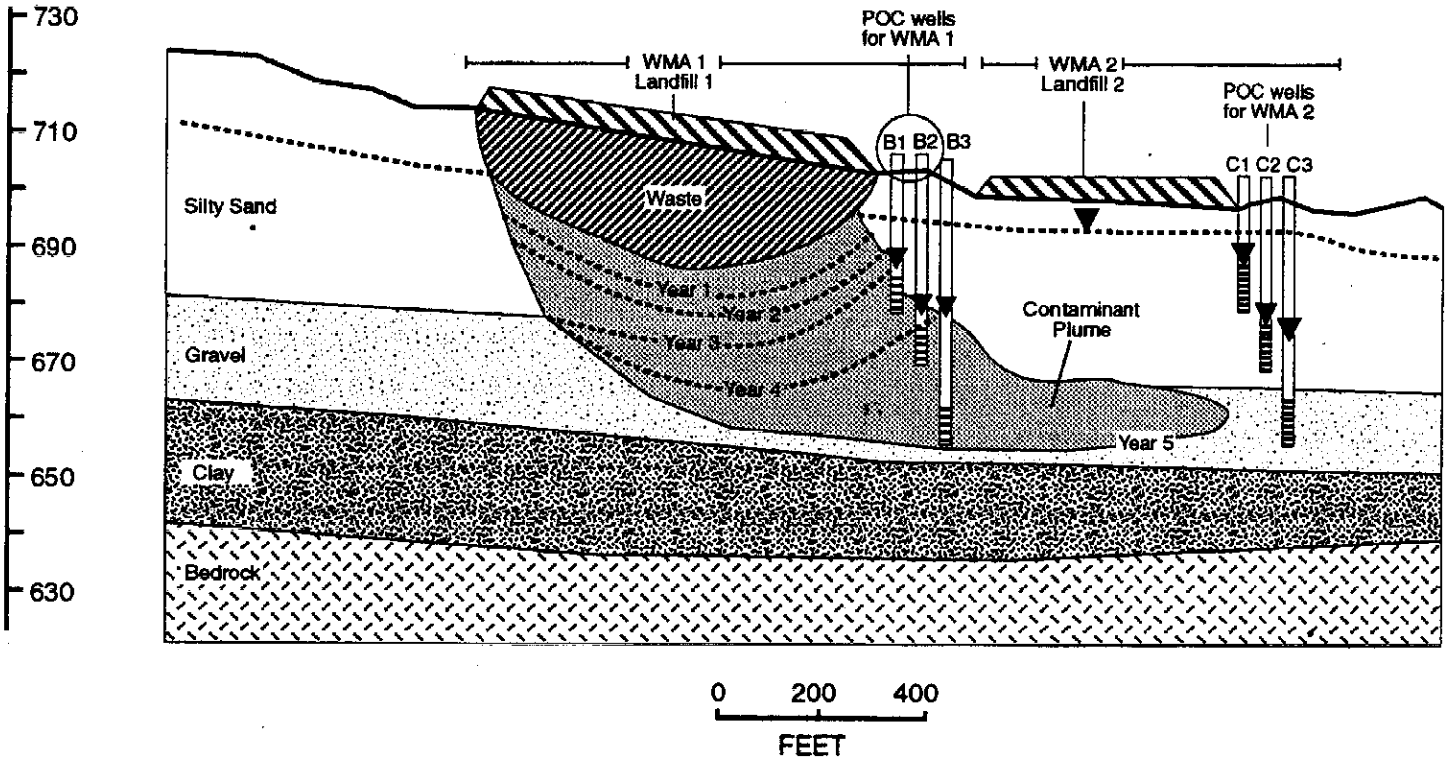


(Modified from Heath, 1982)

WMA Example 5

Effect of High Downward Gradients on Designation of WMAs

A pharmaceutical manufacturing facility manages fly ash in two landfills. A hydrogeologic investigation of the facility indicated that a strong downward hydraulic gradient is present in a silty sand unit with a relatively low horizontal hydraulic conductivity that underlies the landfills. In this scenario, monitoring the uppermost aquifer at wells C1, C2, and C3 would not detect a release from Landfill 1 for many years, and thus would not be protective of human health and the environment. The hydrogeologic conditions at this facility make it necessary to designate two WMAs as shown in the figure and to install POC wells at the downgradient margin of each WMA.



(Modified from Sara, 1991)

Perched Water Tables

In more complex unsaturated zone environments, perched water tables may be present. These discontinuous saturated lenses may act as conduits or migration pathways for contaminants released from a waste management unit. A perched zone may develop on lower hydraulic conductivity lenses or within lenses or layers of higher hydraulic conductivity. A perched zone can be seasonal as it is recharged by precipitation events or by a fluctuating water table. Ground-water flow in a perched zone might not follow the local ground-water flow direction. Because of these complexities, separate ground-water monitoring strategies are often needed for perched water tables. A waste management unit or group of units overlying zones of perched water may be designated as a single WMA.

Lateral and Vertical Changes in Natural Water Chemistry

Lateral and vertical changes in sediment and rock type across a facility can influence the natural ground-water chemistry and consequently are important factors that must be considered in the designation of WMAs. Current EPA guidance (RCRA Ground-Water Monitoring: Draft Technical Guidance, 1992) suggests that the owner/operator screen background and POC monitoring wells in equivalent stratigraphic horizons to obtain comparable ground-water quality data. In cases where the geology is complex, it may be necessary to designate multiple WMAs so that background and POC wells are hydraulically connected.

Geologic Structures

Geologic structures can have a significant impact on ground-water movement by acting as preferential flow paths or by acting as barriers or conduits for ground-water flow. Examples of structures that may influence ground-water movement and direction include faults, fractures, and folded or dipping formations.

Steeply dipping alternating formations of differing hydraulic conductivities can cause preferential movement of ground water along the strike of the geologic units with higher hydraulic conductivities. Changes in structural characteristics can result in variations in the direction of ground-water movement at a single site.

Faults may serve as either conduits or as barriers to ground-water movement. If the fault zone consists of finely ground rock and clay, the material may have a very low hydraulic conductivity (e.g., less than 1 x 10^{-6}cm/s) resulting in significant differences in water level across the fault. If a fault that acts as a barrier to ground-water movement transects a multi-unit WMA, it may be appropriate to designate separate WMAs for the hydrogeologically distinct areas on each side of the fault.

Waste Management Unit Effects

The presence of a waste management unit (e.g., a landfill) can affect ground-water flow under and adjacent to the unit. For example, the compaction of the clay subgrade and any overlying clay liners during landfill construction can have a temporary effect (estimated six months to five or more years) on the potentiometric surface, producing a depression in the water table. In other materials, such as silts, surface loading caused by the landfill, especially the embankments, produces consolidation of the underlying sediment. This consolidation may increase the capillarity of the sediment and result in mounding of the ground water beneath the unit.

Because the owner/operator is required to make an annual determination of ground-water flow direction and rate (including construction of potentiometric surface maps), the permit writer should assess on an ongoing basis whether the effects of waste management units on ground-water flow are sufficient to require a modification of WMAs.

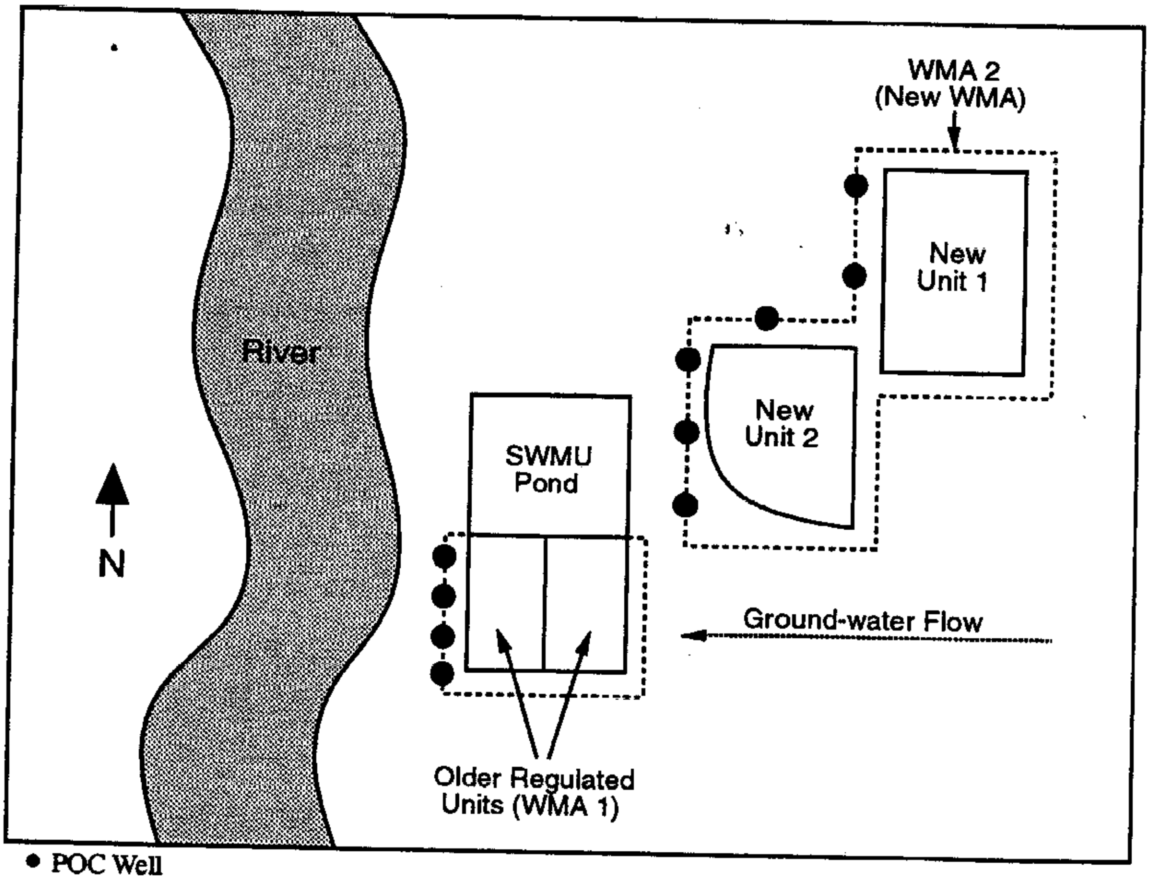
2.2.4 Site History

Historical operating practices at a facility may influence the present-day ground-water monitoring regime. Changes in waste management activities and in waste types handled, the historical or current presence of other solid waste management units (SWMUs), and any associated remedial actions taking place may influence the need for designating multiple WMAs. Example 6 provides an illustration of a facility at which site history influenced the designation of a new WMA.

WMA Example 6

Influence of Site History on the Designation of Multiple WMAs

A facility located in the Blue Ridge Region of the eastern United States is located on thick, layered river deposits. Ground-water flow is to the west, towards a river. The site includes an older SWMU that has contributed to ground-water contamination and is adjacent to two regulated waste management units (currently managed as a single WMA, WMA 1). The two regulated units are in compliance monitoring. Two new state-of-the-art regulated units (New Unit 1 and New Unit 2) are to be constructed upgradient of the older units. In this example, it is appropriate to delineate a new WMA, WMA 2, solely to monitor the new waste management units. If all four regulated units were designated as one WMA with the same POC wells, all the units would be in compliance monitoring, as Subpart F regulations require all regulated units in a WMA to be under the same monitoring program.



2.2.5 Engineering Design of Units

The nature and design of each unit, including any associated engineered structures and ancillary equipment, should be considered in the designation of WMAs. For example, if a unit is poorly constructed or has a high potential for failure or leakage, the permit writer should consider monitoring the unit as a single WMA. Key factors to consider when evaluating engineering design aspects of waste management units are:

- Type of unit (e.g., landfill, surface impoundment, or waste pile);
- Size of units or WMAs; and
- Potential point sources of contaminant releases.

The type of unit and its design can affect its potential for release and the appropriateness of its designation as a WMA. For example, construction materials for liners of surface impoundments can vary from clay to state-of-the-art double liners with leachate collection systems.

The size of a waste management unit also may be a significant factor when considered along with the geology and hydrogeology beneath the unit. If the hydrogeologic setting changes beneath a unit, the most protective strategy for the unit may be designating it as a single WMA with an individual ground-water monitoring system. See Section 2.2.3 of this guidance for a discussion of hydrogeologic factors influencing the designation of WMAs.

Point source contaminant releases can occur where ancillary equipment such as buried pipes and utility trenches are located. Failure of a waste management unit can occur due to age of the unit, poor design, proximity to a hill or slope, or excessive liquid pressure in a pipe or containment vessel. The potential for point source contaminant releases or unit failure should be considered during the designation of WMAs.

2.3 New, Replacement, or Expansion Units

If a new, replacement, or expansion unit is built adjacent to an existing unit, it may be appropriate to incorporate the additional unit into the WMA of the existing unit, thus expanding the WMA overall. If the additional unit is downgradient of the existing unit, the POC for a new combined WMA could be at the hydraulically downgradient limit of the additional unit. The original POC wells at the existing unit could become informational wells and would no longer be subject to POC well monitoring requirements. If old POC wells must be decommissioned, as in the case of expansion of an existing unit, they must be decommissioned properly (American Water Works Association, 1988). If the new unit is upgradient of the existing unit, either the POC for the new combined WMA would remain the same, or it would be necessary to create a new WMA. In both cases, it might be necessary to install new upgradient wells.

2.4 Situations Where A Single WMA Is Appropriate

Many facilities will not require the designation of multiple WMAs to ensure adequate protection of human health and the environment. Four examples of where the designation of a single WMA generally is appropriate include:

1. When units are closely spaced and designating multiple WMAs offers neither significant increase in protection to human health and the environment, nor earlier detection of a release;

2. When units contain unique types of waste. It is easy to identify the source of release by correlating the type of contamination with the waste contained in each unit;

3. When several units are located over materials with high hydraulic conductivity, such as unconsolidated beach sand, and detection of a release would not be subject to an unacceptable delay; and

4. When a small number of wells is needed for additional protection, or the event that necessitates additional wells is infrequent, and SPWs are added (for further discussion, see Section 1.3).

CHAPTER 3

THE SUPPLEMENTAL MONITORING WELL APPROACH

3.1 Description and Intent of the Supplemental Well Approach

The proposed Amendments Rule would modify §264.95(a)(2) to allow the Regional Administrator (RA) to require installation of supplemental wells (SPWs) where complicated site conditions caused by hydrogeology or contaminant characteristics could allow contaminants to move past or away from the point of compliance (POC) without detection. Similarly, under the authority of the omnibus provision (RCRA §3005(c)(3) and 40 CFR 270.32(b)(2)), the RA may require such provisions in permits or orders where deemed necessary to protect human health and the environment. Monitoring the uppermost aquifer at the POC will continue to be the primary component of the Subpart F ground-water monitoring program. However, in certain cases, SPWs may be necessary to improve the performance of the facility's POC ground-water monitoring system to protect human health and the environment.

SPWs are intended to serve multiple purposes and, by definition, are supplemental to the wells required by the RA at the POC. SPWs may function as standard ground-water monitoring wells, piezometers, or monitoring wells designed to monitor specific hydrogeologic or contaminant conditions such as perched water tables, fractured bedrock, or nonaqueous phase liquids (NAPLs). In addition, it may be necessary in some cases for the RA to modify the location, number, and depth of monitoring wells at the POC. For example, if SPWs are needed where contamination could bypass POC wells without detection, the RA may remove the POC well(s) from the monitoring program.

3.2 Defining the Need for Supplemental Monitoring Wells

SPWs may be designated by the RA in cases where site conditions might allow contaminants to migrate past or away from the POC without being detected. The need for SPWs must be determined after considering the site hydrogeology, waste and contaminant characteristics, and the POC monitoring well system. The information used to determine whether SPWs are necessary and to designate SPWs will include existing site characterization data and any other available hydrogeologic studies. The need for SPWs can be evaluated during the permitting process or following subsequent ground-water monitoring (Chapter 4).

In general, as site hydrogeology increases in complexity, and as sites increase in size or number of units, the need for SPWs will be greater. The following sections (3.3 and 3.4) describe several hydrogeologic settings and waste characteristics which may warrant the use of SPWs. Each section includes real and hypothetical case studies. These case studies do not include all possible uses of SPWs, but provide examples of likely scenarios that would result in contaminant releases going undetected without the use of SPWs.

3.3 Hydrogeologic Site Conditions That Might Require Supplemental Monitoring Wells

The hydrogeologic characteristics of a site control the movement of ground water and contaminants. Consequently, the design of the monitoring system and the need for SPWs should take into consideration the hydrogeologic characteristics of a site, such as:

- The subsurface materials below the owner/operator's hazardous waste facility, including:
    - The lateral and vertical extent of the uppermost aquifer;
    - The lateral and vertical extent of upper and lower confining units/layers;
    - The geology at the owner/operator's facility (e.g., stratigraphy, lithology, structural setting); and
    - The chemical properties of the uppermost aquifer and its confining layers relative to local ground-water chemistry and hazardous waste managed at the facility;
- Ground-water flow below the owner/operator's hazardous waste facility, including:
    - The vertical and horizontal directions of ground-water flow in the uppermost aquifer;
    - The vertical and horizontal hydraulic gradient(s) in the uppermost aquifer;

- The hydraulic conductivities of the materials that comprise the uppermost aquifer and its confining units/layers; and
- The average linear horizontal velocity of ground-water flow in the uppermost aquifer.

If geologic units beneath a site are discontinuous, exhibit variations in thickness and/or dip, are highly fractured, or contain conduits, hydraulic conductivity and hydraulic gradients may exhibit frequent and significant variations across a site. Natural and human-induced factors such as fluctuating water levels in nearby surface water bodies and on- or off-site pumping wells also may influence hydraulic gradients and ground-water flow directions.

If a hydrogeologic investigation indicates the existence of such complex hydrogeologic conditions, careful consideration must be given to the need for SPWs to assure the detection of contaminant releases that might not be intercepted by POC wells. The more common types of complex hydrogeologic settings that may require SPWs include:

- Zones of high hydraulic conductivity;
- Presence of fractures and fracture flow;
- Perched water tables;
- Presence of conduits and conduit flow in karst terrains;
- Dipping geologic units;
- Strong vertical gradients;
- Natural fluctuations in ground-water flow direction; and
- Human-induced fluctuations in ground-water flow direction.

The following sections provide a discussion of each of these complex hydrogeologic settings.

3.3.1 Zones of High Hydraulic Conductivity

In geologic formations consisting of units or zones of largely different hydraulic conductivities, ground water generally flows toward, and preferentially migrates in, the zones with higher hydraulic conductivity. Examples of higher hydraulic conductivity zones contained within lower hydraulic conductivity formations include:

- Buried river or stream channels;
- Buried bedrock valleys;
- Fill materials; and
- Buried glacial deposits (e.g., eskers, kames, outwash).

Zones of high hydraulic conductivity located in lower hydraulic conductivity materials may effectively direct contaminant migration away from POC wells, causing a release to go undetected. As shown in Example 1, SPWs can be located in zones of higher hydraulic conductivity to ensure that a contaminant release will be detected.

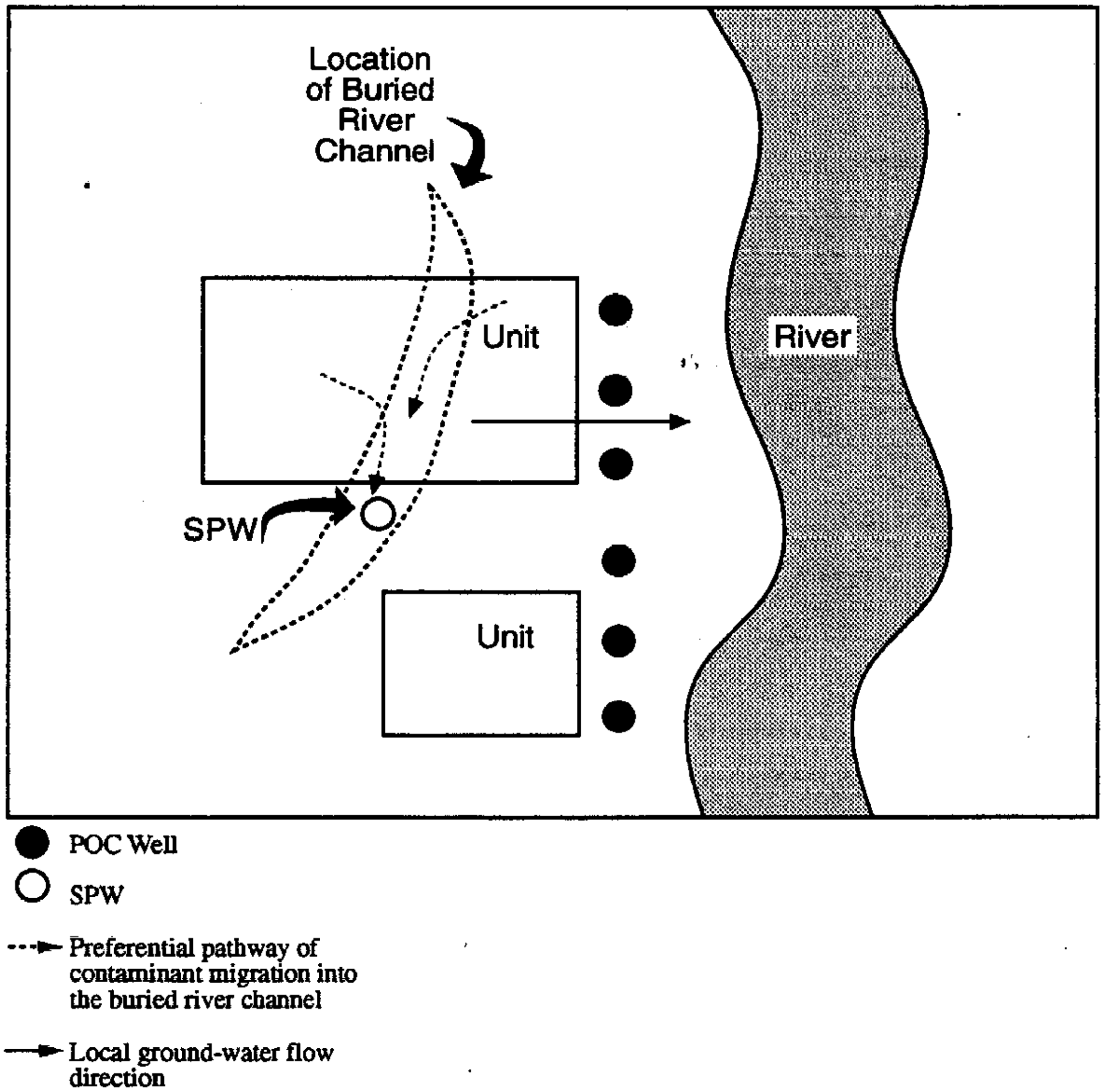
3.3.2 Fractures and Fracture Flow

The migration of contaminants in ground water can be controlled by the orientation, density, and connectivity of fractures or faults in bedrock (e.g., shale, limestone, granite). Fractures can increase the hydraulic conductivity of otherwise "impermeable" bedrock and may provide a conduit or preferential pathway for contaminant migration. If monitoring wells have been installed without consideration of the location of fractures and the direction of fracture flow, contaminants might migrate past the POC without being detected. Although regional flow patterns are generally established during site investigations, flow through fractures is often difficult to predict. Facilities overlying fractured bedrock require additional investigative techniques (e.g., fracture trace analysis, detailed geologic mapping, geophysical investigations, fracture analysis of cores, pump tests to assess anisotropy) to adequately determine ground-water flow pathways and to design a protective ground-water monitoring system. Example 2 illustrates the use of SPWs in areas where contaminants might migrate within bedrock fractures.

SPW Example 1

Zones of High Hydraulic Conductivity

The figure below depicts a geologic setting where ground-water flow under a waste management unit is affected by a buried river channel. The hydraulic conductivity of the channel deposit is significantly greater than the surrounding geologic materials and provides a preferential pathway for ground-water flow and contaminant migration. The ground-water flow direction under the waste management unit is complex, with flow lines on the left side of the unit converging towards the buried channel, because it has high hydraulic conductivity. A SPW was placed within the buried channel to detect releases that could potentially migrate down the channel deposits away from the POC wells.

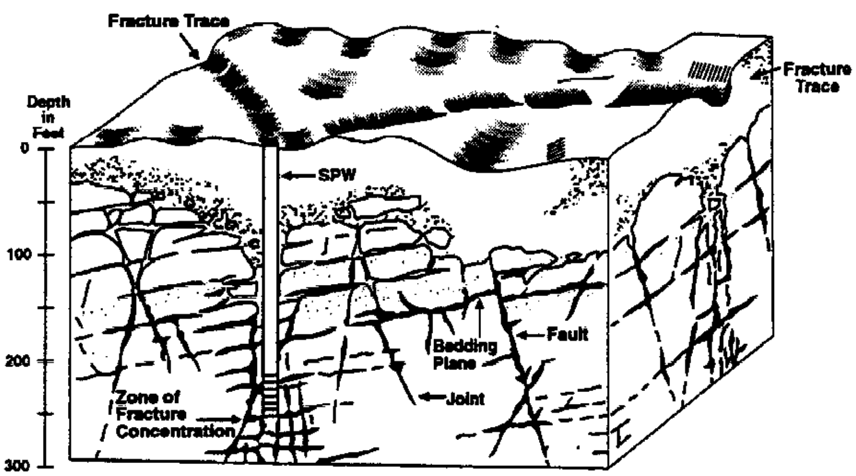


SPW Example 2

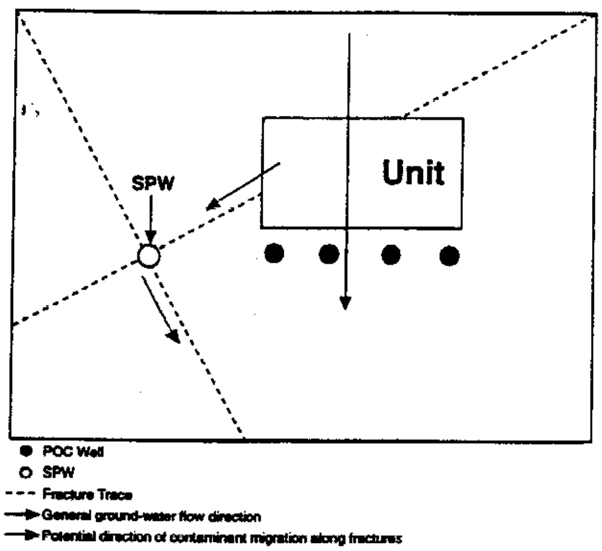
Supplemental Wells to Monitor Contaminant Migration in Fractures

At a RCRA facility located in Tennessee, contaminants were released into fractured bedrock. The bedrock is made up of highly faulted and jointed siltstones, shales, and limestones with complex ground-water flow that is difficult to monitor. The facility performed a fracture trace analysis, drilled soil borings, and performed surface and borehole geophysical investigations to determine the probable locations of subsurface fracture zones that might act as preferential pathways of contaminant migration from the unit. Because the studies revealed that the POC wells were not located in subsurface fracture zones, a SPW was installed at the intersection of two identified fracture traces to intercept a release that might not be detected by the POC wells, as depicted in the plan view below. The cross section depicts the subsurface in the vicinity of the SPW.

CROSS SECTION



PLAN VIEW



(Modified from USEPA, 1991)

3.3.3 Perched Water Tables

Geologic formations consisting of interbedded lenses or units of sand and silt or clay may contain lower hydraulic conductivity lenses that create perched water tables. In some cases, perched zones have not been considered part of the uppermost aquifer, and have not been monitored by Subpart F POC wells. Nevertheless, these zones of saturation may be hydraulically connected to the uppermost aquifer (on a permanent or intermittent basis), and may provide a primary pathway for contaminants to migrate past the POC. Permit writers may need to require SPWs in perched tables to detect releases that migrate past the POC wells undetected. In addition, if perched conditions cause a release to enter the aquifer downgradient of the POC wells, SPWs may be installed in the aquifer downgradient of the compliance wells. Example 3 illustrates a situation where SPWs have been used to detect contaminant migration in perched water tables.

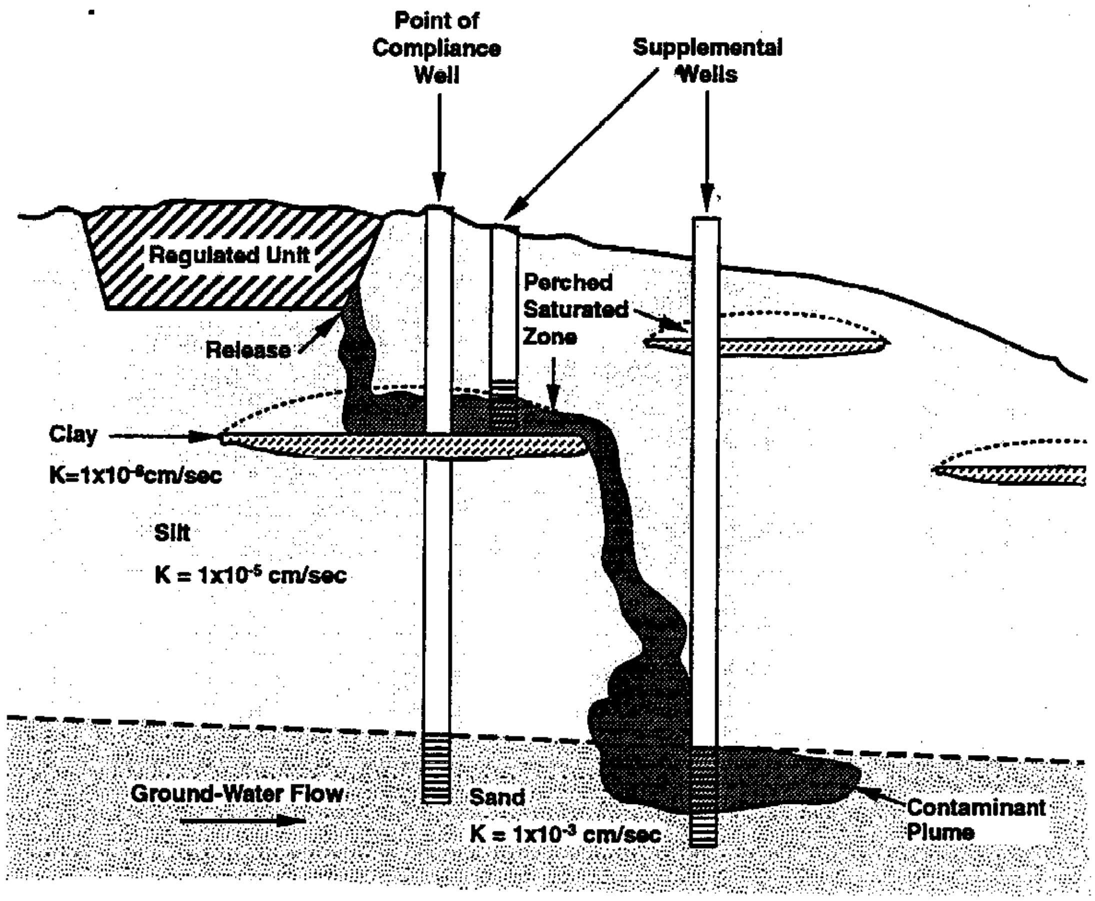
3.3.4 Conduits and Conduit Flow in Karst Terrains

In aquifers in karst terrains dominated by conduit flow, contaminant releases primarily migrate through subsurface conduits. The placement of POC wells in aquifers dominated by conduit flow is rarely effective. Conduits often drain to springs which discharge on land or along surface water bodies. Early and reliable detection of contaminant releases in many karst settings can be performed only at springs and caves, which are commonly outside the boundary of the facility. EPA recommends the monitoring of seeps, springs, and cave streams to supplement POC monitoring well systems in aquifers dominated by conduit flow. Springs and cave streams with proven hydraulic connections to a facility (e.g., as demonstrated by tracer studies) are the easiest and most reliable sites at which to monitor ground-water quality in terrains where conduit flow predominates (Field, 1988; Quinlan, 1989; Quinlan, 1990). A discussion of the sample frequency in aquifers dominated by conduit flow is given in the November 1992 RCRA Ground-Water Monitoring: Draft Technical Guidance (pages 5-18 through 5-21). Example 4 illustrates the use of supplemental monitoring points at off-site springs in a karst area.

SPW Example 3

Intermittent or Perched Water Tables

At a chemical manufacturing facility in West Virginia, POC wells were installed at the downgradient limit of a regulated waste management unit containing filter press sludge. The POC wells were screened in the uppermost aquifer, a well-sorted sand. Ground water perched on clay lenses within an overlying silt layer served as an additional pathway of contaminant migration from the unit. A number of borings were drilled to define the horizontal extent of potentially low hydraulic conductivity zones above the uppermost aquifer. Geologic cross-sections helped identify potential zones of perched water. To ensure that contaminant migration within the perched zones would be monitored, SPWs were screened in the perched zones. SPWs were also screened in the uppermost aquifer at locations downgradient from the POC wells to detect releases that might migrate past the POC wells along unidentified perched zones. A schematic cross-section of the subsurface hydrogeology and the placement of the SPWs is shown in the figure below.



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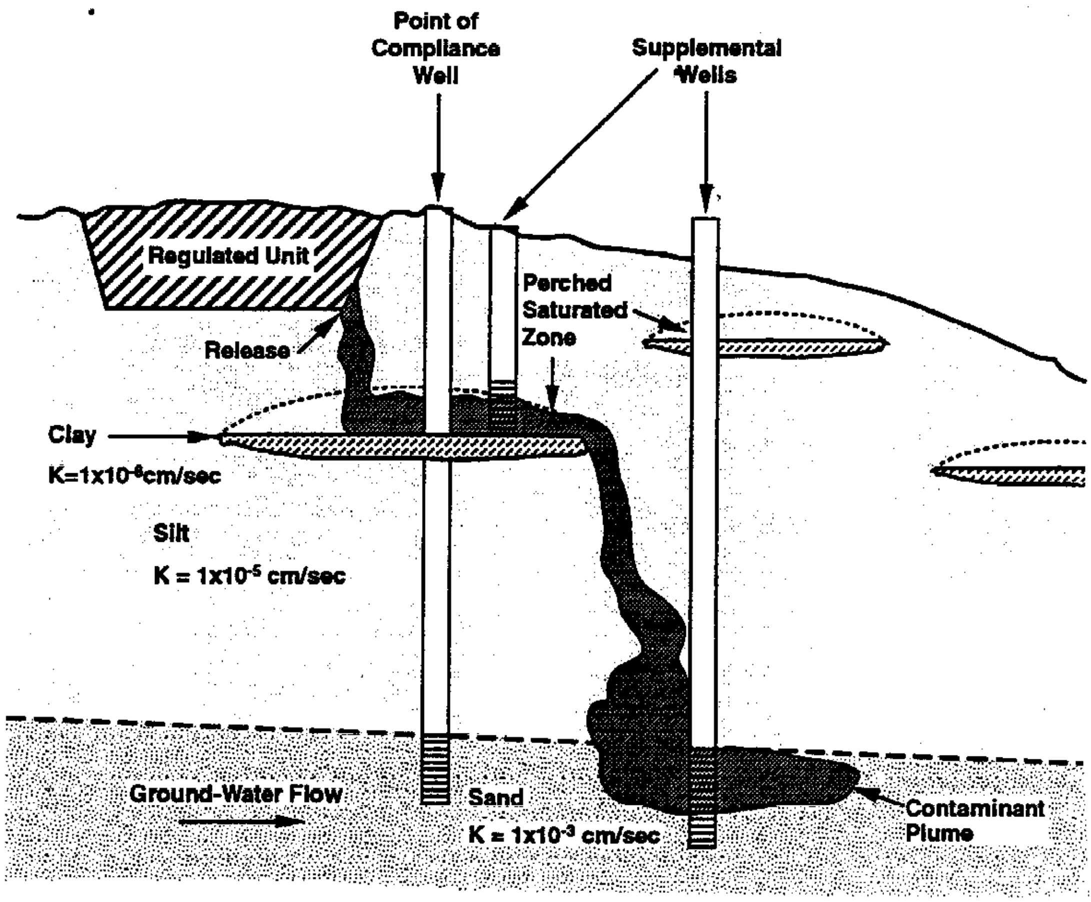
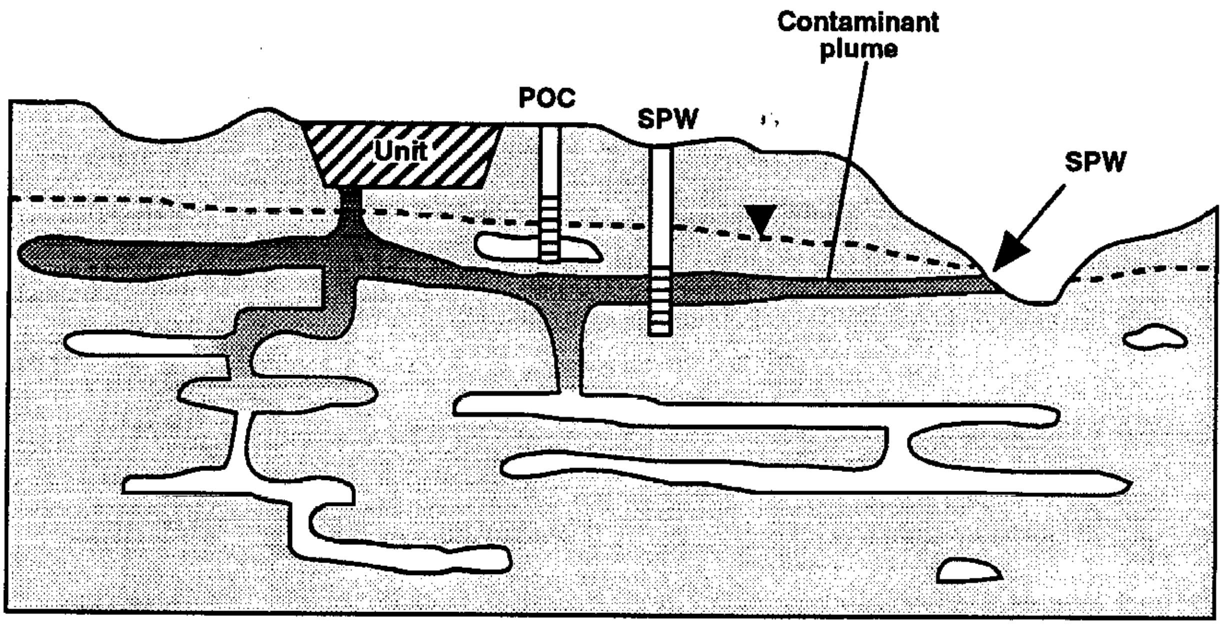


SPW Example 4

Supplemental Monitoring Points in Karst Terrains

The figure below is an example of a site that is located in a karst terrain where ground-water flow is predominantly through conduits. Monitoring wells installed at the POC may not intercept conduits that are hydraulically connected with the hazardous waste management unit, even though the POC wells are located more closely to the unit than off-site springs. Through dye tracing, investigators can determine if there is a hydraulic connection between the waste management unit and local springs. The permit writer can require a monitoring program for hydraulically connected springs that will aid in the detection of a release from the waste management unit. In some cases, it also may be possible to locate SPWs in conduits that are hydraulically connected to the waste management unit.



3.3.5 Dipping Geologic Units

In settings where interbedded geologic units of differing hydraulic conductivities exhibit structural or stratigraphic dip, ground-water flow can occur in the down-dip direction or along strike in one or more of the geologic units. As a result, ground-water flow in dipping geologic units can be locally complex and might not be in the direction of regional ground-water flow. Consequently, dipping geologic units may create a preferential pathway for contaminant migration past the POC.

3.3.6 Strong Vertical Gradients

Strong vertical gradients can cause ground water to take long or complex flow paths that are difficult to monitor with standard POC monitoring systems. Monitoring wells must be placed to reflect both the horizontal and the vertical components of flow. In Example 5, an upper unit has a strong downward gradient with a small westward flow component. This westward flow defines the downgradient side in the upper unit from a standard POC perspective. In contrast, flow in the connected underlying unit is primarily horizontal, and to the east, in the opposite direction. SPWs can be used in conjunction with POC wells to monitor both zones of the uppermost aquifer.

3.3.7 Natural Fluctuations in Ground-Water Flow Direction

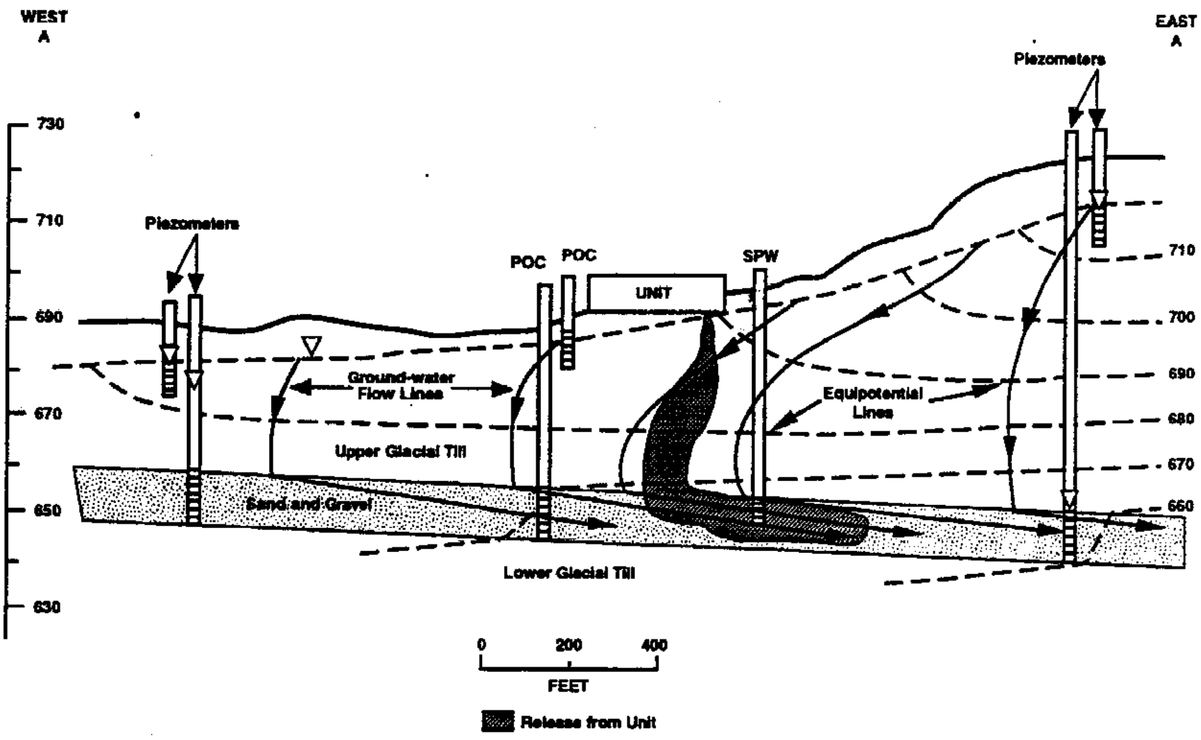
Natural fluctuations in ground-water flow direction may result from tidal or riverine influences, changes in recharge rates, seasonal effects, or precipitation events. SPWs may be necessary in areas where natural fluctuations in water level elevations are suspected to cause variations in ground-water flow directions that might result in contaminant migration past the POC. Example 6 illustrates the placement of SPWs for waste management units that are influenced by lake levels.

Permit writers also may consider imposing additional WMAs to provide a more protective monitoring system in settings where reversals in ground-water flow direction occur. This approach would allow for the waste management unit in Example 6 to be a

SPW Example 5

Complex Flow With a Strong Vertical Gradient

In the figure below, an upper flat-lying glacial till is hydraulically connected to a lower sand and gravel unit that constitutes a regional aquifer. Ground-water flow in the upper till unit is to the west and has a strong downward gradient. In the lower sand and gravel unit however, ground-water flow is to the east. Consequently, POC wells installed at the downgradient limit (the western boundary) of the WMA in the upper till unit would be ineffective in intercepting a contaminant release migrating downward to the lower sand and gravel unit. Accordingly, SPWs should be installed in the sand and gravel unit on the eastern side of the waste management unit (the upgradient side of the waste management unit in the till). Alternatively, if the unit were designated as a single WMA, standard POC wells monitoring the uppermost aquifer could be installed on both sides of the WMA.

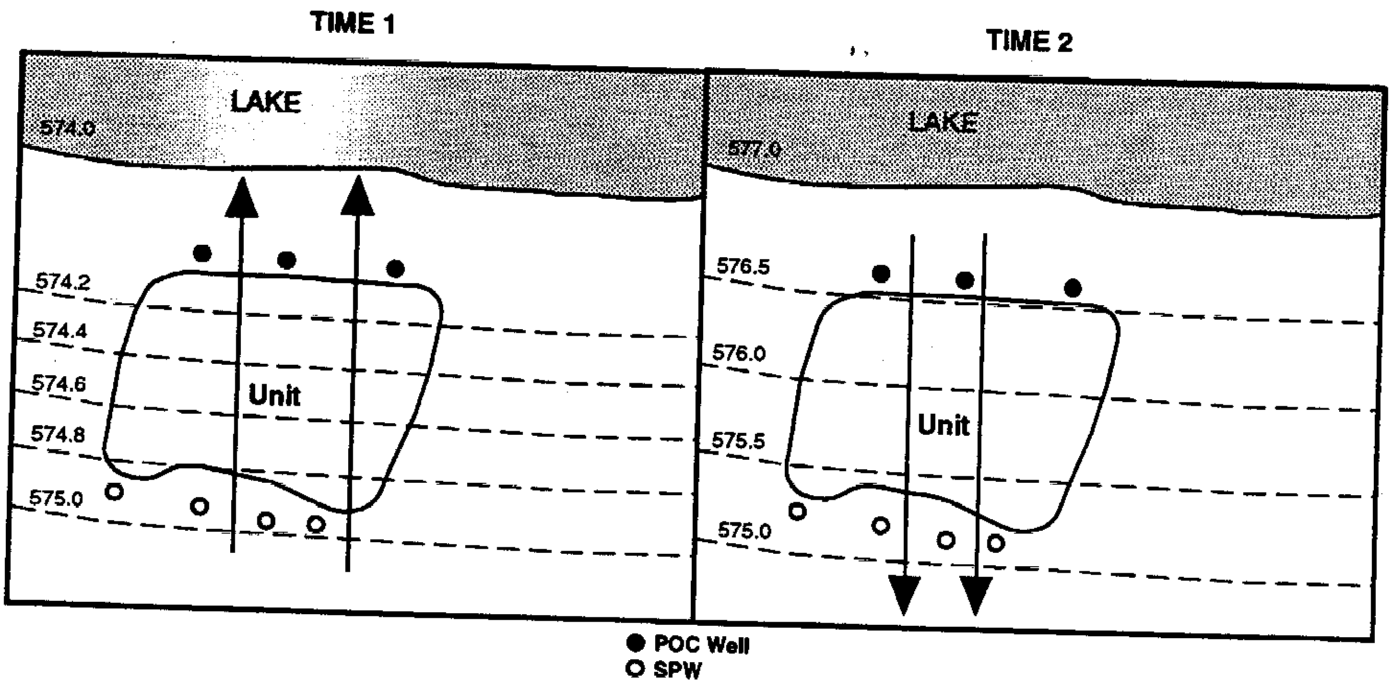


(Modified from Sara, 1991)

SPW Example 6

Fluctuation in Ground-Water Flow Direction Caused by a Surface Water Body

Natural fluctuations in ground-water flow directions may result from fluctuating water levels in nearby surface water bodies, including lakes, rivers, estuaries, and oceans. A facility in northern New York provides an example of how fluctuating lake levels can result in a reversal of ground-water flow direction, particularly in areas where the hydraulic gradient is very low. Water levels measured at Time 1 indicate ground-water flow towards the lake, which is the prevalent ground-water flow direction. Water levels measured at Time 2, however, indicate ground-water discharge from the lake that results in a complete reversal of ground-water flow direction. Depending on the magnitude and frequency of such reversals, it may be necessary to install SPWs to detect contaminant releases in the alternate ground-water flow direction. The permit could be structured, for example, to require monitoring of the SPWs only during high lake levels. Alternatively, if the reversals are frequent, the unit could be designated as a WMA and all the wells could be designated as POC wells.. Similar natural fluctuations in ground-water flow direction may be caused by seasonal fluctuations in the water table or by major precipitation events.



separate WMA, and for POC wells to surround the periphery of the unit. This option may be preferred where the fluctuations in ground-water flow are frequent, such as might occur under tidally influenced conditions. If flow reversals are infrequent, SPWs may be more appropriate. For example, the monitoring requirements for SPWs might be only to sample when the lake level reaches a certain critical height that generates flow reversals. Chapter 2 of this document discusses the designation of additional WMAs.

3.3.8 Human-Induced Fluctuations in Ground-Water Flow Direction

Various human activities can alter ground-water flow directions at a site either on a continuous or intermittent basis. These activities include:

- On- or off-site pumping wells;
- Artificial recharge;
- Irrigation; and
- Changes in land use patterns (e.g., paving, construction).

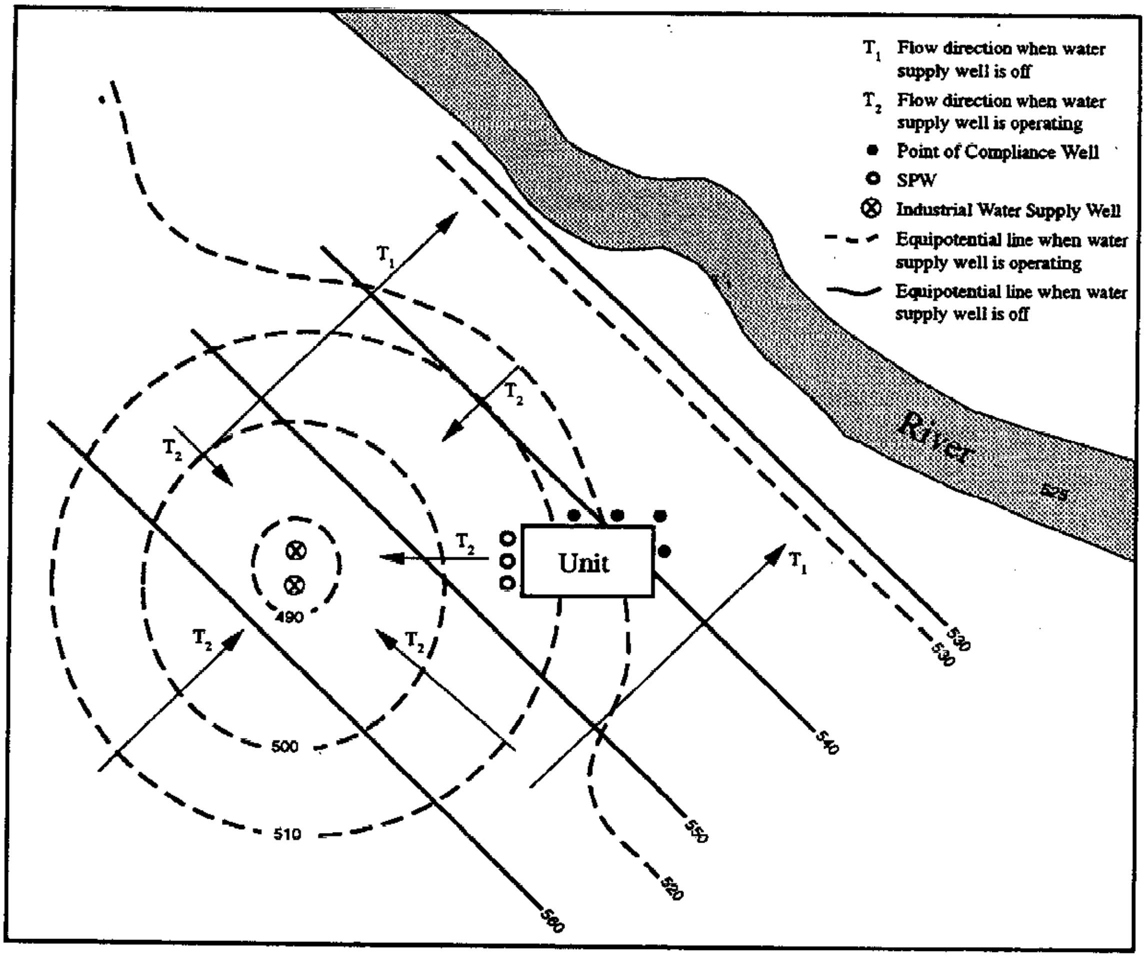
If artificially-induced temporal changes in ground-water flow direction are occurring or are suspected to occur, SPWs should be installed to monitor for contaminant releases when ground-water flow is not in the typically downgradient direction. Example 7 illustrates the use of SPWs for a waste management unit where ground-water flow is influenced by pumping wells. Careful consideration should be given to the need for additional background monitoring wells under conditions where flow direction varies (discussed further in Section 3.5.2).

As discussed in Section 1.3, the authorities of the proposed WMA and SPW provisions overlap because both provisions allow for extra wells in cases where releases might not be detected by POC systems. When changes in flow direction are regular or frequent, the multiple WMA approach may be implemented more appropriately for installing wells that monitor the POC. However, if as in Example 7, where production wells that cause a local flow reversal are used infrequently, SPWs are more appropriate.

SPW Example 7

Fluctuation in Ground-Water Flow Direction Caused by Pumping Wells

Human-induced fluctuations in ground-water flow direction may be produced by pumping wells located near a site, as shown in the figure below. The pumping wells at this facility are only operated certain times of the year for specific batch processes. The pumping wells produce a cone of depression in the water table and cause ground water to flow radially towards the pumping wells. A pumping well can produce either temporal or continual local and regional changes in ground-water flow direction, depending on the magnitude of drawdown at the pumping well, the operating schedule of the well, and aquifer characteristics (hydraulic conductivity, recharge, etc.). Under these conditions, SPWs may be required to detect contaminant releases flowing towards the pumping wells and away from the POC as illustrated below.



3.4 Presence of Nonaqueous Phase Liquids (NAPLs)

Permit writers should carefully consider how the characteristics of wastes and contaminants present at a site may influence their migration such that they might migrate past the POC undetected. In particular, waste management units that contain NAPLs may be candidates for SPWs. This section discusses the migration of NAPLs and provides examples that describe how SPWs may be used to detect NAPLs.

NAPLs are liquids that have low solubilities in water and densities that may be greater than or less than that of water. NAPLs have distinctive properties that govern their fate and transport and may prevent the early detection of contaminant releases or result in contaminant migration past the POC. Therefore, when contaminants that have the potential to exist as NAPLs are present in facility wastes, the need for SPWs to detect their release should be considered.

NAPLs are typically divided into two general categories: Light nonaqueous phase liquids (LNAPLs), which have a specific gravity less than water, and dense nonaqueous phase liquids (DNAPLs), which are denser than water. Most LNAPLs are hydrocarbon oils and fuels. Most DNAPLs are highly chlorinated hydrocarbons (e.g., carbon tetrachloride, tetrachloroethylene, and PCBs). Identifying whether or not a compound exists as an DNAPL or an LNAPL can be complicated by the substance in which it is dissolved. For example, free phase PCBs may be denser than water (DNAPL), but PCBs in oil can be transported as an LNAPL. Additional information on NAPL migration is provided by USEPA (1989), USEPA (1991) and Huling and Weaver (1991).

If wastes at a site contain contaminants that potentially exist as LNAPLs, it may be necessary to install SPWs at the water table to prevent contaminants from migrating past the POC wells undetected. SPWs for monitoring LNAPLs should be screened at the water table and the screened interval should intercept the water table at its minimum and maximum elevation as determined from historical water level data. LNAPLs may become trapped in residual form in the vadose zone and become periodically remobilized and contribute further to aquifer contamination, either as free phase or dissolved phase contaminants, as the water table fluctuates and precipitation infiltrates the subsurface.

The migration of free-phase DNAPLs may be primarily influenced by the geology, rather than the hydrogeology, of the site. That is, DNAPLs migrate downward through the saturated zone because their density is greater than that of water, and then migrate by gravity along less permeable geologic units (e.g., sloping confining units, sloping clay lenses in more permeable strata, or bedrock troughs). Consequently, if wastes disposed at the site are anticipated to exist in the subsurface as a DNAPL, the potential DNAPL should be monitored:

- At the "base" of an aquifer (immediately above a major confining layer);
- In structural depressions (e.g., bedrock troughs) in lower hydraulic conductivity geologic units that act as confining layers;
- Along lower hydraulic conductivity lenses within units of higher hydraulic conductivity;
- "Down-dip" of lower hydraulic conductivity units that act as confining layers, both upgradient and downgradient of the WMA; and
- In higher conductivity lenses or within fractures.

Because of the nature of DNAPL migration (i.e., along structural or stratigraphic trends, rather than along hydraulic gradients), SPWs installed to monitor DNAPLs might need to be installed both upgradient and downgradient of the WMA. It may be useful to construct a structure contour map of lower hydraulic conductivity strata and identify lower hydraulic conductivity lenses, both upgradient and downgradient of the unit, along which DNAPLs may migrate, and locate SPWs accordingly. The reader is cautioned however, that the fate and transport of free phase DNAPL is very complex, and cannot be covered in sufficient detail in this document. Huling and Weaver (1991) provide a useful explanation (with additional references) of the properties and behavior of DNAPLs in the subsurface.

Although NAPLs are frequently described as "immiscible" based on the physical interface that exists between a mixture of NAPLs and water, certain compounds found in NAPLs can dissolve into water in concentrations that are harmful to human health and the environment. Free phase DNAPL trapped in intergranular pore spaces or existing as pools or pockets can "bleed" off low but harmful levels of dissolved contaminants that can contaminate large volumes of water over decades or longer. The dissolved constituents from LNAPL and DNAPL contamination will migrate in the direction of ground-water flow in the same fashion as other dissolved constituents. Consequently, dissolved phase LNAPL and DNAPL plumes can be detected downgradient of WMAs in POC wells (an exception exists when a NAPL is diverted by structural or stratigraphic features so that it comes into contact with the water table downgradient of POC wells, as is illustrated in Example 8). However, free phase LNAPLs and DNAPLs may not be detected by POC wells, and may create an additional dissolved phase that is not detected by POC wells. Example 8 illustrates the use of SPWs to monitor DNAPL migration in shallow sand lenses. Example 9 illustrates the use of SPWs at one site to monitor for both LNAPLs and DNAPLs.

3.5 Relationship Between SPWs and Point of Compliance (POC) Wells

3.5.1 Can Supplemental Monitoring Wells be Used for the Same Purpose as Point of Compliance Wells?

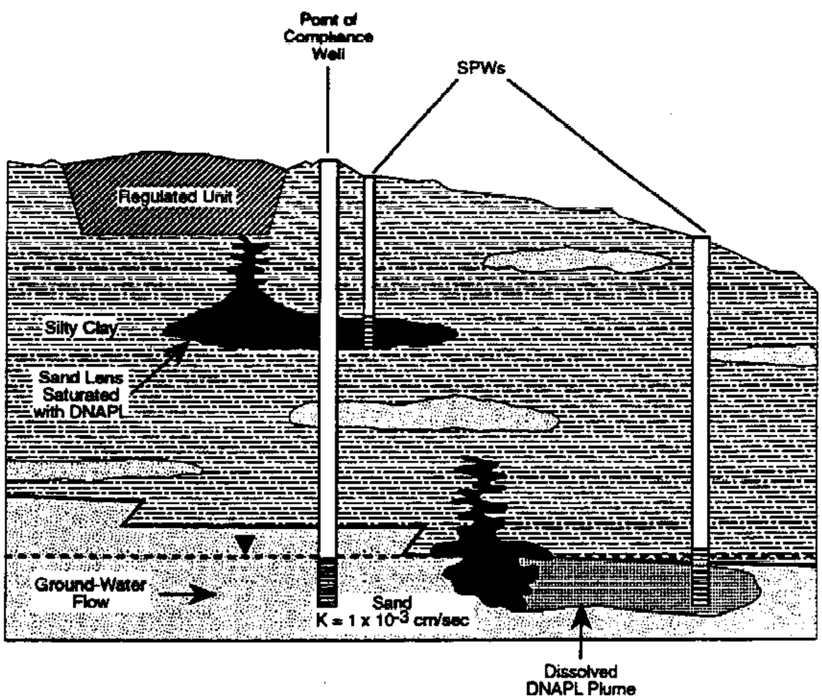
The monitoring requirements for POC wells may be applied to SPWs when necessary to protect human health and the environment. In certain cases, the overseeing Agency would determine that wells at the POC may not require monitoring or may require a modified monitoring program if SPWs provide better information on potential contaminant releases. Ground-water monitoring systems at RCRA facilities are intended to be tailored to the specific site characteristics and contaminants expected at a facility; as more ground-water data and site characterization data are gathered, more appropriate monitoring locations could be identified.

SPW Example 8

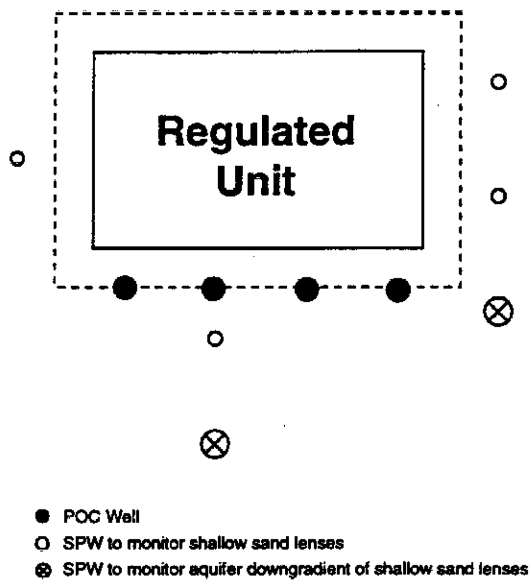
Supplemental Wells Used to Monitor DNAPL in Shallow Sand Lenses

This example is based on a case study of a wood preserving facility located in the Upper Coastal Plain in South Carolina. The geologic setting is characterized by an upper silty clay unit that overlies a sand unit. DNAPL has migrated along grain-size discontinuities and in sand lenses within the unsaturated zone of the upper silty clay unit. In some areas, shallow sand lenses encountered during drilling contain DNAPL, while adjacent over and underlying silty clays contain no DNAPL. Moreover, the shallow sand lenses have promoted DNAPL migration laterally from the unit, and away from POC wells. Therefore, suction lysimeters were installed as SPWs to monitor for DNAPL migration in the shallow sand lenses. [Note that most published diagrams depict DNAPL pooling on top of low permeability lenses, rather than contained within high permeability lenses, as is the case at this actual site. DNAPL fate and transport in the vadose zone can be very complex and is a function of a number of factors, including degree of saturation, entry pressure of DNAPL, pore configuration, viscosity of DNAPL, and other factors.] SPWs also were installed in the uppermost aquifer to detect potential dissolved phase contamination emanating from DNAPL.

CROSS SECTION



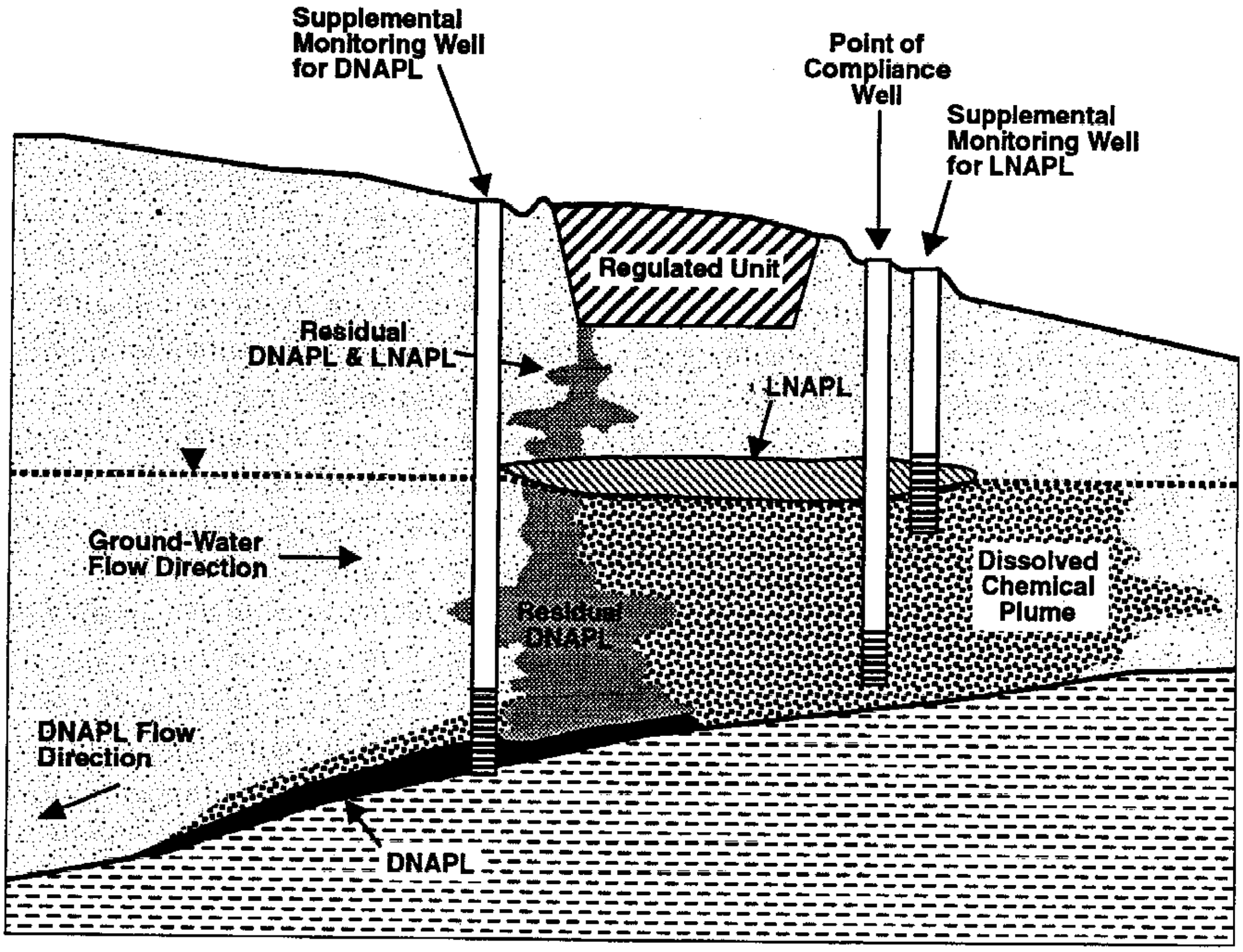
PLAN VIEW



SPW Example 9

Supplemental Wells Used to Monitor LNAPL and DNAPL Plumes

This example is based on a case study of a chemical manufacturing facility in Texas. LNAPL, DNAPL, and dissolved phase contaminants have been detected in ground water at the site. The migration of the dissolved contaminant and LNAPL plumes is in the opposite direction of DNAPL migration. The DNAPL plume has migrated down dip along the boundary of a confining layer, and occurs at a depth of approximately 60 feet, despite a generally upward vertical hydraulic gradient. SPWs have been installed specifically to detect the LNAPL and DNAPL plumes.



3.5.2 What is the Relationship Between Supplemental Monitoring Wells and Background Monitoring Wells?

Background wells installed as part of the ground-water monitoring system under §264.97(a)(1) are not considered SPWs. However, in certain instances, SPWs may be designated under the omnibus authority in addition to the required background wells to obtain supplemental information regarding background or upgradient conditions at a site. For example, a SPW piezometer may be installed to measure upgradient water-level changes that are induced by intermittent pumping of agricultural wells.

Many of the site-specific hydrogeological complexities that warrant the use of SPWs also will make background wells difficult to place. For example, at sites with locally complex flow paths, such as might be caused by fractured and folded bedrock, determining hydraulically connected upgradient locations will require thorough site investigation. In all cases where SPWs are determined necessary, an assessment of the adequacy of existing background wells, and the need for additional wells should be made.

3.6 The Use of SPWs for Interim Measures and Corrective Action

3.6.1 What if Supplemental Monitoring Wells Indicate the Need for Corrective Action?

The RA has the authority to require corrective action when necessary to protect human health and the environment if constituents are detected above specified concentrations in SPWs.

3.6.2 Can Supplemental Monitoring Wells be Used to Implement a Corrective Action?

The use of SPWs for corrective action purposes is appropriate in some circumstances (such as for ground-water extraction, soil flushing, venting, or vapor extraction). The RA has the authority to require the use of SPWs for corrective action purposes under the omnibus and corrective action authorities of RCRA §§3004(a) and (u), 3005(c)(3), and 3008(h).

3.6.3 Can Supplemental Monitoring Wells be Used to Monitor the Effectiveness of Corrective Action?

SPWs can be used to monitor the effectiveness of corrective action. SPWs may be used to collect routine corrective action performance data such as water level measurements, vadose zone sampling (of soil gas as well as pore water), and sampling of ground water in the uppermost aquifer. SPWs that are installed to detect NAPL releases can be used for monitoring the effectiveness of corrective action measures to remediate NAPL contamination.

3.6.4 Can Supplemental Monitoring Wells be Used to Implement or Monitor the Effectiveness of Interim Measures or Stabilization?

Similar to their use in corrective action, SPWs may be used to implement and monitor the effectiveness of measures taken to stabilize the migration of contaminants until a final corrective action is selected.

CHAPTER 4

IMPLEMENTING THE MULTIPLE WMA AND THE SPW APPROACHES

The multiple WMA and the SPW approaches in this guidance may be applied under three circumstances: permit application, permit modification, and permit renewal. Pending promulgation of the final Amendments Rule, the RCRA omnibus provision (RCRA §3005 (c)(3) and 40 CFR 270.32(b)(2)) provides authority for designating multiple WMAs and requiring SPWs. For each facility, information relevant to the designation of WMAs or SPWs will be recorded in the administrative record for the permit as required under §124.9. As with other permitting decisions, if the permittee does not agree with the oversight authority's decision regarding the WMAs or SPWs, he or she has the right to administrative or judicial appeal.

4.1 Permit Application

WMAs should be designated in a facility's permit application. Under §270.14(c)(3), the owner/operator must submit a proposed WMA delineation with Part B of the permit application. During the permit application process, the permit writer may advise owners and operators to carefully evaluate the WMA delineation based on the considerations set out in this guidance and the proposed Amendments Rule. The considerations, which are discussed in Chapter 2, include the number, spacing, and orientation of waste management units; waste type handled; hydrogeologic setting; site history; and engineering design of units. Depending on the conditions at the site, each one of these criteria can affect the designation of WMAs. The RA has the authority to accept or modify the proposed WMAs submitted by the owner or operator under §270.14(c)(3), and should select the appropriate WMA(s) necessary to protect human health and the environment by considering the criteria previously mentioned. The permit must specify those actions necessary to minimize monitoring and response complications posed by the modification to the WMA.

SPWs also should be designated in a facility's permit application. Under §270.14(c)(3) and (5), the owner/operator must submit in the permit application the proposed locations of ground-water monitoring wells and a description of the proposed ground-water monitoring program required under Subpart F. If the need for SPWs is apparent during the initial drafting of the permit, the number, location, and depth of SPWs should be specified in the permit application.

4.2 Permit Modification

The multiple WMA and the SPW approaches in this guidance may be applied as part of a permit modification. Permit modifications may take place at the request of either the RA or the owner/operator pursuant to §§270.41 or 270.42, respectively. If the RA feels that there is a need for designating multiple WMAs or SPWs to protect human health and the environment, he or she can request a modification of the permit pursuant to §270.41, and cite the omnibus provision as authority for the modification.

If the RA or the facility owner/operator initiates a permit modification because of the generation of new wastes; the construction of new, expansion, or replacement waste management units; evidence of a release; removal or delisting of waste, etc., the permit writer should assess the existing WMA configuration at the facility. The assessment will need to determine if the designated WMAs continue to be sufficiently protective of human health and the environment. The assessment could result in a single WMA being divided into multiple WMAs, or multiple WMAs being even further divided. The assessment also could result in consolidating WMAs into fewer WMAs or into a single WMA. An owner/operator with a multi-unit facility designated as a single WMA also may request delineation of multiple WMAs. This request may be made to avoid a facility-wide response action after compliance monitoring or corrective action has been triggered (until the permit is modified, the owner/operator would have to implement compliance monitoring or corrective action at the designated WMA). However, the designation of multiple WMAs does not limit or otherwise affect the site-wide and off-site corrective action authorities under §§3004(u), 3004(v), and 3008(h).

The proposed SPW provision also can be applied as part of a permit modification if the need for SPWs becomes apparent after permit issuance. Hydrogeologic or contaminant characteristics that create complex contaminant flow patterns might not be evident until the implementation of the monitoring program. For example, the RA may consider the necessity for SPWs after a Comprehensive Ground-Water Monitoring Evaluation (CME) or Operation and Maintenance (O&M) Inspection is performed. The CME is a detailed evaluation of the adequacy of the design and operation of ground-water monitoring systems at RCRA facilities. The CME or O&M may show that the existing ground-water monitoring wells would not detect the release of contaminants from the WMA. (Chapter 3 discusses reasons why existing wells might not detect contamination.) Under these circumstances, it might be necessary for the EPA to modify an existing permit to require SPWs.

4.3 Permit Renewal

At the time of permit renewal, the RA and the owner/operator should evaluate the effectiveness of the existing ground-water monitoring system. If a review of the criteria discussed in Chapter 2 indicates the need to establish more than one WMA, the RA should establish multiple WMAs under the authority of the RCRA omnibus provision (RCRA §3005(c)(3) and 40 CFR 270.32(b)(2)). Similarly, if a review of site hydrogeologic conditions, reveals that POC wells are not sufficient for monitoring regulated units, the RA should consider installing SPWs pursuant to the omnibus provision.

4.4 Designating Multiple Monitoring Programs in the Permit

The proposed Amendments Rule would give the RA the authority under 40 CFR 264.91 to designate different monitoring programs (i.e., detection, compliance, or corrective action) for different WMAs defined at a multi-unit facility. This amendment would reduce the potential, in the event of a one-unit release, of one unit unnecessarily causing all other units to adopt the same monitoring or response program, regardless of the source and extent of contamination.

Separate ground-water monitoring systems are not required for each regulated unit when the RA approves a single WMA encompassing multiple units. If it is necessary to have multiple WMAs, then the permit will need to describe the monitoring program for each WMA pursuant to the requirements in §§264.98, 264.99, and 264.100.

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APPENDIX I

Changes to the September 1988 Model Permit Module X
to Incorporate Supplemental Well and
Multiple Waste Management Area Provisions

(Note: Additions to 1988 module are given in <u>underlined bold</u>.)**

MODULE X - GROUND-WATER DETECTION MONITORING for WASTE MANAGEMENT AREAS AND SUPPLEMENTAL WELLS

[Note: This permit module contains conditions that apply to storage, treatment, or disposal of hazardous wastes in any of the following units: surface impoundments, waste piles, land treatment units or landfills. These units require ground-water monitoring unless exempted under 40 CFR 264.90(b).] The goal of detection monitoring is to ensure the earliest possible detection of contaminant leakage from the regulated units. Detection monitoring requires detected leakage to be characterized and determines if further action is warranted. Detection monitoring entails the following:

1. Development of a list of ground-water indicator parameters and monitoring constituents used to indicate a release from the regulated unit(s).

2. Establishment of sampling and statistical analysis requirements to determine if a release has occurred.

3. Establishment of additional requirements if a statistically significant release occurs.]

[Note: On July 9, 1987, a federal rule was finalized to require analysis for 40 CFR 261, Appendix IX, rather than Appendix VIII, hazardous constituents pursuant to 40 CFR 264.98 and 264.99, if a statistically significant increase occurs for any detection monitoring parameters or constituents. The Appendix IX list is an abbreviated Appendix VIII list with several constituents added. This permit module incorporates the new rule.]

[Note: Under 40 CFR 264.91(b) the Regional Administrator may include one or more of the following programs in a permit: (1) detection monitoring (Module X), (2) compliance monitoring (Module XI), and (3) corrective action [Module XII(A)]. **<u>Multiple waste management areas at a facility may be designated and more than one monitoring program at a facility may be operated where deemed necessary to protect human health and the environment pursuant to RCRA §3005(c)(3) and 40 CFR 270.32 (b)(2). Separate programs for each supplemental monitoring well installed pursuant to RCRA §3005(c)(3) and 40 CFR 270.32(b)(2) may also be established. Monitoring programs for supplemental wells can be</u>**

established based on hydrogeologic data and contaminant characteristics as necessary to protect human health and the environment, and can include sampling parameters and frequency, and appropriate response actions. If more than one program is included in the Permit, the Permit Writer is to specify the circumstances or conditions under which each program will be required. It is possible that more than one program will be operable at the same time at a facility, or that the programs will be conditional based on a sequence of events. For example, the sequence set up in the Permit could include a detection monitoring program that triggers an Appendix IX analysis that triggers a Permittee option to apply for a variance (e.g., other contamination source or sampling error) and if the Permittee fails to seek or fails to obtain a variance, then compliance monitoring is triggered. The Permit could also set the ground-water protection standard, with a provision for the Permittee to apply for an Alternate Concentration Limit (ACL), and in the absence of an ACL application or denial of an ACL, or exceedence of an ACL or pre-set limit, the triggering of the corrective action program. The corrective action program could include plume assessment, correction measures study and design, and implementation of corrective action. Setting up such a sequence in the Permit reduces the number of permit modifications that may be needed and decreases the administrative time needed to get on with subsequent steps in the process and ultimately, the time required to get corrective action under way, if needed.]

[Note: The Permit Writer should refer to the RCRA Permit Quality Protocol for additional guidance in developing or reviewing permit conditions. See discussion of the RCRA Permit Quality Protocol in the Introduction to this Model Permit.]

X.A. MODULE HIGHLIGHTS

[The Permit Writer should include a general discussion of the activities covered by this module. The discussion should contain the following information: description of the waste management units (including type and number that require detection monitoring); **description of the waste management areas (including which waste management units comprise each waste management area);** number, location and depth of wells; **which wells are supplemental monitoring wells;** which wells are upgradient and downgradient; the indicator parameters and monitoring constituents specified and their background concentrations; any unique or special features associated with the operation; and a reference to any special permit conditions.]

X.B. WELL LOCATION, INSTALLATION AND CONSTRUCTION

[Note: For specific Agency guidance on monitoring well design and construction, hydrogeologic site characterization and location of monitoring wells, consult the EPA RCRA Ground-Water Monitoring Technical Enforcement Guidance Document (September 1986).]

The Permittee shall install and maintain a ground-water monitoring system as specified below: [40 CFR 264.97]

X.B.1. The Permittee shall (install and) maintain ground-water monitoring wells at the locations specified on the map in Permit Attachment X-1 and in conformance with the following list:

[Note: For each waste management area, the map must show all monitoring well locations and provide unique identifiers for each well. The number and location of monitoring wells utilized for ground-water monitoring is site-specific. The number and location of the wells must meet the requirements of 40 CFR 264.95 (Point of Compliance) and 40 CFR 264.97(a) and (b), if applicable (number, location, and depth of wells). The ground-water monitoring system must: yield samples in upgradient wells that represent the quality of the background ground water unaffected by leakage from any regulated unit(s), and in downgradient wells yield samples that represent the quality of water passing the point of compliance. The number and location of monitoring wells must be sufficient to identify and define all logical release pathways from the regulated units based on site-specific hydrogeologic characterization. The Permit Writer may require the Permittee to install and monitor supplemental monitoring wells where deemed necessary to protect human health and the environment, where hydrogeology or contaminant characteristics can allow contaminants to move past or away from the point of compliance without being detected (e.g., perched water table).]

X.B.2. The Permittee shall **(construct and)** maintain the monitoring wells identified in Permit Condition X.B.1., in accordance with the detailed plans and specifications presented in Permit Attachment X-2.

[Note: The plans and specifications must meet the requirements of 40 CFR 264.97(a) and (c), and should consist of design drawings and design criteria applicable to all wells, and individual well specifications identifying total well depth and location of screened intervals.]

[Note: If determined to be necessary to protect human health or the environment, the Permit Writer should include Permit Conditions X.B.3., specifications on how monitoring wells are plugged and abandoned. HSWA Section 212 provides EPA with this authority. Several states also have regulations which cover monitoring well abandonment.]

X.B.3. All wells deleted from the monitoring program shall be plugged and abandoned in accordance with Permit Attachment X-3. Well plugging and abandonment methods and certification shall be submitted to the Regional Administrator within **[The Permit Writer should specify the submittal period.]** from the date the wells are removed from the monitoring program.

APPENDIX II

Waste Management Area(s) and Corrective Action Management Units: Comparison and Contrast

Both waste management areas (WMAs) and corrective action management units (CAMUs) circumscribe areas or units containing hazardous wastes or constituents. The objectives and use of WMAs and CAMUs are different, however, as described below.

Regulatory Authority

-- A single WMA at a site is authorized by §264.95 of Subpart F. Subpart F regulates ground-water monitoring at regulated units[1]. Multiple WMAs at a site can be designated under the authority of the omnibus provision, as is discussed in this guidance document.

-- A CAMU is authorized by §264.552 of Subpart S (58 FR 8658; February 16, 1993). Subpart S governs corrective action of solid waste management units (SWMUs)[2].

Description and Intent of WMA

-- A WMA is established for the purposes of defining a ground-water monitoring program and the point of compliance (POC). The POC is a vertical surface located at the hydraulically downgradient limit of the WMA. The POC represents the location(s) at which the ground-water protection standard of §264.92 must be met and at which monitoring must be conducted.

A WMA circumscribes regulated units and includes the space taken up by any liner, dike, or barrier designed to contain waste. Under §264.95, if a facility contains more than one regulated unit, a single WMA is described by a line (specified in a RCRA permit) encircling the regulated units. The proposed §264.95(b)(3) would allow the Regional Administrator to designate multiple waste management areas at a facility.

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[1] Regulated units are surface impoundments, waste piles, land treatment units or landfills that receive hazardous waste after July 26, 1982 subject to the requirements of §§ 264.91 through 264.100.

[2] A SWMU is defined as any discernible unit, at a RCRA facility, at which solid wastes have been placed at any time, irrespective of whether the unit was intended for the management of solid and/or hazardous wastes. This definition includes tanks, surface impoundments, waste piles, land treatment units, landfills, incinerators, etc., as well as areas contaminated by "routine and systematic discharges" of wastes from process areas. All regulated units are SWMUs, but a SWMU is not necessarily a regulated unit (see footnote 1).

Description and Intent of CAMU

-- A CAMU refers to an area within a facility, designated by the implementing agency, that is used for management of remediation wastes. CAMUs may or may not include pre-existing "units" such as SWMUs or, in some cases, regulated units[3]. CAMU boundaries will typically be specified on a facility map in the permit or 3008(h) order.

CAMUs are intended to provide flexibility for decision-makers in implementing protective, reliable and cost effective remedies. For example, under the CAMU provisions, remediation wastes can be placed into a CAMU without triggering land disposal restrictions and other RCRA hazardous waste disposal requirements.

Other Primary Differences and Related Issues

-- Although the WMA is a surface delineation, it is linked to the POC which extends to the base of the uppermost aquifer; a CAMU is primarily a surface designation and is not linked directly to any characteristic of the underlying aquifer.

-- WMA and CAMU boundaries could coincide all or in part at a facility. However, the two designations are made for different purposes and are independent of one another from a regulatory standpoint. For example, under the present CAMU rule, the designation of a CAMU does not relieve the owner/operator from requirements to monitor ground water at regulated units that are included within the CAMU.

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[3] In certain circumstances, the Regional Administrator has the discretion to designate a regulated unit as a CAMU, or to include a regulated unit as part of a larger CAMU. However, only closed or closing regulated units would be able to be so designated. The CAMU rule discusses in greater detail the circumstances under which this designation could be made.