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SUBJECT: Guidance On The Definition for Aquifer System

Number: GD0205.100
Issue: 1/25/91
Revised: 07/25/95

PURPOSE: To provide guidance on the meaning of "aquifer system" as defined in the solid waste regulations.

BACKGROUND: OAC Rule 3745-27-01(B)(4) as it applies to municipal, industrial and residual waste landfills defines the term "aquifer system" as "one or more geologic unit(s) or formation(s) that is/are wholly or partly saturated with water and is/are able to store, transmit, and yield significant amounts of water to wells or springs."

There has been much discussion on the interpretation of this definition. It is in response to these discussions that this guidance has been prepared.

This guidance discusses interpretations of various parts of these definitions including:

a) "a geologic formation, group of formations, or part of a formation" and "one or more geologic unit(s) or formation(s)";

b) "wholly or partly saturated"; and

c) "capable or yielding a significant amount of water" and "is/are able to store, transmit, and yield significant amounts of water."

GUIDANCE: A) Geologic Medium

The phrase "one or more geologic unit(s) or formation(s)" refers to the medium in which the aquifer system exists and that this medium can encompass a part of a geologic formation, an entire geologic formation or several geologic formations. Article 6 of the Code of Stratigraphic Nomenclature (1970) defines a "rock-stratigraphic formation" as "the fundamental unit in rock-stratigraphic classification that is a body of rock characterized by lithologic homogeneity; it is prevailingly but not necessarily tabular and is mappable at the earth's surface or traceable in the subsurface."

By the above definition, in order to qualify as a formation, a lithologic unit must possess some distinctive lithologic features (i.e. rock type, bedding, etc) and must be mappable. This criterion for a "formation" also applies to unconsolidated soil-stratigraphic units under Article 18 of the Code of Stratigraphic Nomenclature.

The cause of deposition is not a criterion for defining a geologic formation; but rather that the unit has some unique features when compared to surrounding units and that it is mappable. It has been suggested that mine spoil does not qualify as a formation because it is man-made. However, most mine spoil in the State of Ohio is unique when compared to underlying lithologic units and generally is extensive enough to be mapped; therefore, mine spoil can be considered a formation. For purposes of this guidance, material (blast furnace slag, foundry sand, fly ash, bottom ash, etc.) that has been physically altered, transformed or used during a manufacturing process (i.e., melted or burned) shall be considered a waste material and not a geologic formation.

The phrase "one more geologic unit(s) or formation(s)" also speaks to the presence of upper and lower boundaries for the aquifer system. It must be kept in mind that an aquifer system does not necessarily encompass an entire formation. It may be present only in one section of a formation. An aquifer system is limited to those parts of formations or a group of formations that are capable of a significant yield. General examples of this are shown in Figures 1 and 2.

The sandstone formation in Figure 1 is 100 feet thick. This sandstone is massive and well cemented, except for a ten foot thick area in the center of the formation. This ten foot thick zone is fractured and friable. Monitoring wells installed above and below this zone in the unfractured sandstone can be easily bailed dry and take several weeks to recover. Monitoring wells in the fractured unit can sustain a yield of three gallons per minute (gpm). Therefore, this example shows the aquifer system is present only within the fractured zone of this sandstone formation. The rest of the formation is an aquiclude.

Figure 2 shows a sand seam in a till formation overlying a bedrock aquifer system demonstrated, by a series of aquifer pumping tests, to be interconnected to the bedrock aquifer. The sand seam will sustain a yield of only 0.1 gallon per minute while the bedrock aquifer system will sustain a yield of twenty gallons per minute. Even though these two formations are interconnected hydraulically, the interconnection is not great enough for the sand seam to have a significant yield, hence, it is not part of the bedrock aquifer system. Thus, the upper boundary of the aquifer system is the bedrock till interface and the sand seam is considered a significant zone of saturation under the non-hazardous solid waste rules. ["A zone of saturation that may act as a preferential pathway of migration...," OAC Rules 3745-27-01B(39)]. If the sand seam had a significant yield, when compared to the regional aquifer, then the two units could be considered to have enough interconnection to constitute a single aquifer system.

In summary, a formation is the medium in which an aquifer system exists. A formation is a unique lithologic unit that can be mapped. An aquifer system exists only in formations, parts of formations or groups of formations that sustain a significant yield.

B) Saturation of Media

The phase "wholly or partly saturated" mandates, in situations of water table aquifer systems, that the vadose zone of the permeable formation or group or formations be included as part of the aquifer system. This concept was developed for two reasons. Since the vadose zone of a water table aquifer system is usually as permeable as the saturated portion, the time required for a contaminant to migrate through this zone is usually very short. Also, it is not unusual for the water table to fluctuate within the aquifer system and for portions of the aquifer system that are above the water table one day, to be below it the next. Accordingly the phrase "wholly or partly saturated" was included in the definition for aquifer system so the entire permeable zone could be included in the siting evaluation of a facility.

The classic example of this concept is that of a sand and gravel water table aquifer system (Figure 3). In this case, the sand and gravel formation is 100 feet thick, but it is saturated only in the lower seventy feet of the formation.

The aquifer system encompasses the entire 100 feet of the formation because the permeability and hydraulic properties of the formation above the water table are similar to those below. Again this applies only to non-hazardous facilities.

As in the discussion on aquifer media, it is important to identify the upper boundary of the aquifer system accurately. The upper boundary can be represented by the ground surface (Figure 3) or the lower surface of an impermeable formation (Figure 4).

For fractured bedrock, it is important to consider changes in the overall permeability of the formation when determining the boundaries of the water table aquifer system. Figure 4 represents the water table aquifer system within a fractured sandstone formation. Above the sandstone is a fractured shale.

Even though the two formations exist within the same fracture system, the differences in matrix properties cause the overall permeabilities of the two formations to be different. Boring logs and tests performed on the two formations indicate that the fractures in the shale are not as wide nor as extensive as those fractures in the sandstone. In addition, weathering along the fractures has deposited a significant amount of clay material into the fractures of the shale. Predictably, hydraulic conductivity testing demonstrates that the permeability of the shale was several orders of magnitude less that the sandstone. In this case, the upper boundary of the aquifer system would be established at the top of the sandstone formation since it is probable that even if the shale became saturated it would not yield a significant amount of water and would constitute an aquiclude.

In summary, the phase "wholly or partly saturated" includes the permeable vadose zone that may exist above a water table aquifer system. Definition of the upper boundary of an aquifer system is necessary in order for the siting of a proposed facility to be evaluated.

C) Yield

There is a considerable debate about how to interpret the phrase "is/are able to store, transmit, and yield significant amounts of water." The primary issue of this controversy concerns interpretation of the word "significant."

In the July 26, 1982 Federal Register (Attachment A), USEPA reiterated several public comments about the meaning of the word "significant:"

a. the concept of the term "significant" is site-specific, depending in large part on the demand for ground water; and

b. the minimum yield possible for an "aquifer" could be as low as twenty gallons per day (0.01 gallons per minute) based on the demand of a family of four in a rural area;

In a June 27, 1984 internal memorandum (Attachment B), USEPA appears to have endorsed the above two comments.

Ohio EPA has researched this issue and agrees with USEPA that the term "significant" in the definition of "aquifer system" needs to allow for regional differences in the yield of aquifer systems used for public and private water systems around the state of Ohio. Aquifer systems in the sourthern part of Ohio yield as little as 75 gallons per day (.05 gallons per minute) and are considered viable for use as a domestic water supply. This is not true for much of northern Ohio where aquifer systems used for domestic purposes traditionally yield at least 7200 gallons per day (5 gallons per minute). Becuase of these differences in yield, the Ohio EPA believes that interpretation of the work "significant" needs to be site-specific and based on the historic sustained yield of private wells in the area in question.

In order to determine whether a formation at a particular site has a singificant yield, Ohio EPA utilizes the following information:

a) average sustained yield of the regional aquifer;

b) sustained yield of the saturated unit under the site and how it compares to the average sustained yield of the regional aquifer; and

c) historic use of the saturated zone in question as a water supply.

In reviewing the above information, Ohio EPA considers several criteria. The yield of the saturated zone in question should be significant when compared to the average yield of the regional aquifer. In addition, there should be a reasonable possibility that, at some time in the future the saturated unit will be used or needed. Judgement on reasonableness of future use shall be determined solely on the yield of the formation. The water quality of the saturated zone has no bearing on its status as an aquifer/aquifer system.

Figure 5 provides an example of how the above criteria and information should be used in practice. Here we have a bedrock regional aquifer with an average yield of 5 gallons per minute based on the well logs reported for the area. Above this bedrock aquifer system is ninety feet of till with a two foot saturated sand zone located within the till about twenty feet above the bedrock. Hydraulic testing of the sand zone indicates that it will sustain a yield of 0.9 gallons per minute and there are no connections between it and the bedrock aquifer system. According to records, the sand seam has not been used as a source of water. Based on the above information, a determination must be made as to whether the yield of the sand zone is significant when compared to the yield of the bedrock aquifer system. The yield of the sand zone, in this case, is not significant as its yield is but one-sixth that of the regional aquifer. In addition, there is no reasonable expectation that the zone will be used as a source of water for wells in the future due to its low yield and its proximity to the much higher yielding regional aquifer system.

In summary, interpretation of the word "significant" is determined on a site-by-site basis. This determination considers the yields of both the regional aquifer and the saturated zone in question, and their past or potential uses as water supplies. The Ohio EPA, in determining if a yield is significant, should consider whether the yield of the saturated zone in question is significant when compared to the yield of the regional aquifer. Also, the Ohio EPA should, based on the yield of the formation, consider the reasonable possibility that the saturated formation could be used as a source of water supply.

Ohio EPA has determined in one case that a formation yielding two (2) gpm was not an aquifer system when compared to a regional aquifer yield of 10 gpm. This determination was made as it was unreasonable to assume a person would install a well in a formation uyielding only two gpm when a formation yielding 10 gpm was readily accessible.

Conclusion:

This guidance is intended to explain Ohio EPA's interpretation of several parts of the definition of "aquifer system" as contained in OAC Rule 3745-27-01(B)(4). These parts are those relating to media, media saturation, and media yield.

A formation is a medium in which an aquifer system exists. It is characterized by unique lithology and is mappable. Aquifer systems can exist only in wholly or partly saturated formations that provide a significant yield of water to a well.

The term "wholly or partly saturated" includes the vadose zone as part of a water table aquifer system. The vadose zone of a water table aquifer system ends when its hydrogeologic properties change such that it is no longer reasonable to expect it to yield a significant amount of water if it became saturated.

The term "significant yield" is to be determined on a site-by-site basis by comparing the average yield of the regional aquifer system to the sustained yields of any saturated units above the regional aquifer. To be classified as an aquifer system, the saturated zone must yield an amount of ground water that is significant when compared to the average yield of the regional aquifer. In addition, there must be a reasonable possibility, based on yield, that the saturated zone will be used as a source of water in the future.

Figure 1
Case Where Aquifer/Aquifer System Exists Only Within Part of a Formation

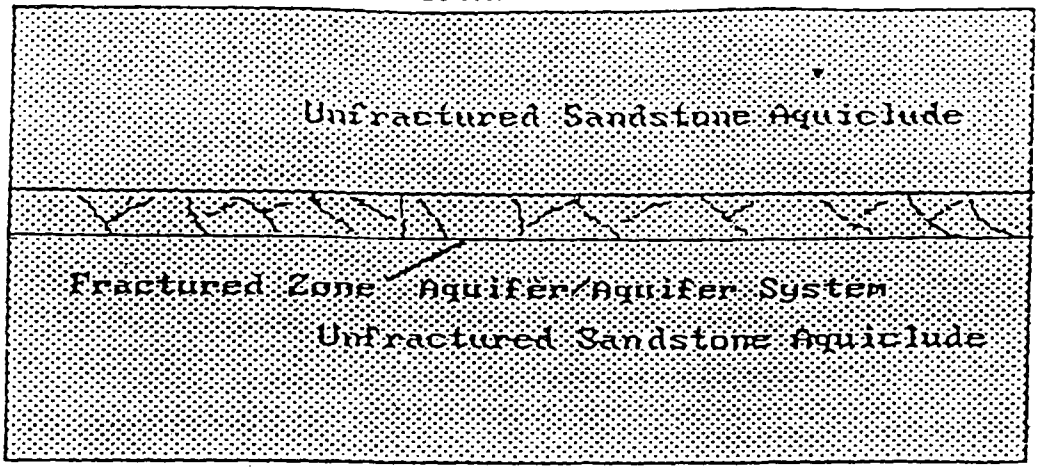


Figure 2
ase Where Interconnection Between Formations Determines
quifer/Aquifer System Boundary

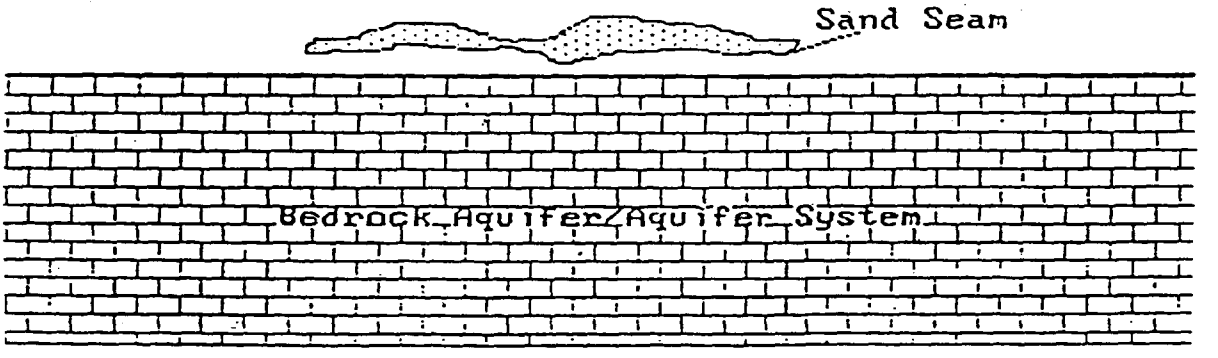


Figure 3
Unconfined Aquifer/Aquifer System Where The Vadose Zone Is A Part Of The Aquifer/Aquifer System

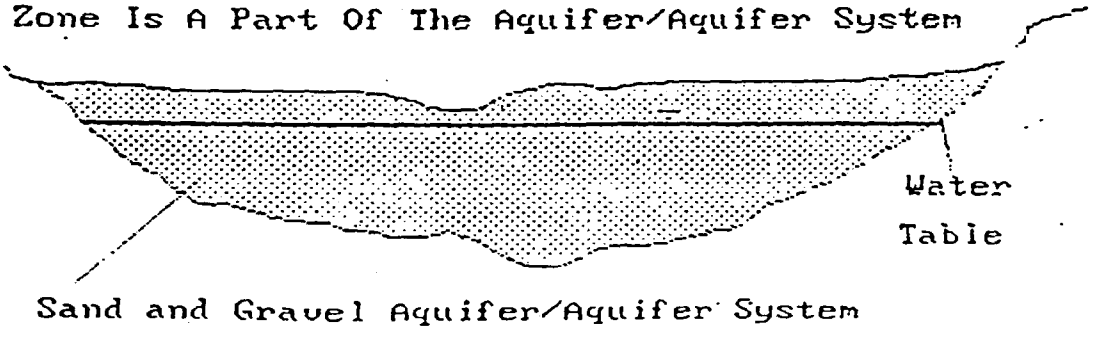


Figure 4
Boundary Determinations Involving Unconfined Aquifer/Aquifer System

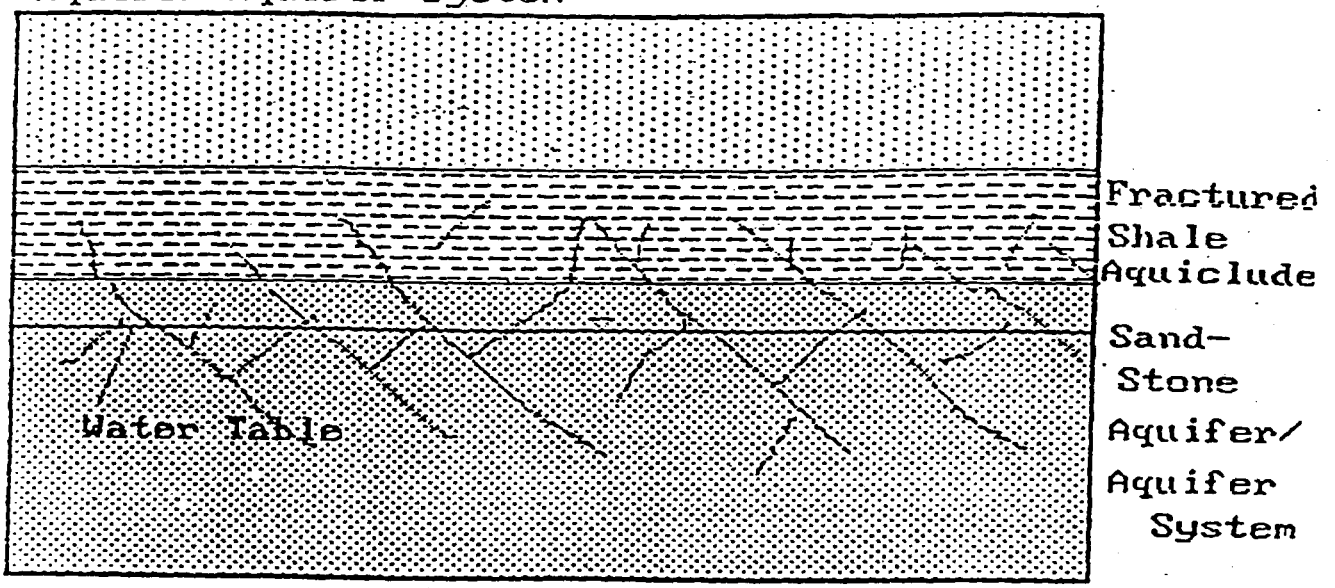
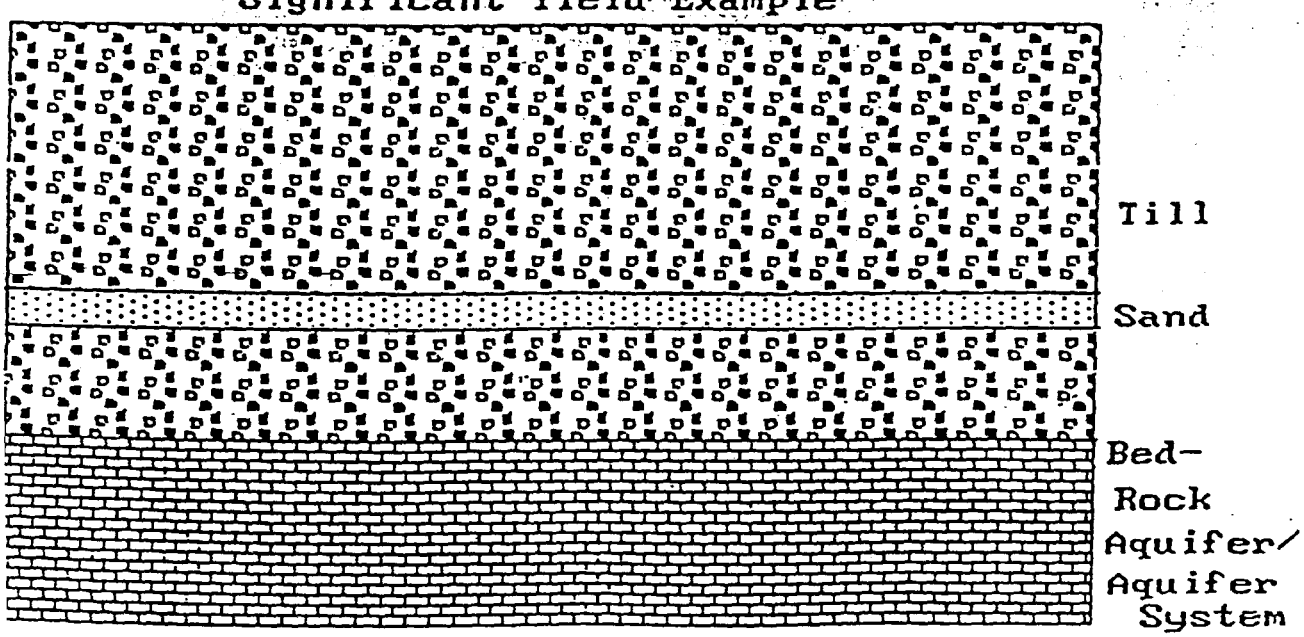


Figure 5
Significant Yield Example



owner or operator engaged in hazardous waste management. Within the facility there will be an area where hazardous waste treatment, storage, and disposal activities occur. This is the waste management area.

The waste management area is made up of one or more waste management units. The provisions in the Part 264 and 265 regulations (principally the technical standards in Subparts K-N) establish requirements that are to be implemented on a unit by unit basis. A waste management unit is a contiguous area of land on or in which waste is placed. A waste management unit is the largest area in which there is a significant likelihood of mixing of waste constituents in the same area. Usually this is due to the fact that each waste management unit is subject to a uniform set of management practices (e.g., one liner and leachate collection and removal system).

Today's regulations establish specific requirements for surface impoundments, waste piles, land treatment units, and landfills. Generally, each of these four terms is synonymous with the concept of a waste management unit. For example, a surface impoundment is typically a single depression in the ground in which wastes are allowed to mix. Landfills may, however, present an exception to this general rule. Some landfills are designed as a series of adjacent trenches that are separately lined. In this situation, the term "landfill" can refer to the entire set of trenches. Yet, each individual trench is a separate waste management unit under today's regulations. (The principal practical implication of this distinction arises in determining what area of the facility is subject to the monitoring and response program in Subpart F. This will be discussed in more detail in Section VII.D. of this preamble.)

EPA's hazardous waste management regulations have also used the term "process" to describe a part of the facility. "Process" refers to general classes of waste management activities (e.g., surface impoundments, piles) and thus embodies a set of units that may be present at a facility. For example, a facility may contain three separate surface impoundments, two waste piles, and a single landfill. Such a facility contains six waste management units and three waste management processes (e.g., surface impoundment, waste pile, and landfill.)

In some parts of today's regulations and in this preamble, the term "facility permit" is used in describing a permit issued under Section 3005. While the broad term "facility" is used, this is not intended to mean that a permit can only be issued for all units at a facility. EPA may issue a permit for some set of units at a facility. (Under these circumstances, the interim status standards of Part 265 continue to apply to units that are not covered by the individual permit and have not been formally denied an individual permit.)

Today's regulations also refer to waste management "portions." This is the smallest area typically referred to in these regulations. This simply means some area within the confines of a waste management unit.

Finally, today's regulations have clarified somewhat the terminology used to describe areas used for land treatment. In the past, EPA has used the term "land treatment facility" to describe the plot of ground on or in which land treatment occurs. This area is esentially the waste management unit as just described. Therefore, EPA intends to use the term "land treatment unit" when describing these areas. This shift in terminology is designed to make the language used in the regulations more precise. It does not reflect a substantive change in the scope of the land treatment requirements. Thus, the term "land treatment unit" in today's regulations is synonymous with the term "land treatment facility" used in previously-issued regulations.

A. Definitions (Part 260)

In today's regulations, EPA is adding several definitions to 40 CFR Part 260 that are used in the land disposal regulations. In addition, EPA is replacing one definition and clarifying the meaning of another.

1. *Aquifer.* The term "aquifer" is defined in Part 260 (promulgated on May 19, 1980) as a geologic formation, group of formations or part of a formation capable of yeilding a significant amount of ground water to wells or springs. Public comments have suggested that "significant amount" is an imprecise term which may leave owners and operators in doubt as to which formations constitute aquifers. Commenters correctly pointed out that the concept of a "significant amount" was actually site-specific, depending upon the demand for ground water. Furthermore, commenters stated, the potential yield (amount) of ground water from one well could be dramatically lower than the yield from a cluster or field of wells at the same location. In water-scarce areas, it is not uncommon to install several wells into the same formation to collect sufficient ground water to feed into a public water supply system. The lower the yield to one well, the greater the number of wells necessary to serve the users of a given water supply system.

In the preamble to the December 18, 1978 proposal, the Agency had suggested 500 gallons per day as the minimum yield which would constitute a "usable quantity," based upon the needs of a family of four persons. The Agency used the design specification of 125 gallons per person per day in arriving at this minimum yield. Commenters pointed out, however, that this design specification is only applicable to municipal public water supply streams and includes allowances for washing of automobiles, lawn watering, central sewerage, minimal fire protection, etc. Commenters suggested that if the agency wished to base the minimum yield specification on the needs of a family of four in a rural area (a typical situation where a single, private ground-water supply well would be used) an individual demand of between 5 and 50 gallons per person per day, to satisfy health and personal hygiene needs, would be appropriate.

Commenters also stated that many land disposal facilities are sited in areas where saturated upper clay layers are available to serve as a natural barrier to the migration of leachate into the ground water in the actual uppermost aquifer. Since any saturated soil material can yield quantities of ground water to wells, even at an extremely low rate, one interpretation of the definition of aquifer could require the saturated clay landfill liner to be monitored in accordance with the ground-water monitoring requirements.

It was never the Agency's intent to consider saturated clay landfill liners to be subject to ground-water monitoring as an aquifer. However, no acceptable criterion was suggested, nor has the Agency been able to produce a universally acceptable interpretation of "significant amount" which is appropriate in all of the various circumstances that may be encountered.

The Agency wishes to define the term "aquifer" more precisely in a manner that is consistent with both the RCRA program and the Safe Drinking Water Act program, and that reflects the ground-water policy that EPA is currently developing to coordinate its ground-water protection programs. EPA is working on this issue, and will announce its result when the work is completed.

2. *Certification.* The terms "certification", "certify", and "certified" are used throughout the regulations, including those promulgated today, to refer to the rendering of a professional opinion concerning compliance with a

ATTACHMENT B

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

DATE: JUN 27 1984

SUBJECT: Definition of Aquifer In Part 260.10

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FROM: John H. Skinner, Director
Office of Solid Waste (WH-562)

TO: James H. Scarbrough, Chief
Residuals Management Branch, Region IV

In your memo of May 1, 1984, you requested clarification of the definition of the word aquifer. You also discuss the usage of the words "aquifer" and "ground water" in Parts 264 and 270.

As you point out, clarification of the term "aquifer" hinges on the term "significant amount." The discussion in the July 26, 1982, preamble (page 32289) points out that the concept of significant amount is site-specific. Local perception of significant amount varies from region to region depending on water demand, the relative quantity and quality of alternative supplies, and land use.

In general, we advocate a conservative approach in defining what is a significant amount; we must provide protection for individual domestic wells especially when considering that such wells typically supply water for use without treatment. The preamble points out that commenters have suggested that in some cases a yield as low as 20 gallons per day may be considered significant in that this is sufficient to satisfy the health and personal hygiene needs of a family of four. This calculation assumes the more conservative amount of five gallons per person per day, while the preamble states that a person may demand between five and 50 gallons per day. On the other hand, the preamble also points out that saturated clay liners are not considered by the Agency to constitute an aquifer.

The definition of aquifer involves several EPA programs including those regulating underground injection, pesticides, and toxic substances. The new Office of Ground Water Protection (OGWP) is in charge of clarifying the definition. As indicated above, however, I anticipate the results will still provide for site-specific and regional differences and a degree of flexibility to the permit writer rather than a precise nation-wide criterion. The OGWP expects to have this definition along with others affecting ground water in about nine months.

Your concern over the definition of aquifer arises because of the distinction between "ground water" and "aquifer" in the regulations. As noted in your memo, while corrective action is required in all ground water, a permittee is only required to monitor in the aquifer, and the ground-water

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protection standard is only applicable in the aquifer. However, we disagree that the permit application requirements to describe the plume (§270.14(c)(4)) are limited to the aquifer. It is essential that applicants provide a full description of all existing ground-water contamination caused by the facility. Early next year we will propose amending the rule, requesting comments on monitoring and level of protection appropriate in low-yielding (i.e., non-aquifer) saturated zones.

Guidance for implementing the existing regulation is available in three manuals:

1. Draft Permit Applicants' Guidance Manual (SW 84-004 May 1983) page 9-17; soon to be reissued.

2. Draft Permit Writers' Guidance Manual for Hazardous Waste Land Treatment, Storage, and Disposal Facilities (October 1983) pages 5-19 to 5-21.

3. Draft Permit Writers' Manual for Ground Water Protection (September 1983) page 22.

I must caution you that guidance in the draft manuals (#2 and #3 above) can be somewhat misleading. It says: "In summary, the Agency considers the hydrologic unit an aquifer if it provides a pathway for migration to any existing or potential point of use or discharge." The next edition of these draft manuals will clarify that this must still be within the context of "significant amount."

In summary, with regard to the Part B applications you are currently reviewing, you may make use of the Part 270 requirement to require in the permit application a description of the contamination of all ground water (i.e., water in the saturated zone) beneath the facility. However, with regard to the proposed monitoring systems, the regulations will only support the requirement for monitoring the ground water in the uppermost aquifer. In those cases where there is clear environmental rationale for requiring the permittee to monitor ground water above the aquifer, (i.e., where aquifer monitoring will not provide necessary protection) we suggest that you also consider Section 3013 of the Act. You must keep in mind, however, that the ground-water protection standard for a facility (§264.92) is only applied in the uppermost aquifer. Therefore, while we may require information concerning ground-water contamination above the aquifer, compliance with the ground-water protection standard is keyed to contamination in the aquifer. Imminent Hazard provisions, however, may be used where appropriate.

I hope this provides some help. Complete resolution will require further guidance from the OGWP and regulatory changes that must first be proposed.

cc: Regional Division Directors, Regions I-III, V-X
Bruce Weddle
Mark Greenwood
Ken Shuster
OSW-041