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A Manual for Evaluating Contamination Potential of Surface Impoundments

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A MANUAL FOR EVALUATING CONTAMINATION POTENTIAL OF SURFACE IMPOUNDMENTS

This manual was written

by

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Ground Water Protection Branch
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PREFACE

The Manual for Evaluating Contamination Potential of Surface Impoundments was prepared specifically for implementing a standardized evaluation system for the EPA Office of Drinking Water Surface Impoundment Assessment (SIA) and serves as the training manual for that assessment. The SIA evaluation system set forth in the manual is based upon the previous work by Harry E. LeGrand who began over 15 years ago to develop a standardized, consistent approach to the selection of proper waste disposal sites. This system departs from the LeGrand system in order to accommodate certain philosophical differences concerning ground-water protection and specific technical aspects related to surface impoundments. In no way does this detract from the importance of the LeGrand system in serving as the basis for the SIA evaluation system.

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INTRODUCTION

An objective of the surface impoundment assessment (SIA) program (see Figure 1) is to rate the contamination potential of ground water from surface impoundments and to develop practices for the evaluation of different surface impoundments (elsewhere referred to as pits, ponds, and lagoons). One of the activities conducted under the SIA program is the application of the evaluation system described in the present manual. This evaluation system applies a numerical rating scheme to different impoundments that yields a first round approximation of the relative ground-water contamination potential of these impoundments.

The basis of this system was developed by Harry E. LeGrand in 1964. LeGrand and Henry S. Brown expanded and improved the system in 1977 under contract to the Office of Drinking Water. The present system described in this manual has been modified by the Office of Drinking Water through consultation with LeGrand and Brown to reflect its ground-water protection philosophy. Before the selection of the present evaluation system, other standardized systems were considered (Cherry, et. al., 1975; Pinder, et. al., 1977; Phillips, 1976) but were not deemed as suitable for the purposes of the assessment. The system is designed to provide an

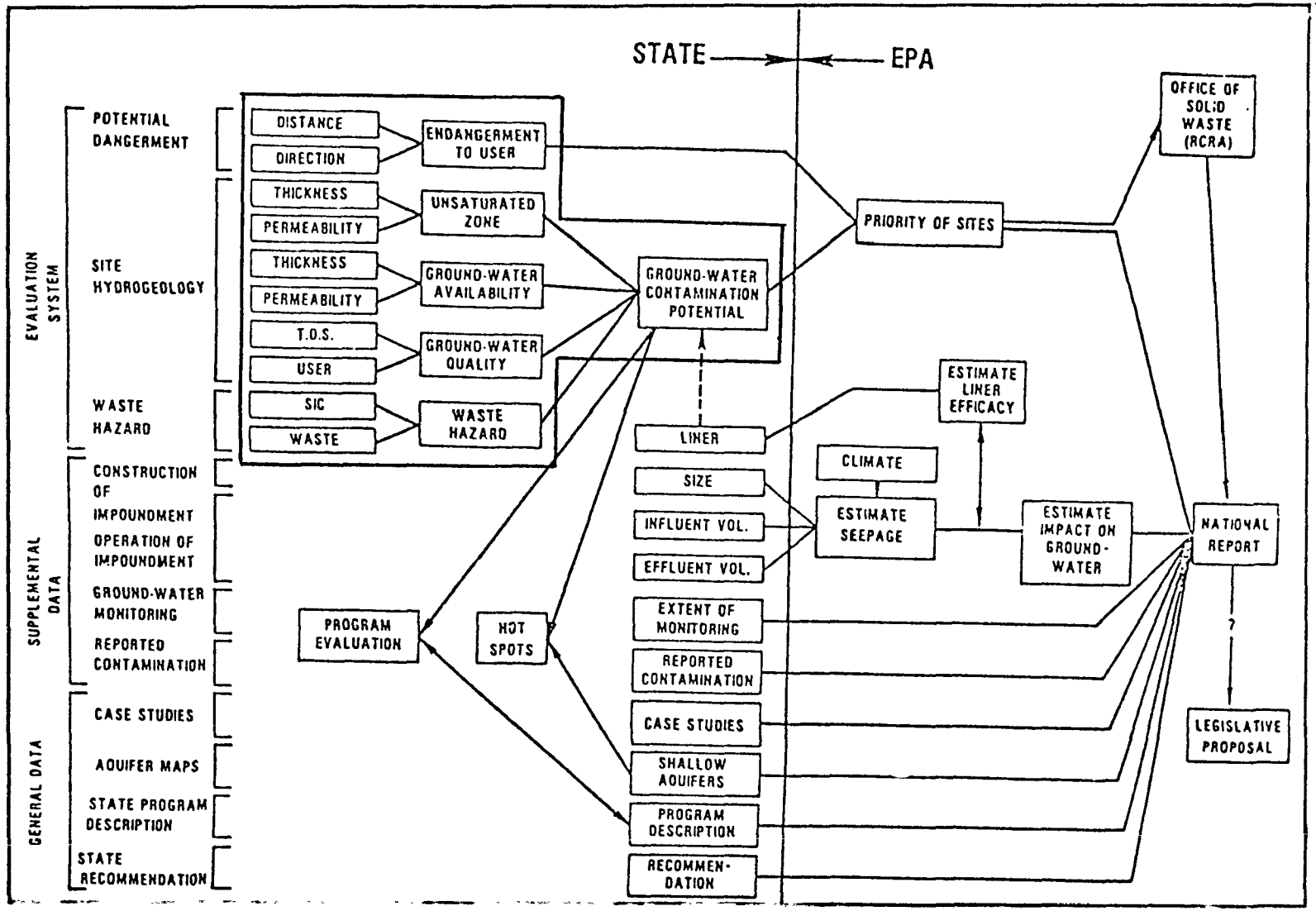


Figure 1. Flow chart of the Surface Impoundment Assessment. The outlined portion is the evaluation system described in this manual.

approximation of the ground-water contamination potential of impoundments at a minimum cost. Precise, in-depth investigations of actual ground-water contamination from surface impoundments (i. e., drilling, etc.) would be too costly and time-consuming and are not involved in this first-round site evaluation. The specific site investigations into actual contamination would begin after this assessment is finished in order to optimize expenditures. Those sites identified as high contamination potential would be addressed first.

The philosophy guiding the development of this surface impoundment evaluation system is that underground drinking water sources must be protected for both present and future users as intended by Congress in the Safe Drinking Water Act, 1974. Ground-water pollution occurs when contaminants reach the water table (saturated zone) beneath the site. This is contrary to the commonly held view that ground-water contamination cannot legally be determined until the contaminated ground water crosses the property boundaries of the facilities. EPA believes that in order to protect the nation's ground-water resources it is necessary to identify potential contamination at the source where preventive measures may be initiated. The purpose of this evaluation system is to rank impoundments

in terms of their relative ground-water contamination potential. The evaluation system considers several hydrogeologic parameters in the rating of the site. There are numerous parameters that may be used in evaluating a site. However, many of these parameters are related and their simultaneous consideration would be redundant. Thus, only selected parameters representative of different processes, have been included. The present evaluation system provides a standardized methodology which will ensure more consistent national results.

The parameters used in the present SIA system have been separated into two distinct groups which correspond to the two phases of the evaluation, i. e., 1) the rating of the ground water contamination potential itself and 2) the rating of the relative magnitude of potential endangerment to current users of underground drinking water sources. The parameters considered unique in rating the ground-water contamination potential are 1) the thickness of the unsaturated zone and the type of earth material of that zone, 2) the relative hazard of the waste, and 3) the quantity and quality of the underground drinking water source beneath the site. The parameters considered unique in determining the rating for the potential for endangerment of currently used water resources include: 1) the type of water source, i. e. ground water or surface water, 2) whether that water source is in the anticipated flow direction of the contaminated ground water

(if such contamination occurred); and 3) the distance between the potential contamination source and the water source. These parameters account for the basic processes and factors which determine the contamination potential of the site and which indicated the relative threat to underground drinking water sources.

The level of contamination of ground water is subject to varying degrees of attenuation as the water flows through the unsaturated zone and on through the aquifer; however, the evaluation focuses on the potential for contamination of underground water sources. Attenuation mechanisms are very complex, varying with the type of waste, earth material, and physico-chemical environment. A general site evaluation system concerned with an approximation of the contamination potential cannot consider the specific attenuative capabilities of different earth materials for different wastes, particularly since there exists a vast variety of complex wastes possible. This evaluation system therefore treats attenuation in an indirect manner by considering it in combination with permeability.

The evaluation is performed in a sequence (see Figure 2). The first four steps involve the evaluation of the potential for ground water to be contaminated by rating the site's hydrogeology and waste character. The fifth step then determines the site's overall contamination potential relative to other rated sites by combining the first four steps. It must be stressed that this overall rating will express only a site's hydrogeologic

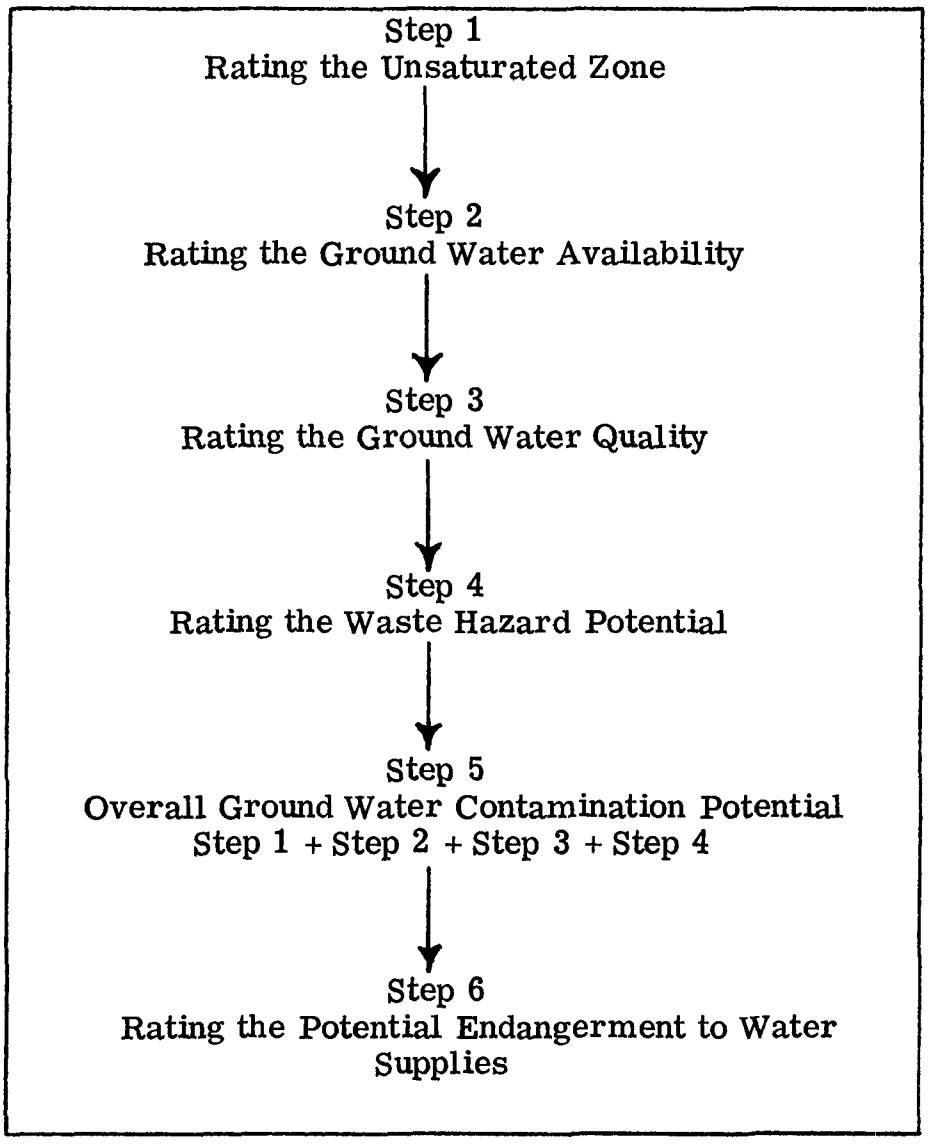


Figure 2. Generalized sequence of steps involved in the SIA evaluation system.

conditions relative to those conditions for all possible sites, and does not relate to a site's absolute degree of ground-water contamination. Such determination of actual contamination involving ground-water monitoring and sampling procedures must be made following site specific investigations. This system allows the investigator to assign priorities to sites on the basis of contamination potential so that the investigator could then concentrate resources upon the further investigation of these sites that rank highest in terms of their contamination potential.

Precise data is not necessary for the application of the SIA evaluation system. Performing precise measurements of the the depth to the water table, the character of the earth materials underlying the site, the hydrogeology at the site, etc., can be costly and time consuming. It must be remembered that this evaluation system is a first-round approximation and therefore estimates based on the best available information will be used with the expectation that they will provide satisfactory results for first-round evaluations.

STEP 1

GUIDANCE FOR RATING THE UNSATURATED ZONE

The earth material characteristics of the unsaturated zone underlying the surface impoundment are rated to determine the potential for contaminants to reach the water table. This step involves the combined rating of a) the thickness of the unsaturated zone, and b) earth material (both consolidated and unconsolidated rock) in the unsaturated zone (see Table I).

Step 1, Part A, Determination of the depth to the saturated zone for Step 1

Contaminants attenuate to varying degrees as they migrate down through the unsaturated zone, depending upon the thickness and the type of earth material. Therefore, more favorable conditions exist where the water table is deeper. The depth to the saturated zone is the depth from the base of the surface impoundment to the water table. This depth may be measured to the water table in unconfined aquifers (See Site 1 in Figure 3) or, in the case of a confined aquifer, to the top of the confined aquifer (See Site 2 in Figure 3). Where a perched water table is known to occur, the depth may be measured

TABLE I

Step 1. Rating of the Unsaturated Zone.

GUIDELINES FOR DETERMINING CATEGORY						
Earth Material Category	I	II	III	IV	V	VI
Unconsolidated Rock	Gravel, Medium to Coarse Sand	Fine to Very Fine Sand	Sand with $<$15% clay, Silt	Sand with $>$15% but $\leq$50% clay	Clay with $<$50% sand	Clay
Consolidated Rock	Cavernous or Fractured Limestone, Evaporites, Basalt Lava Fault Zones	Fractured Igneous and Metamorphic (Except Lava) Sandstone (Poorly Cemented)	Sandstone (Moderately Cemented) Fractured Shale	Sandstone (Well Cemented)	Siltstone	Unfractured Shale, Igneous and Metamorphic Rocks
Representative Permeability in gpd/ft^2 -	$>$200	2 - 200	0.2 - 2	$<$0.2	$<$0.02	$<$0.002
in cm/sec -	$>10^{-2}$	10^{-4} - 10^{-2}	10^{-5} - 10^{-4}	$<10^{-5}$	$<10^{-6}$	$<10^{-7}$
RATING MATRIX						
Thickness of the Unsaturated Zone (in Meters) $>$30	9A	6B	4C	2D	0E	0F
$>$10 $\leq$30	9B	7B	5C	3D	1E	0G
$>$3 $\leq$10	9C	8B	6C	4D	2E	0H
$>$1 $\leq$3	9D	9F	7C	5D	3E	1F
$>$0 $\leq$1	9E	9G	9H	9I	9J	9K

to it rather than the underlying regional water table (See Site 3 in Figure 3). The investigator will decide whether to measure the depth to the perched water table or ignore it and measure to the regional water table. This decision should be based on the extent and thickness of the perched water table and its usefulness as a drinking water source. If the perched water table is currently being utilized as a drinking water source, the depth should be measured to it.

Water tables fluctuate on a diurnal, seasonal and annual basis due to natural and artificial causes. For this assessment system the depth to the water table should be determined on the basis of the seasonal high water table elevation. As is shown in Table I, the depth determination does not have to be exact since the intervals are large. Illustrations of possible well hydrographs are shown in Figures 4 and 5. Figure 4a depicts a hydrograph of a well in Illinois which is only affected by seasonal climatic variation. The depth to water table would be taken as approximately five feet (1.6 meters). In Figure 4b the well hydrograph illustrates a water table which is affected by seasonal pumping variation. Pumping is greatest and, as a result, the water table is lowest during May through September, the hot season when consumption

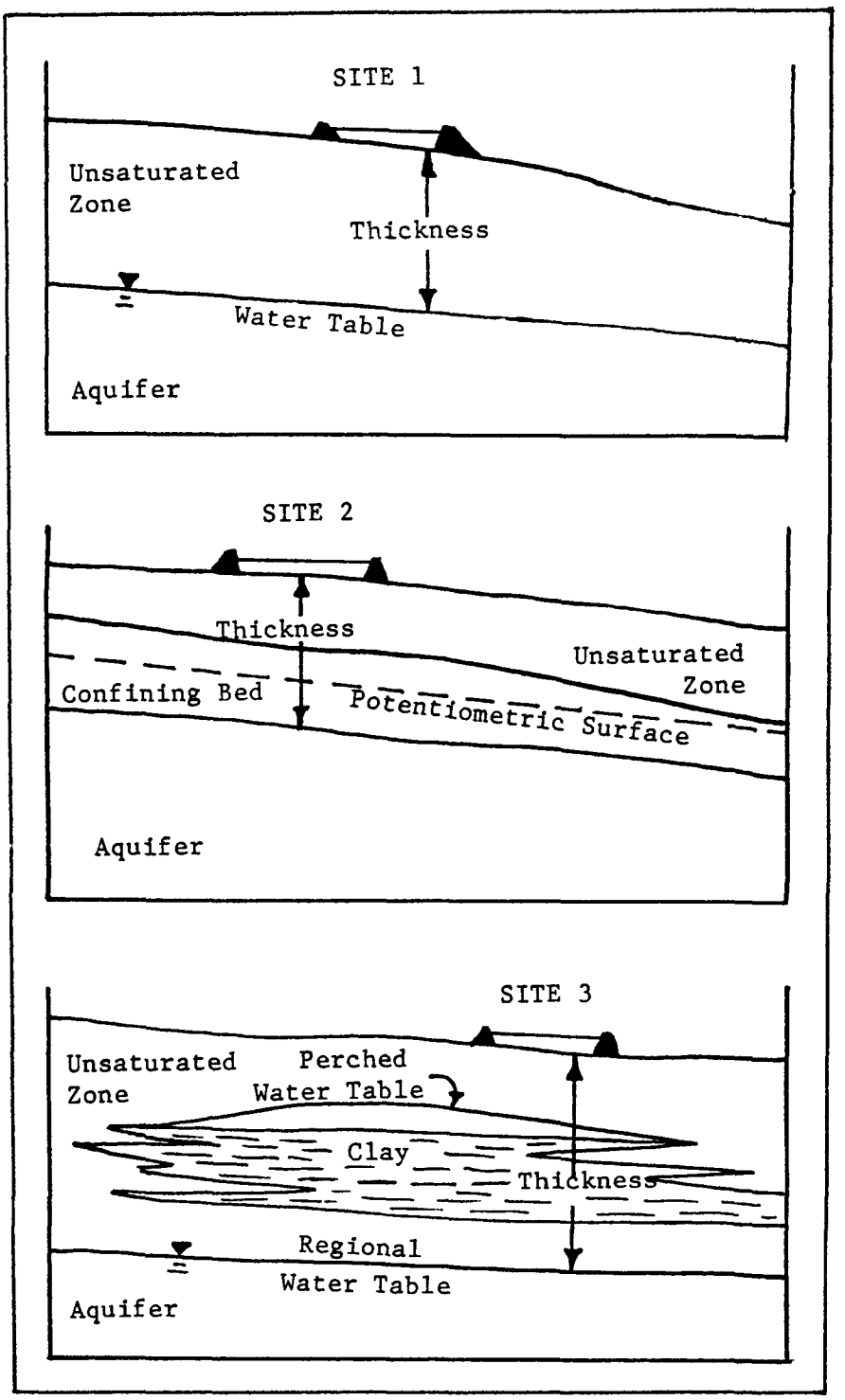


Figure 3. Guide for the determination of the depth to the saturated zone (water table in the unconfined case or top of confined aquifer) for completion of Step 1.

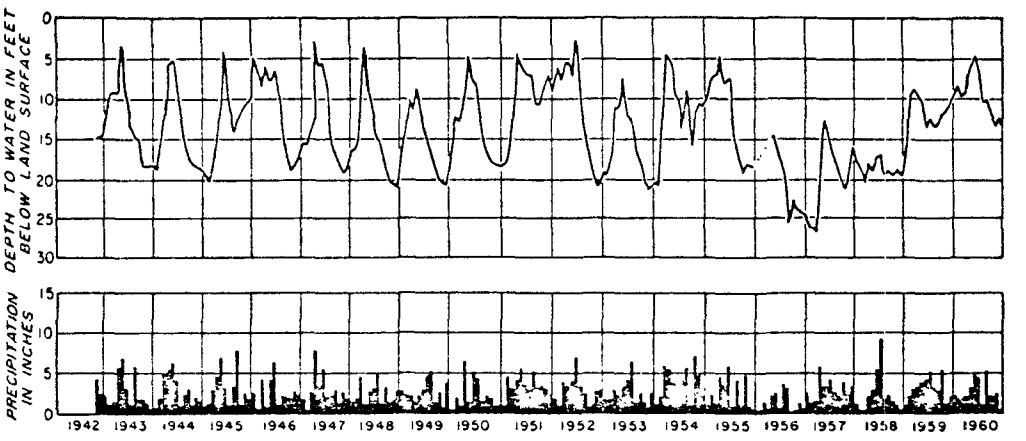


Figure 4A

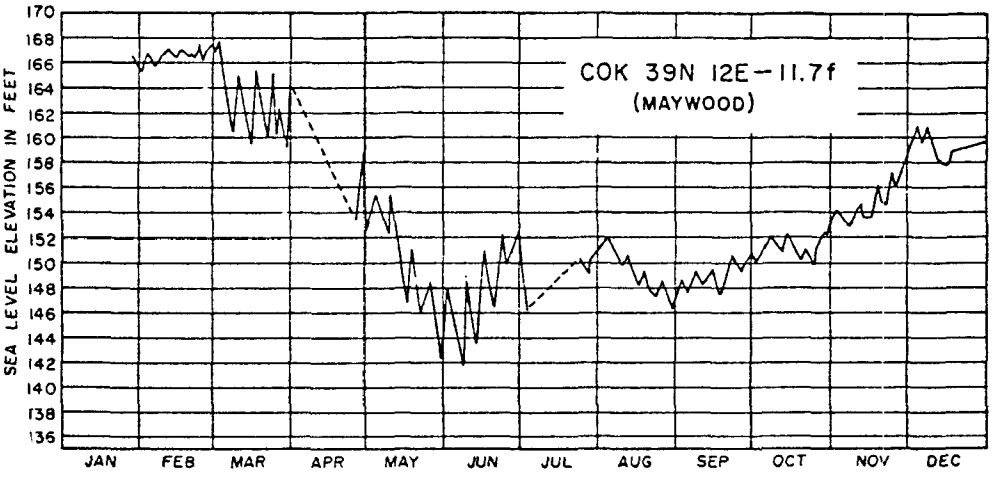


Figure 4B

Figure 4. Well hydrographs of a water well at Maywood, Illinois, showing, in Figure 4A, seasonal fluctuations in a well remote from pumping well influences; and in Figure 4B, fluctuations in a well close to a ground water pumping area (from Walton, 1970, p. 106).

is greatest. During the winter months of November through March the demand decreases and the ground-water table recovers. In this case the depth to the water table would be computed at the highest level, at 168 feet (51.2 meters) of elevation rather than the summer levels of 142 feet (43.3 meters).

Figure 5 shows a long period of record for a well hydrograph located in Ainsworth, Nebraska, in which annual and longer term fluctuations exist. Although the maximum change in water level amounts to only about 6 or 7 feet (2 meters), other areas of the country do experience much greater variation and should be considered. However, in this example, the water level used in determining the depth to the water table should be the higher level of 34 feet (10.4 meters) below the surface. Note that in all these examples, the more conservative estimate is used for depth to the water table.

In the situation where a confined (artesian) aquifer is encountered below a disposal site and an unconfined (water table) aquifer does not exist, the depth is measured to the top of that confined aquifer. Due to the nature of the confined aquifer, the net hydrostatic head of the system may decrease the possibility of contamination. However, conditions are not steady-state and other phenomena may affect the

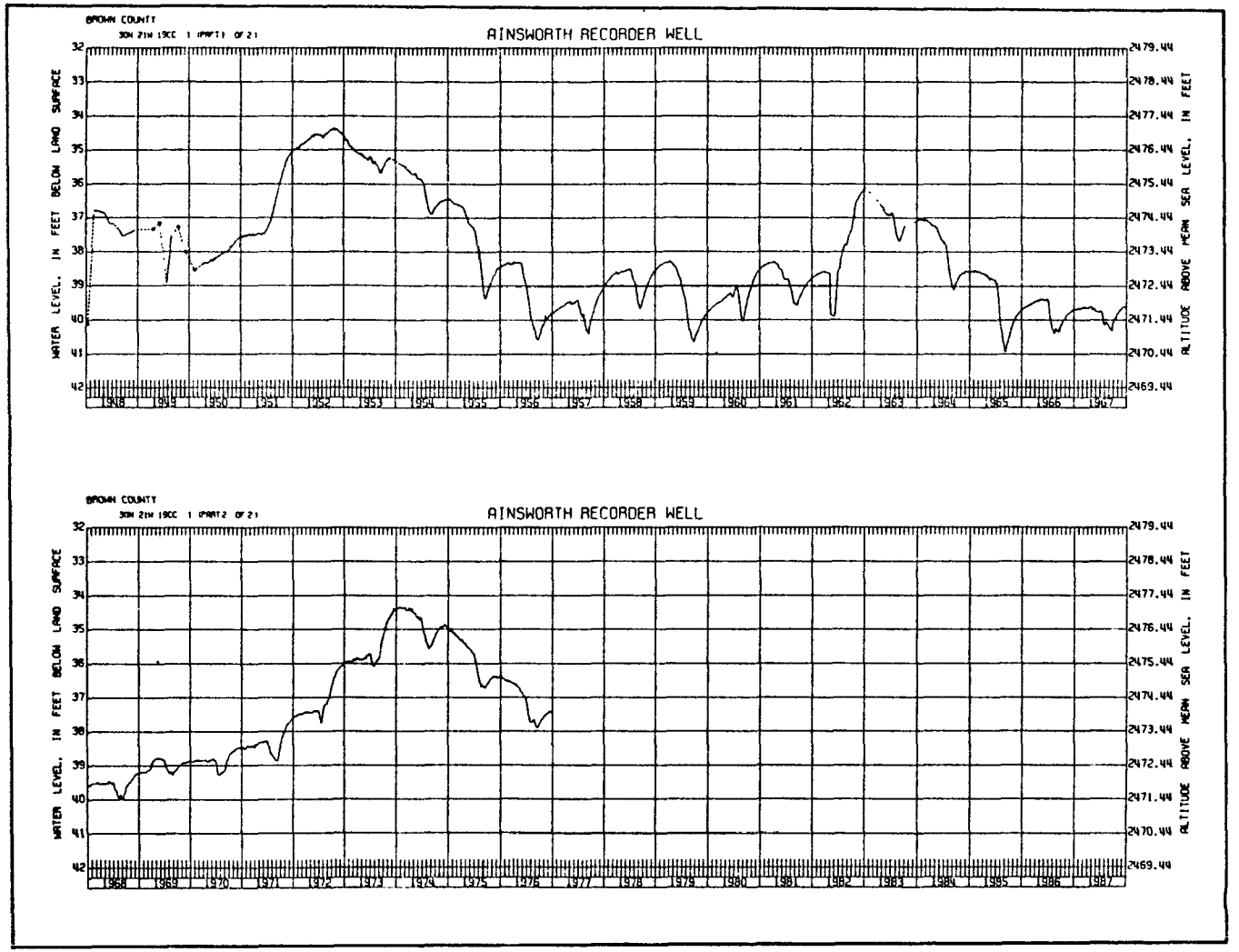


Figure 5. Well hydrograph of the Ainsworth, Nebraska, water supply well showing annual and longer term ground water level fluctuations (from Ellis and Pederson, 1977, p. 67).

net hydrostatic head of the confined aquifer. With the reductions of head which can be experienced (as in many irrigated areas of the country), confined aquifers may become vulnerable to contamination from surface sources through over pumping.

Step 1, Part B, Determination of the earth material category for Step 1

The type of earth material must be identified in order to complete Step 1. Table I contains an ordinal ranking of the general categories of earth materials based upon permeability, secondarily upon sorption character. The inclusion of sorption is based on the general relationships between grain size/surface area and permeability/sorption. Grain size (or pore size) is proportional to permeability and inversely proportional to surface area which is an important factor in sorption mechanisms. As grain size is inversely proportional to sorption capacity, sorption capacity is inversely proportional to permeability. Thus, going from left to right across the earth material categories in Table I, permeability decreases while sorption generally tends to increase. The categories take into account whether the permeability of the material is primary (properties existing at the time of formation such as the pore spaces) or secondary (properties of the material imposed upon it sometime after formation such as joints, fractures,

faults and solution channels). Secondary permeability is usually much greater than primary permeability due to the larger pathways. This distinction is very important in the categorization of earth materials as the presence of secondary permeability increases the flow of water and decreases attenuation. Fractures, joints, and faults are caused by earth movement and generally become closed and tighter with depth (generally within a hundred meters) because of increased pressures and decreased weathering effects. Faults often have an associated zone of crushed rock (fault breccia) which may be highly permeable.

The classification of the earth material should follow the guidelines of Table I and of Figures 6 and 7 which supply further assistance in the classification. Figure 6 gives a fairly comprehensive list of driller's terms found in driller's logs and the equivalent classification for Table I. Some groups of terms are assigned to more than one category, in which case the investigator must make a judgement. In Figure 7, the equivalent Unified Soil Classification System codes are shown.

I

Gravel, Sand, Sand and Gravel, and Similar Materials
Specific yield 25 per cent

Boulders	Gravel and sand
Coarse gravel	Gravel and sandrock
Coarse sand	Medium sand
Cobbles	Rock and gravel
Cobble stones	Running sand
Dry gravel (if above water table	Sand
Float rocks	Sand, water
Free sand	Sand and boulders
Gravel	Sand and cobbles
Loose gravel	Sand and fine gravel
Loose sand	Sand and gravel
Rocks	Sandy gravel
	Water gravel

II or III

Fine Sand, Tight Sand, Tight Gravel, and Similar Materials
Specific yield 10 percent

Sand and clay	Sandy loam
Sand and clay strata (traces)	Sandy loam, sand, and clay
Sand and dirt	Sandy silt
Sand and hardpan	Sandy soil
Sand and hard sand	Surface and fine sand
Sand and lava	
Sand and pack sand	Cloggy sand
Sand and sandy clay	Coarse pack sand
Sand and soapstone	Compacted sand and silt
Sand and soil	Dead sand
Sand and some clay	Dirty sand
Sand, clay, and water	Fine pack sand
Sand crust	Fine quicksand with alkali streak
Sand-little water	Fine sand
Sand, mud, and water	Fine sand, loose
Sand (some water)	Hard pack sand
Sand streaks, balance clay	Hard sand
Sand, streaks of clay	Hard sand and streaks of sandy clay
Sand with cemented streaks	
Sand with thin streaks of clay	Hard sand rock and some water sand
	Hard sand, soft streaks
Coarse, and sandy	Loamy fine sand
Loose sandy clay	Medium muddy sand
Medium sandy	Milk sand
Sandy	More or less sand
Sandy and sandy clay	Muddy sand
Sandy clay, sand, and clay	Pack sand
Sandy clay—water bearing	Poor water sand
	Powder sand
Sandy clay with streaks of sand	Pumice sand
	Quicksand
Sandy formation	Sand, mucky or dirty
Sandy muck	Set sand
Sandy sediment	Silty sand
Very sandy clay	Sloppy sand
	Sticky sand
	Streaks fine and coarse sand
Boulders, cemented sand	Surface sand and clay
Cement, gravel, sand, and rocks	Tight sand
Clay and gravel, water bearing	Brittle clay and sand
Clay & rock, some loose rock	Clay and sand
Clay, sand and gravel	Clay, sand, and water
Clay, silt, sand, and gravel	Clay with sand
Conglomerate, gravel, and boulders	Clay with sand streaks
	More or less clay, hard sand and boulders
Conglomerate, sticky clay, sand and gravel	Mud and sand
Dirty gravel	Mud, sand, and water
Fine gravel, hard	Sand and mud with chunks of clay
Gravel and hardpan strata	
Gravel cemented sand	Silt and fine sand
Gravel with streaks of clay	Silt and sand
Hard gravel	Soil, sand, and clay
Hard sand and gravel	
Packed gravel	Topsoil and light sand
Packed sand and gravel	
Quicksand and cobbles	Water sand sprinkled with clay
Rock sand and clay	
Sand and gravel, cemented streaks	Float rock (stone)
Sand and silt, many gravel	Laminated
Sand, clay, streaks of gravel	Pumice
Sandy clay and gravel	Seep water
Set gravel	Soft sandstone
Silty sand and gravel (cobbles)	Strong seepage
Tight gravel	

IV or V

Clay and Gravel, Sandy Clay, and Similar Materials
Specific yield 5 percent

Cemented gravel (cobbles)	Clay and sandy clay
Cemented gravel and clay	Clay and silt
Cemented gravel, hard	Clay, cemented sand
Cement and rocks (cobbles)	Clay, compact loam and sand
Clay and gravel (rock)	Clay to coarse sand
Clay and boulders (cobbles)	Clay, streaks of hard packed sand
Clay, pack sand, and gravel	Clay, streaks of sandy clay
Cobbles in clay	Clay, water
Conglomerate	Clay with sandy pocket
Dry gravel (below water table)	Clay with small streaks of sand
Gravel and clay	Clay with some sand
Gravel (cement)	Clay with streaks of fine sand
Gravel and sandy clay	Clay with thin streaks of sand
Gravel and tough shale	Porphyry clay
Gravelly clay	Quicksandy clay
Rocks in clay	Sand—clay
Rotten cement	Sand shell
Rotten concrete mixture	Shale and sand
Sandstone and float rock	Solid clay with strata of cemented sand
Silt and gravel	Sticky sand and clay
Soil and boulders	Tight muddy sand
	Very fine tight muddy sand
Cemented sand	
Cemented sand and clay	Dry sandy silt
Clay sand	Fine sandy loam
Dry hard packed sand	Fine sandy silt
Dry sand (below water table)	Ground surface
	Loam
Dry sand and dirt	Loam and clay
Fine muddy sand	Sandy clay loam
Fine sand, streaks of clay	Sediment
Fine tight muddy sand	Silt
Hard packed sand, streaks of clay	Silt and clay
	Silty clay loam
Hard sand and clay	Silty loam
Hard set sand and clay	Soft loam
Muddy sand and clay	Soil
Packed sand and clay	Soil and clay
Packed sand and shale	Soil and mud
Sand and clay mix	Soil and sandy shale
Sand and tough shale	Surface formation
Sand rock	Top hardpan soil
Sandstone	Topsoil
Sandstone and lava	Topsoil and sandy silt
Set sand and clay	Topsoil—silt
Set sand, streaks of clay	
Cemented sandy clay	
Hard sandy clay (tight)	Decomposed hardpan
Sandy clay	Hardpan and sandstone
Sandy clay with small sand streaks, very fine	Hardpan and sandy clay
	Hardpan and sandy shale
Sandy shale	Hardpan and sandy strata
Set sandy clay	Hard rock (alluvial)
Silty clay	Sandy hardpan
Soft sandy clay	Semi-hardpan
Clay and fine sand	Washboard
Clay and pumice streaks	
Ash	Hard pumice
Caliche	Porphyry
Chalk	Seepage soft clay
Hard lava formation	Volcanic ash

V or VI

Clay and Related Materials
Specific yield 3 percent

Adobe	Lava
Brittle clay	Loose shale
Caving clay	Muck
Cement	Mud
Cement ledge	Packed clay
Choppy clay	Poor clay
Clay	Shale
Clay, occasional rock	Shell
Crumbly clay	Slush
Cube clay	Soapstone
Decomposed granite	Soapstone float
Dirt	Soft clay
Good clay	Squeeze clay
Gumbo clay	Sticky
Hard clay	Sticky clay
Hardpan (H.P.)	Tiger clay
Hardpan shale	Tight clay
Hard shale	Tule mud
Hard shell	Variable clay
Joint clay	Volcanic rock

VI

Crystalline Bedrock (fresh)
Specific yield zero

Granite	Hard rock
Hard boulders	Graphite and rocks
Hard granite	Rock (if in area of known crystalline rocks)

Figure 6. Common driller's terms used in estimating specific yield (from Todd, 1970, p. 205) and the equivalent evaluation system earth material categories.

Step 1 Earth Material Category (and Step 1 Designation)	Unified Soil Classification System Designation	Permeability Range (cm/sec)
Gravel (I)	GW, GP	Permeable $> 10^{-4}$ cm/sec
Medium to Coarse Sand (I)	SW, SP	
Fine to Very Fine Sand (II)	SW, SP	
Sand with $\leq$15% Clay, Silt (III)	GM, SM, SC	Semi-permeable 10^{-2} to 10^{-6} cm/sec
Sand with $>$15% but $\leq$50% Clay (IV)	GM, SM, ML	
Clay with $<$50% Sand (V)	OL, MH	Relatively impermeable $< 10^{-6}$ cm/sec
Clay (VI)	CL, CH, OH	

Figure 7. Earth material categories and their approximate Unified Soil Classification System equivalents.

The geologic conditions beneath the site can be a very complex layering of clays, sands and gravels or consolidated sedimentary rocks such as sandstone, limestone and shale. In these layered situations the rating may be accomplished by considering the probable hydrology of the system. Where the different layers have similar hydrologic properties, the layers may be considered a single hydrologic unit for rating purposes. Where contrasting layers are encountered, best judgement must be exercised in rating the site. For example, if an impermeable shale overlies permeable sandstone rate only the thickness of shale. The investigator must be cautioned, however, that in rating a case where hydrologically unlike layers alternate, the waste is more likely to move through the more permeable zones and avoid the impermeable layers. As an example, a sand containing clay lenses should be rated as if only sand were present (See Figure 8). Similarly, where secondary permeability is present (i. e. fractures, joints and faults) the major path of waste movement is through the large conduits of secondary permeability rather than the interstices of primary permeability. This results in a short circuit of any attenuation capability present in the material. In such cases, the earth material would be rated as the more permeable categories.

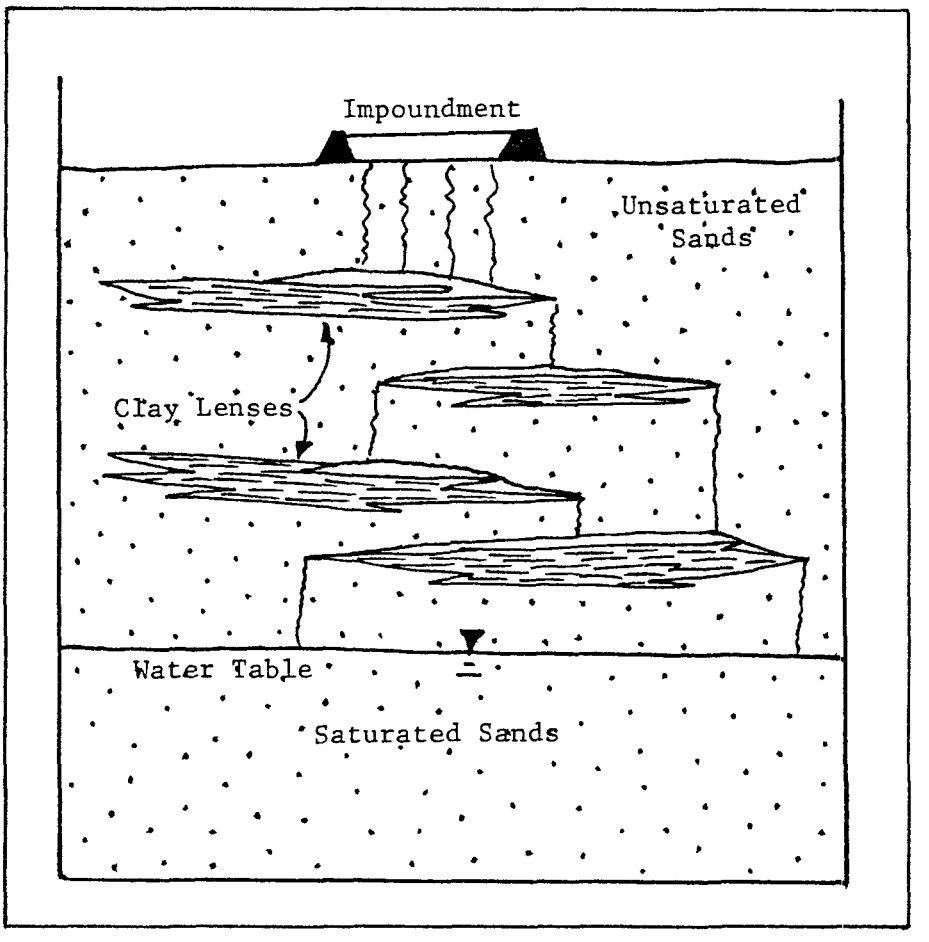


Figure 8. Hypothetical flow paths of waste fluids seeping from a surface impoundment through unsaturated sands containing clay lenses.

Step 1, Part C, The Scoring of Step 1.

After the thickness of the unsaturated zone and the type of earth material in the unsaturated zone have been determined, refer to the Step 1 matrix (in Table 1) and record the appropriate score for the particular values of thickness and material.

Sources of information for completing Step 1.

Many data sources exist for the depth to the water table and the geologic material beneath a site. The site may have specific data available from State files if the site is permitted. The owner/operator may have data on shallow bedrock and soils available from borings or trenches made for the impoundment or nearby building foundations. Nearby water wells may provide data on the geology and ground-water levels, and adjacent road cuts can provide additional information on the subsurface.

General information is available from State agency reports such as the State geological survey, State departments of transportation soil borings, water resources agencies or universities with departments concerned with geology and ground-water resources. The United States Geological Survey also publishes reports and

maintains files on ground water occurrence in each State. The U.S. Department of Agriculture, Soil Conservation Service, publishes county soils reports and maps with information on local soil profiles and bedrock, depth to the water table and depth to unweathered bedrock or parent material of the soil.

Example for determining the score for Step 1.

To score a site for Step 1, information is needed on: 1) the depth to the saturated zone and 2) the earth material of the unsaturated zone. The following example illustrates the method of scoring a site and will be utilized in all steps of the evaluation system.

A poultry processing plant, located in the Appalachian Valley and Ridge Province of a Mid-Atlantic State, operates a two acre waste treatment lagoon (about 8000 m) for disposal of poultry processing waste water. The waste treatment lagoon is shown in the site plan of Figure 9; Figure 10 gives the site location in relation to local topography.

Example Step 1, Part A. Determine the depth to the water table to establish the thickness of the unsaturated zone. In this example the

depth to the water table may be obtained from the driller's log of the plant water well. Figure 11 shows the driller's report which indicates that the depth to the static water table is 33 feet (about 10 meters). This static water table level is not the seasonal high water table at this site. The seasonal high water table would be expected to occur around 25 feet (7.5 meters).

The depth to the water table could also be estimated by studying the topographic map in Figure 10 if no well data was available. The elevation of the lagoon bottom is estimated to be about 1020 feet (311 meters) Mean Sea Level as the site is located between two 1020 foot contours. The river is about 100 feet (30 meters) to the west and, in the humid eastern climate, the water table can be assumed to be the river level at the river. Since the lagoon is close to the river, the water table is estimated to be about the same elevation as the river, i.e., 990 feet (302 meters). This is determined by noting that the 980 foot (299 meters) elevation crosses the river about 1 mile (1.6 kilometers) downstream and the 1000 foot (305 meters) elevation crosses about 1 mile upstream. Interpolation between 980 and 1000 gives a river elevation of 990 feet. By estimating the lagoon elevation (1020 feet) and adjacent

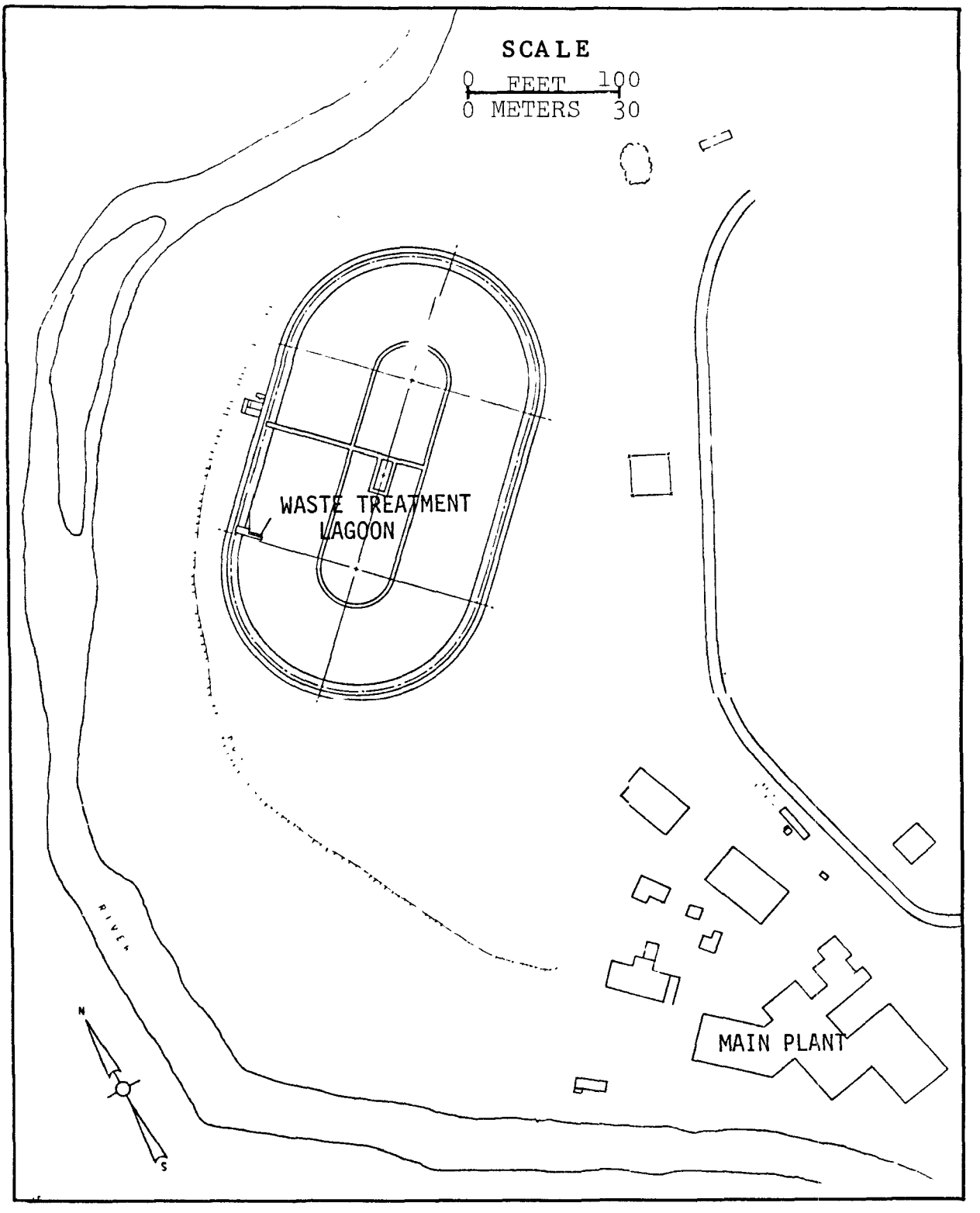


Figure 9. Poultry Processing Plant site plan.

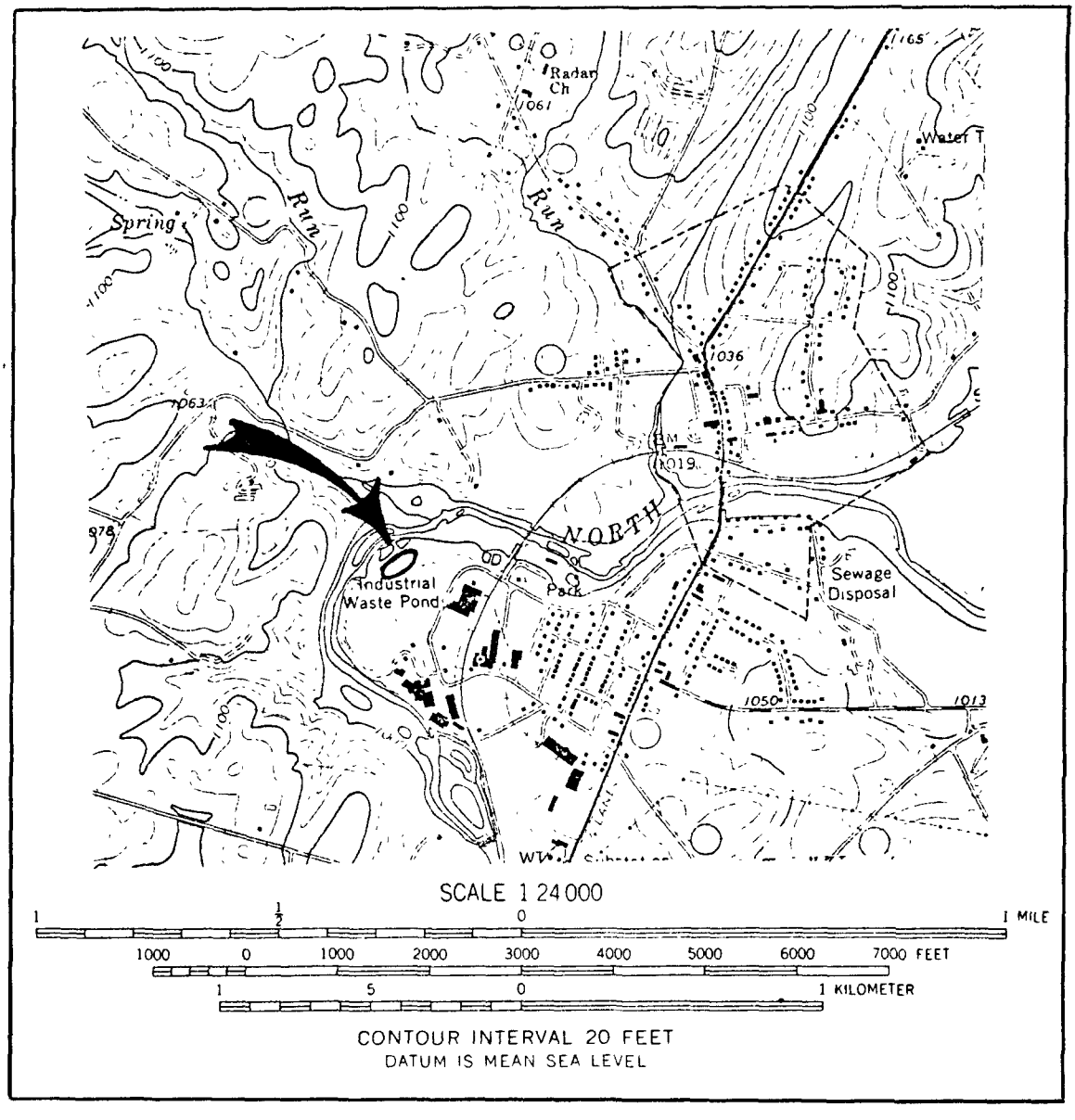


Figure 10. Portion of the 7.5 minute quadrangle topographic map of the Poultry Processing Plant (Marked by arrow).

Well 182-76 WATER CONDITIONS

DEPTH

STATIC WATER LEVEL 33'

WATER ZONES (fissures or formations supplying water)

(from) (to) (from) (to)

ft. ft.

ft. ft.

QUANTITY OF WATER

WELL PUMPED (or bailed) at 15 Gal. per Min. with 400 feet DRAWDOWN after 2 HOURS PUMPING.

FLOW (natural) G.P.M. HEAD ft. (above ground)

REMARKS: Had 15 GPM above 300'

QUALITY OF WATER

COLOR Clear TASTE OK

ODOR No OTHER

ANALYSIS: AVAILABLE— Yes ☐ No ☐: ATTACHED Yes ☐ No ☐

TEMPERATURE

WATER (from) ft. (to) ft.

(salt, brackish, iron, sulfur, acid, other)

USE OF WATER: Domestic ☐ Town ☐ Industry ☐ Farm ☐ Public ☐

CONSTRUCTION

RIG TYPE (or method) Air Rotary

(rotary, cable, bored, driven, etc.)

DATE: Started 8-2-60; Completed 8-8-60

TOTAL DEPTH ft.

BEDROCK at 17 ft.

GROUTING INFORMATION

METHOD USED Gravity

GROUTING MATERIAL Cement + Water

DEPTH OF GROUTING 50

HOLE SIZE (diam) in	(from) ft	(to) ft	CASING SIZE (diam) in	(from) ft	(to) ft
10	0	50	6 5/8	0	51' 6"
6 1/2	50	474			

SCREEN (or perforations)

(diam) in (from) ft (to) ft (opening size)

Figure 11. Portion of the driller's report on the water supply well drilled at the Poultry Processing Plant showing the static ground-water level.

river elevations (990 feet), the water table depth is estimated at 30 feet (about 9 meters). This estimate is fairly close to the measured static water level in the well. This method of estimating ground-water levels is useful only for perennial streams and is not reliable in the arid western United States where streams are intermittent. In such cases the ground-water level is often deeper than the stream bed and may have no relationship to the stream level or topography.

Example Step 1, Part B. The second part of completing Step 1 is to estimate the composition of the earth material of the unsaturated zone. For the Poultry Processing Plant, there is a substantial amount of data available from a county geologic report, the driller's report for the water well at the site and, several test borings conducted at the lagoon site. Figure 12 and 13 show the surface bedrock configuration and the structural cross-section of the area. The bedrock at the site is the Edinburg Formation composed of shale and limestone layers tilted at about 70 degrees to the west. The Driller's report containing the well log (Figure 14) indicates that about 16 feet (about 5 meters) of unconsolidated clay and gravel overlie a considerable thickness of variable limestone down to 424 feet (129 meters).

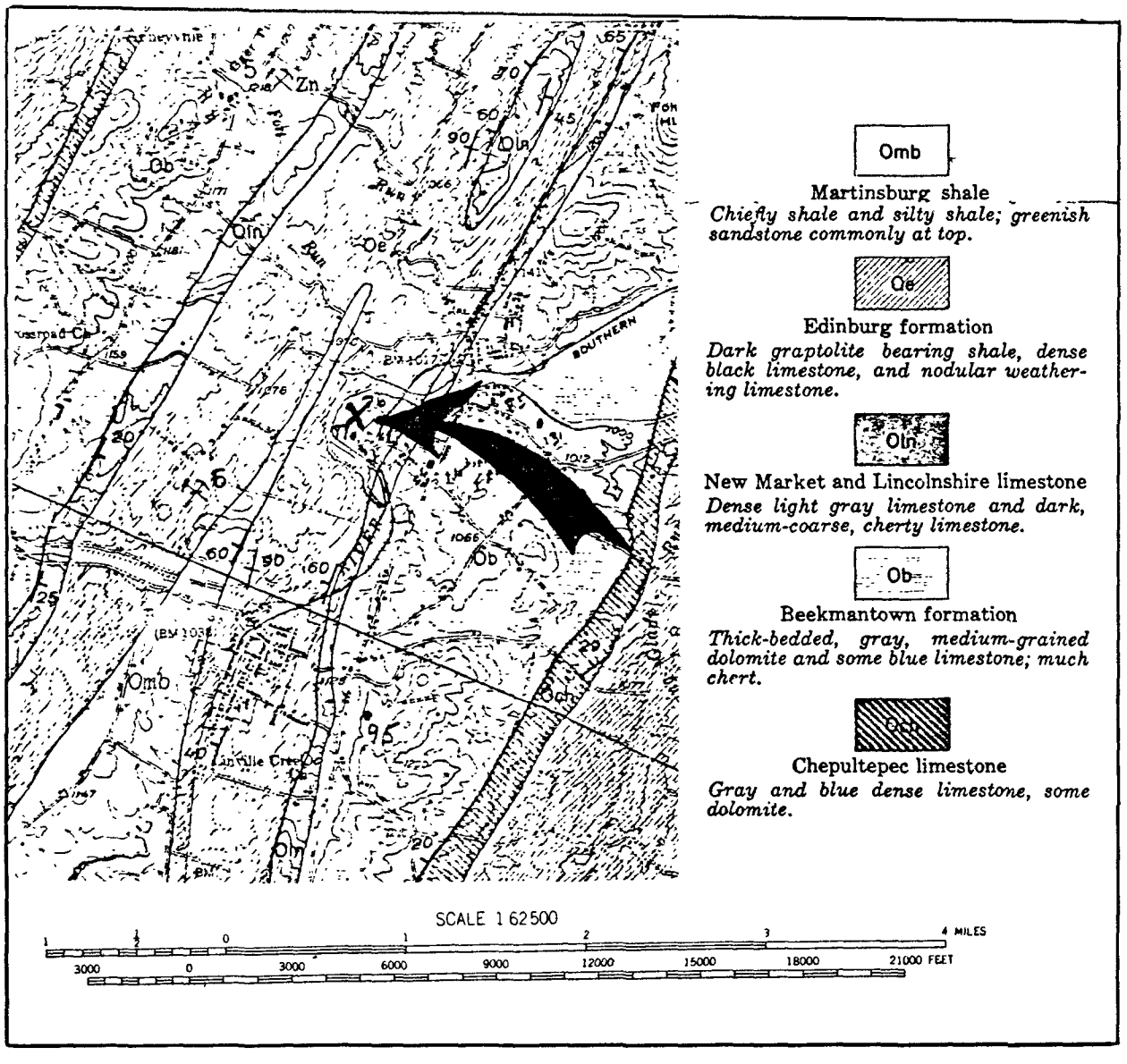
The logs of the test borings shown in Figures 15 indicate a quite variable thickness of sand and gravel (from 12 to 60 feet, or 3 to 18 meters) above limestone. It would be expected in this area of steeply tilted limestone and shale layers to have a rough, variable bedrock surface as a result of differential weathering.

Example, Step 1, Part C. After determining the thickness of the unsaturated zone (7.5 meters) and the type of earth material in the unsaturated zone, the Step 1 score can be determined from the Step 1 matrix in Table I for the following parameters:

Thickness of the unsaturated zone = 7.5 meters

Material of the unsaturated zone = 3 meters of sand and gravel
4.5 meters of limestone

As the sand, gravel and limestone are of similar hydrologic character and in the same earth material category of Step 1, their thickness can be combined so that the Step 1 score would be determined for 7.5 meters of category "I" material rated at 9C. (The presence of a liner would be noted by recording the appropriate code in the reporting form.)



Fugure 12. Portion of the geologic map from the County Geologic Report containing the location of the Poultry Processing Plant (marked by an X and an arrow).

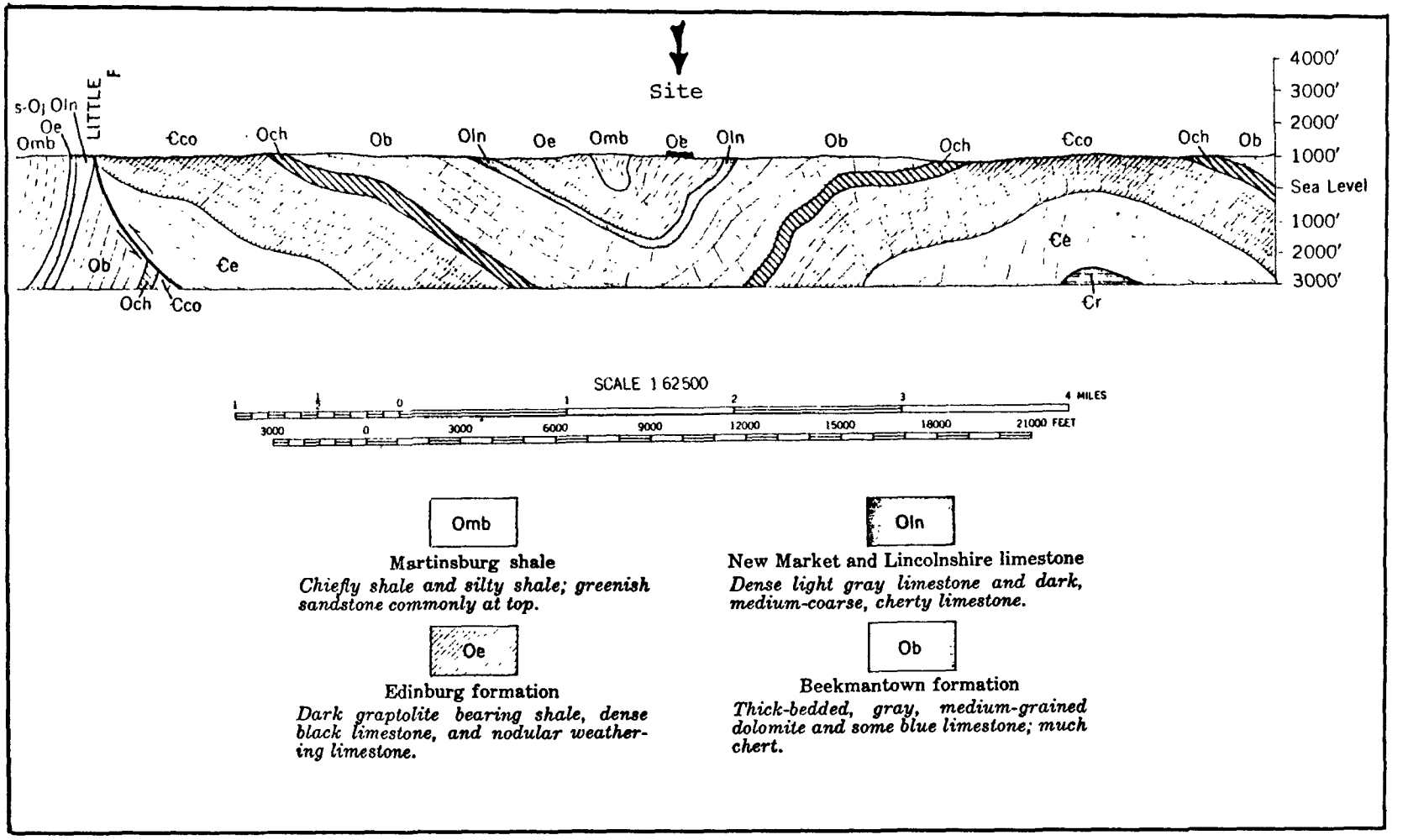


Figure 13. Portion of a geologic cross-section from the County Geologic Report depicting the general subsurface geologic structure around the Poultry Processing Plant (marked by the arrow).

DEPTH (feet) FROM	TO	TYPE OF SOIL OR ROCK PENETRATED (gravel, clay, etc., hardness, color, etc)	REMARKS (water, caving, shot, screen, sample, etc)
0	4	Top Soil	Well 182-76
4	5	Red clay	
5	13	clay - gravel cemented	
13	16	Red clay	
16	23	Gray Limestone	
23	74	" "	
74	75	white Rock Blue Lime Some Water	3-4 GPM
75	108	Blue Lime with white Rock	
108	118	Blue Lime	
118	119	white Rock	
119	280	Blue Lime with white Rock	10-12 GPM
280	398	Blue Lime Hard + Soft	
398	418	Soft Blue Lime	
418	424	Hard Blue Limestone	

Figure 14. Portion of the driller's report on the water supply well drilled at the Poultry Processing Plant showing the well log.

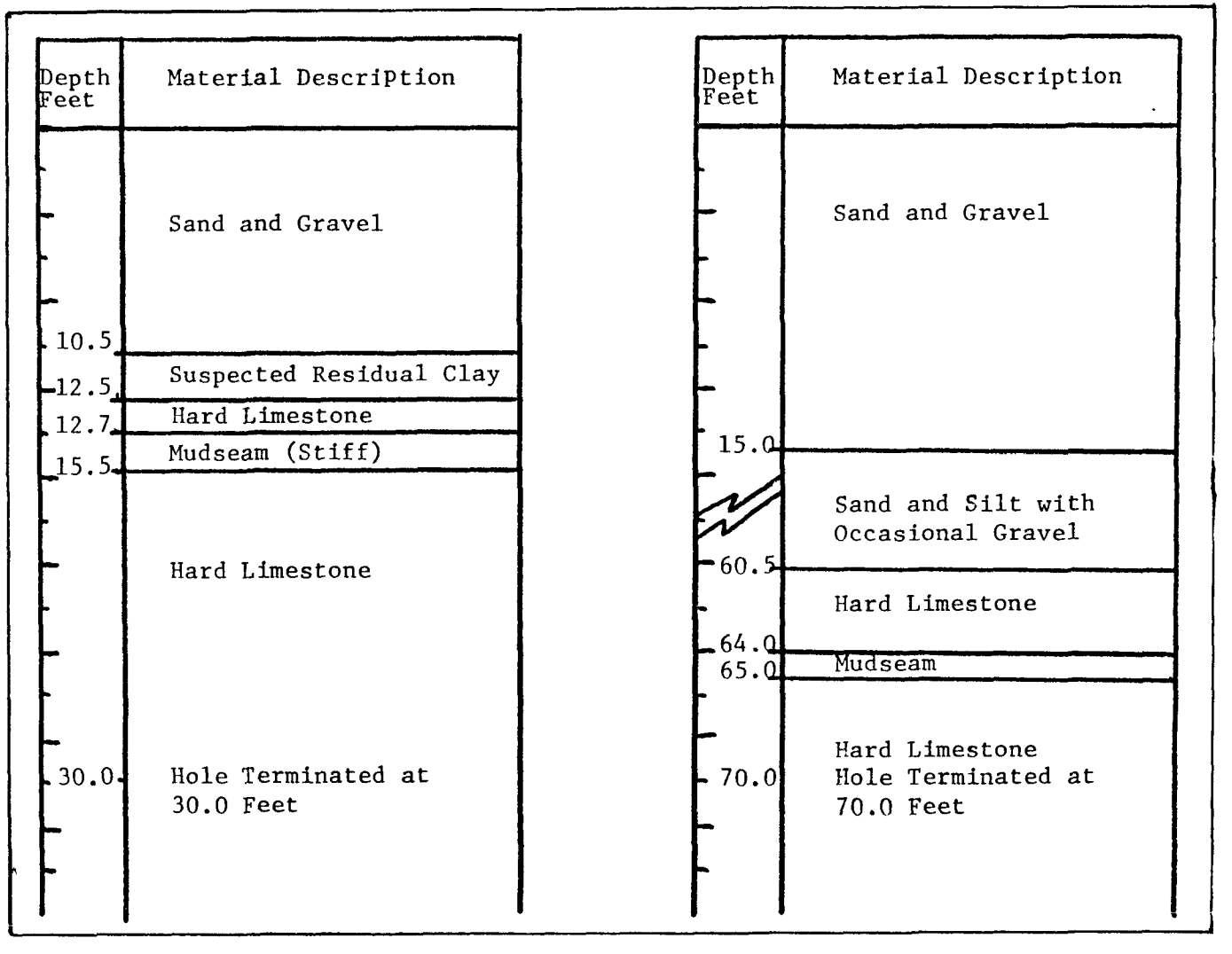


Figure 15. Driller's logs of test borings beneath the waste treatment lagoon at the Poultry Processing Plant.

STEP 2

GUIDANCE FOR RATING GROUND WATER AVAILABILITY

Determining the ground-water availability ranking.

The ability of the aquifer to transmit ground water depends upon the permeability and saturated thickness of the aquifer. Step 2 provides the guidance to determine the ground-water availability rating of the aquifer. Since this evaluation system is a first-round approximation, the ground-water availability rating is not exact, but an approximation. The categories of earth material which make up the saturated zone are the same categories as used in Step 1 but have been combined into good, fair and poor aquifer material categories (Table II).

Estimate the aquifer's saturated thickness (in meters) and the type of earth material in the saturated zone as done for Step 1. Choose the appropriate ranking in the matrix of Step 2 (Table II) from the respective saturated thickness and earth material category. The letter accompanying the ranking is for the purpose of identifying what the ranking's derivation is if, at sometime in the future, there is reason to verify the number.

Sources of information for completing Step 2 .

Sources of information in determining the parameters of Step 2 are similar to those of Step 1.

TABLE II

Step 2. Rating of the Ground Water Availability

GUIDELINES FOR DETERMINING CATEGORY

Earth Material Category	I	II	III
Unconsolidated Rock	Gravel or sand	Sand with $\leq$ 50% clay	Clay with $<$ 50% sand
Consolidated Rock	Cavernous or Fractured Rock, Poorly Cemented Sandstone, Fault Zones	Moderately to Well Cemented Sandstone, Fractured Shale	Siltstone, Unfractured Shale and other Impervious Rock
Representative Permeability			
in gpd/ft^2	$>$ 2	0.02 - 2	$<$ 0.02
in cm/sec	$>10^{-4}$	10^{-6} - 10^{-4}	$<10^{-6}$
RATING MATRIX			
Thickness of Saturated Zone (Meters) $\geq$ 30	6A	4C	2E
3-30	5A	3C	1E
$\leq$ 3	3A	1C	0E

Example, Step 2.

The type of earth material of the saturated zone can be determined from the county geologic map and cross-section (Figures 11 and 12) and the driller's log of Figure 13. Generally, the material down to greater than 400 feet (122 meters) below the surface is limestone with shale interbeds. From the drillers' report of the pump test (shown in Figure 10) the water supply well near the surface impoundment had 400 feet of drawdown at 15 gpm (57 liters per minute) after 2 hours pumping. From this data the limestone is very tight with little permeability and very little development of open fractures. The category in Step 2 for rating this material would be category II as the saturated zone is capable of producing water but only at moderate to low quantites. From the above sources of information the thickness of the saturated zone is estimated to be several hundred feet. The score for the ground-water availability ranking would be determined for earth material category II and greater than 30 meters thickness, i.e., the Step 2 ranking is "4C."

STEP 3

GUIDANCE FOR RATING THE GROUND-WATER QUALITY

Ground-water quality is a determinant of the ultimate usefulness of the ground water. Waste disposal sites situated in an area of poor quality ground water unsuitable as a drinking water supply would not present the same degree of pollution potential to ground water as the same site situated in an area having very good quality ground water. Step 3 (Table III) is used to determine the ranking of the aquifer's ground-water quality. The ranking is based upon the criteria that has been set forth in the proposed Underground Injection Control Regulations (40 CFR Part 146) of the Safe Drinking Water Act of 1974 (P. L. 93-523). The descriptions are to be used as basic guidelines to assist the investigator in arriving at the appropriate rating of ground-water quality. Consideration of only the background water quality of the aquifer is intended.

Determine the Aquifer Quality Ranking

Determine the total dissolved solids content of the ground water and apply it to the appropriate rating in Step 3, Table III. If the ground water is presently a drinking water supply, the ranking would be a "5" regardless of its total dissolved solids content.

Table III

Step 3. Rating the Ground-Water Quality

Rating	Quality
5	≤ 500 mg/l TDS or a current drinking water source
4	> 500 - ≤1000 mg/l TDS
3	> 1000 - ≤3000 mg/l TDS
2	>3000 - ≤10,000 mg/l TDS
1	>10,000 mg/l TDS
0	No ground water present

Sources of information for completing Step 3 .

Ground-water quality data for the determination of the Step 3 rating may be obtained from several sources. If the aquifer is presently used by individuals or communities, no further documentation is required. If industries or agriculture use the ground water, but not currently for human consumption, further quality data may be required for the rating. Many State agencies (i. e., geological surveys, health departments, water boards or commissions and State engineers) and the U.S. Geological Survey have considerable water quality data on file, in published reports and as maps outlining the ground-water quality in the States by aquifer.

Example, Step 3.

The quality of the ground water beneath the Poultry Processing Plant site would be rated "5" since the aquifer does supply drinking water, and in addition based upon driller's report, general State files and published reports, the aquifer has an overall good quality with very low total dissolved solids.

STEP 4

GUIDANCE FOR RATING THE WASTE HAZARD POTENTIAL

Contaminants that may enter ground water have been evaluated by their potential for causing harm to human health (Hazard Potential). The hazard potential rankings for contaminants range from 1 to 9 with 1 being least hazardous and 9 being most hazardous.

Contaminants and their hazard potential rankings are classified in two ways: (1) by contaminant source (Table IV), and (2) by contaminant type (Table V). Standard Industrial Classification (SIC) numbers are used to classify sources. Common sources and types of contaminants and their hazard potential ranges are illustrated in Figure 16.

There are many variables that influence a substance as it enters the ground-water environment such that its true hazard potential as a ground-water contaminant is not likely to be the same as its apparent hazard potential. Most such variables tend to reduce hazard potentials. The hazard potential rankings considered the following factors and their interactions.

TOXICITY - The ability of a substance to produce harm in or on the body of living organisms is extremely important in ranking the hazard potential of that substance. While some substances are highly toxic they may possess low mobility and thus be assigned a lower hazard potential ranking than a less toxic but highly mobile substance.

TABLE IV

CONTAMINANT HAZARD POTENTIAL RANKINGS OF WASTE, CLASSIFIED BY SOURCE FOR STEP 4.

SIC Number		Description of Waste Source	Hazard Potential Initial Rating
01		AGRICULTURAL PRODUCTION - CROPS	1-2
02		AGRICULTURAL PRODUCTION - LIVESTOCK	
	021	Livestock, except Dairy, Poultry and Animal Specialties	3 (5 for Feedlots)
	024	Dairy Farms	4
	025	Poultry and Eggs	4
	027	Animal Specialties	2-4
	029	General Farms, Primarily Livestock	2
10		METAL MINING	
	101	Iron Ores	4
	102	Copper Ores	6
	103	Lead and Zinc Ores	5
	104	Gold and Silver Ores	6
	105	Bauxite and other Aluminum Ores	5
	106	Ferroalloy Ores Except Vanadium	5
	108	Metal Mining Services	4
	1092	Mercury Ore	6
	1094	Uranium-Radium-Vanadium Ores	7
	1099	Metal Ores not elsewhere classified	5
11		ANTHRACITE MINING	7
12		BITUMINOUS COAL AND LIGNITE MINING	7
13		OIL AND GAS EXTRACTION	
	131	Crude Petroleum and Natural Gas	7
	132	Natural Gas Liquids	7
	1381	Drilling Oil and Gas Wells	6
	1382	Oil and Gas Field Exploration Services	1
	1389	Oil and Gas Field Services not elsewhere classified	Variable depending on Activity
14		MINING AND QUARRYING OF NON-METALLIC MINERALS, EXCEPT FUELS	
	141	Dimension Store	2
	142	Crushed and Broken Stone, Including Riprap	2
	144	Sand and Gravel	2
	145	Clay, Ceramic, and Refractory Minerals	2-5
	147	Chemical and Fertilizer Mineral Mining	4-7
	148	Nonmetallic Minerals Services	1-7
	149	Miscellaneous Non-metallic Minerals, except Fuels	2-5

(TABLE IV continued)

SIC Number		Description of Waste Source	Hazard Potential Initial Rating
16		CONSTRUCTION OTHER THAN BUILDING CONSTRUCTION	
	1629	Heavy Construction, not elsewhere classified (Dredging, especially in salt water)	4
20		FOOD AND KINDRED PRODUCTS	
	201	Meat Products	3
	202	Dairy Products	2
	203	Canned and Preserved Fruits and Vegetables	4
	204	Grain Mill Products	2
	205	Bakery Products	2
	206	Sugar and Confectionery Products	2
	207	Fats and Oils	3
	208	Beverages	2-5
	209	Misc. Food Preparation and Kindred Products	2
22		TEXTILE MILL PRODUCTS, ALL EXCEPT LISTINGS BELOW	
	223	Broad Woven Fabric Mills, Wool (including dyeing and finishing)	6
	226	Dying and Finishing Textiles, except Wool Fabrics and Knit Goods	6
	2295	Coated Fabrics, Not Rubberized	6
24		LUMBER AND WOOD PRODUCTS, EXCEPT FURNITURE	
	241	Logging Camps and Logging Contractors	2
	242	Sawmills and Planing Mills	2
	2435	Hardwood Veneer and Plywood	4
	2436	Softwood Veneer and Plywood	4
	2439	Structural Wood Members, not elsewhere classified (laminated wood-glue)	3
	2491	Wood Preserving	5
	2492	Particle Board	4
	2499	Wood Products, not elsewhere classified	2-5
26		PAPER AND ALLIED PRODUCTS	
	261	Pulp Mills	6
	262	Paper Mills Except Building Paper Mills	6
	263	Paperboard Mills	6

(TABLE IV continued)

SIC Number		Description of Waste Source	Hazard Potential Initial Rating
28		CHEMICALS AND ALLIED PRODUCTS[1]	
	2812	Alkalies and Chlorine	7-9
	2813	Industrial Gases	
	2816	Inorganic Pigments	3-8
	2819	Industrial Inorganic Chemicals, not elsewhere classified	3-9
	2821	Plastic Materials, Synthetic Resins, and Nonvulcanizable Elastomers	6-8
	2822	Synthetic Rubber (Vulcanizable Elastomers)	6-8
	2823	Cellulose Man-Made Fibers	6-8
	2824	Synthetic Organic Fibers, except Cellulosic	6-8
	2831	Biological Products	6-9
	2833	Medicinal Chemicals and Botanical Products	3-8
	2834	Pharmaceutical Preparations	6-9
	2841	Soap and Other Detergents, except specialty cleaners	4-6
	2842	Specialty Cleaning, Polishing and Sanitation Preparation	3-8
	2843	Surface Active Agents, Finishing Agents, Sulfonated Oils and Assistants	6-8
	2844	Perfumes, Cosmetics, and other Toilet Preparations	3-6
	2851	Paints, Varnisher, Lacquers, Enamels, and Allied Products	5-8
	2861	Gum and Wood Chemicals	5-8
	2865	Cyclic (coal tar) Crudes, and Cyclic Intermediates, Dyes and Organic Pigments (Lakes and Toners)	6-9
	2869	Industrial Organic Chemicals, not elsewhere listed	3-9

(TABLE IV continued)

SIC Number		Description of Waste Source	Hazard Potential Initial Rating
	2873	Nitrogenous Fertilizers	7-8
	2874	Phosphatic Fertilizers	7-8
	2875	Fertilizer Mixing Only	5
	2879	Pesticides and Agricultural Chemicals, Not Elsewhere Listed	5-9
	2891	Adhesives and Sealants	5-8
	2892	Explosives	6-9
	2893	Printing Ink	2-5
	2895	Carbon Black	1-3
	2899	Chemicals and Chemical Preparations, not Elsewhere Listed	3-9
29		PETROLEUM REFINING AND RELATED INDUSTRIES	
	291	Petroleum Refining	8
	295	Paving and Roofing Materials	7
	299	Misc. Products of Petroleum and Coal	7
30		RUBBER AND MISCELLANEOUS PLASTICS PRODUCTS	
	301	Tires and Inner Tubes	6
	302	Rubber and Plastic Footwear	6
	303	Reclaimed Rubber	6
	304	Rubber and Plastics Hose and Belting	4
	306	Fabricated Rubber Products, not Elsewhere Classified	4
31		LEATHER AND LEATHER PRODUCTS	
	311	Leather Tanning and Finishing	8
		(Remaining Three-Digit Codes)	1-3
32		STONE, CLAY, GLASS, AND CONCRETE PRODUCTS	
	321	Flat Glass	4
	322	Glass and Glassware, Pressed or Blown	4
	324	Cement, Hydraulic	3
	3274	Lime	3
	3291	Abrasive Products	3
	3292	Asbestos	3
	3293	Gaskets, Packing, and Sealing Devices	3
33		PRIMARY METAL INDUSTRIES (EXCEPT AS NOTED BELOW)	3
	3312	Blast Furnaces, Steel Works, and Rolling and Finishing Mills	6
	333	Primary Smelting and Refining of Nonferrous Metals	7

(TABLE IV continued)

SIC Number		Description of Waste Source	Hazard Potential Initial Rating
34		FABRICATED METAL PRODUCTS, EXCEPT MACHINERY AND TRANSPORTATION EQUIPMENT (EXCEPT AS NOTED BELOW)	5
	347	Coating, Engraving, and Allied Services	8
	3482	Small Arms Ammunition	7
	3483	Ammunition, Except for Small Arms not Elsewhere Classified	7
	3489	Ordnance and Accessories, not Elsewhere Classified	7
	349	Misc. Fabricated Metal Products	3-6
35		MACHINERY, EXCEPT ELECTRICAL	5-7
36		ELECTRICAL AND ELECTRONIC MACHINERY, EQUIPMENT AND SUPPLIES (EXCEPT AS NOTED BELOW)	5-7
	3691	Storage Batteries	8
	3692	Primary Batteries, Dry and Wet	8
37		TRANSPORTATION EQUIPMENT	5-8
38		MEASURING, ANALYZING, AND CONTROLLING INSTRUMENTS; PHOTOGRAPHIC, MEDICAL, AND OPTICAL GOODS; WATCHES AND CLOCKS (EXCEPT AS NOTED BELOW)	4-6
	386	Photographic Equipment and Supplies	7
39		MISCELLANEOUS MANUFACTURING INDUSTRIES	3-7
49		ELECTRIC, GAS, AND SANITARY SERVICES	
	491	Electric Services	3-5
	492	Gas Production and Distribution	3
	494	Water Supply	2
	4952	Sewerage Systems	2-5
	4953	Refuse Systems (except Municipal Landfills)	2-9
	496	Steam Supply	2-4

TABLE V

CONTAMINANT HAZARD POTENTIAL RANKINGS OF WASTES, CLASSIFIED BY TYPE[1] FOR STEP 4

	Description	Hazard Potential Initial Rating	ID Number *
A.	SOLIDS		
	Ferrous Metals	1-4[2]	1100
	Non-Ferrous Metals	1-7[2]	1200
	Resins, Plastics and Rubbers	2	1300
	Wood and Paper Materials (except as noted below)	2	1400
	- Bark	4	1401
	Textiles and Related Fibers	2	1500
	Inert Materials (except as noted below)	2	1600
	- Sulfide Mineral-Bearing Mine Tailings	6	1601
	- Slag and other Combustion Residues	5	1602
	- Rubble, Construction & Demolition Mixed Waste	3	1603
	Animal Processing Wastes (Except as noted below)	2-4	1700
	- Processed Skins, Hides and Leathers	6	1701
	- Dairy Wastes	4	1702
	- Live Animal Wastes-Raw Manures (Feedlots)	5	1703
	- Composts of Animal Waste	2-4	1704
	- Dead Animals	5	1705
	Edible Fruit and Vegetable Remains - Putrescables	2-3	1800
B.	LIQUIDS		
	Organic Chemicals (Must be chemically Classified)[2]		2000
	- Aliphatic (Fatty) Acids	3-5	2001
	- Aromatic (Benzene) Acids	7-8	2002
	- Resin Acids		2003
	- Alcohols	5-7	2004
	- Aliphatic Hydrocarbons (Petroleum Derivatives	4-6	2005
	- Aromatic Hydrocarbons (Benzene Derivatives)	6-8	2006
	- Sulfonated Hydrocarbons	7-8	2007
	- Halogenated Hydrocarbons	7-9	2008
	- Alkaloids	7-9	2009
	- Aliphatic Amines and Their Salts	1-4	2010
	- Anilines	6-8	2011
	- Pyridines	2-6	2012
	- Phenols	7-9	2013
	- Aldehydes	6-8	2014
	- Ketones	6-8	2015
	- Organic Sulfur Compounds (Sulfides, Mercaptans)	7-9	2016
	- Organometallic Compounds	7-9	2017
	- Cyanides	7-9	2018
	- Thiocyanides	2-6	2019
	- Sterols		2020
	- Sugars and Cellulose	1-4	2021
	- Esters	6-8	2022

Description	Hazard Potential Initial Rating	ID Number*
Inorganic Chemicals (Must be Chemically Classified)[2]		2100
- Mineral and Metal Acids	5-8	2101
- Mineral and Metal Bases	5-8	2102
- Metal Salts, Including Heavy Metals	6-9	2103
- Oxides	5-8	2104
- Sulfides	5-8	2105
- Carbon or Graphite	1-3	2106
Other Chemical Process Wastes Not Previously Listed (Must be Chemically Classified)[2]		2200
- Inks	2-5	2201
- Dyes	3-8	2202
- Paints	5-8	2203
- Adhesives	5-8	2204
- Pharmaceutical Wastes	6-9	2205
- Petrochemical Wastes	7-9	2206
- Metal Treatment Wastes	7-9	2207
- Solvents	6-9	2208
- Agricultural Chemicals (Pesticides, Herbicides, Fungicides, etc.)	7-9	2209
- Waxes and Tars	4-7	2210
- Fermentation and Culture Wastes	2-5	2211
- Oils, including Gasoline, Fuel Oil, etc.	5-8	2212
- Soaps and Detergents	4-6	2213
- Other Organic or Inorganic Chemicals, includes Radioactive Wastes	2-9	2214
Conventional Treatment Process Municipal Sludges	4-8	2300
- From Biological Sewage Treatment	4-8	2301
- From Water Treatment and Conditioning Plants (Must be Chemically Classified)[2]	2-5	2302

* ID Number is for identification of waste type in the Reporting Form.

[1]Classification based on material in Environmental Protection Agency Publication, 670-2-75-024, pages 79-85, Prepared by Arthur D. Little, Inc. and published in 1975.

[2]For individual material ranking refer to solubility-toxicity tables prepared by Versar, Inc. for the Environmental Protection Agency.

MOBILITY - The material must be able to enter the ground-water environment and travel with the ground water. Certain substances are essentially immobile (eg., asbestos fibers) while others are highly mobile with most substances falling between these extremes.

PERSISTENCE - Some substances such as halogenated hydrocarbons decay or degrade very slowly and receive a higher hazard potential ranking than other equally toxic materials that decay more rapidly.

VOLUME - Some substances, such as tailings or slimes from mining operations, are only moderately toxic but because they are produced in enormous quantities are given a somewhat higher hazard potential ranking.

CONCENTRATION - Substances entering the ground-water environment in concentrations which could potentially endanger human health are ranked. Concentration may decrease with dilution and attenuation but the amount of decrease at a given place depends, in part, on waste mobility, waste interaction with soils and aquifer material, etc.

Determining the Waste Hazard Potential for Step 4 .

Wastes may be simple in composition, but most are complex and the hazard potential rankings given in Tables IV and V are maximum values based on the most hazardous substance present in the contaminant. Such rankings are, of necessity, generalizations because of the unknown interactions that occur between substances and the variables of the ground-water environment.

For those substances or sources that show a hazard potential ranking range (e. g., 5-8) additional information concerning the specific nature of the source or contaminant is required for assigning a specific ranking. Specific rankings in such cases must be personal judgements by the assessor. Additional information for determining a specific ranking may be available from the source of the contaminant, i. e., the industry may be able to supply specific information about the contaminant. In the event specific information is not available from the source, additional information may be obtained from an examination of descriptions of average contaminant characteristics listed in several publications cited below. For cases when there is considerable pretreatment of the waste, the ranking may be lowered to the bottom of its range. If no additional information is available, the first round approximation ranking must assume the worst case and a low confidence rating be given the ranking.

If sufficient information exists about the material (i. e., exact composition, concentration, volume, treatment prior to coming in contact with the ground, etc.) the rating may be lowered. In considering whether to lower the rating, some compounds degrade aerobically or anaerobically and the products of degradation are more hazardous than the parent chemical. Initial rankings may be modified downward provided:

1. The hazardous material in question has been effectively treated to lower its hazard potential as a ground-water pollutant. Several references describe best available methods for treating contaminants to reduce their toxicity, for example see:

- Sax, 1965, Dangerous Properties of Industrial Materials.
- Identification of Potential contaminants of underground water sources from land spills, by Versar, Inc. (Task II of EPA contract No. 68-01-4620.
- EPA, 1973, Report to Congress on Hazardous Waste Disposal
- Powers, 1976, How to Dispose of Toxic Substances and Industrial Wastes.

2. It can be shown that the hazardous material in question has low mobility in the specific site it is contaminating. Most solid and inert substances have low mobility. Substances with high solubilities tend to be most mobile. Mobility depends on a complex interplay of many factors and only a few substances have been studied sufficiently to predict with any degree of confidence their specific mobilities at a specific site.

3. The volume and/or concentration of the hazardous material is so small that there is a good probability that it will be diluted to safe (drinking water standard) levels at the point of concern.

Example for Determining the Score for Step 4 .

The waste in the Poultry Processing Plant lagoon is a meat product waste, SIC number 201 and would receive a "3" rating.

STEP 5

DETERMINATION OF THE SITE'S OVERALL GROUND-WATER CONTAMINATION POTENTIAL

After the site has been rated on Steps 1, 2, 3 and 4, the overall ground-water contamination potential of the site can be determined by totalling these scores. This overall score allows a comparison of one site with other rated sites by indicating the general, overall contamination potential. Sites may be rated identically, yet be very different in one or several of the parameters included in the overall score; thus the overall score of Step 5 should be used with caution in assessing a particular site's potential to allow ground-water contamination. In addition, this overall score cannot be used to assess the actual amount of ground-water contamination at the site. The score is only for relative comparison with other sites. An actual determination of ground-water contamination requires an intensive on-site investigation.

EPA has not formulated an interpretation of the overall ground water contamination score other than as a relative means to prioritize sites.

Step 5. Determination of the Site's Ground-Water Contamination Potential Rating.

The site's ground-water contamination potential rating is the addition of the rating scores for the first four steps:

Contamination Potential = Step 1 + Step 2 + Step 3 + Step 4.

The highest ground-water contamination potential rating a site can receive is "29" while the lowest is "1."

Example for determining the score for Step 5.

The overall ground-water contamination potential score for the Poultry Processing Plant lagoon is determined in Step 5 by adding the scores from Steps 1, 2, 3, and 4:

$$\text{Step 5 Rating} = \text{Step 1} + \text{Step 2} + \text{Step 3} + \text{Step 4}$$
$$= 9 + 4 + 5 + 3 = 21$$

STEP 6

DETERMINATION OF THE POTENTIAL ENDANGERMENT TO CURRENT WATER SUPPLIES

The distance from the impoundment to a ground or surface water source of drinking water and the determination of anticipated flow direction of the waste plume are used to ascertain the potential endangerment to current water supplies presented by the surface impoundment. For many assessments this step can be accomplished by measuring the horizontal distance on a 7.5 topographic map, or similar scale. In order to use this step, the anticipated direction of ground water flow within 1600 meters (1 mile) of the impoundment must be determined. Ground-water movement depends upon natural ground-water flow direction, variations due to pumping wells, mounding of the ground water beneath the site and other factors influencing flow direction, such as faults, fractures and other geologic features.

In the case of artesian wells, the anticipated flow direction of the waste plume generally would not be in the direction of the artesian well intake. Artesian wells are located in confined aquifers separated hydraulically from the surface sources of contamination by relatively impermeable confining layers, and wells tapping the confined zone generally will not be drawing ground water from upper zones.

Artesian wells should not be considered in this step unless there is an indication that the anticipated flow direction of the contaminated ground water would be in the direction of that well. To score Step 5, prioritized cases (cases A-D) have been established for rating the site according to the potential magnitude of endangerment to current sources. These priorities are detailed in Step 6 (Table VI). To score a site when a water table is nearly flat and the flow direction is indeterminable, a circle with a 1600 meter radius should be drawn around the site for designating the area of concern. In this situation the evaluator would use the same criteria, in sequential order, begining with Case A, Case B, and then Case D, eliminating Case C.

After the distance has been determined, use the Step 6 rating matrix to determine the rating under the column of the appropriate case.

TABLE VI

Step 6. Rating the Potential Endangerment to a Water Supply

Case A - Highest Priority: Rate the closest water well within 1600 meters of the site that is in the anticipated direction of waste plume movement.

Case B - Second Priority: If there is no well satisfying Case A, rate the closest surface water within 1600 meters of the site that is in the anticipated direction of the waste plume movement.

Case C - Third Priority: If no surface water or water well satisfying Case A or B exists, rate the closest water supply well or surface water supply within 1600 meters of the site that is not in the anticipated direction of waste plume movement.

Case D - Lowest Priority: If there are no surface waters or water wells within 1600 meters of the site in any direction, rate the site as "0D."

Select the appropriate rating for the given distance and case:

Distance (Meters)	Case A	Case B	Case C	Case D
≤200	9A	8B	7C	-
>200, ≤400	7A	6B	5C	-
>400, ≤800	5A	4B	3C	-
>800, ≤1600	3A	2B	1C	-
>1600				0D

Example for determining the score for Step 6.

The potential health hazard to existing water supply sources which the Poultry Processing Plant presents is found by determining what types of water supplies are present and their distances from the lagoon. The drilled well described in Figure 11 is for industrial water supply. Surface water (a river) is within about 30 meters of the lagoon as shown in Figure 9. Step 6 requires an estimation of the anticipated flow direction. In this example, the anticipated flow of the waste plume is to the river. The rating of Step 6 would be based on Case B, and would be scored "8B".

STEP 7

DETERMINING THE INVESTIGATOR'S DEGREE OF CONFIDENCE

The evaluation of a surface impoundment's ground-water contamination potential involves three steps and about twice as many separate variables. In many situations the investigator will not have comprehensive information concerning the variables and will have to evaluate the site on the basis of estimation or approximation. For this reason a rating of the investigator's confidence in scoring each step will be made. The following outline is intended to assist the investigator in rating the confidence of the data for each step, with "A" the highest confidence, "C" the lowest.

Step 1 confidence rating for determining the earth material of the unsaturated zone.

Rating	Basis for Determination of Rating
A	Driller's logs containing reliable geologic descriptions and water level data; U. S. Department of Agriculture soil survey used in conjunction with large scale, modern geologic maps. Published ground-water reports on the site.
B	Soil surveys or geologic maps used alone.

	General ground-water reports.
	Drillers' logs with generalized descriptions.
	Drillers logs or exposures such as deep road cuts near the site of contamination allowing interpolation within the same general geologic unit.
C	On site examination with no subsurface data and no exposures of subsurface conditions nearby.
	Estimation of water levels or geology based on topography and climate.
	Extrapolations of well logs, road cuts, etc. where local geology is not well known.
	Estimation based on generalized geologic maps.
	Estimations based on topographic analysis.

Step 2 confidence rating for determining the ground-water availability ranking.

This step involves the earth material categorization and thickness of the aquifer's saturated zone. The confidence rating for Step 2, Part A follows the same basis as Step 1, Part B above.

Step 3 confidence rating for determining background ground-water quality.

Rating	Basis for Determination of Rating
A	Water quality analyses indicative of background ground-water quality from wells at the site or nearby wells or springs or known drinking water supply wells in vicinity.

B	Local, county, regional and other general hydrogeology reports published by State or Federal agencies on background water quality. Interpolation of background ground-water quality from base flow water quality analyses of nearby surface streams.
C	Estimates of background ground-water quality from mineral composition of aquifer earth material.

Step 4 confidence rating for waste character.

Rating	Basis for Determination of Rating
A	Waste character rating based on specific waste type.
B	Waste character rating based on SIC category.

Step 6 confidence rating for determination of the anticipated direction of waste plume movement.

Rating	Basis for Determination of Rating
A	Accurate measurements of elevations of static water levels in wells, springs, swamps, and permanent streams in the area immediately surrounding the site in question. Ground-water table maps from published State and Federal reports.

B	Estimate of flow direction from topographic maps in non cavernous area having permanent streams and humid climate.
	Estimate of flow direction from topographic maps in arid regions of low relief containing some permanent streams.
C	Estimate of flow direction from topographic maps in cavernous, predominantly limestone areas (karst terrain).
	Estimate of flow direction from topographic maps in arid regions of highly irregular topography having no permanent surface streams.

Example for determining the confidence rating for each step.

Based upon the guidance just presented, the confidence ratings for the Poultry Processing Plant are:

	Confidence Rating
Step 1	A--Based upon measurement in on site well.
Step 2	A--Based upon well logs of on site well.
Step 3	A--Based upon water well analyses.

Step 4	B--Based upon SIC category.
Step 6	B--Estimate of flow direction from topographic map in humid region.

STEP 8

MISCELLANEOUS IDENTIFIERS

This step allows the evaluator to identify any additional significant variable not noted in the rating system. Such parameters are:

Identifier

R - The site is located in a ground-water recharge area,

D - The site is located in a ground-water discharge area,

F - The site is located in a flood plain and is susceptable to flood hazard,

E - The site is located in an earthquake prone area,

W - The site is located in the area of influence of a pumping water supply well,

K - The site is located in karst topography or fractured, cavernous limestone region.

C - The ground water under the site has been contaminated by man-made causes (i. e., road salt, feed lot, industrial waste).

M - Known ground-water mound exists beneath the site.

I - Interceptor wells or other method employed to inhibit contaminated ground-water migration (endangerment to water supply wells may be reduced).

STEP 9

RECORD THE FINAL SCORE

In order to present the rating scores from the previous nine steps of the evalution system in a logical manner, Step 9 provides a systematic format in which the evaluation of the site can be recorded. The nine steps are not recorded in numerical order as the focus of the evaluation is on the ground-water pollution potential score of Step 5. Thus, Step 5 is listed first, followed by Steps 1, 2, 3, 4, 6 and 8. The example of the Poultry Processing Plant waste treatment lagoon has been listed on page 63 on the following sample reporting form. The confidence scores of Step 7 have been distributed among the appropriate steps.

TABLE VII

RATING OF THE GROUND WATER POLLUTION POTENTIAL:

9	C	A	4	C	A	5	A	3	B	2	1	8	B	B	R	F	
Unsat. Zone		Confidence	G. W. Avail.		Confidence	G. W. Qual.	Confidence	Waste	Confidence	G. W. Poll. Potential		Health Hazard		Confidence	Miscellaneous Identifiers		
STEP 1			STEP 2			STEP 3		STEP 4		STEP 5		STEP 6					

APPENDIX A

TYPICAL SOURCES AND TYPES OF DATA USEFUL IN APPLYING THE ASSESSMENT SYSTEM

Type of Data	Typical Sources	Useful in determining Steps			
		1	2&3	4	6
Property survey	County Records, property owner	*		X	
Well drillers logs	Well Driller, property owner, state records	*	*		X
Water level measure ments	Well owners' observations, well drillers' logs, topo-graphic maps, ground water maps (reports)	*	X		*
Topographic Maps	U.S. Geological Survey and designated state sales offices	X			*
Air Photos	U.S. Dept of Agriculture, U.S. Forest Service, etc.				*
County Road Maps	State agencies				*
Ground Water Reports	U.S. Geological Survey, State agencies	*	*		X
Soil Surveys of Counties	U.S. Department of Agriculture	*	X		X
Geologic Maps	U.S. Geological and State Surveys	X	X		X
Waste Character	Owner/operator, State or Federal permits, SIC Code			X	

* - Source of data may be especially useful

X - Source of data may be of slight use or may be used indirectly

APPENDIX B

MEASURING UNIT CONVERSION TABLE

inch (in)	x	2.54	=	centimeter (cm)
centimeter	x	0.3937	=	inch
feet (ft)	x	0.3048	=	meter (m)
meter	x	3.2808	=	feet
mile (mi)	x	1.609	=	kilometer (km)
kilometer	x	0 621	=	mile
U.S. gallon (gal)	x	0.0038	=	cubic meter (m^3)
cubic meter	x	264.17	=	U.S. gallon
cubic feet (ft^3)	x	0.0283	=	cubic meter
cubic meter	x	35.314	=	cubic feet
acre-foot (ac-ft)	x	123.53	=	cubic meter
cubic meter	x	0.0008	=	acre-feet
hectare	x	10,000.0	=	square meter (m^2)
square meter	x	0.0001	=	hectare
hectare	x	2.471	=	acre
acre	x	0.4047	=	hectare
<u>Hydraulic Conductivity</u>				
gpd/ft^2	x	4.72×10^{-5}	=	cm/sec
cm/sec	x	21.2×10^{3}	=	gpd/ft^2
Darcy	x	18.2	=	gpd/ft^2
Darcy	x	8.58×10^{-4}	=	cm/sec

APPENDIX C

GLOSSARY

Aquifer - a formation, group of formations or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Artesian ground water - synonymous with confined ground water which is a body of ground water overlain by material sufficiently impervious to sever free hydraulic connection with overlying ground water. Confined ground water is under pressure great enough to cause water in a well tapping that aquifer to rise above the top of the confined aquifer.

Discharge area - geographic region in which ground water discharges into surface water such as at springs and seeps and subsurface seepage into streams, lakes and oceans (referred to as base flow in streams).

Karst topography - geologic region typified by the effects of solution of rocks by water. Rock types most likely effected are limestone dolostone, gypsum and salt beds. Features produced are caverns, collapse features on the surface (sink holes), underground rivers and zones of lost circulation for well drillers.

Perched water table - unconfined ground water separated from an underlying body of ground water by an unsaturated zone. Its water table is a "perched water table" and is sustained by a "perching bed" whose permeability is so low that water percolating downward through it is not able to bring water in the underlying unsaturated zone above atmospheric pressure.

Plume of contaminated ground water - as contaminants seep or leach into the subsurface and enter the ground water, the flow of the ground water past the site of contamination causes the contaminated ground water to move down gradient. This action results in the creation of a "plume" shaped body of ground water containing varying concentrations of the contaminant, extending down gradient from place of entry. The shape of the plume of contaminated ground water is affected by attenuation of the specific contaminants and, to a lesser extent, by dispersion.

Primary permeability - permeability due to openings or voids existing when the rock was formed, i. e. , intergranular interstices.

Recharge area - geographic region in which surface waters infiltrate into the ground, percolate to the water table and replenish the ground water. Recharge areas may be well defined regions such as limestone outcrops or poorly defined broad regions.

Saturated Zone - the zone in the subsurface in which all the interstices are filled with water.

Secondary permeability - permeability due to openings in rocks formed after the formation of the rock, i. e., joints, fractures, faults, solution channels and caverns.

Unsaturated zone - formerly the "zone of aeration" or "vadose zone". It is the zone between the land surface and the water table, including the "capillary fringe".

Water table - that surface in an unconfined ground-water body at which the pressure is atmospheric. Below the water table is the saturated zone and above is the unsaturated zone.

APPENDIX D

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16. ABSTRACT

This manual was specifically prepared for implementing a standardized evaluation system for the EPA Office of Drinking Water Surface Impoundment Assessment. The manual describes a first round evaluation system for rating the ground water contamination potential of surface impoundments. The evaluation system contains eight steps:

1. Rating the unsaturated zone
2. Rating the ground water availability
3. Rating the ground water quality
4. Rating the waste hazard potential
5. Computing the overall ground water contamination potential
6. Rating the potential endangerment to current users of the ground water
7. Rating the investigator's confidence in the data
8. Miscellaneous identifiers

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