In the above settings, the TDS of naturally occurring saline water may be 3 to 10 times greater than the 10,000 mg/l criterion. Owing to natural concentration gradients, a zone of diffusion is normally observable between the saline and fresh ground waters. The 10,000 mg/l TDS isometric surface will generally be situated within the diffusion zone separating the waters of contrasting salinities.

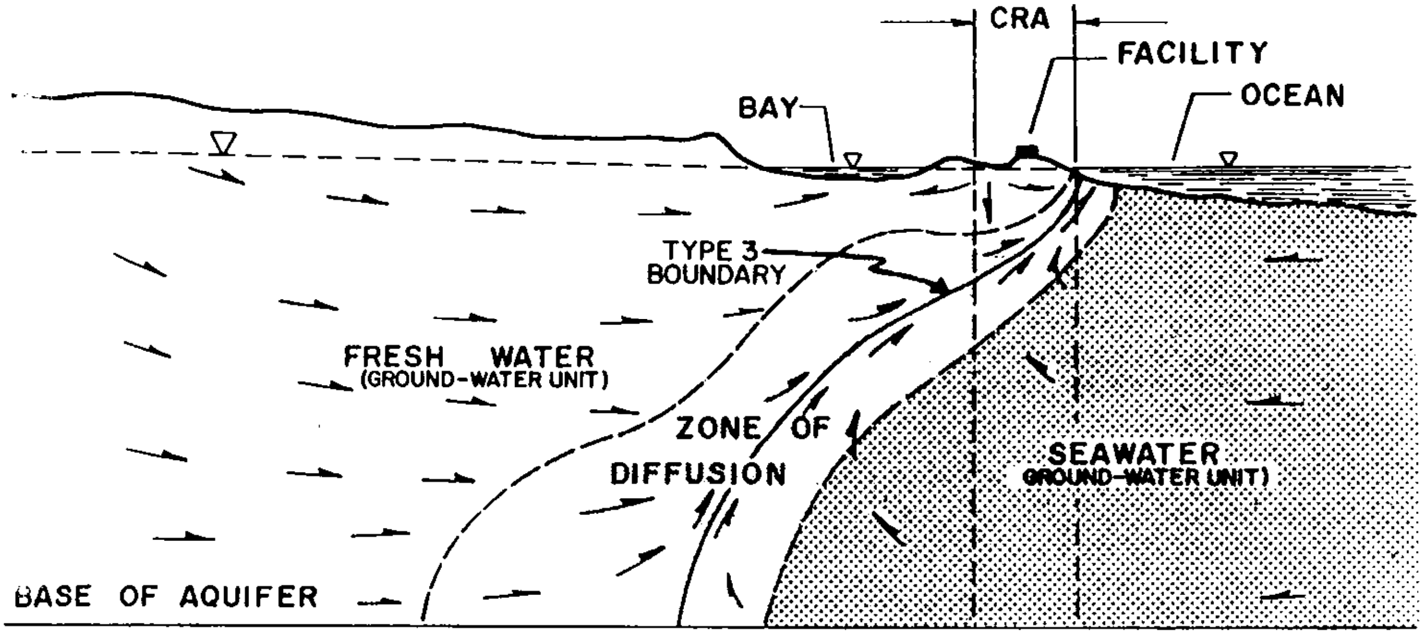
Figure 4-7 illustrates how a wedge of sea water which has intruded into an unconfined aquifer is identified as a separate ground-water unit of higher salinity and density relative to an adjacent ground-water unit, in the same aquifer, containing fresh water. In this setting, there exists a zone of diffusion between two flow systems that contain fresh water and sea water. The salinity boundary would occur along the 10,000 mg/l TDS isometric surface.

Figure 4-8 illustrates a second hydrogeologic setting characterized by the presence of near-surface evaporite deposits overlying deeper bedrock units. Salts are dissolved from the evaporite units by the circulating ground waters and a shallow zone of saline waters coexists with fresh ground waters within the same flow system. However, based on the delineation of a Type 3 boundary, two distinct ground-water units can be identified.

Although the saline water is primarily confined to the low-permeability evaporite formation, this water leaks into the underlying aquifer creating a zone of diffusion within the underlying aquifer. The boundary between the two adjacent ground-water units would be drawn along the 10,000 mg/l TDS isometric surface within the diffusion zone. The diffusion zone would be a stable feature assuming the flow system is in both hydraulic and geochemical steady state. The degree of interconnection between these adjacent ground-water units is defined to be intermediate. The type of setting illustrated in Figure 4-8 is not as common as the coastal intrusion setting illustrated in Figure 4-7, but it is known to exist in selected parts of the United States.

In the above two settings, the intermediate degree of interconnection between ground-water units is due to the limited potential for the exchange of waters across a Type 3 boundary within a diffusion zone. In the first setting, the salt water and fresh water are in separate, but adjacent flow systems. In the second case, the diffusion zone is more extensive and may or may not be within a single flow system. A third case involves a single regional flow system with the diffusion zone in the deeper and more downgradient end of the system.

FIGURE 4-7
EXAMPLE OF TYPE 3 BOUNDARY THROUGH AN
UNCONFINED AQUIFER IN A COASTAL SETTING



EXPLANATION

>30,000 mg/l TDS WATER

DIFFUSION ZONE

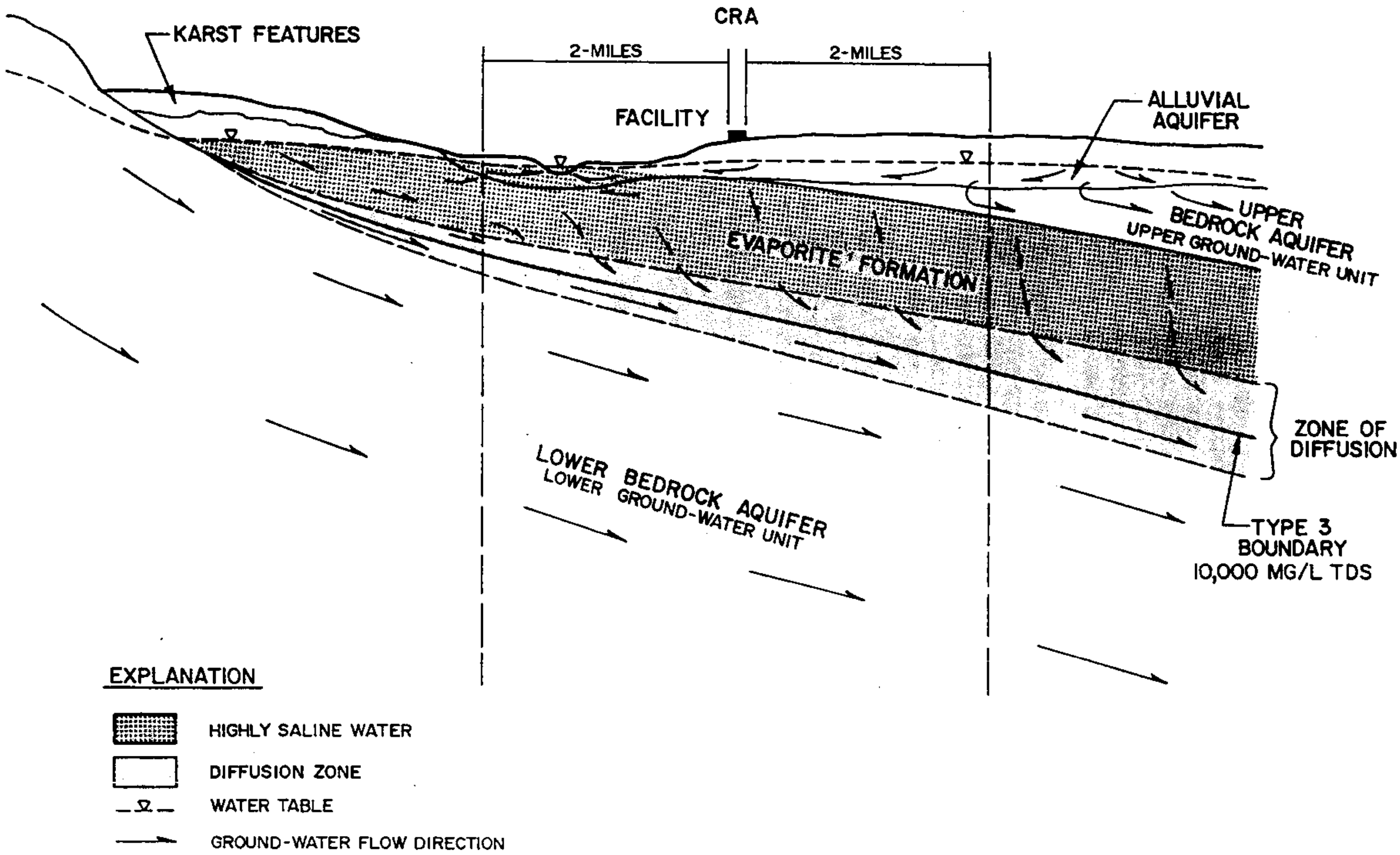
GROUND-WATER FLOW DIRECTION

WATER TABLE

CLASSIFICATION REVIEW AREA

10,000 mg/l TDS ISOCONCENTRATION LINE

FIGURE 4-8
EXAMPLE OF TYPE 3 BOUNDARY IN AN EVAPORITE/SALINE WATER SETTING

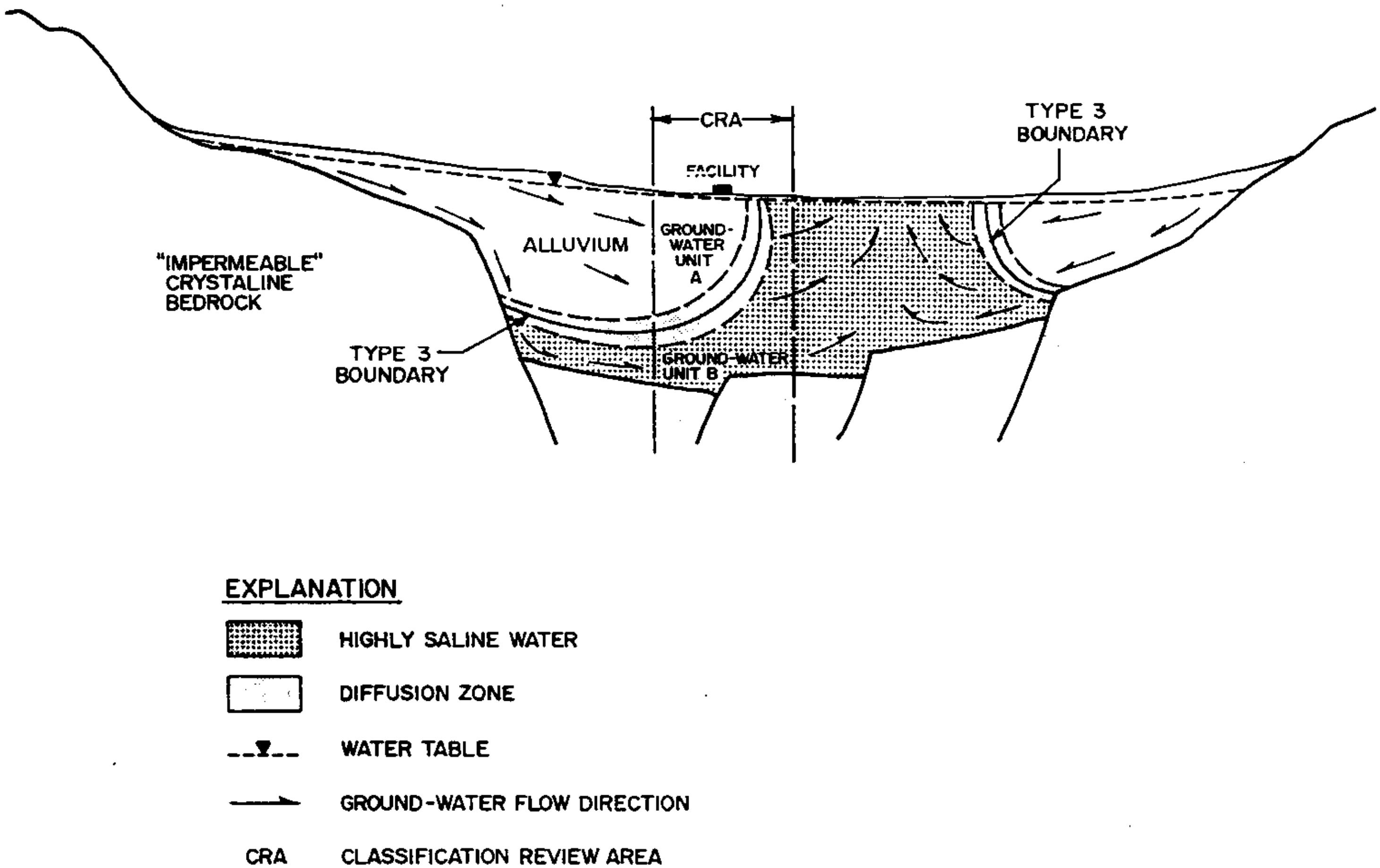


The third setting includes naturally saline ground water contained within topographically-closed structural basins within arid parts of the western United States (e.g., the Great Salt Lake Desert). Figure 4-9 shows an example of such a setting where the water is recharged from runoff from mountain ranges adjoining the basin, circulates to the center of the basin, moves vertically through confining beds, and discharges to playa lakes and the atmosphere. These settings are known to have brine waters greatly in excess of the 10,000 mg/l Class III criteria within the discharge area to depths as great as 2000 feet below land surface.

Distinct ground-water units can be delineated based on the identification of Type 3 boundaries as shown in Figure 4-9. Under natural conditions the diffusion zones encompassing these boundaries are stable and ground-water units A and B can be identified as shown. Large-scale withdrawals from upgradient fresh (Class II) ground water or injection into the saline (Class III) ground-water can laterally displace the diffusion zone. The pumped wells may eventually yield saline water and will cease to be sources of drinking water. Thus, the potential to cause adverse water-quality effects may result from improper resource management.

Type 3 boundaries are the least interpretive of the boundary types because they are simply equivalent to the 10,000 mg/l TDS isometric surface through the ground-water regime. These boundaries are then easily recognized and mapped when TDS data are available for ground waters from various depths and locations in the Classification Review Area. The elevations at which ground-water TDS is equal to or greater than 10,000 mg/l has been mapped and published for selected basins and regions. The principal sources for such data are the USGS and state geological surveys, especially in states having abundant oil and gas resources. In areas of known sea-water intrusion, or upconing of salt water due to pumpage, published data are occasionally available which will show in vertical section or plan view the extent of the salt-water wedge. This may be conservatively taken as the 10,000 mg/l TDS boundary where more specific TDS data are not available. In areas of known high temperature geothermal resources, published data are available to estimate the Type 3 boundary location. Because these areas, are few in number and are limited in areal extent, few will be co-located with potential Classification Review Areas. Equally limited are data bases for saline water settings associated with soluble evaporite deposits. At specific sites in these areas, the relationship between water quality, soluble strata, and ground-water flow directions can be established and the Type 3 boundary mapped. This relationship can be assumed in

FIGURE 4-9
EXAMPLE OF TYPE 3 BOUNDARY THROUGH BASIN FILL IN A CLOSED BASIN/ARID CLIMATIC SETTING



adjacent areas, where the stratigraphy and flow patterns are known, in order to extrapolate the Type 3 boundary to other parts of the Classification Review Area.

4.3.5 High Interconnection Scenarios

High interconnection of waters is assumed to occur within a given ground-water unit and where ground water discharges into adjacent surface-water bodies. The latter situation is specially relevant in identifying Subclass IIIA ground waters, for occasions where these are not potential sources of drinking water.

Subclass IIIA can be associated with shallow, unconfined, aquifers that underlie broad, urbanized, industrial areas where numerous diffuse sources of contamination have degraded water quality. Figure 4-10 shows hydrogeologic settings that may qualify for Class IIIA (Untreatable). The two examples shown include urban/industrial areas located near major surface waters and overlying alluvial sediments that are saturated at relatively shallow depths. As shown, the degraded water must be contained within a shallow ground-water unit that discharges to the local surface-water body.

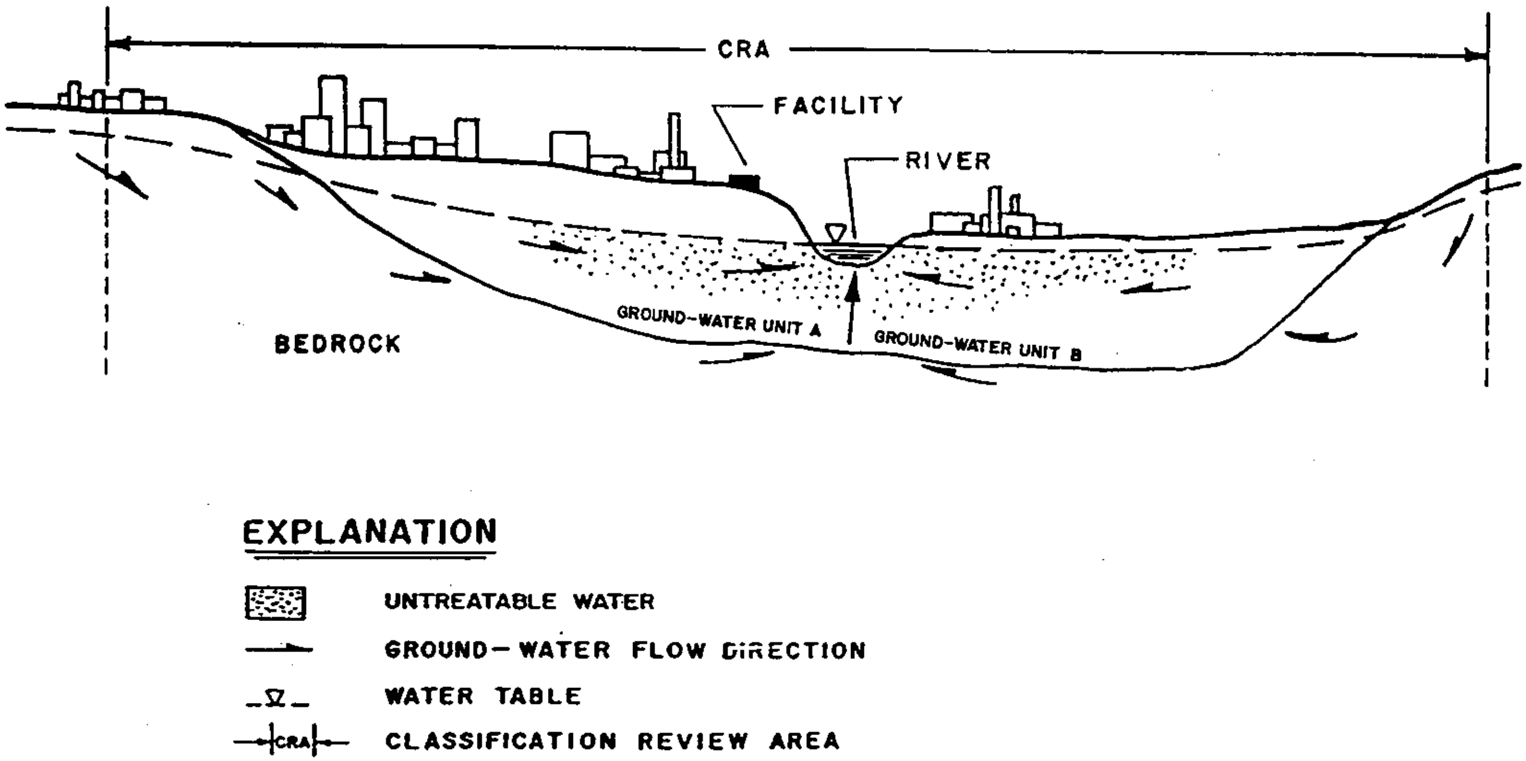
4.3.6 Example of Subdividing a Classification Review Area

Figures 4-11 through 4-13 illustrate how a hypothetical Classification Review Area is subdivided into ground-water units and the potential classification decision for each unit. It should be emphasized that for purposes of an actual classification decision, not all the subdivisions illustrated here would be necessary, as only the ground-water unit relevant to the facility would be classified.

The facility for which a classification decision is needed is located on the floodplain of a perennial stream that flows in a direction towards the viewer in Figure 4-11. The water table is relatively shallow beneath the floodplain and is essentially at the land surface in wetland areas adjoining the stream. The habitat for an endangered species is located in a wetland on the opposite side of the stream from the facility.

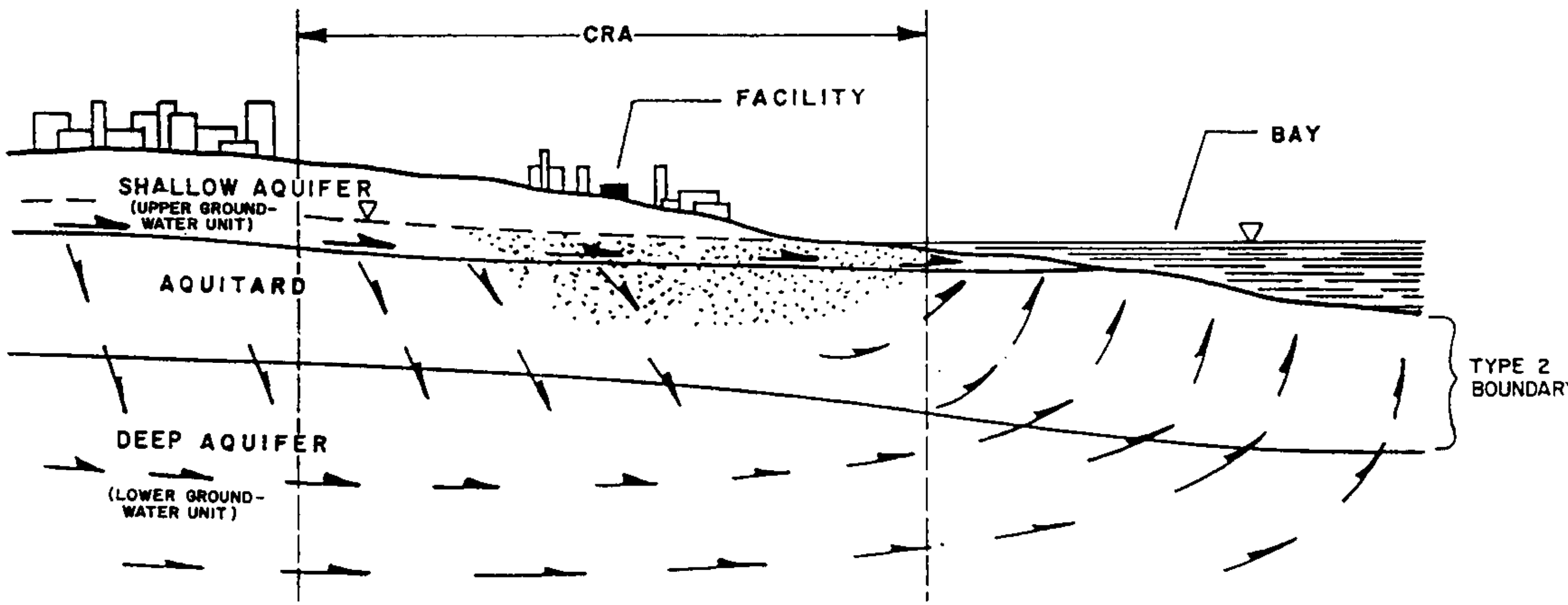
The geology of the Classification Review Area consists of essentially flatlying sedimentary formations overlying a crystalline basement composed of undifferentiated granitic and metamorphic rocks. Three local aquifers and two aquitards are recognized in the area. The uppermost aquifer is a water-table aquifer defined as the saturated part of a sand

FIGURE 4-10
EXAMPLES OF HIGH INTERCONNECTION BETWEEN GROUND-WATER UNIT AND SURFACE WATER



a) Alluvial aquifer separated into two ground-water units with high interconnection to a river.

FIGURE 4-10 (CONTINUED)
EXAMPLES OF HIGH INTERCONNECTION BETWEEN GROUND-WATER UNIT AND SURFACE WATER



EXPLANATION

- UNTREATABLE WATER
- GROUND-WATER FLOW DIRECTION
- WATER TABLE
- CLASSIFICATION REVIEW AREA

b) Shallow ground-water unit is highly interconnected to bay. The lower ground-water unit is separated from the bay by Type 2 boundary; and, therefore, has a low degree of interconnection even though it discharges to the bay through the aquitard.

and gravel deposit overlying a low-permeability shale formation. This aquifer is recharged by the infiltration of precipitation and discharges primarily to the stream and wetland areas. It is locally used for water supply by domestic wells in a nearby residential development.

Figure 4-11 shows a deeper middle aquifer that is sandwiched between two regionally extensive shales that serve as aquitard confining beds. Ground water is pumped from the middle aquifer at a municipal well which supplies water to a nearby city. The city also receives water pumped from deeper wells in the lower aquifer, however, these wells are located on the other side of the city off the left edge of Figure 4-11. Pumpage from these wells has caused sea water to intrude the lowest aquifer from the ocean located off the right edge of Figure 4-11. The lower aquifer is underlain by crystalline rocks which have low permeabilities and are not used as an aquifer in the area.

Figure 4-12 illustrates the cylinder-shaped volume of earth material that underlies the Classification Review Area. The ground-water regime is defined to include all ground water and earth materials between the water table in the uppermost aquifer and the contact between the lower aquifer and the basement rocks. Figure 4-13 shows how the regime can be subdivided into five ground-water units. For purposes of an actual classification decision, only the ground-water unit that could potentially be affected by the facility would be pertinent.

Ground-water units 1 and 2 are subdivided along a Type 1 ground-water flow divide boundary beneath the sinuous perennial river. This boundary is inferred from a mapping of the flow pattern within the uppermost aquifer. The aquitard beneath the aquifer exhibits no evidence of discontinuities within the Classification Review Area. It is present in all deep wells in the area and consistently shows large vertical gradients across it. Even so, the estimate of the rate of ground-water flow per unit area through the unit (based on these gradients and hydraulic conductivities) is no greater than 10^{-6} cm/sec which is negligibly small relative to ground-water flow rates in adjacent aquifers. Based on these characteristics, the aquitard constitutes a Type 2 low hydraulic conductivity, non-aquifer boundary. The vertical extent of ground-water units 1 and 2 is thus, delineated by the existence of this physical boundary.

Ground water within the middle aquifer is identified as a third ground-water unit with the overlying and underlying aquitards constituting Type 2 boundaries. In addition to the

FIGURE 4-11
HYPOTHETICAL SETTING FOR DEMONSTRATING THE SUBDIVISION OF A CLASSIFICATION REVIEW AREA

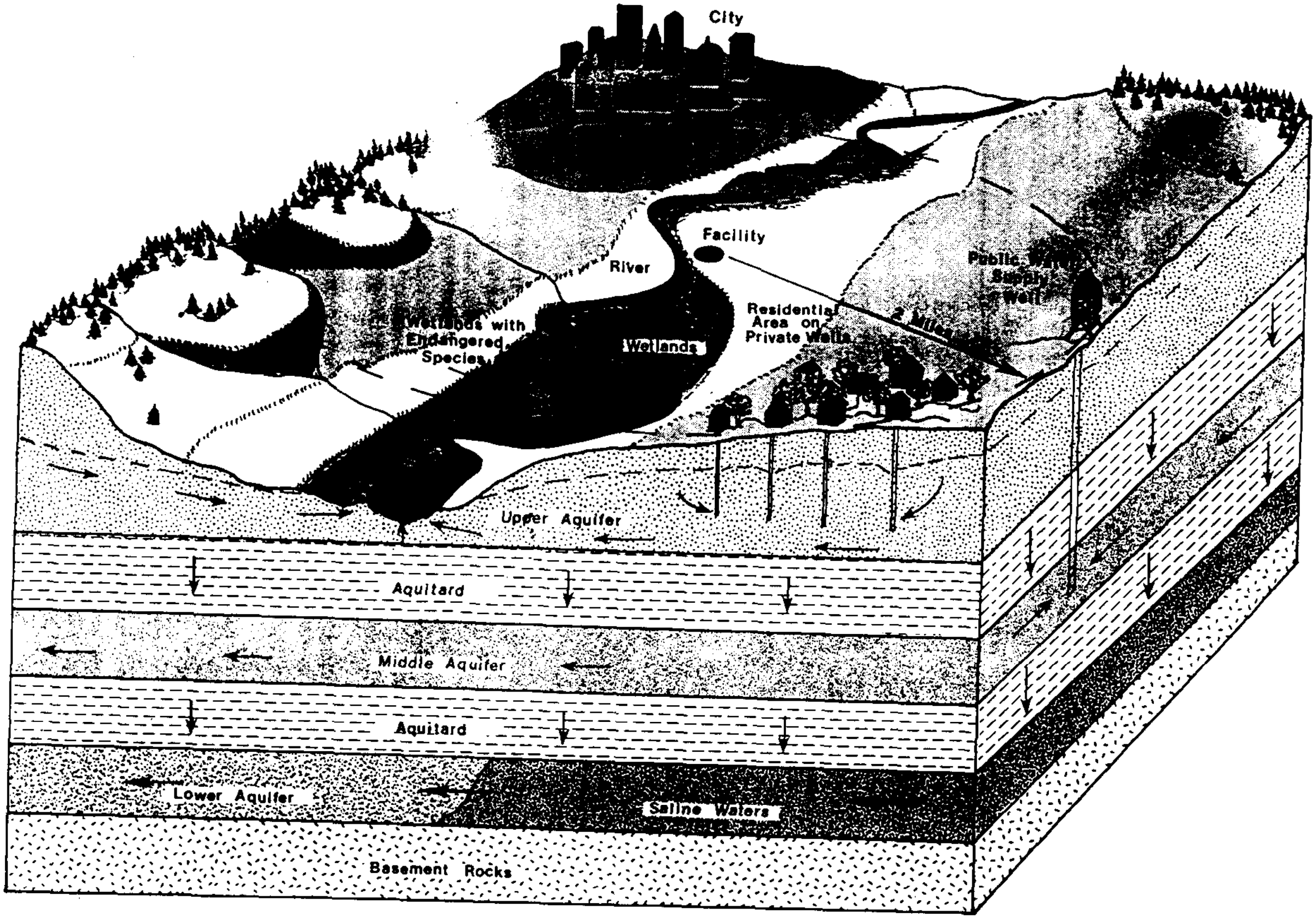


FIGURE 4-12
HYPOTHETICAL CLASSIFICATION REVIEW AREA

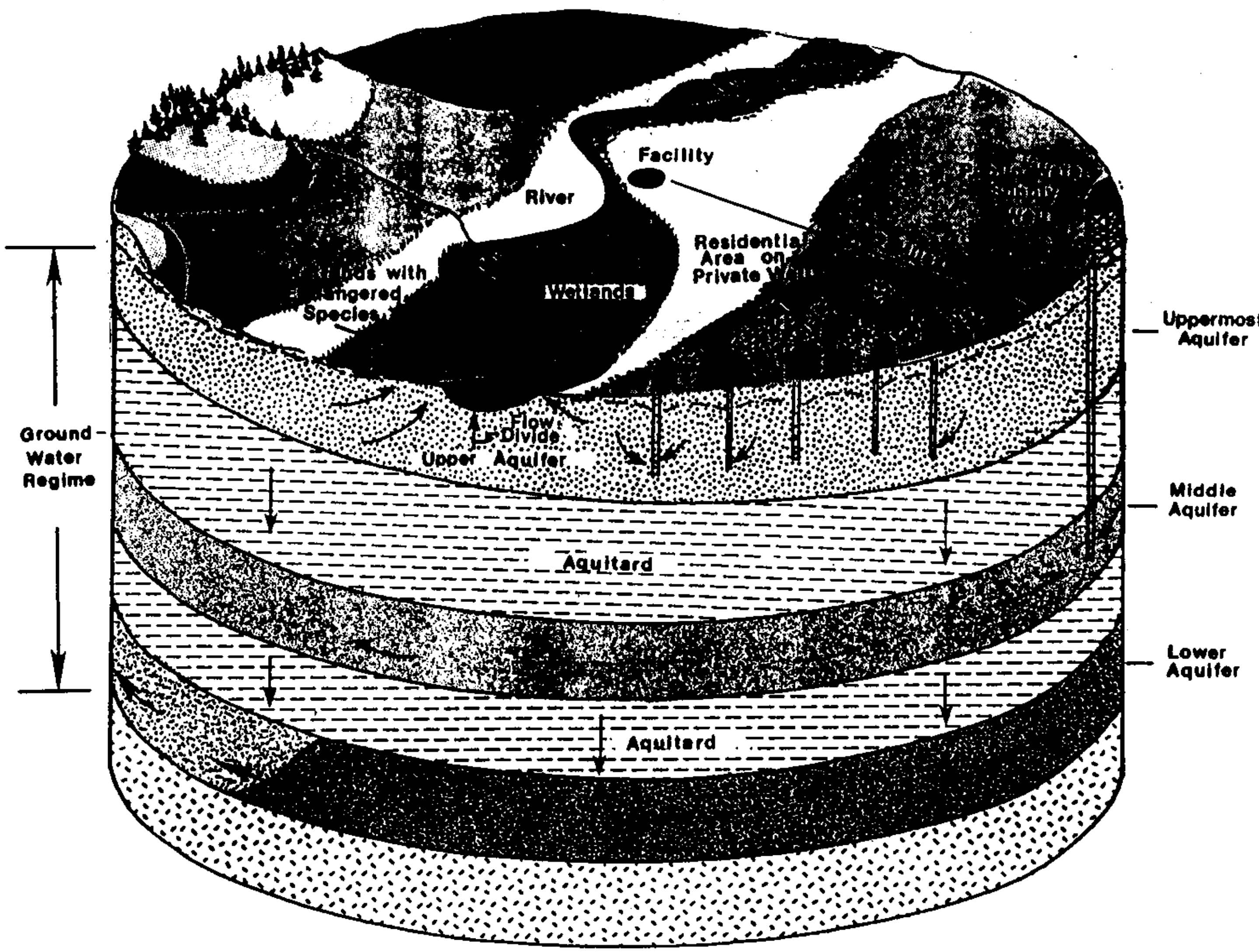
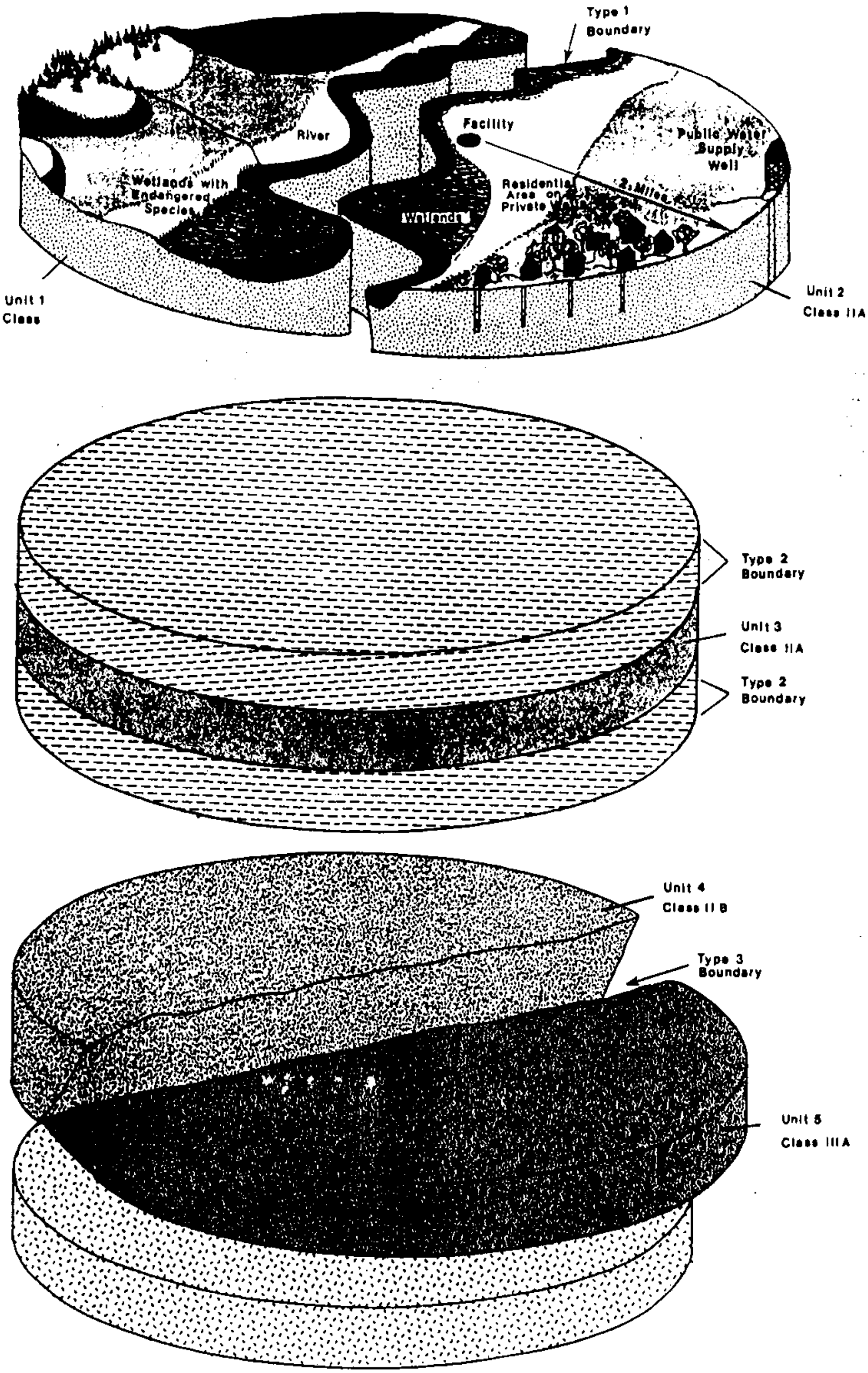


FIGURE 4-13
SUBDIVISION OF A HYPOTHETICAL CLASSIFICATION REVIEW AREA
INTO THE GROUND-WATER UNITS



characteristics described above for the uppermost aquitard, long-term aquifer tests have been performed on the municipal wells completed in the middle and lower aquifer. These tests indicate that less than ten percent of water pumped from the aquifers is derived from the leaking aquitards, thus their designation as Type 2 boundaries is justified.

Ground water within the lower aquifer is generally moving towards a major pumping center located outside of the Classification Review Area. A significant part of the water in this aquifer has been replaced by sea water having TDS concentrations in excess of 30,000 mg/l. The problem has been studied by the U.S. Geological Survey in cooperation with the city. The movement of the interface between fresh and saline water is being monitored with a few deep wells. The approximate location of the interface at the time of subdivision was approximately known and, lacking specific TDS data, is taken as the 10,000 mg/l TDS Type 3 boundary separating ground-water units 4 and 5 on Figure 4-13. Because the actual 10,000 mg/l TDS boundary is probably several hundred feet further towards the well field, use of the interface as this boundary makes ground-water unit 4 larger and unit 5 smaller than it actually may be. These errors are conservative in the sense of providing levels of protection to these waters as determined by class designation.

Based on the above general discussion of classification related criteria the ground-water units may be classified, as shown on Figure 4-13, as follows:

- Unit 1 may be Class I Ecologically Vital Ground Water due to the endangered species habitat within the discharge area, wetland environment and potentially vulnerable condition,

- Unit 2 may be Class IIA, current source of drinking water due to the residential wells screened in this unit,

- Unit 3 may be Class IIA current source of drinking water owing to its use for water supply but is poorly interconnected to the Class IIA water in the uppermost aquifer,

- Unit 4 may be Class IIB potential source of drinking water even though it maybe used for water supply outside the Classification Review Area

- Unit 5 may be Class IIIA, not a potential source of drinking water because it has a TDS above 10,000 mg/l and has a intermediate degree of interconnection with adjacent Unit 4, a potential source of drinking water.

4.4 Determining Irreplaceability

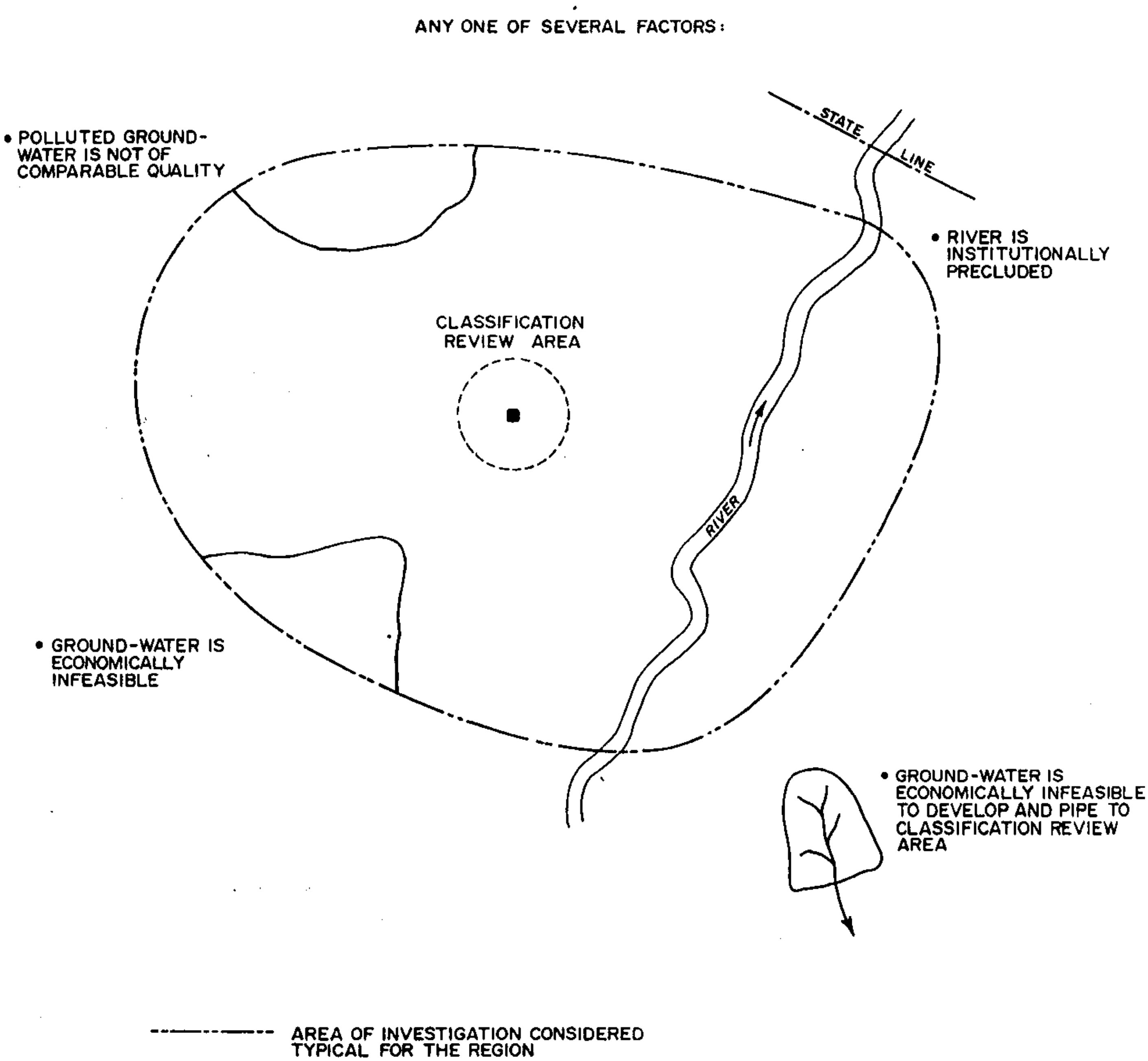
Figure 4-14 displays the general concept of irreplaceability for Class I ground water. The goal is to identify those waters of such relatively high value that unusually high protection is warranted. For the purposes of classification, this is not meant to be an extremely rigorous, costly exercise. In many instances, estimates will suffice. For example, a census of residents should not be performed to determine whether a substantial population is affected -- if available information suggests that current water users approximate the required thresholds, the criterion should be considered satisfied. Similarly, irreplaceability will be assumed unless an analysis is deemed desireable; typically when a permit applicant feels that a Class II situation is truly the case. If an analysis is performed, it should not be necessary to evaluate every possible replacement source; rather, rough estimates developed for no more than a small number of representative replacement water sources should be adequate to indicate the presence or absence of a irreplaceable source. These "shortcuts" are necessary since detailed water-supply alternative studies are inordinately expensive and are reserved for such major projects as large multiple-purpose dams and reservoirs.

A ground water serving a substantial population is considered irreplaceable, if alternatives are not suitable due to any one or more of the following five criteria:

- Use of the alternative source would require piping water over an unreasonable or uncommon distance
- The alternative source is incapable of providing water of quality that is comparable to typical quality of ground water used for drinking in the Region
- The alternative source is incapable of yielding water in sufficient quantity to serve the substantial population
- Access to the alternative source is precluded due to institutional constraints
- Use of the alternative source is economically infeasible.

Again, the general procedure is to first determine if the ground water within the Classification Review Area or the appropriate subdivision serves a substantial population. If

FIGURE 4-14
CRITERIA FOR CLASS I - IRREPLACEABLE



so, then the source is considered irreplaceable until demonstrated otherwise using the above five criteria.

The following sections discuss definitions for the more specific procedures, and key factors related to irreplaceability:

- Substantial population
- Uncommon pipeline distance
- Comparable quality
- Comparable quantity
- Institutional constraints
- Economic infeasibility.

Each of the following sections describes particular methods based on data available from Federal and State agencies and other easily accessible sources. Each section identifies and characterizes relevant data sources. Where appropriate, example calculations are used to illustrate data application and appropriate quantitative methods for determining irreplaceability.

In these Draft Guidelines, the Agency is also soliciting comment on approaches to judging two aspects of the "irreplaceable" criterion. Option A incorporates a quantitative determination of the population served by the source and the economic feasibility of replacing the source. Under this approach, a drinking water source would be considered "irreplaceable" if it serves at least 2500 people and the annual cost of typical user of replacing the source exceeds 0.7 to 1.0 percent of the mean household income in the area. Option B focuses on a qualitative assessment of the replaceability of the ground water. Under this approach, the relative size of the population served by the source and the cost of replacing the source would be factors to consider in assessing the source's "replaceability." The Guidelines would not under Option B, provide a set methodology, nor one or more numerical cut-offs. Again, the determination would focus on best professional judgment. A user following Option B may choose, however, to consider some of the quantitative methods or approaches in Option A, if deemed relevant in a particular classification decision. Comments on these two options, as well as other options for assessing "substantial population" and "irreplaceable" (from an economic standpoint) will be considered by the Agency in determining how best to incorporate these factors in classification decisions.

4.4.1 Substantial Population (Option A)

Under Optional A, ground water is deemed to serve a substantial population if at least twenty-five hundred persons are served by (Figure 4-15):

- centralized public water supply well(s) within the Classification Review Area or appropriate subdivision whether the population lies inside or outside Classification Review Area or

- private wells within the Classification Review Area or appropriate subdivision for persons living in a densely settled area (i.e., census definition based on 1,000 persons-per-square mile) or

- a combination of the above.

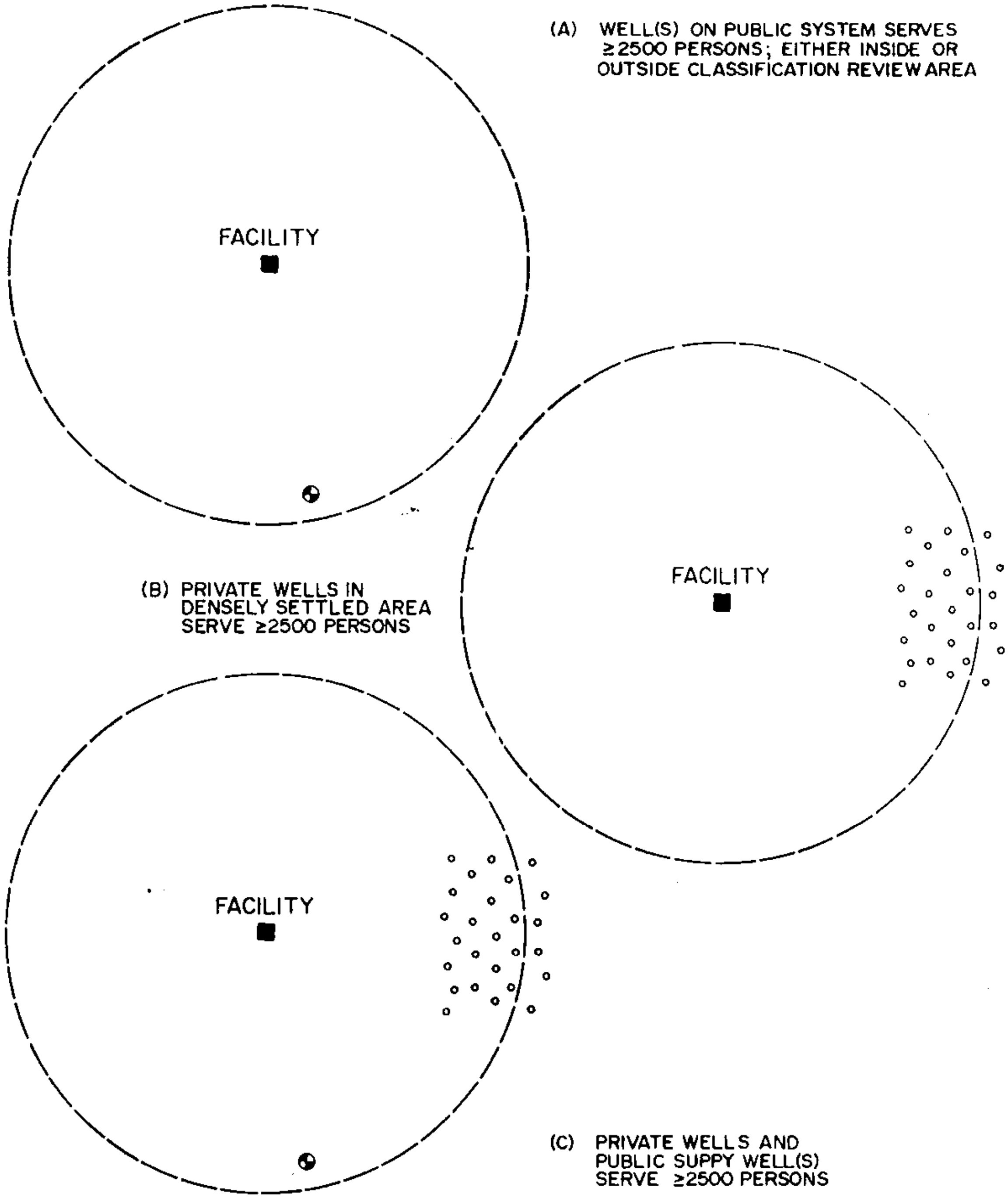
This definition of substantial population is based on numerical thresholds and concepts already used by the Census Bureau. The population data necessary to make these determinations is widely accessible and sufficiently up-to-date.

In most instances, making these determinations will be straightforward. If the well(s) in the Classification Review Area or appropriate subdivision service a public water system, an estimate of the number of user households multiplied by the average number of persons-per-household (2.7 on a national basis, each state or locality may be somewhat different) should approximate the total population served; if the population is served by other water sources, these should be accounted for proportionately. (Water supplied for industrial and agricultural purposes should not be included.) For private well users, it will be necessary both to estimate the population in the Classification Review Area not served by public water systems and, also, to calculate the population density. The EPA maintains a data system called GEMS (for Graphical Exposure Modeling System) which can be used to estimate both population and population densities for a variety of areas around a point (see Appendix E for details).

4.4.2 Substantial Population (Option B)

Option B differs from Option A in that no specific numerical cut-offs are dictated for determining "substantial population" or the "economic feasibility" of replacement. Rather, the relative size of the population served by the source would simply be factors to consider in assessing the source's "replaceability." A determination that a source is "irreplaceable" would require a qualitative assessment of the

FIGURE 4-15
EXAMPLE CLASS I - SUBSTANTIAL POPULATION



technical and economic feasibility of replacing it taking into account all of the factors that may be relevant in any specific case. Some of the same steps in data gathering and analysis included in Option A might be utilized, or alternatively, other procedures could be substituted. The overall approach to determining replaceability would, however, be more qualitative in character, and be more dependant on professional judgment.

4.4.3 Uncommon Pipeline Distance

Designating an uncommon pipeline distance for the Region is an important early step in determining irreplaceability. This uncommon distance will set a hypothetical radial boundary around the site within which an alternative source of water can be located. It, therefore, restricts the number of alternative sources that should be considered in the classification decision. If no alternative institutionally available water source of comparable quantity and quality can be located within a reasonable distance, the ground water in the Classification Review Area should be considered to be Class I irreplaceable. In theory, this is the maximum distance water is currently piped from the raw water source to the distribution system for each population category.

The determination of uncommon pipeline distance depends on many factors, including topography, geology, hydrology, availability of developed water resources (e.g., lakes, reservoirs, etc.), institutional constraints on water development, water demand, and economic resources. As a result, distances can vary significantly. In the semi-arid regions of the West, water may be conveyed 50 miles or more from the source to the distribution system. In the more humid East, however, water is typically piped five miles or less. Piping distances can also range considerably even among neighboring states.

Although it is reasonable to define an uncommon pipeline distance for different population categories, it is in practice, extremely difficult to set rigid criteria. In the absence of an exhaustive survey, guidance on these distances is available in Table 4-3, based on information provided by EPA's research laboratories and the Federal Reporting Data System (FRDS) maintained by EPA's Office of Drinking Water. The distances proposed in Table 4-3 are based on the application of a one percent income threshold that is applied as an economic criterion for other Class I tests. These distances can be calculated for other threshold levels. Working from data provided by EPA's Cincinnati water-quality laboratories, which estimate the costs of piping various quantities of

TABLE 4-3
UNCOMMON PIPELINE DISTANCES FOR DIFFERENT POPULATIONS
(Based on an 1% Economic Threshold)

Population Size	Uncommon Pipeline Distance
<5,000	25 miles
5,000-10,000	35 miles
10,000-25,000	70 miles
25,000-100,000	100 miles
>100,000	150 miles or more

These distances could be computed for different levels of income thresholds (e.g., 0.2%, 0.5%).

water (the size of pipes varied with the amount of water being delivered to a certain size of population), EPA proposes indexing these costs to the amount of dollars expressed by the income threshold for a certain size of population. For example, a population of 2500 persons would exceed their 1% income threshold when the costs of piping water exceed $2.4 million. This dollar amount roughly translates into an average piping distance of 13 miles when estimating the costs of installing and pumping along the pipes of the diameter needed to deliver a sufficient amount of water to 2500 persons. The result of this approximation should be used as general guidance for the lower bound of uncommon pipeline distance.

4.4.4 Comparable Quality Analysis

Once a potential alternative water source has been located, it is important to determine whether the quality is comparable to that of other drinking water in the EPA Region. The term "comparable quality" is defined as a level of water quality that is not substantially poorer than other raw drinking water resources in the EPA Region.

4.4.4.1 Water Quality Parameters

To be considered of comparable quality, the quality of the alternative water resource should be -- within an order-of-magnitude -- as good as or better than, existing drinking water resources, taking into account the precision of the measurement of each parameter. For example, an existing water source may have an average of 93 mg/l TDS, with a range of 75 mg/l to 100 mg/l. An alternative water source may be considered not of comparable quality, if it has an average TDS of 1,300 mg/l with a range of 1,000 mg/l to 1,600 mg/l. For some parameters of interest (e.g., taste, color, odor), the evaluation may be highly subjective. It is again meant to be a relative test which considers a few general categories of parameters (e.g., TDS, organic compounds, heavy metals, radionuclides and other secondary physical/chemical properties).

Existing information on water quality should be used, given the very high cost of new series of sampling and analysis. The comparison is intended to be relative and subject to professional judgment.

4.4.4.2 Sources of Information

At the Federal level, three important sources for water quality information may be consulted: EPA, the Army

Corps of Engineers, and the United States Geological Survey (USGS). Each of these agencies has conducted, or continues to conduct, comprehensive surveys that describe water resources in the U.S. Although not always designed specifically to provide detailed water quality data, these studies provide information sufficient to facilitate the comparable quality considerations of the ground-water classification system.

EPA has funded comprehensive studies of Regional water quality to determine the principal point and non-point sources of pollution. These studies, conducted under section 208 of the Clean Water Act, for example, give a broad overview of water quality (U.S. EPA, 1980b).* They are generally obtainable through the State and local agencies which received the funding. The Army Corps of Engineers conducts similar regional water-resource studies in order to examine water supply and demand within specified river and lake basins in the United States. The most useful resource of data from USGS will often be the published basin-wide investigations of ground- and surface-water resources. USGS also maintains the National Water Data Exchange (NAWDEX) which is designed to assist users in identification, location, and acquisition of information on water resources. The National Water Well Association (NWWA), Worthington, Ohio, maintains a library of all USGS and State Geological Survey information on water supply and quality. Using automated searching capabilities, the NWWA can identify and list all publications concerning a specific geographic area.

On a more local level, regional planning boards and councils of government, may also have information on potential drinking water supplies and river, lake, and stream, quality in their regions. State agencies that administer environmental protection, land use planning, agricultural, geological survey, public health, and water programs, are excellent information sources. State universities (particularly land-grant universities) may sometimes serve as repositories of information concerning ground- and surface-water supplies.

4.4.5 Comparable Quantity Analysis

Within a reasonable distance range, as determined by the "uncommon pipeline" distance analysis, a number of alternative sources of water may be identified. These sources may include both surface or ground water. Common examples of surface water that can be considered as a replacement source re rivers, streams, natural lakes, and impoundments. Alternative ground-water sources may be located in the same aquifer, or in another nearby aquifer, horizontally or vertically separated from the source aquifer.

Determining whether the alternative source, or sources, can yield adequate quantity requires three analytical steps:

- determine current users' present water-supply needs
- characterize potential sustainable water yield of alternative source
- compare potential supply and current demand.

Each of these steps is discussed briefly below.

Step 1: Determine current supply needs of water users

If the ground water to be classified supplies a public water system, current supply needs will be known by the water utility. If the ground water to be classified serves a substantial population using private wells, current water needs must be estimated using population figures and assumptions concerning typical water use.

Step 2: Characterize potential sustainable water yield of alternative water supply

This information is best obtained from the previously mentioned, published studies. In addition, routine water shortages in communities currently served by an alternative source, for example, would indicate that the alternative source may not (conceptually) be able to provide water for an additional population increment. Rapidly falling ground-water levels over time also indicate that an alternative source may not be capable of consistently providing sufficient yield year-round. However, levels which are not falling may also indicate a source which is unavailable for additional usage, but one which is being properly managed. In cases where the ability of an alternative source to meet the needs of the substantial population is unclear, a more quantitative analysis may be necessary.

Step 3: Compare alternative water supply and existing water demand

In cases where the alternative source is located in a water-rich area, the comparison of user needs and source yield may be done on an annual basis. The comparison should be conducted on a monthly basis where the alternative source is ground water under existing or potential stress or where the alternative source is a surface water with considerable month-to-month variability in flow. Important sources for water-quantity information include local water utilities, State water agencies, and the U.S. Geological Survey.

4.4.6 Institutional Constraints

Institutional constraints involve legal, administrative, and other similar forms of control over access to water. For purposes of this Guidance, the Agency has adopted the following definition of institutional constraint:

> An institutional constraint is a situation in which, as a result of a legal or administrative restriction, delivery of replacement water may not be assured through simple administrative procedures or market transactions.

While a detailed examination of legal and institutional issues is rarely called for, a preliminary review should indicate whether an institutional constraint is present. The following discussion presents a breakdown of potential institutional constraints and a general procedure for determining whether a binding institutional constraint is present in a particular situation. Appendix E provides a more detailed description of constraints as well as information sources.

The Agency has analyzed the potential constraints and determined which are probably binding, which may be binding in some cases or possibly binding, and which are unlikely to be binding. For a straight-forward assessment, comparison of the constraints affecting a particular source of water, the list of constraints presented in Table 4-4, should suffice. In those cases where a detailed assessment is warranted, the procedure outlined in Figure 4-16 is suggested.

4.4.6.1 Example of Considerations for a More Detailed Assessment

A potential source of replacement water (e.g., the Rio Grande River) may be subject to an international treaty (e.g., the 1944 Treaty between the United States and Mexico on Utilization of the Waters of the Colorado and Tijuana Rivers and of the Rio Grande) limiting the amount of water that may be withdrawn by users in the United States, and to an Interstate Compact limiting the amount of water that may be used within a particular state. In addition, that portion of the river flow assigned to a particular state may already be fully taken up by other users. Finally, the

TABLE 4-4

POTENTIAL INSTITUTIONAL CONSTRAINTS

<u>Probably Binding Constraints</u>

- Water is subject to international treaty
- Water is subject to interstate water apportionment compact
- Water is allocated by the U.S. Supreme Court as a result of litigation among states
- Water is subject to Federal or Indian reserved right

<u>Possibly Binding Constraints</u>

- Water is allocated by litigation among persons
- Water is allocated by permit
- Water is allocated by local water district or another local authority

- Amount of water that may be used is limited:
  - by public trust doctrine
  - by instream flow protection requirements
  - by state law
  - by permit
  - by local management authority
  - by prior appropriation(s) that are all for highest beneficial use
  - by Federal navigational servitude
- Place of use of water is limited:
  - by st[illegible] law
  - by [illegible]
  - by [illegible] authority

<u>Constraints Unlikely to be Binding</u>*

- Water is subject to prior appropriation (unless for highest beneficial use)
- Water is subject to riparian right
- Physical access to property is restricted:
  - by property rights of other persons limiting rights-of-way for pipes, ditches, conduits, etc.
  - by Federal or State statutes requiring environmental impact assessment or establishing other procedural requirements.

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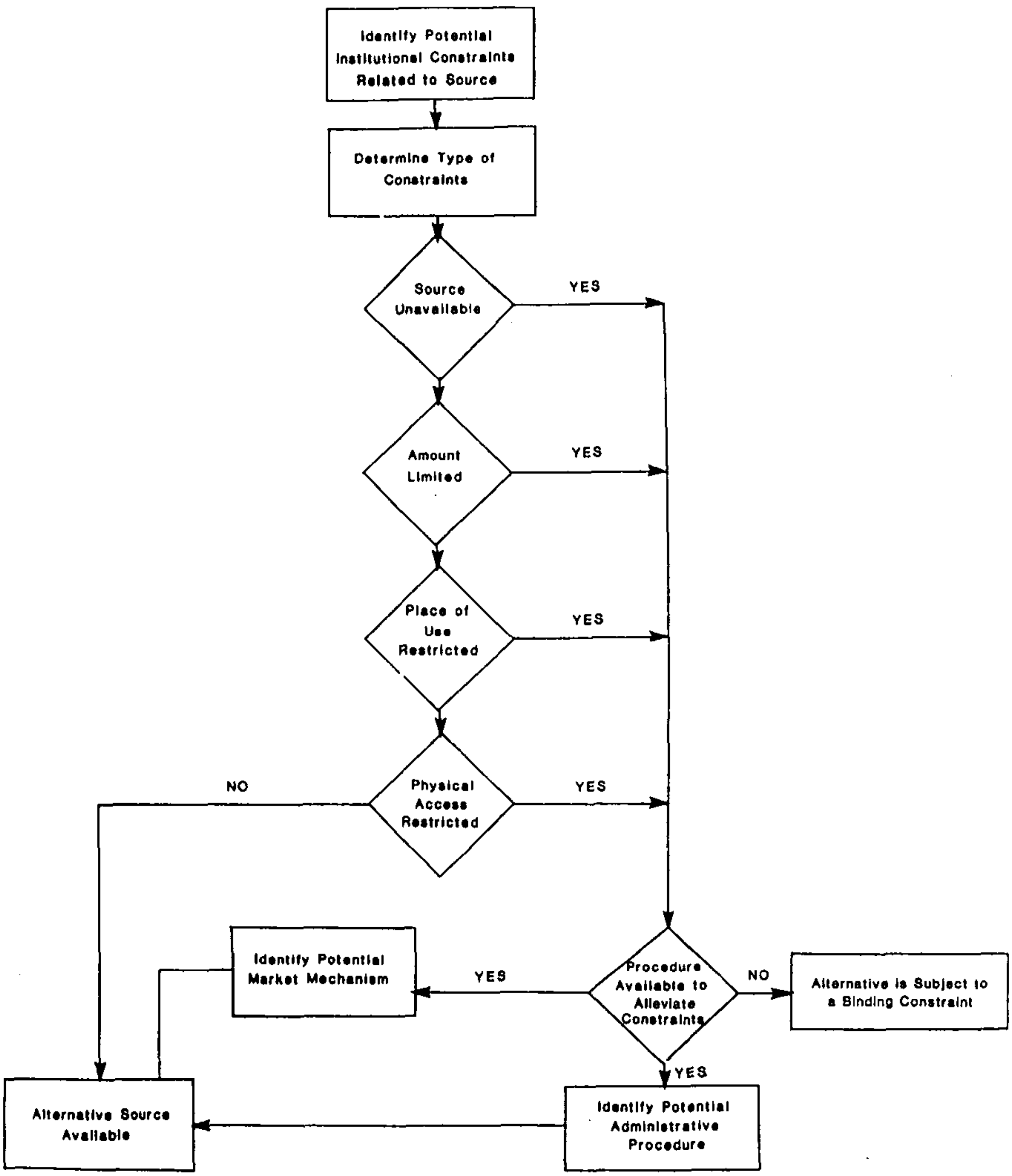
*Upon application of simple administrative procedures or market transactions.

FIGURE 4-16
OUTLINE OF PROCEDURE FOR ANALYZING POTENTIAL INSTITUTIONAL CONSTRAINTS TO THE USE OF AN ALTERNATIVE SOURCE OF WATER



use for which the water is being considered as a potential alternative source may be situated some distance from the river and require a right-of-way in order to get access to the water.

In this situation, the treaty, the interstate compact, the water allocation system, and the property rights of other persons, are all potential institutional constraints. Each should be considered separately. The treaty and the interstate compact may be impossible to avoid or change through simple administrative procedures. A phone call to the State office in charge of water allocation would probably indicate that the water allocation could potentially be revised by a simple administrative procedure; or, that market transactions can be used to change the current allocation of water. Similarly, informal contact with a State Attorney General's office, should indicate that the problem of access potentially could be resolved through purchase of an easement or right-of-way; or, that the administrative process of eminent domain potentially could be used to provide access to the water. In such situations, a binding institutional constraint would probably not be present, despite the potential constraints that were identified.

4.4.7 Economic Infeasibility (Option A)

The Agency has defined economic infeasibility of an alternative water source principally in terms of community ability to pay. This does not in any way imply that the Agency expects that communities will be required to replace water supplies or pay for such replacements. Again, this is a relative test to determine the extent to which ground waters potentially affected by a facility/activity are truly "special". The definition states that access and use of an alternative water source is economically infeasible, if the annual cost to a typical user (i.e., a household) for that alternative exceeds 0.7 to 1.0 percent of the mean household income in the community. Determining whether an alternative water source is economically infeasible requires that a rough estimate of the costs of the alternative water system be generated. These costs are then compared to household income to determine the relative "burden" of the alternative supply.

Following is a list of the major replacement cost items, categorized according to the type of cost incurred: capital costs, operation and maintenance (O&M) costs, and others. Approximations of these costs will suffice for the purposes of classification:

- Capital costs:
  - Well field development
  - Raw water intake structure (wells)
  - Water treatment facility
  - Pumping stations
  - Storage
  - Transmission system
  - Rights-of-way
  - Land
  - Relocation of utilities

- O&M costs:
  - Labor, equipment
  - Utilities
  - Parts/inventory
  - Administration

- Other costs:
  - Architectural and engineering fees
  - Legal and administrative fees

There are ample sources of information that may be used for estimating costs. These include Federal and State agencies, architectural and engineering consulting firms (A/E firms), trade associations, and local water utilities (ACT Systems, Inc., 1977, 1979; Temple, Barker and Sloane, Inc., 1982; AWWA, 1981). Costs can vary somewhat from one region of the country to another. For purposes of classification, only a general estimate is needed and, initially, there is no need to undertake a detailed cost estimation study.

Various EPA reports on water supply and waste-water treatment are also a good source of information on costs (e.g., Culp, et al, 1978). The results of such studies are presented in the form of tables and cost curves, subdivided into construction costs and O&M costs. This data can be updated simply to allow for inflation and geographical variations by energy and labor costs.

Another useful data source is the NWWA Nationwide Water Well Drilling Cost Survey (NWWA, 1979). The results of this survey are summarized in the form of tables giving drilling, as well as casing costs, as a function of the well diameter, hydrogeologic conditions, and other factors. Although this survey dates back to 1979, it is the most recent available from NWWA. The data in the survey should be escalated to account for inflation. Cost indices published quarterly by Engineering News Record give a very recent indication of construction, operation, labor, and other costs.

The remaining portion of Section 4.4 provides useful supplementary information for most classification decisions. More advanced procedures for use in special cases, are provided in Appendices E and G.

4.4.7.1 Annualizing Capital Costs

Capital costs are the initial costs of investments needed to develop a new drinking water source. They may include architectural and engineering fees, as well as legal, real estate or other fees incurred as part of planning, constructing, and implementating a new water system for this analysis.

For purposes of determining economic feasibility, capital costs must be annualized before they can be added to O&M costs to obtain the total annual costs of the alternative. Capital costs are annualized by multiplying by an annualization factor:

Capital Costs x Annualization Factor (AF) =
Annualized Capital Costs

The annualization factor divides the total capital costs into equal annual payments that would be required if the capital expenditures were financed using a standard fixed-rate mortgage. As a first cut, a factor of 0.1 can be used. A more refined factor should not be necessary but can be computed according to Appendix E.

4.4.7.2 Using Water Supply Utility Rates and Fees to Estimate Costs of Alternative Water Supply

In some circumstances, the cheapest alternative water supply available to a community will be a nearby water-supply utility. The alternative water-supply system may be modeled after an existing system that serves a community in the same region that is similar in both population size and characteristics. In such cases, the cost of the alternative supply may be estimated using the rates and fees charged by the existing utility to its service population.

4.4.7.3 Household Income of Substantial Population

The final step in determining economic infeasibility involves comparing the annual costs of the alternative water system to average household incomes in the community. Income data is generally available in two forms: per household income and per capita income. The two may be used interchangeably, by factoring in the average number of persons per household. In addition, income is sometimes reported as "personal income" or "money income." Household money income should be the income figure used for this exercise and is available from a number of sources.

4.4.8 Economic Infeasibility (Option B)

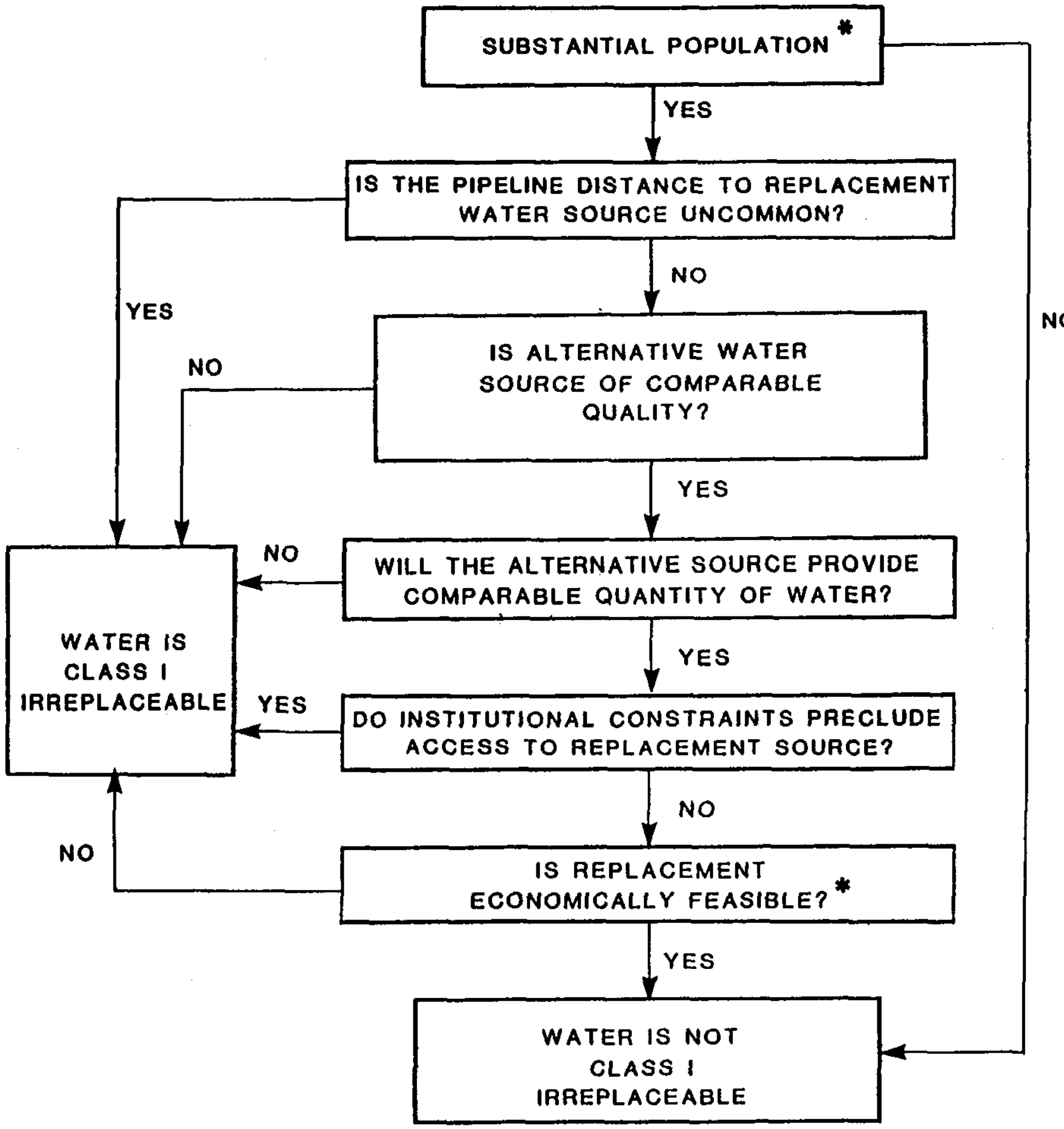
Option B differs from Option A in that no specific numerical cut-offs are dictated for determining "substantial population" or the "economic feasibility" of replacement. Rather, the relative size of the population served by the source would simply be factors to consider in assessing the source's "replaceability." A determination that a source is "irreplaceable" would require a qualitative assessment of the technical and economic feasibility of replacing it taking into account all of the factors that may be relevant in any specific case. Some of the same steps in data gathering and analysis included in Option A might be utilized, or alternatively, other procedures could be substituted. The overall approach to determining replaceability would, however, be more qualitative in character, and be more dependant on professional judgment.

4.4.9 Summary

The criteria for Class I irreplaceability may be best summarized through a hypothetical example. Consider the city of Waterfed, an urban area with a population of 25,000, that receives its water from a public well system. The water meets prim[illegible] drinking water standards and is of good chemical [illegible]y. The average daily usage is 7 million gallons-p[illegible].

There is an alternative to Waterfed's central well field. For the sake of simplicity, assume that this source is either representative of other sources, or is the only alternative drinking water source within a reasonable distance of the city. If the alternative is to serve as a replacement, it must satisfy the set of criteria which is depicted in Figure 4-17. The first criteria is that the alternative water source must be of comparable quality to water in the surrounding area. If the alternative source were substantially inferior to Waterfed's water and conventional treatment could not improve the quality to a comparable level, the city's ground water would be considered Class I irreplaceable. In this case, the alternative is inferior in terms of organic materials, but is substantially equiva-

FIGURE 4-17
TEST FOR CLASS I - IRREPLACEABLE GROUND WATER



* UNDER OPTION B, THESE STEPS ARE CONSIDERED QUALITATIVELY

lent in terms of heavy metals and other inorganics, radionuclides, and other physical and chemical properties. The level of organic contamination is not unusual in the Region. Conventional water treatment can remove the organic contaminants; and, Waterfed's water, therefore, is not Class I Irreplaceable by this criterion.

The next criteria area to address is the comparable quantity of water. If the alternative cannot provide Waterfed with the 7 million gallons of water it needs every day, the ground water would be classified as Class I.

The next criteria area addresses established laws, administrative systems, or other forms of social control over access to water which may preclude the use of the potential replacement water source. If there are any institutional restrictions that do not allow the replacement water to be obtained through administrative procedures or market transactions, Waterfed's well water would be considered Class I. No such barriers exist, and Waterfed's well water is not Class I irreplaceable by this criterion.

If Waterfed's water is not to be considered Class I irreplaceable, replacing the city's well water must be an economically viable option. Under Option A, the annualized replacement cost to a typical user must be within or greater than 0.7 to 1.0 percent of the mean household income in the community to be Class I. Waterfed's mean household income is $20,000 per year and there are 9,100 households. If the annualized cost of replacing the city's ground water is within or greater than the range of $1.27 - $1.82 million ($20,000 times 9,000 times 0.7 - 1.0 percent), the water may be designated Class I irreplaceable under this option. Based on rough estimates, the capital cost for constructing the pipeline to pump water from the alternative source is approximately $2 million. Using the simplified annualization factor of 0.1 yields an annualized capital cost of $200,000. The annual operating and maintenance costs are likely to be between $150,000 and $200,000, yielding a total annualized replacement cost of between $350,000 and $400,000. Since this is at most, 0.31 percent of the mean household income, Waterfed's current water source is replaceable and, therefore, is, in the final analysis, not Class I irreplaceable. There is no need to perform a more detailed economic analysis.

Under Option B, these or other cost/ability-to-pay factors would be addressed in a more qualitative fashion. Such analyses may indicate, for example, that the area is not "water-short" and that the community generally seems able to afford such services as water supply improvement. Thus, the supply is considered "replaceable" under Option B as well.