CHAPTER V

PATTERNS OF RAINFALL
(40 CFR 264.94(b)(2)(iv))

Precipitation is a driving factor for ground-water recharge and discharge. These two processes are basic components of the hydrogeology at a facility. To verify a claim of attenuation due to dispersion, precipitation data in support of ground- water flow and contaminant transport information must be submitted. This chapter describes the type of precipitation information that should be submitted in support of an attenuation-based demonstration.

The permit applicant should focus the discussion of precipitation around the site's hydrologic regime. If the applicant's ACL demonstration clearly shows that ground-water discharge to surface waters is unlikely, then the discussion of precipitation events can be limited to effects on infiltration, evapotranspiration, and ground-water recharge. However, if ground-water discharge to surface water is an important element of the ACL demonstration, then precipitation events should be related to recharge and discharge of ground water.

Precipitation events are variable and occur with different intensities, amounts, and durations. The geographical distribution of rainfall also varies from one area to another within a region. However, over a long period of time (years), the precipitation data for an area can be represented by events with definite amounts that occur at various frequencies. These frequencies are classified in terms of duration and yearly return periods. For example, a one-day/l0-year storm event is defined as the amount of rainfall that is expected to occur during a 24-hour period once every 10 years. The amount of precipitation for a storm of specific return period and duration is used to produce an estimate of the amount of precipitation for a given geographical area.

Attenuation-based demonstrations should contain general information on the precipitation characteristics of a site. This includes data on rainfall and snowfall, expressed as its equivalent in rainfall. The National Oceanic and Atmospheric

Administration, the National Weather Service, or climate data in Ruffner (1980 and 1981) may be sources of this information if on-site data is unavailable. Regional precipitation data may be used if it was generated within 15 km of the facility. Regional data from greater than 15 km of the facility should be correlated with available on-site data. The monthly mean and range of this data, the specific time period from which the data was collected, and the location of the precipitation gauge(s) in relation to the facility should be provided. The permit applicant should discuss this information in terms of temporal effect on infiltration and seasonal ground-water recharge. These processes should be related to any effects on contaminant transport.

If the ACL demonstration does not involve surface water exposures, then the permit applicant can proceed to the next chapter. However, if the facility is located near surface water bodies (see Chapter VI), or if surface water discharge is used as an argument in an ACL demonstration, then more detailed information on precipitation events should be submitted. The permit applicant should submit data on specific storm frequency patterns and discuss how these storms relate to flood and infiltration/discharge characteristics of the facility.

The predicted amount of precipitation produced over a 24-hour period by storms of return frequencies of 1, 10, 25, and 100-years should be submitted. The l-year and 10-year storm frequency information gives insight into ground-water infiltration and discharge patterns. The 25-year and l00-year storm frequency data are useful in assessing discharge during flood conditions.

The l00-year floodplain should be described on a USGS topographic map. The floodplain information should be readily available to the applicant, since it is required by Section 270.14(b) permitting requirements. Federal Insurance Administration flood maps can be a useful source for this information. If the facility has any special flood prevention measures, they should also be shown on the map. These measures could include any dikes, berms, dams, and special flood retention walls. The effect of these devices on ground-water infiltration and discharge should be discussed. Furthermore, any special site conditions that affect infiltration and discharge should be discussed. These include site topography, solar orientation of the regulated unit, and wind patterns.

The ground-water discharge patterns at the facility should also be delineated on a topographic map. All streams, ditches, culverts, and sewers that receive ground water should be clearly identified. Normal ground-water discharge patterns (1-year storm) and discharge during flood conditions (25 and 100-year storms) should be clearly marked. Snow melt pathways should be identified, if appropriate. Any discharge abatement or collection devices, such as detention basins, swales, and canals, should also be described.

Evapotranspiration should also be considered in both recharge and discharge evaluations. Vegetation can use a large amount of water and reduce significantly the amount of infiltration reaching the water table, especially during the growing season.

CHAPTER VI

PROXIMITY OF SURFACE WATER AND GROUND-WATER USERS (40 CFR 264.94(b)(1)(iv) and (2)(v))

This chapter and the next chapter discuss important factors necessary for assessing probable exposure pathways for the ACL constituents through surface and ground water. This chapter discusses the location of surface water and ground-water users in the vicinity of the facility. All ACL demonstrations should contain a discussion of the proximity and types of water uses near the facility. If the demonstration is attenuation-based, then more detailed information will be necessary. The uses of surface and ground water in the vicinity of the facility are discussed in Chapter VII.

A key factor involved in assessing exposure is the proximity of surface water and ground-water users to the facility. For ACL demonstrations, "proximity" is liberally defined to include both spatial and temporal concepts. Linear distance may be more appropriate for judging potential surface water exposures, while time of travel is important for ground-water exposures. Proximity should be expressed in terms of both linear distance and time required for ground-water flow and contaminant transport.

The level of information necessary to satisfy the proximity of users requirement depends on the basis of the ACL. If the applicant is attempting to show that contaminants will safely attenuate into a surface water body, then data on the specific physical attributes of the surface water body will be necessary. This includes information necessary to estimate the mixing potential and mechanisms of the water body. Likewise, if the aquifer is nonpotable, then data showing that it is not fit for consumption must be supplied.

Surface Water

ACL demonstrations relying on transport mechanisms should include a discussion of the potential effects of the facility on surface waters. The initial evaluation includes assessing the facility's proximity to surface waters and involves:

1. Identifying each surface water body in the vicinity of the facility,
2. Determining the distance from the waste management area boundary to each surface water body, and
3. Identifying ground-water discharge pathways to surface waters.

Each water body within five kilometers downgradient (or downstream) of the facility boundary should be identified. The owner or operator of the facility should supply an appropriately scaled map identifying each water body. All streams, rivers, ponds, lakes, estuaries, and marine waters should be clearly marked. All ditches, streams, sewers, and runoff pathways that serve as ground-water discharge or infiltration areas should be delineated on the map. A table specifying the name of each water body and the distance from the waste management area to the closest part of each water body should be provided by the owner or operator of the facility.

The travel time of the ACL constituents from the facility to the discharge areas should be discussed by the permit applicant. Ground water and hazardous constituents may move at various rates due to different physical and chemical properties. Therefore, discharge calculations should include estimates of both hydraulic transport and waste transport. The ground-water transport models and methods discussed previously in Chapter IV should be used to estimate the hydraulic and hazardous constituent loading rates. Actual seepage measurements may be necessary to verify model estimates if ground-water discharges are estimated to be a significant portion of the annual hydraulic load to a water body.

A greater level of detail on characteristics of surface water bodies is needed if the applicant is attempting to show that the contaminants will attenuate safely into surface water (i.e., not cause a statistically significant increase in concentration). In these cases, the physical characteristics of each identified downgradient (or downstream) water body should be included in a table. Important lake and pond characteristics are:

1. Surface area,
2. Mean depth,
3. Volume,
4. Temperature stratification, and
5. Hydraulic residence time.

Information on estuarine and marine areas should include:

1. Surface area,
2. Mean depth, and
3. Tidal periodicity and amplitude.

Pertinent stream and river characteristics are:

1. Mean width,
2. Mean depth,
3. Flow rate, including average flow and lowest flow that would be expected to occur during a continuous 7-day period, once every l0 years (Q7-l0), and
4. Lowest recorded flow rate.

This information is necessary in order to estimate the discharge zones of each type of surface water in the vicinity of the facility. The temporal and spatial variability of flow rates, tidal factors, and hydraulic residence times are also essential factors for establishing discharge zones.

The permit applicant should synthesize this information to support arguments of no statistically significant increase in surface water concentrations. The expected amount of attenuation and the zones of probable discharge areas should be discussed. The permit applicant should be aware that certain States have approved surface water models that are used in the NPDES permitting program. If approved models are available, they should be used by the applicant to determine discharge zones in surface waters. The EPA document Technical Support Document for Water Quality-Based Toxics Control (U.S. EPA 1985a) is a good source of this information. In general, one quarter of the cross-sectional area of a stream may be used in estimating the discharge zone. This area could then be applied over the width of the ground-water contaminant plume as it enters the river to derive the discharge zone.

Ground Water

In order to assess the likelihood of exposure of current ground-water users, every ACL demonstration relying on attenuation mechanisms must discuss the proximity of ground-water users to the facility. This requires determining:

1. The distance of the ground-water users' withdrawal point (i.e., well or spring) from the facility, and
2. The hydrologic transport time for the contaminants to reach the closest wells or springs.

The users of ground water within a five kilometer radius of the facility boundary should be identified. Both upgradient and downgradient wells should be included because of their potential to change the direction or quantity of ground-water flow. The applicant should delineate each ground-water withdrawal or injection well on a scaled site map. The distance of each well from the waste management area should be given in a table. The following uses of each well should be clearly marked:

1. Potable (municipal and residential),
2. Domestic nonpotable,
3. Industrial,
4. Agricultural, and
5. Recharge.

CHAPTER VII

CURRENT AND FUTURE USES OF GROUND WATER AND SURFACE WATER IN THE AREA (40 CFR 264.94(b)(1)(v) and (2)(vi))

Once the location of the surface water and ground-water users has been determined, the nature of the use should be considered. A major objective of an ACL demonstration relying on transport arguments is to show that ground-water contamination at a facility will not adversely affect any water use. The supporting arguments for the ACL can center around the fact that the ground-water contamination at the facility is not degrading the designated beneficial uses of the water resources. This requires the permit applicant to review federal, state, and local standards or guidelines that govern the uses of both ground and surface water to ensure that the presence of a contaminant plume is not inconsistent with any published regulations, ordinances, or guidelines. This chapter points out the types of water uses that should be investigated, and the information that should be submitted on those water uses to support an attenuation-based ACL demonstration.

All ACL demonstrations should generally discuss current and likely future uses of water resources near their facility. However, ACL demonstrations based on attenuation arguments need to provide detailed information on these uses. Information gathered to satisfy data requirements on the proximity of water resource users (see Chapter VI) will be adequate to identify major water resources near the facility. In order to aid the permit reviewer, the water resource use information should be structured around the following general categories:

1. Agricultural - irrigation and animal watering;
2. Industrial - process, cooling, and boiler water;
3. Domestic and municipal - potable, bathing, washing, and lawn/garden watering;
4. Environmental - ground-water recharge or discharge, fish and wildlife propagation, unique areas; and

5. Recreational - fishing, swimming, boating, and other contact uses.

The permit applicant should examine pertinent aspects of both ground water and surface water uses. Both the current uses and the possible future uses of the water resources should be discussed. The specific type of ground-water use information is described in the following section.

Ground-Water Uses

It should be obvious that ground-water use can be critical in the setting of ACLs at a facility. Facilities that are contaminating or have contaminated ground waters should examine local ground-water uses if their demonstration is attenuation-based.

The U.S. EPA has developed a Ground-Water Protection Strategy (U.S. EPA, 1984a) that states that ground water should be protected to its highest beneficial use. Three general classes of ground water are recognized:

Class I: Special ground waters are those that are highly vulnerable to contamination because of the hydrological characteristics of the area under which they occur and that are also characterized by either of the following two factors;

a) Irreplaceable--no reasonable alternative source of drinking water is available to substantial populations, or
b) Ecologically vital--the aquifer provides the base flow for a particularly sensitive ecological system that, if polluted, would destroy a unique habitat.

Class II: Current and potential sources of drinking water and waters with other beneficial uses including all other ground waters that are currently used or potentially available for drinking water or other beneficial uses.

Class III: Ground waters not considered potential sources of drinking water and of limited beneficial use are those that are heavily saline, with total dissolved solids (TDS) levels over 10,000 mg/1, or are otherwise contaminated beyond levels that allow cleanup using methods that are reasonably employed in public water system treatment. These ground waters also must not migrate to Class I or II ground waters or discharge to surface water that could cause degradation.

Facilities that are contaminating or have the potential to contaminate Class I or Class II ground waters should incorporate human health factors (see Chapter IX) into their ACL demonstration because these resources are either potential or current sources of drinking water. If the ground water is Class III, then health- based concerns may be secondary to environmental concerns in the setting of ACLs. ACLs in Class III ground water will be assessed on a case-by-case basis.

The permit applicant should discuss the ground-water use in the vicinity of the facility in terms of these three classes or other appropriate State-approved classification schemes. The Agency's Office of Ground-Water Protection is developing guidance containing specific criteria for designation of ground water as Class I, II, or III. These draft Guidelines for classifying ground water were available in December 1986. Until this guidance is finalized, we recommend only conservative use of the "unuseable" criterion as a basis for an ACL.

Information from the State and/or local government as to the beneficial use of the ground water should be included if the ground water has been classified. Otherwise, the permit applicant should have its ground-water classification data reviewed by the State. When ground water has been classified on a State, regional, or local level, this classification should be re-evaluated and verified using site specific data. The State's review should be included in the ACL demonstration.

Surface Water Uses

Surface water uses should be discussed by the permit applicant if contaminated ground water can migrate to surface waters. The previous chapter on proximity of surface waters should aid in deciding which water bodies are of interest. If no surface water impacts are likely, then the data discussed in this section do not have to be submitted.

The established guidelines, criteria, and/or standards for each water body identified in Chapter VI should be examined. The permit applicant should list in a table the designated use of each water body, a citation of the local, State, or Federal regulations governing the use, and the agency responsible for implementing the regulation. The following general use categories should be used by the permit applicant in preparing the table:

1. Drinking water source (including other domestic uses),
2. Fish and wildlife propagation area,
3. Industrial or agricultural water source,
4. Area of special ecological concern, and
5. Recreational area.

The surface water use information will aid in determining appropriate ACLs by identifying surface water exposures that can occur. The data gathered to fulfill the requirements of this section will be used to prioritize the likely exposure pathways and to determine whether human health and environment factors should be assessed in further detail (see Chapters IX and X).

CHAPTER VIII

EXISTING QUALITY OF GROUND WATER AND SURFACE WATER, AND OTHER SOURCES OF CONTAMINATION (40 CFR 264.94(b)(1)(vi) and (2)(vii))

In order for "benchmark" levels of contamination to be set, the background levels of hazardous constituents in the ground water should be determined in every ACL demonstration. If surface water exposure to the ground-water contaminants is part of the ACL demonstration, the background levels of the ground-water contaminants in the surface water must also be determined. If the ground water and surface water sampled for background levels appear to be contaminated, the facility owner or operator should examine the possibility of other sources of contamination in the vicinity of the facility. This chapter discusses the type of background water quality data that should be submitted in an ACL demonstration in order to adequately assess the cumulative impacts associated with any contamination emanating from the facility.

Background Water Quality

For ACL purposes, background water quality is the quality that would be expected to be found if the facility was not leaking contaminants. Careful planning must be used in deciding where representative background water samples should be taken. Under Section 264.97, the regulations specify a procedure for establishing background levels for hazardous constituents for purposes of setting ground-water standards. Essentially, background monitoring wells must yield ground-water samples from the uppermost aquifer that represent the quality of ground water that has not been affected by leakage from a facility's regulated unit. For most sites, this is an upgradient area that can be determined readily from the water level data. The permit applicant is directed to the Draft RCRA Permit Writers' Manual for Ground-Water Protection (U.S. EPA, l983a) and the RCRA Ground-Water Monitoring Technical Enforcement Guidance Document (U.S. EPA, 1986a) for further guidance on ground-water monitoring and station locations. Background surface water quality must be assessed only in cases where surface waters receive contaminated ground-water discharges (see Chapters VII and X).

The permit applicant should submit a site map that identifies the location of background sampling stations and monitoring wells, and the direction of both stream flow and ground-water movement. Any flood discharge pathways and directions should also be shown on the site map.

The permit applicant may find historical ground-water monitoring studies and ambient surface water monitoring programs to be useful when assessing background water quality. The U.S. Geological Survey, U.S. EPA, State, and local environmental program offices can be good sources of historical data. The background concentrations in both ground water and surface water of constituents for which ACLs are being proposed should be included in a summary table. The uppermost aquifer and any surface water bodies that receive contaminants should be listed separately. If additional monitoring studies are necessary for determining background water quality, the EPA Regional Office may assist by reviewing the monitoring work plans. Regardless of the source of the background water quality data, the permit applicant should submit quality assurance and quality control information on sample collection, sample analysis, well construction, and environmental conditions. Documents from which any data were taken should be available for review if they are requested by the permit writer.

Ground-Water Contamination Sources

The permit applicant should investigate other sources of ground-water contamination if background monitoring wells exhibit contamination and the ACL demonstration is based on attenuation arguments. If no contamination is found, or the POE is set at the POC, the permit applicant can omit the following discussion and proceed to the surface water discussion. The types of upgradient pollution sources and the impacts of the contamination on ground-water use are important and should be considered. Identifying potential pollution sources is necessary in order to assess the cumulative impact of pollution sources on human health and the environment. The following potential pollution sources should be identified within a five kilometer radius of the site:

1. Other RCRA facilities and Superfund sites,
2. Solid waste management units,
3. Industrial areas,
4. Deep well injection sites, and
5. Agricultural areas.

Likely sources of contamination should be delineated on a map with an appropriate scale. The distance of each source from both the facility and the upgradient monitoring wells should be discussed. Available ground-water data on any of the identified sources should be submitted and discussed. Some areas may have hazardous constituents present in the ground water because of natural processes occurring in the ground water. For example, some metals may be found at fairly high levels in certain ground waters. However, natural sources of synthetic organic compounds (e.g., chlorinated solvents) are not expected. If synthetic organic compounds are found in background samples, then the permit applicant should attempt to identify the source of contamination.

The water-use impacts from the contamination should be discussed by the permit applicant if upgradient ground water is impaired by any source of contamination. In Chapter VII of this guidance, the current and future uses of ground water are discussed in more detail.

Surface Water Contamination Sources

The permit applicant should examine other sources of surface water contamination if the applicant's facility discharges to a surface water resource and detectable quantities of contaminants are found in the surface water. Consideration should be given to both point and nonpoint sources of contamination. Any point sources of pollutant loading to surface waters should be identified on an appropriately scaled map. The point sources should include:

1. Discharges from industrial facilities,
2. Discharges from Publicly Owned Treatment Works (POTW), and
3. Past waste discharges.

The permit applicant should submit a table that includes the name of each point source and the water body into which the point source discharges. The NPDES permit number of each point source should also be included in this table. If they are available, the discharge rate, load allocations, permit discharge conditions, and mixing zones should be provided and discussed. The applicant should focus these discussions around the impact of the facility's discharge on these factors.

Any nonpoint sources of pollution to surface waters that may affect the ACL decision should also be discussed. The permit applicant should submit information on:

1. Urban storm run-off,
2. Agricultural run-off,
3. Ground-water infiltration, and
4. Other RCRA facilities and Superfund sites.

Actual monitoring data may be submitted along with loading model calculations, if they are applicable.

CHAPTER IX

POTENTIAL HEALTH RISKS
(40 CFR 264.94(b)(1)(vii) and (2)(viii))

A health risk assessment should be included in an ACL demonstration if human exposure to the ground-water contaminants is likely. The applicant need not assess possible health risks in detail if the probability of exposure can be shown to be quite low; such a case may arise if the point of exposure is set at the point of compliance.

The purpose of the health risk assessment is to determine allowable human exposure concentrations at a point of exposure for the constituents for which ACLs are requested. These allowable exposure concentrations can be proposed as ACLs or they can be used as a basis to calculate the ACLs at the point of compliance. When determining potential health risks, certain assumptions are usually made when complete data on specific human effects are lacking. Both the information necessary to sufficiently support proposed allowable exposure concentrations and the areas where assumptions may be necessary are discussed in this chapter. The applicant may find the EPA document Superfund Public Health Evaluation Manual (U.S. EPA, 1986b) useful in making these determinations.

There are four components to an evaluation of health risks. An exposure assessment is the first component of a health risk assessment. The exposure analysis must identify and describe the current and potential human exposure pathways. The second component, usually referred to as hazard identification, involves a qualitative assessment of whether or not a chemical poses a hazard to humans. The third component, the dose-response assessment, attempts to quantitatively describe the expected human response to a given dose of a hazardous constituent, typically relying heavily on data from long-term animal studies. The final component is the risk characterization step. For purposes of developing ACLs, this step involves the integration of the three previous steps to determine allowable human exposure levels for the ACL constituents. Depending on the results of the environmental risk analysis described in Chapter X, the allowable human exposure levels can be used as the ACLs or as the basis to calculate the ACLs.

Exposure Assessment

The exposure assessment should follow the Agency's final guidelines (U.S.EPA, l986c). The types of likely human exposure pathways that should be investigated include:

1. Drinking water exposure from either a ground-water or a surface water source,
2. Ingestion of contaminated food (e.g., aquatic organisms, agricultural products), and
3. Inhalation of volatile compounds.

The type of information needed to satisfy the health risk requirement depends on the exposure pathway. As an example, if the facility property boundary is located adjacent to a surface water body that is a source of drinking water and a sustained fishery, and the contaminated ground water is discharging into this surface water body, then the health risk information must be based on exposure from the consumption of contaminated ground water and aquatic organisms. In this case, the Ambient Water Quality Criteria for the protection of human health from the consumption of contaminated water and aquatic organisms could be proposed directly as the ACLs (i.e., POE = POC). If an exposure pathway is from a ground- water source of potential drinking water, the health assessment must address the consumption of contaminated drinking water. In this case, the health-based drinking water levels could be proposed as the ACLs.

The inhalation exposure pathway should be considered in cases where volatile compounds are either likely to volatilize from the contaminated ground water during use (e.g., during showering) or can be expected to penetrate subsurface structures such as basements. The permit applicant should comment on the probability of the occurrence of these two types of exposures. The applicant will have to address inhalation in the health assessment in those situations where the use of ground water or the presence of subsurface structures allows for probable exposures. It should be noted that the Agency is currently examining air releases from hazardous waste facilities. If standard inhalation assumptions are developed, they may be appropriate for ACL decisions concerned with the inhalation pathway.

The location of the potential points of exposure is discussed in Chapter I. The potential point of exposure to the ground-water contaminants is assumed to be at the facility's waste management boundary, the plume boundary, or the property boundary for most cases in which an ACL application is being prepared.

If the applicant is proposing that the POE be at the facility property boundary and there are drinking water wells nearby, or some contaminants will be discharging into a surface water body, then the possibility of multiple exposures should be considered. For instance, if some members of the local population work in a factory where they are exposed to substance X, and the applicant is proposing an ACL for this substance with the POE at the facility boundary, the applicant should account for that workplace exposure in determining an allowable dose for the population. Similarly, if the potentially exposed population uses water that contains some naturally occurring compounds, the interaction of ambient constituents and the constituents for which the ACLs are proposed should be accounted for in the ACL demonstration.

If any population or subgroup is or will be exposed to the ACL constituents, the cumulative effect of multiple exposures should be accounted for whenever possible. The likelihood of such exposure occurring under the Agency's ACL policy is small, but in some situations this may be a factor of concern. The National Center for Health Statistics, U.S. Department of Health and Human Services, may be a good source of information on sensitive populations or individuals.

Hazard Identification

The two principal sources of data for determining hazard potential are epidemio- logical studies and experimental animal studies. The permit applicant is responsible for providing information on health effects of the hazardous constituents present in the ground water for which ACLs are requested. This can be as simple as providing the Agency maximum contaminant levels (MCLs), reference doses (RfDs), or risk specific doses (RSDs) for the ACL constituents. Appendix D of this document contains a survey sheet on health effect factors that can be used to summarize the toxics information.

If an ACL constituent has no MCL, RfD or RSD, then the applicant should perform a comprehensive literature search for health effects data on that contaminant. The applicant should distinguish between ground-water contaminants having threshold (toxic) and nonthreshold (carcinogenic) effects. The permit applicant should discuss any other effects associated with the contaminants, including odor and taste, mutagenic, teratogenic, reproductive, fetotoxic, and synergistic or antagonistic effects. A reference citation and a summary should be submitted for each study that was used to determine the type of effect for each contaminant.

In the development of ACLs, the permit applicant may find that the grouping of hazardous constituents is a useful simplification. The applicant may investigate health effects data developed for entire classes of compounds, such as polynuclear aromatic hydrocarbons (PAHs), halomethanes, or polychlorinated biphenyls (PCBs), as well as compound-specific data. Grouping of constituents should follow a two-step process. First, the applicant should perform a qualitative assessment of the constituents' physical, chemical, and toxicological properties. Second, a quantitative analysis should be performed to determine the most hazardous compound within each group identified in the first step. This step will be examined in more detail in the dose-response section of this chapter.

The qualitative assessment should include an initial screen of the structure activity relationships (SAR) of the constituents. Constituents with similar physical and chemical structures may be initially grouped together. These groupings should then be further evaluated on their toxicological effects. The predominant adverse biological effect for each constituent in each SAR group should be identified. The final grouping(s) should contain constituents with similar physical and chemical structures, and should result in the same toxic endpoints. This subgroup could form the basis for the exposure assumptions used in deriving the allowable concentrations for the ground-water contaminants. All of this information should be presented in tabular form to facilitate easy reference.

Dose-Response Assessment

This assessment attempts to quantitatively describe the expected human response to a given dose of a hazardous constituent, typically relying heavily on data from long-term animal studies. These animal studies are usually based on exposures at high dose levels, often orders of magnitude higher than doses encountered by humans. Therefore, mathematical models are used to estimate allowable dose levels from low-dose extrapolations. The mathematical models yield reference doses (RfDs) for toxic compounds and potency factors (PFs) for carcinogenic compounds. The RfD refers to the amount of the chemical to which humans can be exposed on a daily basis over long periods of time without suffering an adverse effect. A PF represents, in most cases, the largest possible linear slope at the 95% upper confidence limit of low extrapolated doses that is consistent with the dose- response data.

If Agency-compiled data on threshold (toxic) contaminants are not available, then the applicant can submit dose-response information reflecting the acute, subchronic, chronic, and "no-effect" levels for the threshold contaminants. Body surface area and weight, and absorption and excretion rates may be assumed to estimate equivalent oral doses based on data from inhalation or dermal exposure studies.

A conservative approach to risk assessment that includes groupings of compounds could reduce the amount of data needed to quantify potential human health effects. The quantitative step for grouping compounds consists of identifying the most potent compound in each group identified in the hazard identification step. For toxic compounds, the most potent compound would have the lowest RfD. For carcinogens, the compound with the lowest RSD, or highest PF, would be considered the most potent. This conservative number can then be applied to each compound within the group. It must be emphasized that this quantitative determination should only be performed after a qualitative assessment of the chemical, physical, and toxicological properties of each compound has been performed.

As a simplified example of the grouping process, assume that an applicant's contaminant plume contains PAHs. After analysis, the PAHs are found to be dibenzo(a,h)anthracene, benzo(j)fluoranthene, benzo(a)anthracene, benzo(b)-flouranthene, and benzo(a)pyrene. Since all of these are suspected carcinogens and their chemical structures are similar, these five could be qualitatively grouped. A literature search would reveal that benzo(a)pyrene is the most potent carcinogen, and a RSD could then be obtained from EPA for this compound. The RSD could then be applied to the other four PAHs to calculate allowable exposure levels. To be acceptable to the Agency, this example would require much more supportive information and a number of references.

Risk Characterization

Allowable exposure concentrations can be derived by using MCLs or applying appropriate exposure assumptions to established RfDs or PFs, or alternate dose levels derived from the literature if established dose levels are not available.

When deriving an ACL for those ground waters that are current or potential sources of drinking water, MCLs set under the Safe Drinking Water Act should be examined for use in setting the allowable concentration level at the point of exposure (POE). In those cases where a MCL does exist for the particular contaminant, and the potential exposure route is human drinking water, the MCL should normally be used as the allowable POE concentration. If a MCL does not exist for a hazardous constituent, then either RfDs or RSDs should be used to set the allowable exposure levels.

There are other circumstances where it may be necessary to apply an allowable exposure level other than the MCL at the POE. The circumstances depend on the site-specific factors involved and include the following scenarios:

- Where there are multiple contaminants in the ground water at a site, individual contaminant levels may have to be set below the MCL in order to achieve an overall carcinogenic risk level in the range of 10^{-4} and 10^{-7}.

- Where drinking water is but one of the possible exposure routes.

In the first case, the permit applicant should examine the RSD or RfD value and consider using some form of additivity to derive the appropriate POE concentration. In the latter case, the MCL should be compared to the allowable exposure levels for the other potential receptors. The level at the POE should be set at the lowest allowable exposure level in order to protect all potential receptors.

The permit applicant should use generally accepted standard factors in the exposure assessment, some of which are listed in Appendix E. The allowable exposure level can be calculated for toxic compounds using the RfD and the exposure assumptions of a 70 kg adult consuming two liters of water per day. The following formula should be used to calculate the allowable exposure concentration:

$$\text{RfD Exposure level (mg/l)} = \frac{\text{RfD} \times 70}{2}$$

A potency factor (PF) is used to estimate a risk specific dose for a hazardous constituent concentration that corresponds to a particular statistical lifetime cancer risk value. For example, a contaminant concentration corresponding to a lifetime cancer risk of 10^{-6}, assuming that a 70 kg adult consumes two liters of water per day, is estimated by the following formula:

$$\text{RSD Exposure level (mg/l)} = \frac{70 \times 10^{-6}}{2 \times \text{PF}}$$

In general, the Agency has made decisions to allow concentrations of carcinogens where the individual risk values have been within the range of 10^{-4} to 10^{-7}. In setting ACLs, the following factors should be considered in choosing a risk level within the 10^{-4} to 10^{-7} range:

1. Other environmental health factors borne by the affected population, and
2. Level of uncertainty in the data base and models used in the risk analysis.

As a general matter, a level of 10^{-6}, the middle of the range, should be used as the point of departure when proposing a risk level within the 10^{-4} to 10^{-7} range for a particular facility. Justification should then be provided for using a different level of risk.

In order to account for cumulative impacts of the hazardous constituents for which ACLs are requested, an assessment of the existing concentrations of the ACL constituents in the potentially affected ground water or surface water should be performed. This data is necessary to determine the total concentration of the ACL constituents in the affected water resource, the health effects associated with the concentrations, and the relative exposure contribution of the ACL constituents emanating from the site to the total exposure concentration. At a minimum, an additive approach based on contaminants that produce the same adverse effects by similar mechanisms should be used to estimate health effects from exposure to mixtures of contaminants.

The applicant should submit an allowable health effects exposure level for each ACL constituent. The health-risk assessment should be based on conservative health based numbers. Table I lists the compounds for which RfDs and RSDs have been derived by the U.S. EPA at the time of publication of this document (their derivation is an ongoing process). The RfD summary sheets and the RSDs can be obtained by contacting the Health Assessment Section, in the Office of Solid Waste at the U.S. EPA in Washington D.C. (Phone number: 202-382-5219). If the applicant uses less conservative numbers as a basis for the health risk assessment, the applicant must submit information to justify the use of these numbers. As discussed previously, the allowable exposure levels for a group of constituents can be based on the toxicity of the most potent constituent within that group if such a grouping is sufficiently justified. If sufficient toxicity information on any compound has not been submitted, and the compound cannot be grouped, the concentration limit will be set at the background level or at the maximum concentration listed in Table 1 of Section 264.94(a) of the regulations.

TABLE 1

A. CHEMICALS WITH POTENCY FACTORS

Acrylonitrile
Aldrin
Aniline
Arsenic
Benzene
Benzidene
Benz[a]anthracene
Benzo[a]pyrene
Bis(2-chloroethyl)ether
Cadmium
Carbon tetrachloride
Chlordane
Chlorinated ethanes
1,2-Dichloroethane
1,1,2,2-Tetrachloroethane
Chloroform
Chromium VI
DDT
Dibenzo(a,h)anthracene
3,3'-Dichlorobenzidine
1,1-Dichloroethylene
(Vinylidene chloride)
Dichloromethane
(Methylene chloride)
Dieldrin
2,4-Dinitrotoluene
1,4-Dioxane
Ethylene oxide
Hexachlorobenzene
Hexachlorobutadiene
3-Methylcholanthrene
4,4-Methylene-bis-2-chloroaniline
N-nitrosopyrolidine
Pentachloronitrobenzene
Pronamide
2,4,6-Trichlorophenol
Tetrachloroethylene
Trichloroethylene
Vinyl chloride

TABLE 1 (continued)

B. CHEMICALS WITH VERIFIED REFERENCE DOSES

Acetone
Aldrin
Allyl alcohol
Antimony
Barium
Beryllium
Bis(2-ethylhexy1)phthalate
Bromodichloromethane
Bromomethane
n-Butane
Carbon Disulfide
Carbon Tetrachloride
Chlordane
Chlorobenzene
Chlorodibromomethane
Chloroform
Crotonaldehyde
Cyanide (free)
2,4-D
DDT
D-n-butylphthalate
1,2-Dichlorobenzene
Dichlorodifluoromethane
1,1-Dichloroethylene
2,4-Dichlorophenol
Diethylphthalate
2,4-Dinitrophenol
Disulfoton
Diphenylamine
Ethylacetate
Ethylbenzene
Ethyl Ether
Famphur
Fluoride
Heptachlor epoxide
Hexachlorobutadiene
Hexachlorocyclopentadiene
Isobutyl alcohol
Isophorone
Mercury (inorganic)
Methylene Chloride
Methanol
Methyl ethyl ketone
Methyl isobutyl ketone
Nitrobenzene
Pentachlorobenzene
Pentachloronitrobenzene (PCNB)
Pentachlorophenol
Phenol
Pyridine
Silver
Styrene
1,2,4,5-Tetrachlorobenzene
Tetrachloroethylene
2,3,4,6-Tetrachlorophenol
2,4,5-Trichlorophenol