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Industrial Surface Impoundments in the United States

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Office of Solid Waste
U.S. Environmental Protection Agency
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In memory of the late Oliver Fordham,
who performed the field sampling for this study.

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Executive Summary

EPA's study, *Industrial Surface Impoundments in the United States*, originates from the Land Disposal Program Flexibility Act (LDPFA), an amendment to the Resource Conservation and Recovery Act (RCRA) enacted in 1996. The LDPFA exempts certain decharacterized wastes from provisions of the RCRA land disposal restrictions. "Decharacterized" wastes are hazardous wastes that have had their hazardous characteristics–that is, ignitability, corrosivity, reactivity, or toxicity–removed through dilution or other treatment. The LDPFA exemption allows decharacterized wastes to be either: (1) placed in surface impoundments that are part of wastewater treatment systems whose ultimate discharge is regulated under the Clean Water Act (CWA), or (2) disposed of in Class 1 nonhazardous injection wells regulated under the Safe Drinking Water Act. Because of concerns regarding constituents that might remain in the wastes after removal of the characteristic, Congress required, in the LDPFA, that the Environmental Protection Agency (EPA) conduct a study "to characterize the risks to human health or the environment associated with managing decharacterized wastes in CWA treatment systems" and to "evaluate the extent to which risks are adequately addressed under existing State or Federal programs and whether unaddressed risks could be better addressed under such laws or programs."[1]

Additionally, in 1997 EPA agreed to an amendment to an existing consent decree, *Environmental Defense Fund vs. Whitman,* D.C. Circuit, 89-0598 (EDF consent decree), to include a requirement for a study of air risks from surface impoundments. The amended consent decree required a study of air risks from several different kinds of waste management units and an evaluation of gaps in regulatory controls for air risks posed by waste management practices. The specific part of the air risk consent decree requirement pertaining to surface impoundments in essence became a complementary study for the LDPFA study, since its time frame for completion matched the LDPFA study and it imposed similar requirements on EPA–a risk assessment and evaluation of regulatory coverage. Two of the major differences between the consent decree requirements and the LDPFA study were the consent decree requirement's focus on a single route of human exposure to pollutants–the air inhalation route–and the regulatory status of the wastes required to be studied. While the LDPFA requires a study of nonhazardous wastes that, at some point in time, exhibited a characteristic of hazardous waste, the consent decree requires EPA to study nonhazardous wastes that have never been classified as hazardous wastes. The consent decree also requires EPA to identify potential regulatory gaps in the current RCRA hazardous waste characteristics and the Clean Air Act (CAA) programs.

This report summarizes EPA's study. It begins by describing the nature and variety of industrial surface impoundments and the wastewaters they manage. In 1996, when EPA began

[1] Congress, in the LDPFA, also required that EPA conduct a study of nonhazardous injection wells. The results and findings of that study are reported in U.S. EPA, Office of Groundwater and Drinking Water, 2001, *Class I Underground Injection Control Program: Study of the Risks Associated with Class I Underground Injection Wells,* Washington, DC.

this study, there was limited information on industrial impoundment sizes, designs, and operating characteristics, and there was limited information on the wastewaters managed in industrial impoundments. This report, comprising an analysis of survey data, risk analysis, and regulatory coverage findings, is the result of EPA efforts over the past 5 years to fill information gaps and meet legislative and consent decree obligations. The report quantifies and describes the potential risks to human health and the environment posed by chemical constituents present in the wastewaters managed by industrial surface impoundments. It also identifies existing regulatory controls and nonregulatory programs that can be used to address potential risks.

Overview of Survey and Risk Assessment Findings

Methodology

EPA estimates that, in the 1990s, there were approximately 18,000 industrial surface impoundments in use throughout the United States. These surface impoundments were present at about 7,500 facilities located primarily east of the Mississippi River and in Pacific Coast states. Because of the scope of the universe, EPA conducted the study focusing on a sample of U.S. facilities that use impoundments to manage industrial nonhazardous waste. Most of the facilities selected for the study were chosen randomly to ensure that the sample facilities would be representative of the facilities in the study population. EPA sent surveys to 221 facilities to collect information on their impoundments and the wastes managed in them. EPA requested information on the presence and quantities of 256 chemical constituents in the impoundments, as well as on the impoundments' design and operation. EPA used these data to characterize the potential risks that may be posed by managing the wastes in impoundments. The survey responses on the presence and concentrations of specific chemical constituents were particularly central to EPA's analysis. EPA also collected and analyzed wastewater and sludge from impoundments at 12 facilities in the study and used that information to illuminate the completeness and accuracy of the survey data. EPA also used data from a variety of other sources such as facility permit files, U.S. Census data, and technical references.

In the first part of this report, EPA presents the survey findings, then the risk assessment findings. The survey data provide information on the sizes and nature of the industrial impoundment population, the impoundments' environmental settings, historical summaries of liner failure and overtopping events, and the impoundments' designs and operating practices. EPA conducted a risk assessment using the survey data and other sources of data. The risk assessment consisted of a risk analysis in which EPA developed estimates of the chronic risks that are potentially posed by three pathways (air, groundwater, and groundwater to surface water) and a risk screening in which EPA considered the potential for other indirect pathway and ecological hazards.

EPA conducted the risk analysis and risk screening in stages in order to screen the thousands of possible data points, focus the analysis where most warranted, and, ultimately, characterize the potential risks associated with industrial surface impoundments. In the first stage, EPA applied precautionary exposure assumptions to screen out impoundments of no concern and identify those that merited additional analysis. In subsequent stages, EPA used data on actual exposure and used various fate and transport modeling tools to estimate potential risks.

EPA's risk screening of the other indirect pathways and ecological hazards was similar to the initial stages of the risk analysis. Thus, the characterization of the other indirect pathway hazards and ecological hazards developed in this study is less certain than the characterization of risks via air, groundwater, and groundwater to surface water.

In the risk analysis, EPA used several chronic risk and hazard measures to evaluate potential threats to human and ecological receptors from chemical constituents managed in surface impoundments. EPA developed estimates of the excess individual lifetime cancer risk posed to humans by exposure to carcinogenic chemicals. Chemicals with noncancer health effects were evaluated using threshold measures of hazard. EPA developed hazard quotients (HQs), which are the ratio of the dose of contaminant expected at an exposure point to an appropriate safe reference dose. Other risk measures were also developed for the risk screening to examine the threats associated with consumption of contaminated fish and with ecological hazards. In determining what risks were of concern at each stage of the analysis, EPA generally used a cancer risk of 1 or more in 100,000 and an HQ of 1 or more as the criteria for deciding whether to retain an impoundment for the next stage of evaluation.

Characterization of Surface Impoundments

In the United States, industrial surface impoundments are an important and widely used industrial materials management unit. Surface impoundments serve a variety of beneficial uses in a number of industrial processes. Industrial facilities that produce wastewaters often use surface impoundments to perform necessary wastewater treatment prior to discharge into surface waters. In other cases, industrial facilities may need to control wastewater flows and use surface impoundments for storing excess wastewater. In still other cases, industrial facilities may use surface impoundments to manage their excess wastewaters through evaporation or seepage into the ground.

EPA's best estimate is that two-thirds of the 18,000 industrial impoundments in the United States, or about 11,900 impoundments located at 4,500 facilities, contain at least one of the 256 chemical constituents that were of interest for this study or contain high (11 to 12.5) or low (2 to 3) pH wastewater. Surface impoundments are used by many industrial sectors, such as manufacturing, bulk petroleum storage, air and truck transportation, waste management, and national security. The wastewaters managed in these surface impoundments are primarily from manufacturing and washing processes and certain contaminated stormwaters. More than half of the impoundments with chemical constituents or pH of interest are in the chemical, concrete, paper, and petroleum industries.

Industrial impoundments vary greatly in size, from less than a quarter of a hectare (1/3 of an acre) to several hundred hectares. The larger impoundments provide the bulk of the total national industrial impoundment capacity. On a volume basis, the paper and allied products sector manages roughly two-thirds of the total quantity of wastewater, more waste in impoundments than all of the other industry categories combined.

Industrial impoundments frequently use management techniques that increase the potential for chemical releases and frequently are found in environmental settings that increase the potential for impacts to humans or ecosystems in the event of a chemical release. In this study, EPA found that most industrial impoundments are located only a few meters above groundwater and that, in most cases, shallow groundwater discharges to a nearby surface waterbody. More than half of the impoundments do not have liner systems to prevent the release of wastes to soil or groundwater. In addition, about 20 percent of impoundments are located within 150 meters of a fishable waterbody, so migration through the subsurface to the nearby surface water is possible. Finally, while aeration can have certain benefits, it also increases volatilization and the potential for airborne contaminant migration. EPA found that about 45 percent of the total wastewater quantity managed in impoundments is aerated.

There is potential for people to be exposed to chemical constituents released from industrial impoundments. EPA estimates that more than 20 million people live within 2 kilometers (or about 1.2 miles) of an industrial impoundment that was in operation during the 1990s, and about 10 percent of the impoundments have a domestic drinking water well located within 150 meters of the impoundment's edge.

After evaluating impoundment settings and operations and confirming there was potential for releases, EPA went a step further and conducted a risk assessment to examine the degree to which the chemicals found in impoundments were likely to be released from impoundments and ultimately expose people to harmful chemicals.

The results of the survey are presented in Chapter 2. Appendix A outlines the survey methodology and quality assurance procedures. Appendix B presents more comprehensive and detailed reporting of results. Appendix E discusses the field sampling effort.

Risk Analysis Findings

EPA is basing its conclusions on two sets of risk results. The first set of risk results are those calculated using reported survey values for specified constituent concentrations present in the impoundments. These risk results, therefore, reflect model results from reported concentrations. The second set of risk results are those calculated either using imputed values, where survey respondents reported constituents as being present but did not provide quantities, or using detection limit levels when constituents were reported at less than a limit of detection. Consequently, the second set of risk results are considerably more uncertain.

On a national scale across all pathways in the risk analysis, EPA found that only 5 percent of the estimated 4,500 in-scope facilities and 2 percent of the estimated 11,900 impoundments may pose **risks** to human health. However, EPA also found that 21 percent of facilities nationally, corresponding to 24 percent of impoundments, have the potential for **environmental releases** to occur from impoundments. While these releases do not appear to pose risk to human health, they do indicate that selected contaminants in excess of health-based levels have the potential to move beyond the surface impoundment confines and into the environment.

In the risk analysis, in addition to the national aggregated results, EPA developed risk estimates for three pathways of potential exposure by which chemical constituents could move from an impoundment, through the environment, and be available to be inhaled or ingested by people nearby:

- Direct inhalation risks can occur if a constituent of concern evaporates from the impoundment's water surface, is carried by air dispersion to nearby residences, and then is inhaled by residents. EPA developed risk estimates for the closest residences, based on locations reported in the surveys or identified through census information, and generated national estimates.

  About 92 percent of impoundments were found to pose no air inhalation risk of concern. About 1 percent of impoundments are estimated to have a risk of concern from the inhalation of airborne contaminants. In addition, an estimated additional 3 percent of impoundments do not pose air inhalation risks to people nearby, but do generate releases to the air that exceed health-based levels at a distance of 25 meters from the impoundments. The remaining 4 percent of impoundments could not be evaluated conclusively because of the use of detection limits or inferred data due to incomplete reporting.

- Groundwater risks can occur if impoundments release a constituent of concern through the bottom or sides of the impoundment and these chemicals enter groundwater and move through the subsurface to a drinking water well. EPA estimated risks that could occur due to consumption of water from the closest drinking water wells reported in the surveys or identified through census information, and then generated national estimates. Groundwater contaminant migration depends on many factors, but migration can be slow. EPA's modeling did not examine the speed of contaminant movement, so some of the reported risks may occur in the future.

  Groundwater risks also appear low; 67 percent of impoundments have no evidence of risk. Less than 1 percent of impoundments are estimated to have the potential for risk exceedances. In addition, 11 percent of impoundments have the potential to generate contaminated groundwater plumes that may extend 150 meters or more beyond the unit boundary. The remaining 22 percent of impoundments, while not estimated to cause a risk, could not be evaluated conclusively for their potential to result in a release to the environment because of incomplete reporting of concentration information.

- Groundwater to surface water risks can occur if constituents in an impoundment migrate through groundwater, discharge into nearby surface water, and contaminate fish and make drinking the surface water a concern. From the survey data, EPA generated national risk estimates that identified situations where human health ambient water quality criteria (HH-AWQC) might be exceeded in surface waterbodies.

EPA estimates that less than 1 percent of impoundments contribute to exceedances of HH-AWQC in nearby surface waters. EPA estimates 19 percent of impoundments, while not causing exceedances of HH-AWQC once dilution has occurred in the surface water, are estimated to generate releases that could cause groundwater to exceed the HH-AWQC at the point of groundwater discharge into the surface water.

Risk Screening Findings

EPA also screened for potential risks to human health through indirect pathways that were not considered in the risk analysis and for potential risks to ecological receptors. The objective of the screening was to determine the worst case potential for wastes of concern to cause harm.

- Indirect pathway hazards can occur when humans ingest foods that have been contaminated indirectly by surface impoundment releases. For example, constituents can evaporate, move by dispersion through air, and then deposit on nearby crops and contaminate food sources. EPA's methodology resulted in estimates of potential indirect pathway hazards that were ranked categorically. Approximately 6 percent of the facilities fell into the highest category, indicating that this group of facilities has the greatest potential to result in an indirect risk of concern. However, this analysis does not confirm that facilities in this group actually have indirect risks of concern.

- Industrial wastes managed in surface impoundments may potentially cause adverse effects on nonhuman organisms and natural systems. Many impoundments are located near waterbodies and are freely accessible to wildlife. For this study, EPA assessed the potential for impoundments to pose risks to populations and communities of ecological receptors that live in and near surface impoundments both during their operation and in the event that the impoundments were closed with exposed wastes remaining in place. EPA estimates that approximately 29 percent of facilities may have localized ecological impact during their operation or after closure if ecological receptors inhabit the impoundment area or the nearby areas affected by undiluted impoundment runoff.

The results of the risk analysis and risk screening are presented in Chapter 3 of this report. Appendix C describes the methodology and more detailed findings.

Evaluation of Existing Federal and State Programs

Methodology

The LDPFA requires EPA to assess the various federal and state regulatory and nonregulatory programs that address potential risks from surface impoundments and evaluate the adequacy of such programs. In addition, the EDF consent decree requires us to determine the need for a RCRA air characteristic to address potential air pathway risks from the studied surface impoundments.

Our general approach for the regulatory coverage analysis included a detailed review of applicable federal and state regulatory and nonregulatory programs. The regulatory coverage analysis and identification of gaps in this coverage focused on the potential for risks as determined by our human health and ecological risk screening analyses. The regulatory analysis addresses each of the health pathways of concern and potential risks to ecological receptors. We divided our analysis into two parts: (1) regulatory coverage of direct air inhalation risks, and (2) regulatory coverage of all other "nonair" risks.

To evaluate regulatory coverage and potential gaps for direct air inhalation risks, we reviewed two federal statutes: RCRA, that is, the hazardous and nonhazardous waste programs under this act, and the CAA. The CAA analysis involved three interrelated elements: (1) a waste management unit analysis to identify CAA provisions that can address surface impoundments; (2) a constituent coverage analysis, which focused on the constituents of concern from the risk assessment; and (3) an industry coverage analysis, which focused on the industry categories that were within the scope of this study. We then evaluated possible regulatory coverage by state programs. For potential nonair pathway risks posed by nonhazardous wastes in surface impoundments, we (1) identified constituents of concern from the groundwater and groundwater to surface water pathways, (2) identified federal regulations and programs that may address such risks, and (3) assessed coverage by state programs.

Regulatory Analysis Findings

Overall, the study shows that regulatory and nonregulatory coverage of potential air risks is extensive and that any gaps in coverage appear to be limited to specific industry sectors, individual facilities that meet certain CAA exemptions, or specific air pollutants. The primary regulatory program that addresses potential air risks from industrial surface impoundments is the CAA National Emission Standards for Hazardous Air Pollutants program. Pursuant to section 112 of the CAA, all source categories that emit hazardous air pollutants and pose risks to human health should be regulated when the maximum achievable control technology program is fully implemented. There also are several other existing regulatory and nonregulatory programs that, to varying degrees, address air releases from industrial surface impoundments. These programs include the RCRA Corrective Action Program, the CAA Criteria Air Pollutant Program, state regulations pursuant to State Implementation Plans, the Voluntary Industrial Waste Management Guidance Program, and federal and state waste minimization programs.

For groundwater, the study shows that regulatory and nonregulatory coverage of potential groundwater risks is extensive, but may still have some limited gaps. Potential groundwater risks from industrial surface impoundments, including the groundwater to surface water pathway, are addressed primarily through state regulatory and nonregulatory programs. Based on our available information, most states have one or more programs that include provisions for controlling or addressing groundwater releases from industrial nonhazardous waste surface impoundments. The level of regulatory control or ability to address these releases, however, varies from state to state. These state regulations may be implemented under either general solid and industrial waste management authority or under water program authority, for example, a state National Pollutant Discharge Elimination System (NPDES) program. Additionally, there are RCRA, CWA, and Safe Drinking Water Act (SDWA) programs that also, to varying degrees, address groundwater releases or assess the susceptibility of drinking water sources to contamination. These programs, for example, include the SDWA Source Water Assessment Program, SDWA Wellhead Protection Programs, RCRA Corrective Action Program, the Voluntary Industrial Waste Management Guidance Program, NPDES program, and federal or state waste minimization programs.

The results of EPA's regulatory analysis are presented in Chapter 4 of this report. In addition to identification of potential regulatory "gaps," EPA discusses the limitations of the analysis and existing and future regulatory or nonregulatory tools that may be used to address identified gaps.

Study Conclusions

Today's study satisfies both the requirements of the EDF consent decree and the LDPFA with regard to evaluating the risks and regulatory programs for surface impoundments receiving "decharacterized" wastewaters and never characteristic wastewaters. In both cases, EPA has conducted an extensive analysis of the impoundment universe to understand the risks that may be posed and the extent to which risks are addressed by current and emerging federal and state programs.

In conducting the study pursuant to the EDF consent decree, EPA obtained the information necessary to determine whether a rulemaking to promulgate a hazardous waste characteristic should be initiated. Specifically, EPA examined the universe of impoundments that manage nonhazardous wastewaters. In addition, EPA characterized the pollutants of concern, likely releases, and pathways from these impoundments and assessed potential risks to human health and environment. Little risk has been found, and any risk found is not widespread, but may exist at a facility-specific level. Further, EPA examined the regulations that may apply to impoundments under a variety of federal and state authorities and found that coverage is extensive, but may not be complete in all cases. EPA identified a number of tools (for example, CAA, RCRA, state programs) that can be used effectively to mitigate risks as alternatives to a new hazardous waste characteristic.

In conducting the study pursuant to the LDPFA, EPA completed a study of "decharacterized" wastewater that characterizes the risks to human health or the environment associated with such management. The completed surface impoundment risk study will be undergoing a formal peer review process by EPA's Science Advisory Board expected to begin in early summer. In light of the planned peer review, any technical data in the report should be used with appropriate caveats and cautions. Further, EPA examined existing federal and state programs to evaluate the extent to which risks are adequately addressed under those programs and looked at whether the risks could be better addressed under such laws or programs. EPA concluded that there are some limited gaps in regulatory coverage, but did not find any serious risks that are unaddressed by existing programs. The Agency has not yet determined whether any specific regulatory actions are appropriate to mitigate the potential risks identified in the study.

Chapter 1

Study Background

This chapter explains the legal framework and issues that form the Surface Impoundment study's background, the previous studies of industrial surface impoundments, and the specific purpose and scope of this study. A brief overview of the technical part of the study methodology is included. Further explanations of the technical and program coverage methodologies are found in Chapters 3 and 4.

1.0 Introduction

In the late 1970s to mid-1980s, the U.S. Environmental Protection Agency (EPA) conducted research on industrial surface impoundments. Between 1990 and 1997, certain issues arose concerning industrial impoundments, the nonhazardous (or formerly hazardous) wastes managed in them, the potential risks posed by managing those wastes in impoundments, and how existing regulations address potential risks. These issues were identified in the Land Disposal Program Flexibility Act (LDPFA) legislation that amended the Resource Conservation and Recovery Act (RCRA) and also in a consent decree (*EDF v. Whitman*). Both the legislation and the consent decree required EPA to study the issues. To resolve these issues, EPA needed specific information that was not available from previous research.

1.1 Previous Studies Defining and Characterizing Surface Impoundments

EPA performed a comprehensive census of agricultural, mining, industrial and municipal surface impoundments in the late 1970s and early 1980s (U.S. EPA, 1983b). In this census, the investigators located and categorized approximately 30,000 industrial surface impoundments (SIs). The census included information on these impoundments' geographic distribution, sizes, industry categories, functions, and potential for groundwater contamination. The data identifying the facilities and their locations were not available to be used to help design this study.

At the time this census was performed, the federal RCRA hazardous waste regulations were just beginning to be implemented. These regulations included requirements for surface impoundment design and operation; the original requirements for hazardous waste surface impoundments were tightened in the mid-1980s. These requirements caused many facility owners and operators to change their waste management practices for hazardous wastes and manage more of their wastes in tanks rather than in surface impoundments.

In 1985, EPA conducted a telephone screening survey (U.S. EPA, 1987) of facilities that managed nonhazardous waste in onsite waste management units, including surface impoundments. The definition of surface impoundment used in the telephone screening survey was slightly different from the definition used in the 1983 census, and the telephone screening survey study involved selected industry sectors rather than the broader range of industry sectors covered in the 1983 census. The 1985 telephone screening survey results indicated that approximately 15,000 surface impoundments were being used to manage nonhazardous waste.

During this study, EPA conducted a literature search to determine whether other organizations had performed either national or regional studies of surface impoundments. There was limited information in the public domain, and many of the published references on surface impoundments that EPA found were journal articles describing topics relating to a single impoundment or a single facility's impoundments. EPA found very few published risk assessments of human or ecological effects posed by managing wastes in surface impoundments.

1.2 Legal Framework and Issues

1.2.1 Resource Conservation and Recovery Act - Background

RCRA establishes "a 'cradle-to-grave' regulatory structure overseeing the safe treatment, storage, and disposal of hazardous waste."[1] The first step in the cradle-to-grave process is determining which wastes are hazardous. The statute delineates two types of hazardous wastes: those wastes listed specifically by EPA as hazardous, and those that are hazardous because they exhibit some objectively quantifiable property or characteristic (such as ignitability, corrosivity, reactivity, or toxicity) identified by EPA. This study concerns the latter type: so-called "characteristic" hazardous wastes.

In 1984, Congress amended RCRA to prohibit land disposal of hazardous wastes unless hazardous constituents in the wastes are substantially destroyed, removed, or immobilized so that threats to human health and to the environment posed by the wastes' land disposal are minimized. Normally, this land disposal restrictions (LDR) requirement is satisfied by pretreating hazardous wastes before they are land disposed. Implementing this requirement for characteristic hazardous wastes, however, raises significant issues about the extent to which

[1] *United Technologies Corp. v. EPA*, 821 F. 2d 714, 716 (D.C. Cir. 1987).

pretreatment can be required. This is because, under RCRA regulations, characteristic wastes are no longer identified as hazardous wastes once they no longer clearly exhibit a hazardous waste characteristic. For example, a waste acid with pH less than 2 no longer exhibits the corrosivity characteristic when its pH is greater than 2 and, thus, is no longer a hazardous waste (assuming corrosivity is the only reason this waste was classified as hazardous).

The issue raised for purposes of the LDR program was whether EPA could require further treatment of characteristic wastes even if they no longer exhibited a characteristic. Such treatment could be needed to minimize threats posed by the wastes' land disposal (the overall standard for assessing when land disposal is permissible) because characteristic hazardous wastes may pose hazards for reasons in addition to the characteristic property they exhibit. For example, characteristic hazardous wastes can contain problematic concentrations of hazardous constituents. In its rule of June 1, 1990, EPA imposed further treatment of characteristic hazardous wastes even when the wastes no longer exhibited a characteristic. Such treatment was intended to minimize threats posed by land disposal.

Because the statute requires that hazardous constituents must be destroyed, removed, or immobilized in order for threats to be minimized, this means, ordinarily, that hazardous constituent levels cannot be reduced by means of dilution. EPA's LDR rules thus contain a prohibition on dilution being used as a substitute for treatment that destroys, removes, or immobilizes hazardous constituents. Applied to characteristic hazardous wastes, this means that merely removing a characteristic property by dilution is inadequate treatment if the waste also contains hazardous constituents (as most characteristic wastes do), since the hazardous constituents would not be immobilized or destroyed, and, consequently, threats posed by land disposal would not be minimized.

The most difficult issue presented by the question of dilution of characteristic wastes, and the one that (eventually) occasioned this study, arises when wastewaters exhibit a characteristic, become decharacterized as a result of dilution, and are then land disposed in waste management units affected by either the Clean Water Act (CWA) or the Safe Drinking Water Act (SDWA). The chief example is where a manufacturing plant's wastewaters, some of which exhibit a characteristic, are commingled—resulting in decharacterization by dilution— and then treated in a surface impoundment, a land disposal unit. The ultimate discharge of wastewaters from the impoundment to navigable waters, or to publicly owned treatment works (POTW), is regulated by the Clean Water Act.

Although in such a case the wastewater would be land disposed (i.e., placed in the impoundment) without hazardous constituents in the characteristic wastes being destroyed, removed, or immobilized (i.e., they would be merely diluted), EPA chose, in the June 1, 1990, rulemaking, not to require treatment in advance of land disposal because of the likelihood of substantial disruption of CWA treatment programs. Subsequently the D.C. Circuit Court agreed with EPA only partially, holding that such dilution was permissible only to the extent treatment in the impoundment removed the same amount of hazardous constituent before ultimate discharge as would otherwise be required by the treatment standard. (*Chemical Waste Management, Inc. et al. v. EPA.*)

It is this aspect of the Court's opinion that Congress addressed in the 1996 Land Disposal Program Flexibility Act (Public Law 104-119). Instead of immediately requiring the equivalent treatment requirement adopted by the D.C. Circuit Court, Congress amended the statute to allow most characteristic wastes to be decharacterized by any means (including dilution) and managed in surface impoundments whose ultimate discharge is regulated under the Clean Water Act[2] or managed in underground injection wells regulated under the Safe Drinking Water Act. Congress further required EPA to study risks to human health and to the environment posed by managing decharacterized hazardous wastes in surface impoundments whose ultimate discharge is regulated by the CWA or by managing decharacterized hazardous wastes in underground injection wells regulated under the Safe Drinking Water Act. For risks found, EPA is required by the LDPFA to evaluate the extent to which those risks are adequately addressed under existing regulatory or nonregulatory programs. If risks are found that are not adequately addressed, then EPA may "impose additional requirements" or rely on other state or federal programs to address risks found (RCRA section 3004(g)(10)).

EPA's Office of Solid Waste (OSW) conducted this study on surface impoundments, and EPA's Office of Groundwater and Drinking Water (OGWDW) separately conducted the study on underground injection wells (U.S. EPA, 2001).

In 1997, as part of negotiations over the terms of a consent decree in U.S. District Court,[3] EPA agreed to study human health risks from air inhalation posed by the nonhazardous wastes managed in surface impoundments that were not part of the LDPFA study. These consent decree nonhazardous wastes are called **never characteristic** wastes in the rest of this report. The LDPFA study wastes are called **decharacterized** wastes in the rest of this report.

1.2.2 <u>Clean Water Act - Background</u>

The Clean Water Act establishes a program that controls the discharge of pollutants into the waters of the United States. When facilities use water for some purpose and contaminate it through use, or channelize precipitation that runs off into surface water, they generally direct the flow

- Toward or into surface water
- Into a municipal wastewater collection system (where it is treated in a POTW)
- Into a topographic depression (low-lying area) where it either evaporates or percolates into the ground.

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[2] RCRA sections 3004(g)(7) and (8). Decharacterized wastes for which EPA specified a method of treatment remain prohibited from land disposal, as do reactive cyanide wastes (RCRA section 3004(g)(8)).

[3] *Environmental Defense Fund, Inc. vs. Christine Todd Whitman, Administrator, United States Environmental Protection Agency, et al., Defendants, and American Petroleum Institute, et al., Intervenor-Defendants*, Civ. No. 89-0598, in the United States District Court for the District of Columbia.

The first way of handling the excess water is called **direct discharge**. At the point where the excess water enters the surface water, a CWA National Pollutant Discharge Elimination System (NPDES) permit, or an equivalent permit issued by an authorized state environmental agency, specifies the amount of pollutants that may enter the surface water without degrading the surface water quality.

The second way of handling excess water is called **indirect discharge**. The facility that generates the excess water directs it into a publicly owned treatment works that includes both a collection system and a treatment plant. In the POTW collection/treatment system, the excess waters typically mix with the wastewaters from many other collection/treatment system users. Once the wastewaters are treated, the discharge from the treatment system goes directly into surface water, and that discharge is a direct discharge. The discharge from the treatment system requires a Clean Water Act permit.

The third way of handling excess water, by directing or allowing it to flow into a low-lying area, then recycling it back into facility processes or waiting for it to evaporate or drain (infiltrate) into the ground, is called **zero discharge** because the excess water does not go into surface water—at least not in a rapid or visually observable way. The term "zero discharge" refers to the fact that there is no intended discharge into surface water or to a POTW.

For the direct dischargers, EPA or the authorized state environmental agency receives permit applications and writes the permits. For indirect dischargers, pretreatment standard regulations and/or a POTW collection/treatment system sets treatment levels for indirect discharger users. Zero dischargers sometimes are regulated under the CWA and sometimes are not. In general terms, an authorized state's environmental laws and their implementation determine whether that state issues permits for zero dischargers. In many states, the authorized state agency does not issue NPDES permits for zero dischargers.

1.2.3 Clean Air Act - Background

Section 112 of the Clean Air Act (CAA) requires EPA to regulate emissions of the most potent air pollutants: those that are known or suspected to cause serious health problems such as cancer or birth defects. The Clean Air Act refers to these pollutants as hazardous air pollutants (HAPs).

When amending the CAA in 1990, Congress directed EPA to use a technology-based approach to significantly reduce emissions of air toxics from major sources of air pollution,[4] followed by a risk-based approach to address any remaining, or residual, risks. Under the technology-based approach, EPA develops standards for controlling the emissions of air toxics from each major source of HAPs. The standards are to result in the maximum reduction in emissions of hazardous air pollutants achievable and cannot be any less stringent than the average emission limitation achieved by the best performing 12 percent of existing sources

[4] Major sources are defined as sources that emit 10 tons per year of any of the listed toxic air pollutants or 25 tons per year of a mixture of air toxics.

within a source category for which EPA has emission information.[5] Standards may be more stringent than this base level of control (typically called a floor) after EPA considers cost, energy, and nonair quality health and environmental impacts of potentially more stringent standards**.** Standards thus typically reflect the performance of the maximum achievable control technology (MACT). Eight years after each MACT standard is issued, EPA must assess the remaining health risks from source categories. If necessary, EPA must implement additional standards that address any significant remaining risk.

1.2.4 Interaction of RCRA, CWA, and CAA

The CWA and CAA were enacted to control and minimize water and air pollution, respectively. These two laws caused facilities to collect and manage pollutants that previously had been discharged into the nation's waterways and into its air. RCRA was enacted in recognition of the need to manage these collected pollutants appropriately so that they would not become waterborne or airborne again (RCRA section 1002(b)). This section discusses how these three laws interact with respect to the particular issue of risks to human health and the environment posed by managing nonhazardous wastes in surface impoundments.

A traditional focus of the RCRA hazardous waste program has been on risks posed by collected wastes, such as air and water pollution control residues, and protecting groundwater resources from contamination from those residues. The RCRA hazardous waste program exempts from RCRA substantive and permitting requirements tank systems that are part of CWA treatment systems. CWA NPDES permits issued by states, using state environmental statutes, occasionally contain prohibitions on groundwater contamination. Because the CWA program's traditional focus has been on protecting surface water rather than groundwater, however, questions have arisen about whether wastes managed in CWA-regulated treatment systems, but exempt from RCRA requirements, might contaminate groundwater. An example is one part of the controversy that the LDPFA addressed: the potential for groundwater contamination from decharacterized wastes managed in CWA treatment systems. In a CWA treatment system in which wastewater flows first through a tank system and then into surface impoundments, the wastewater treatment unit exemption from RCRA substantive and permitting requirements would apply to the tank system part of the wastewater treatment system. Thus, characteristic hazardous wastes could be introduced into the RCRA-exempt tank system part of the treatment train, become diluted during treatment, and no longer exhibit the hazardous characteristic by the time they reach a surface impoundment. This situation gave rise to the concern that hazardous constituents present in the wastewater could still be present and available to contaminate groundwater.

Historically, EPA's rules implementing the CWA have not addressed pollution from air emissions emanating from wastewater collection and treatment systems. In some instances, the RCRA hazardous waste program does address air emissions from wastewater collection and treatment, and, in other instances, the CAA hazardous air pollutant (air toxics) program addresses certain emissions from wastewater collection and treatment. However, there could be situations

[5] For new sources, the standard is the level of emission reduction achieved by the best performing single source within a source category.

in which wastewaters containing volatile HAPs are not regulated under either the RCRA hazardous waste program or the CAA air toxics program. The consent decree sought to have EPA investigate such situations and requires that EPA explicitly include certain facilities and impoundments with a particular CAA section 112 status. EPA must assess whether these facilities and impoundments, and the chemicals managed in them, pose risks by the direct air inhalation pathway.

1.2.5 Requirements To Conduct This Study

1.2.5.1 LDPFA Requirements. Section 3004(g)(10) of the LDPFA requires the Administrator of EPA to complete a study of wastes that: (1) no longer exhibits a hazardous characteristic prior to management in any land-based solid waste management unit; and (2) is treated in a treatment system that subsequently discharges to waters of the United States pursuant to a permit issued under section 402 of the Federal Water Pollution Control Act, treated for the purposes of the pretreatment requirements of section 307 of the Clean Water Act, or treated in a zero discharge system that, prior to any permanent land disposal, engages in treatment that is equivalent to treatment required under section 402 of the CWA for discharges to waters of the United States.

Not later than 5 years after the date of enactment of the LDPFA (i.e., by March 26, 2001), EPA must complete a study of these wastes to characterize the risks to human health or the environment associated with such management. In conducting the study, EPA must evaluate the extent to which risks are adequately addressed under existing state or federal programs and whether unaddressed risks could be better addressed under such laws or programs. Upon receipt of additional information or upon completion of such study and as necessary to protect human health and the environment, EPA may impose additional requirements under existing federal laws, including subsection 3004(m)(1) or rely on other state or federal programs or authorities to address such risks.

1.2.5.2 EDF Consent Decree Requirements. Paragraph 11.1 of the consent decree requires EPA to perform two studies on gaps in the hazardous waste characteristics. The studies must also evaluate the resulting potential risks to human health posed by the inhalation of gaseous and nongaseous air emissions from wastes managed in tanks, surface impoundments, landfills, wastepiles, and land treatment units. For surface impoundments, the consent decree specifically excludes those surface impoundments receiving decharacterized wastewaters that are being studied under the LDPFA. With respect to the consent decree studies, at a minimum, EPA is required to address releases from waste management units that: (1) are at facilities that are not within source categories subject to the scope of the CAA NESHAP program, (2) are at facilities that are not major sources under the CAA, and (3) are excluded under a specific NESHAP MACT rule due to unit or chemical type. For the surface impoundments, EPA is required to evaluate those impoundments receiving wastewaters that never exhibited a hazardous waste characteristic.

The purpose of these studies is “to obtain such information as the Administrator may require to determine whether a rulemaking to promulgate a hazardous waste characteristic that addresses potential risk to human health through the direct inhalation pathway should be initiated." In May 1998, EPA released the first of the two required studies covering the waste management units other than surface impoundments. (See *Air Characteristic Study,* U.S. EPA 1998, subsequently revised November 1999a.) The Consent Decree calls for completion and public release of the surface impoundment study by March 26, 2001.

1.3 Study Purpose

This study's purpose is to fulfill, in a single place, the separate requirements posed by the LDPFA and the consent decree, which are

> "to characterize the risks to human health or the environment associated with [managing decharacterized wastes in CWA treatment systems]" and to "evaluate the extent to which risks are adequately addressed under existing State or Federal programs and whether unaddressed risks could be better addressed under such laws or programs." (RCRA section 3004(g)(10))

and

> The Administrator shall...perform [a] stud[y] on gaps in the hazardous waste characteristics and relevant Clean Air Act ("CAA") controls, and the resulting potential risks to human health, posed by the inhalation of gaseous and non-gaseous air emissions from wastes managed in...surface impoundments (excluding those impoundments receiving decharacterized wastewaters that the Agency is obliged to study pursuant to section 3004(g)(10) of RCRA, 42 U.S.C. S 6924(g)(10))....[6]

Both the statute and the consent decree require a risk assessment and then an evaluation of existing mechanisms that address risks posed by this waste management practice. There are differences between the statutory requirement and the consent decree requirement. EPA chose to conduct a multimedia[7] risk assessment, which satisfies the statutory requirement and goes beyond what is required in the consent decree. EPA also performed an evaluation of existing programs, both regulatory and nonregulatory, which satisfies the statutory requirement and goes beyond what is required in the consent decree.

As a result, the study has two primary objectives: (1) to assess risks posed by the waste management practices described in the statute and consent decree, and (2) to describe how existing regulatory and nonregulatory programs address any risks that may be present.

[6] Civ. No. 89-0958, *Environmental Defense Fund, Inc. vs. Whitman et al.* June 12, 1997.

[7] In this context, "multimedia" refers to multiple environmental media— air, water, soil, and biota.

1.4 Study Scope

1.4.1 Definition of Surface Impoundment

In the RCRA hazardous waste regulations, the definition of "surface impoundment" at 40 CFR 260.10 is

> . . . a facility or part of a facility which is a natural topographic depression, man-made excavation, or diked area formed primarily of earthen materials (although it may be lined with man-made materials), which is designed to hold an accumulation of liquid wastes or wastes containing free liquids, and which is not an injection well. Examples of surface impoundments are holding, storage, settling, and aeration pits, ponds, and lagoons.

Historically, there have been some difficulties in interpreting this definition related to distinguishing between surface impoundments and tanks for purposes of interpreting whether the hazardous waste regulations do or do not apply to a particular waste management unit. In a 1983 memorandum, EPA distinguished between tanks and impoundments (U.S. EPA, 1983a) by an engineering test of a wastewater holding unit's structural integrity and interpreted the unit to be either a tank (if it can withstand the forces applied during the engineering test) or a surface impoundment (if it cannot withstand the applied forces).

In this study, EPA considered using this definition, but was concerned that the difficulties in distinguishing between tanks and impoundments would pose problems with the screening survey, which was intended to identify a sample of facilities with impoundments. EPA reviewed the definitions used in the 1983 census and the 1985 telephone screening survey and chose to use a modified version of the definition in the 1983 census. The definition OSW finally used in its surveys for this study (U.S. EPA, 1999b, 1999c) used both text and graphics and is shown in Figure 1-1)

1.4.2 Other Scope Decisions

EPA faced several decisions on scoping the study on matters that were not specified in the legislation. EPA received and considered public comments on many of the scope decisions. (EPA's strategy for involving the public in the study design and implementation is described in Section 1.5.) These specific decisions are described as follows.

Economic Sectors To Include in the Study. EPA chose to focus the study on those sectors most likely to generate characteristic hazardous waste and, thus, to potentially have decharacterized waste that might be managed in impoundments. The sectors included were the manufacturing industries (including food processing; textiles; paper and allied products; stone, clay and glass; chemicals and allied products; petroleum and allied products; and primary metals), bulk chemical and petroleum storage, sewerage and refuse systems, scrap and waste materials, airport terminals, truck transportation terminals, and national security. EPA generally excluded the economic sectors that had already been studied in considerable detail under the various statutory RCRA exclusions for large-volume wastes (the so-called "Bevill exclusions"

A surface impoundment is a natural topographic depression, artificial excavation, or dike arrangement for storing, treating, or disposing of wastewater (i.e., liquid or semi-solid waste with less than 5% solids by weight). A surface impoundment may be constructed above the ground, below the ground, or partly above the ground and partly below the ground. A surface impoundment's length or width is greater than its depth (for example, it is not an injection well). Here are some examples (side view):

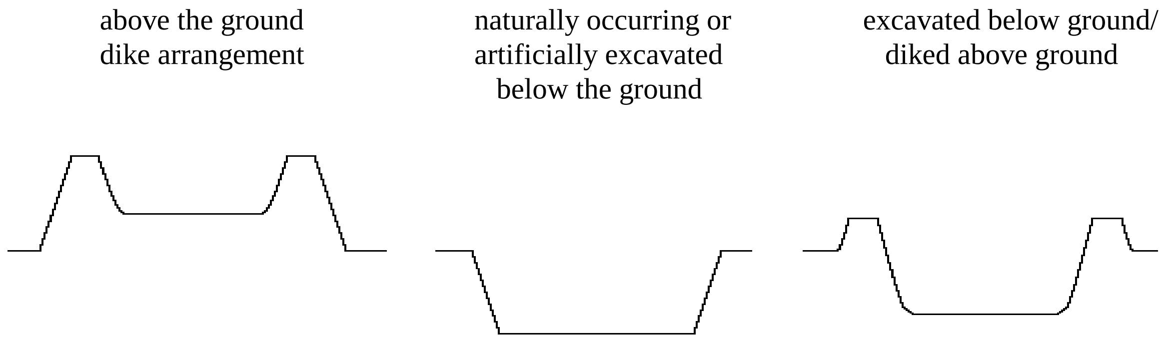

Figure 1-1. Definition of surface impoundments used in this study.

found at RCRA section 3001(b)(3)). However, some facilities whose wastes are excluded under these statutory exclusions inadvertently were included in the study population because it was not possible to separate them from facilities in the economic sectors of interest.

Time Frame in Which Impoundments Operate. Because impoundments sometimes operate for many decades, EPA needed to define practical boundaries for the operating period time frames this study would review. EPA did not believe that facility owners would have information readily available concerning old impoundments that had closed many years ago. EPA decided that, since the original LDPFA issue came about due to the so-called "third third" 1990 land disposal restrictions, it was appropriate to focus attention on only those impoundments that were potentially affected by those regulations (promulgated on June 1, 1990). Thus, EPA limited the study's scope to impoundments that had received waste on or after June 1, 1990.

Geographic Range. In RCRA, the term "state" refers to the 50 states, the District of Columbia, Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands. The study's geographic range includes all of these areas.

Whether To Include both Wastewater and Sludge. For this study, EPA defined wastewater as "liquid or semi-solid waste with less than 5% solids by weight" and sludge as "any solid, semi-solid, or liquid waste containing 5 weight percent or more solids, that is generated in the course of treating or managing wastewater." Initially, EPA proposed including sludge and sludge management practices in the study's scope. However, the issue of sludge management after removal from the impoundment (or sludge management in impoundments, where the impoundment is the final disposal unit for the sludge) was not part of the original LDPFA issue.

In addition, the complexity of the ongoing nature of sludge management (with such diverse practices as dewatering, land application, landfilling, and beneficial reuse) would have complicated the data collection. Thus, EPA decided to limit the study to wastewater and sludge present in an impoundment and not to study risks posed by sludges after they are intentionally removed from an impoundment.

Chemical Constituents of Concern. The legal issues that prompted the study revolved around hazardous constituents in these wastes remaining after the characteristic property is removed (in the case of the LDPFA) and around a list of 105 specific constituents that the consent decree required EPA to study. EPA combined the list of 105 specific constituents with a list of constituents that had been identified previously as being of concern in the LDR program (certain so-called "universal treatment standards" constituents), or more broadly in the RCRA hazardous waste program (additional constituents that were being considered under the Hazardous Waste Identification Rule [HWIR] proposal in early 1997). The combined list consisted of 256 chemicals (or, in some cases, classes of chemicals) that were the subject of the study.

1.5 Overview of Methodology

1.5.1 Public Involvement in Study Design and Identification of Data Needs

Soon after the Land Disposal Program Flexibility Act was enacted, EPA placed a notice in the *Federal Register* about the legislation's requirement to conduct the study, requested public comments on the "data collection, quality assurance/quality control of data, development of risk assessment methods, establishment of a peer-review structure for the study, and assessment of current State/Federal/Tribal regulations or programs that address risks"[8] and invited stakeholders to submit ideas for the study design. The general nature of the comments submitted was that EPA would need to collect detailed, site-specific information from a representative sample of facilities to be able to assess potential risks accurately. EPA chose to design the study using many of the public comments received. EPA also sought a consultation from a committee of EPA's Science Advisory Board (SAB) to gain expert scientific input on the design of the risk assessment portion of the study.

Based on the public comments and expert scientific input, EPA identified three broad categories of data needs:

- Data on chemical constituents' health effects and physical/chemical properties
- Information on federal and state regulatory and nonregulatory programs
- Data on sources and wastes including
  - Environmental settings in which impoundments are found

[8] Vol. 61, *Federal Register*, pp. 38684-38687, July 25, 1996.

- Impoundment design features

- Impoundment operating and closure practices

- Wastes managed in impoundments (quantity of the waste matrix and its chemical composition—presence, identification and quantities of chemical constituents)

- Presence, location, and activities of people and nonhuman organisms.

The data in the first category are available in the scientific literature. For the information in the second category, EPA used various public data sources. For the data in the third category, although some data were readily available in public data sources, EPA had no way to judge their representativeness. Thus, a major challenge EPA faced in performing the study was how to identify facilities that used surface impoundments meeting the criteria spelled out in the legislation and consent decree in order to select a representative sample of facilities with impoundments and how to collect from them the data in the third category.

1.5.2 Overall Framework of Risk Assessment

The basic framework for the risk assessment portion of the study can be summarized in five steps:

1. Characterize the target population of facilities and impoundments and draw a probability sample

2. Develop the risk assessment framework

3. Conduct a pilot study

4. Collect and process data for the risk assessment

5. Perform the risk assessment.

The first step consisted of targeting impoundments that were likely to manage the kinds of wastes the legislation and consent decree required to be studied and that were likely to manage the hazardous constituents that were at issue in both the legislation and the consent decree. Because impoundments are sometimes used to manage stormwater that is merely precipitation runoff and potentially contains very few, if any, of these constituents, EPA was not interested in including impoundments holding stormwater only. However, many facilities use impoundments to hold stormwater and some process wastewater, and some facilities use impoundments to hold cooling water (which could be combined with stormwater, process wastewater, or both). The wide variety of situations led EPA to decide on a list of wastewater attributes to use as criteria for screening out impoundments that were unlikely to have constituents of concern. The criteria were included in a "screening" survey that was used to target the study's focus on impoundments most likely to be of interest.

The second step was to develop the risk assessment framework. During the study period, both computing technology and risk assessment "state of the science" developed rapidly, and EPA continually revised its approach for conducting the risk assessment to take advantage of these developments. Using guidance from EPA's Science Advisory Board and technical expertise in risk assessment, EPA developed a series of data analysis protocols to apply to the information identified as necessary for the risk assessment.

The third step was to conduct a pilot study to test the data collection, data processing, and risk assessment framework on a limited number of facilities. EPA used the results from the data collection test to improve the survey used to collect the detailed data necessary for the risk assessment. EPA also gauged the level of effort, both for the pilot study facilities to complete the survey and for EPA to process and analyze the data, and made adjustments in the study's scope and the risk assessment framework to improve the data collection and analysis efficiency.

The fourth step, collecting and processing the data, took the largest amount of time. For situations such as this study, the Paperwork Reduction Act requires federal agencies to publish draft surveys and accept public comments in two separate *Federal Register* notices before receiving Office of Management and Budget (OMB) approval for sending out surveys. EPA designed the data collection as a two-stage sample: the first stage was necessary to identify facilities with impoundments meeting the study criteria, and the second stage was necessary to collect the detailed information needed for the risk assessment. EPA used the screener survey for the first stage and a long survey for the detailed information in the second stage. At the end of the second stage, EPA also performed "field sampling" of wastewater and sludge samples taken from impoundments at some of the study facilities. The total elapsed time for conducting the pilot and completing the data collection part of the second stage survey was 3 years (see Figure 1-2 for study timeline showing key milestones).

The fifth step, performing the risk assessment, was altered from the pilot study approach due to the advances in computing technology, the availability of environmental fate and transport models, and the need to perform further screening to remove from consideration those facilities, impoundments, and constituents that present very little or no risk. EPA prepared a technical plan for conducting the risk assessment and obtained input from independent peer reviewers before embarking on the task of analyzing the survey and field sampling data. In performing the risk assessment, EPA encountered certain situations not anticipated, so the final risk assessment approach differed somewhat from the approach outlined in the technical plan. The approach used is described in Chapter 3 and in Appendix C.

1.5.3 Representativeness of Facilities in This Study

Section 2 of the LDPFA described the three types of CWA facilities: direct, zero, and indirect dischargers. Facilities that are one of these three types of dischargers and use surface impoundments are the population the LDPFA directed EPA to study. At the beginning of this study, EPA did not have a list of facilities in the United States with impoundments meeting the criteria described in the statute or the consent decree. For direct dischargers, EPA had a database, called the Permit Compliance System (PCS), that had some facility name and address information, but did not identify very many facilities that used impoundments. For zero

Date	Activity
March 1996	Land Disposal Program Flexibility Act (LDPFA) enacted
July 1996	*Federal Register* notice requesting comment on study methodology
September 1996	Preliminary consultation on methodology with Science Advisory Board
October 1996 to April 1997	Prepare methodology for Science Advisory Board peer review
April 30/May 1, 1997	Science Advisory Board peer review of proposed methodology
July 1997	Begin pilot study
February 1998	Draw random sample of facilities to receive screener surveys First Paperwork Reduction Act *Federal Register* notice
April to June 1998	Revise surveys based on public comments
July 1998	Complete pilot study report; Second Paperwork Reduction Act *Federal Register* notice; Submit Information Collection Request to Office of Management and Budget (OMB)
August 1998	Science Advisory Board peer review report on proposed methodology
December 1998	OMB approves Information Collection Request
February to September 1999	Send out screener surveys, process data from returned surveys; draw random sample of facilities to receive long survey
November 1999 to July 2000	Long survey data collection
February to March 2000	Peer review of technical plan for risk assessment
May to August 2000	EPA "field sampling"
May 2000 to January 2001	Human health and ecological risk assessment
September 2000 to March 2001	Review of existing regulatory requirements and nonregulatory programs
February to March 2001	Final Agency review

Figure 1-2. Study timeline.

dischargers and indirect dischargers, there was no corresponding database that listed facility names and addresses.

After extensive research, EPA concluded that the three subpopulations (direct, zero, and indirect dischargers) presented different challenges for conducting the study. EPA was able to use PCS as the data source to locate direct dischargers with impoundments. EPA constructed an essentially complete list of the direct dischargers and drew a stratified random sample from that list. For the direct dischargers, EPA believes that the sample is a representative one. EPA constructed a new national list of zero dischargers from data supplied by state environmental agencies and certain other sources. This list reflects the known zero discharger subpopulation, but may not accurately reflect the entire national zero discharger subpopulation. However, it is the most complete national list of zero dischargers that was possible to construct under this study's constraints. Thus, EPA believes the sample of zero dischargers is representative of the facilities on the list but may not be representative of all zero dischargers in the study population. For the indirect dischargers, EPA concluded that, of the many thousands of indirect dischargers across the country, it was likely that, at most, several hundred used impoundments. As a result, EPA concluded that it was infeasible to locate a representative sample of this small subpopulation. Instead, EPA chose to identify a nonrepresentative sample of the indirect dischargers, selected to represent the known range of industries, and simply compare the results for this group with the results for the direct and zero dischargers.

Figure 1-3 illustrates the steps taken to identify a representative sample of direct and known zero dischargers and to identify the sample of indirect dischargers for this study.

In the rest of this report, EPA presents the survey data and risk assessment results for the direct and zero dischargers. Although EPA included some indirect dischargers in the study and performed the same risk assessment steps for those indirect dischargers, none were found to pose risks at levels of concern. For simplicity, the indirect dischargers are omitted from the descriptions in the rest of the report (although the data on their impoundments and wastes are included in the appendixes and other supporting materials).

1.5.4 Peer Review of Study Components

EPA has a policy that requires peer review of major scientific and technically based work products (U.S. EPA, 1994). One group that performs peer reviews of selected EPA work products is the Science Advisory Board. EPA requested a SAB peer review of the proposed study methodology. SAB agreed to review the proposed methodology, and convened a special subcommittee of its Environmental Engineering Committee to perform the peer review. EPA presented the proposed study design to the subcommittee in April 1997. The Science Advisory Board's report for this peer review is available at http://www.epa.gov/sab/eec9809.pdf. (U.S. EPA, 1998).

EPA made use of many of the SAB recommendations during the study's implementation. One topic on which EPA requested advice was the question of obtaining peer review at different points in the study's implementation. SAB's advice on this topic was that EPA should consider, plan for, and seek "...the peer review for minimum disciplinary acceptability of the

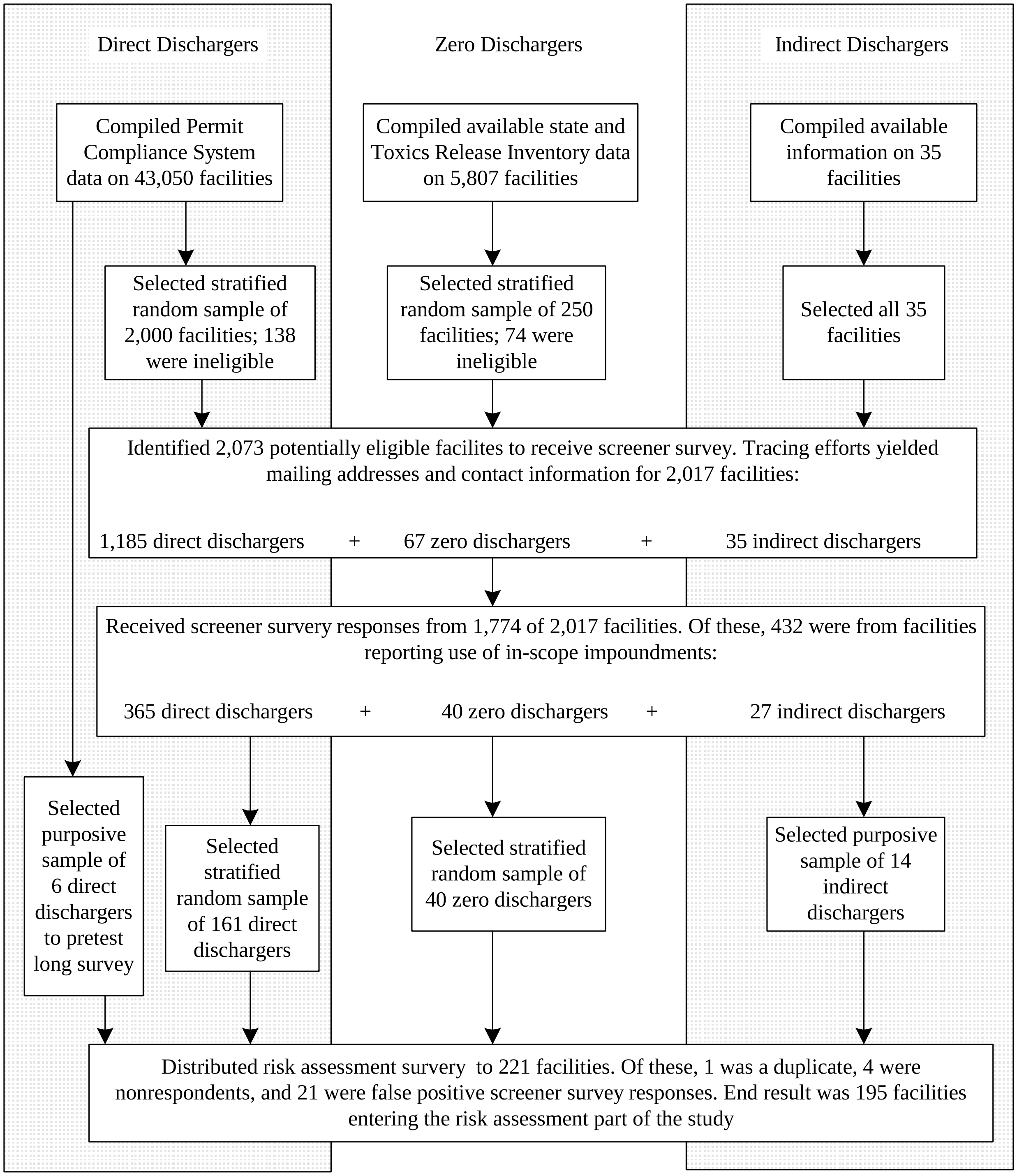

Figure 1-3. Selection of facilities for study.

information...the validity of the technical interpretation, and...the relevance of the technical data and interpretation to a policy decision...” while suggesting that there should be flexibility in exactly which parties perform these three functions (U.S. EPA, 1998). EPA chose to follow this advice using already existing mechanisms in place for obtaining public input and to seek formal peer review by independent scientific experts at two points: a review of the technical plan for the risk assessment prior to implementing it, and a review of the final risk characterization results. The review of the technical plan for the risk assessment is described in more detail in Appendix C. An SAB peer review of the risk characterization results will occur after completion of the study.

1.6 Organization of This Report

The rest of this report describes the methodology, results, and conclusions of the risk portion of the study and the corresponding analysis of regulatory and nonregulatory program coverage of potential risks found. The risk portion of the study is described in Chapters 2 and 3, the existing program coverage portion of the study is described in Chapter 4, and the risk conclusions and the program coverage conclusions are summarized in Chapter 5.

Chapter 2 explains the long survey data that were used to develop the bulk of the study’s conclusions about potential risks. It also includes a discussion of the field sampling results and how they illustrate the strengths and weaknesses of the long survey data on waste characterization. The survey data are a critical component of the overall risk portion of the study because they provide the context for the formal risk assessment results.

Chapter 3 presents the two parts of the formal risk assessment: the risk analysis, which yielded numerical estimates of risks potentially posed via three human health “pathways,” and a risk screening, which did not yield numerical estimates of risks. The risk analysis consists of

- Estimates of potential risks to actual current, or likely future, receptors
- An assessment of environmental releases that are occurring and would cause potential risks if people or ecological receptors were present at certain locations.

Chapter 4 presents the evaluation of the extent to which existing regulatory and non-regulatory programs address the potential risks found and described in Chapter 3. For human health risks from the direct air inhalation pathway, EPA identified provisions in both RCRA and CAA programs that address surface impoundments, the extent to which any of the 256 constituents are specifically addressed by such programs, and the extent to which the industry categories covered by the SI Study are addressed by the programs. For "non-air risks," EPA identified federal and state regulations and programs that may address such risks and identified the constituents of concern and assessed their coverage by these regulations and programs.

Chapter 5 summarizes the important findings from the survey data, summarizes the results from the risk assessment, and summarizes the overall assessment of how well the existing programs address the potential risks found.

Appendix A explains the statistical study design, the survey implementation, and data processing steps.

Appendix B provides a detailed profile of the study population. The particular attributes of impoundments, and the wastes managed in them, which can contribute to their probability of causing environmental releases and/or human or ecological risks are described in considerable detail. These data are important for understanding the context of the risk assessment results and conclusions.

Appendix C provides a detailed description of the risk assessment methodology and more details about the risk assessment results.

Appendix D provides a detailed description of the "existing program" analysis methodology and more details about the coverage found.

Appendix E provides an overall summary of the field sampling waste characterization data and the detailed information underlying the Chapter 2 description of how the field sampling data illustrate the strengths and weaknesses of the long survey waste characterization data.

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Chapter 2

Characterization of Industrial Surface Impoundments

This chapter presents the survey findings of EPA's 5-year study of the population of surface impoundments that manage industrial nonhazardous wastewaters. This presentation accompanies the risk assessment results discussed in Chapter 3 and the regulatory gap findings addressed in Chapter 4. Main findings are discussed under the following sections:

2.1 Overview of Surface Impoundment Population

2.2 Chemicals and Management Practices at Surface Impoundments

2.3 Factors Related to Transport of Chemicals from Surface Impoundments

2.4 Proximity of Humans to Surface Impoundments

2.5 Regulatory, Exemption/Exclusion, and Operating Status of Surface Impoundments

2.6 Conclusions

For background information on EPA's study, including the sampling methodology and survey instrument, see Chapter 1 and Appendix A. A more detailed presentation of the data from the survey is provided in Appendix B of this report.

2.1 Overview of Surface Impoundment Population

This section provides an overview of surface impoundment population characteristics, such as impoundment age, location, industrial classification, and size.[1] The data presented here portray a snapshot in time and, therefore, cannot account for changes in given industrial sectors that have already taken place since the survey or may take place at some point in the future.

[1] Throughout this chapter, rounded figures on the number of facilities, number of impoundments, and total wastewater volume are presented in the text. Estimates of these variables shown in tables and figures are left unrounded. Due to differing patterns of missing data, the weight adjustments for missing data lead to slightly different estimates presented for the same variable in some tables/figures. See Appendix B for the standard errors associated with these estimates.

2.1.1 *Population of Surface Impoundments*

EPA estimates that there are approximately 18,000 industrial nonhazardous surface impoundments[2] located at 7,500 facilities that received waste between June 1990 and June 2000 and met the other criteria for being in this study. Of these nonhazardous industrial impoundments, approximately 11,900 manage wastewaters that contain one or more chemicals of concern and/or have either high or low pH (see Table 2-1). These impoundments are located at an estimated 4,500 facilities and account for roughly 650 million metric tons (t) of wastewater quantity managed. Although only 15 percent of these facilities manage any decharacterized wastes, the volumes of decharacterized wastewater managed make up 70 percent of the entire wastewater quantity. This study presents results for these 11,900 impoundments that contain wastewaters with chemicals/pH of concern.[3]

Management of wastewaters in impoundments can include storage, treatment, and, in some cases, disposal. Approximately two-thirds of all facilities have more than one impoundment onsite and roughly 5 percent have more than 10 impoundments onsite that manage wastewaters. Usually, storage and treatment functions are performed before the wastewater is discharged to a surface waterbody under a National Pollutant Discharge Elimination System (NPDES) permit; facilities employing this approach are often referred to as "direct dischargers." As shown in Table 2-1, there are 3,940 facilities and 10,990 surface impoundments that manage approximately 618,000,000 metric tons of wastewater through direct discharge.[4]

Impoundments used for disposal of wastewater are referred to as "zero discharge" impoundments. The practice of wastewater disposal in impoundments is less common than storage and treatment of wastewater in impoundments. Disposal is usually achieved by allowing the wastewater to evaporate or to percolate into the ground and does not include discharge to a surface waterbody. EPA estimates that there are 510 zero discharge facilities, or 880 impoundments, that manage approximately 27,000,000 metric tons.

In the economic sectors that are the subject of this study, surface impoundments are used for the management of wastewater, stormwater, and cooling water. As shown in Figure 2-1, the majority of impoundments were constructed within the past 30 years. Furthermore, 40 percent of impoundments came on line in the 1970s, probably in response to environmental programs promulgated early in that decade requiring greater treatment of industrial wastewaters. The impoundments that were in operation before 1970, approximately one-quarter of the population, were likely employed in some aspect of water supply management associated with the industrial processes at these facilities.

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[2] Actual estimates of the number of industrial nonhazardous waste impoundments vary from 16,700 (based on the long survey) to 18,400 (based on the screener survey). See Appendix A for a detailed discussion of these estimates.

[3] In comparison, in the United States today, there are just under 50 facilities with roughly 200 surface impoundments that are used to manage hazardous waste. These hazardous waste surface impoundment figures are based on data extracted from EPA's RCRAInfo in January 2001.

[4] Number for facilities, impoundments, and quantities of wastewater managed are rounded in this chapter.

Table 2-1. Overview of Facility, Impoundment, and Wastewater Quantity Estimates

Characteristic	Direct Dischargers	Zero Dischargers	Total Population
Estimated number of facilities	3,944	512	4,457
Estimated number of impoundments	10,987	876	11,863
Total quantity of wastewaters managed (metric tons)[a]	627,218,336	27,250,309	654,468,645

[a] The estimate of the wastewater quantity for the total population differs from the estimates shown in Tables 2-2 and 2-15. This is due to missing data associated with this variable. Refer to Appendix A on missing data and Appendix B for the standard error associated with this variable.

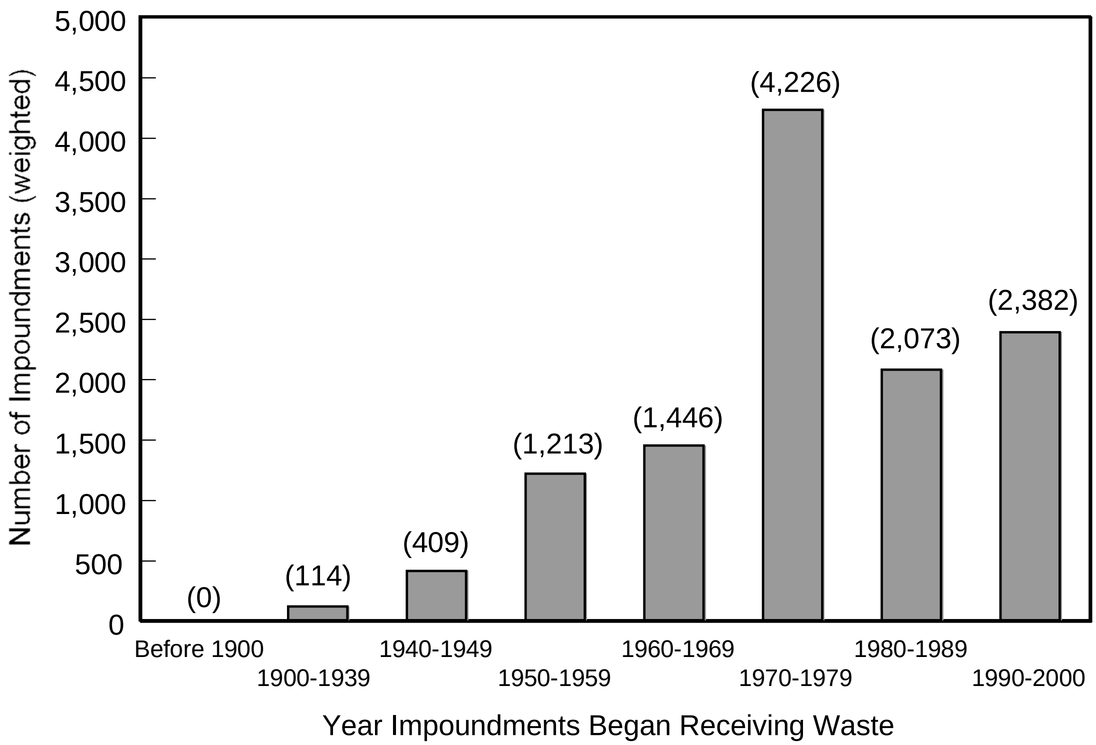


Figure 2-1. Distribution of 11,863 impoundments by year unit began receiving waste.

2.1.2 Location of Surface Impoundments

Generally, surface impoundments are located in areas with fairly significant precipitation levels and availability of water. Figure 2-2 shows the breakdown of the 11,900 impoundments from the survey by EPA Region across the United States. The greatest proportion of impoundments are located in Gulf Coast states and along the East Coast. EPA's Region 3 has the greatest density of impoundments per 100 square miles; EPA Region 4 has the highest number of impoundments. Zero discharge facilities are generally distributed across the regions evenly, with the exception of EPA Regions 1 and 8, which have none.

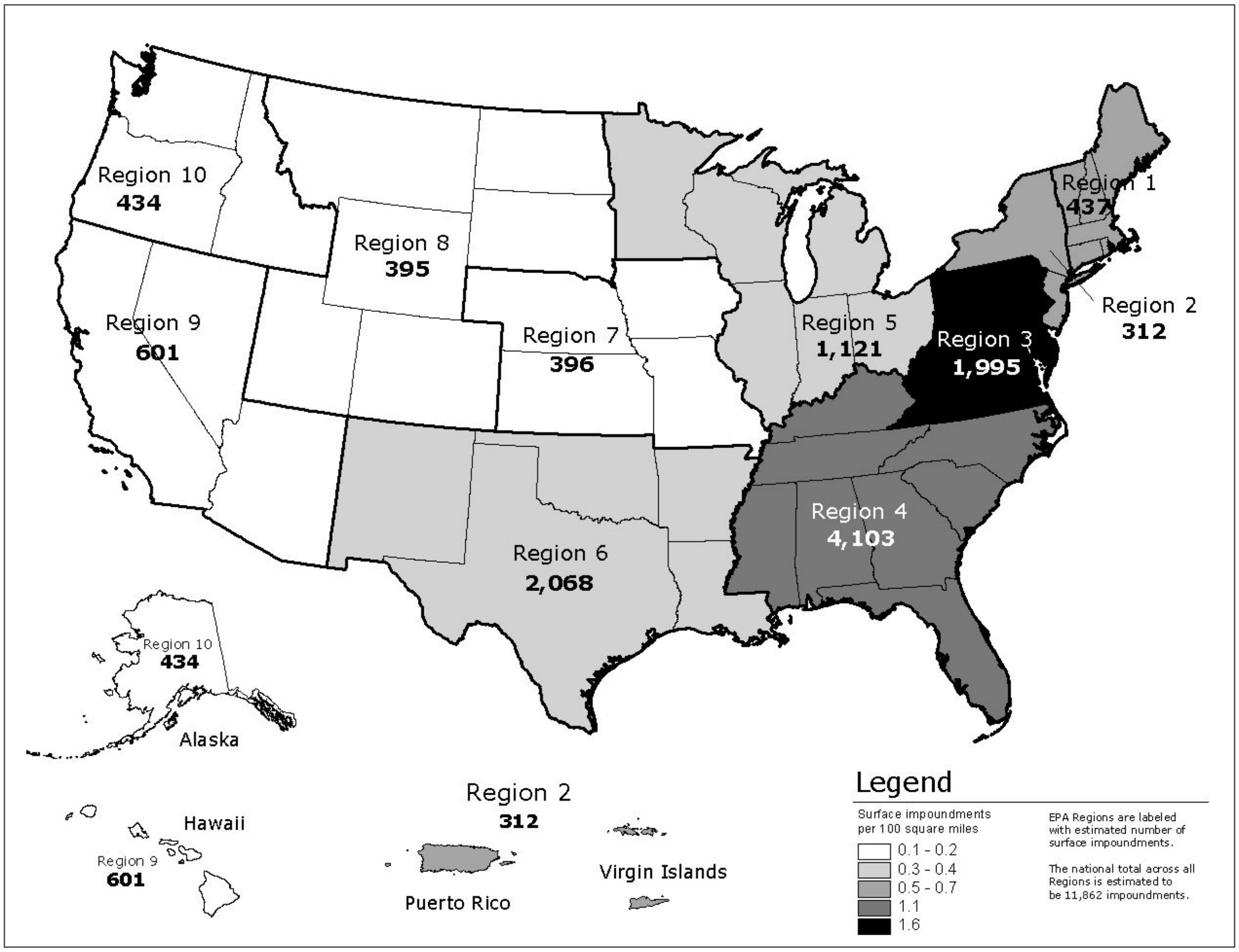


Figure 2-2. Regional distribution of surface impoundments.

2.1.3 Breakdown of Surface Impoundments by Industry

Surface impoundments have been and continue to be used widely in the management of industrial wastewaters. For this study, EPA chose a scope of economic activities that generally matched the "industrial" categories of the December 1983 *Surface Impoundment Assessment National Report*, focusing on the manufacturing sector, along with certain other economic sectors that were likely to have surface impoundments with wastes containing chemical constituents. The nonmanufacturing sectors included were trucking, motor freight terminal maintenance, airports, the waste management and sanitary services sector, industrial supplies, chemical and allied product bulk storage, petroleum bulk stations, national security, and miscellaneous services. (See Chapter 1 and Appendix A for a discussion of the industry coverage in the sample selection for the study.)

According to the survey data, approximately two-thirds of the total wastewater quantity managed in the 11,900 impoundments is managed at paper and allied product sector facilities (see Table 2-2). This industrial sector, however, represents only 6 percent of the population of facilities and just over 10 percent of all impoundments. Furthermore, an analysis at the 4-digit

Table 2-2. Breakdown by 2-Digit SIC Code of Surface Impoundments that Manage Chemicals/pH of Concern and of Quantities of Wastewater Managed

SIC Code Descriptor	Percent of 4,457 Facilities	Percent of 11,863 Impoundments	Percent of 653,314,426 [a] Metric Tons Wastewater
Chemical and Allied Products (SIC 28)	19	23	9
Stone, Clay, Glass, Concrete Products (SIC 32)	15	13	1
Wholesale Trade-Nondurable Goods (SIC 51)	12	10	4
Primary Metals Industry (SIC 33)	10	8	7
Food and Kindred Products (SIC 20)	8	8	5
Petroleum and Coal Products (SIC 29)	7	11	6
Paper and Allied Products (SIC 26)	6	12	66
All Other SIC Codes	23	15	2

SIC = Standard Industrial Classification.

[a] The estimate of the wastewater quantity for the total population differs from the estimates shown in Tables 2-1 and 2-15. This is due to missing data associated with this variable. Refer to Appendix A on missing data and Appendix B for the standard error associated with this variable.

Standard Industrial Classification (SIC) code level reveals that roughly 40 percent of the total wastewater quantity falls in the pulp mills industry (SIC 2611), a subsector of the paper and allied products industry.

Examining the data in Table 2-2 regarding the overall industrial coverage, the top four sectors account for 56 percent of the population of facilities; these sectors are chemical and allied products; stone, clay, glass, concrete products; wholesale trade-nondurable goods; and primary metals. These sectors manage only 20 percent of the total wastewater volume. The breakdown of industries differs at the impoundment level. The chemical and allied product sector and the stone, clay, glass, concrete products sector represent an estimated 36 percent of the population of impoundments. However, the next highest sectors in impoundment representation are the petroleum and coal product sector and the paper and allied products sector, with a total of 23 percent of the impoundments in the population.

2.1.4 *Surface Impoundment Size and Appearance Characteristics*

Impoundments vary considerably in surface area and depth. A size breakdown of impoundment surface area for the impoundment population is shown in Table 2-3. The depth of the impoundment can fluctuate, especially with larger units. These factors determine the overall volume of wastewater managed in any given impoundment. The relationship of impoundment surface area and wastewater volume is discussed in Section 2.2.3.

Table 2-3. Breakdown of Impoundment Surface Area

Size Range (hectares)	Impoundment Surface Area (Percent of 11,863 Total)
0 to 1/4 hectares	6,013 (51%)
1/4 to 1 hectares	2,953 (25%)
1 to 5 hectares	1,989 (17%)
5 to 10 hectares	456 (4%)
10 to 500 hectares	452 (4%)

As shown in Table 2-3, 51 percent of all impoundments have a surface area of 1/4 hectare or less. The medium size range of impoundments, from 1/4 to 5 hectares, constitutes 42 percent of the total population. The upper 8 percent of impoundments range from 5 to 500 hectares in size. The direct and zero discharge populations each have roughly the same size breakdown as that shown in Table 2-3 for the total population of impoundments.

Figures 2-3 through 2-5 show three pictures of impoundments taken during EPA's field sampling (see Appendix E for details on field sampling). Surface impoundments range from engineered structures that have the appearance of being man-made to marsh-like areas that an observer might not realize were used for wastewater management. Some have vegetation growing in the impoundments; many have vegetation growing along the edges. For impoundments with "liner" systems (one or more layers of material placed on the sides and bottom to prevent the wastewater from seeping into the ground), the aboveground part of the liner may be visible. Frequently, equipment such as pumps, flow control devices, and aeration equipment is present. There can be vehicle access roads constructed on top of the berms that form the sides. The color of the wastewater can be many different hues, and the wastewater can have a floating layer of oil or grease, a frothy appearance from foam, and/or a distinct odor. Impoundments can be located immediately adjacent to agricultural or residential areas or in areas of heavy industrial concentration.

2.2 Chemicals and Management Practices at Surface Impoundments

Surface impoundments provide a relatively low-maintenance/low-cost method of effectively managing nonhazardous wastewater, and thus serve a useful purpose in protecting waterbodies from receiving highly contaminated industrial wastes. However, impoundments can have an impact on the environment: chemicals can volatilize from the wastewater surface, contamination of the groundwater can occur if wastewater leaches from the impoundment, and nearby surface waterbodies can become polluted. Additionally, impoundments can experience overtopping releases through significant precipitation events or berm failure.

Figure 2-3. Surface impoundment located at a fruit processing facility.

Figure 2-4. Surface impoundment at a petroleum refinery.

Figure 2-5. Surface impoundment at a nylon manufacturing plant.

This section describes the sources for the chemical data used in this study, discusses the chemicals that can be present in wastewater and sludge in impoundments, identifies impoundment size and wastewater volume characteristics of the population of impoundments, and examines the management practices employed at surface impoundments.

2.2.1 Data Sources for Chemical Data

In this study, EPA is using two sources of data to identify the chemicals present in the impoundments and to quantify the amounts of those chemicals that are present: survey data and field sampling data.

2.2.1.1 Survey Data. In the SI survey, EPA requested that respondents identify the chemicals of concern present in their impoundments and, if known, state the average quantity of each chemical present

- In the preceding 3-year period, or
- In any 3-year period since 1990, if no data were available for the most recent 3-year period.

EPA encouraged respondents to conduct analytical tests to produce their answers, but allowed respondents to report estimates based on their knowledge of their wastes and processes. If data were unavailable, the survey respondents were not required to provide information. However, many survey respondents conducted sampling in order to respond to the survey.

Based on the survey data, methanol, fluoride, acetone, manganese, zinc, barium, and nickel are present in the greatest quantity in wastewater. See Section 2.2.2 for a more detailed discussion of frequently occurring chemicals.

2.2.1.2 Field Sampling Data. Of the major industry categories represented in the survey sample, EPA selected 12 facilities and, based on the survey responses and general knowledge of each industry, identified chemicals likely to be present in those facilities' impoundments. EPA then visited the facilities to obtain wastewater and sludge samples, analyzed those samples, and used the field sampling data for comparison with the survey data.[6] For more information on the field sampling, see Appendix E of this report. EPA performed the field sampling to accomplish two primary objectives. The risk assessment relies on the survey data regarding the presence and quantities of constituents. If the survey data on constituent quantities do not reflect the actual quantities of constituents in an impoundment (that is, are inaccurate), then the risk assessment results based on those data will be inaccurate as well. Similarly, if survey respondents did not report all the constituents present in an impoundment, then the survey data on the presence of constituents will be incomplete and the risk assessment results will likewise be incomplete. The field sampling effort provided an independent check, or verification, of the survey data on constituent presence and quantities. Thus, the field sampling objectives were

- To evaluate the degree to which the concentrations of constituents reported in the survey agree with the concentrations measured in the field

- To evaluate the degree to which the field sampling results revealed omissions in the reported survey data on presence and quantities of constituents.

For those constituents reported in the survey data and for which the field sampling confirmed their presence at the particular facilities and impoundments, the reported survey data values of chemical quantity agree, in most instances, within an order of magnitude of the corresponding field sampling quantity (see Figure 2-6). Furthermore, in almost all instances, the reported survey values agree within 2 orders of magnitude of the corresponding field sampling values. This finding indicates that, where chemical constituents were reported by survey respondents, EPA's field sampling did not find evidence of underreporting.

One limitation of this comparison is the fact that the survey requested average values over a 3-year period, while the field sampling data were obtained on a 1- or 2-day visit. Another limitation is that, because the facilities selected for field sampling were not chosen randomly, the results cannot be statistically extrapolated. However, EPA believes that the comparisons provide useful insights into the overall quality of the survey data and into certain critical areas of uncertainty in the risk assessment.

[6] For more information on the field sampling, see Appendix E of this report.

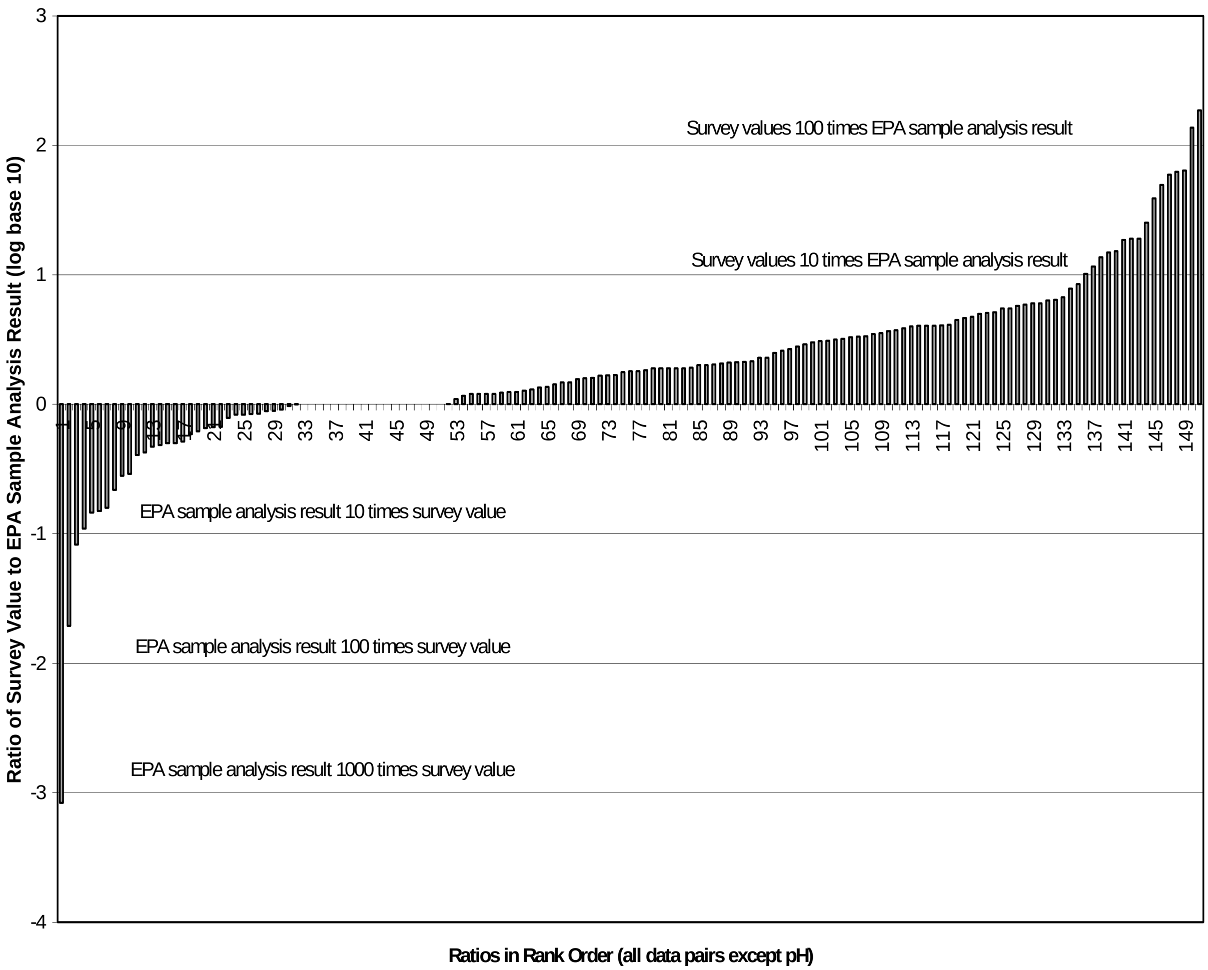


Figure 2-6. Relationship between survey values and corresponding EPA measurements.

As an indication of whether constituents might tend to be present that were not reported in the survey, EPA compared the number of constituents reported by each of the 12 field sampling facilities with the number of constituents found in the field sampling. Table 2-4 presents the results of this comparison.

Table 2-4 suggests that the reported survey data on the presence of chemical constituents may be incomplete. At each of the 12 facilities visited for sampling, EPA found unreported constituents above a limit of detection. The number of unreported constituents found at a facility ranged from 3 to 30.

Based on the agreement between the concentrations reported in the survey and those measured during EPA's field study, EPA has concluded that there is no reason to question the concentration data provided in the facility survey. However, based on the discrepancies observed as to the presence of some constituents in the impoundments sampled, there is evidence to suggest that facility operators do not necessarily have comprehensive knowledge of all the individual constituents contained in their impoundments.

Table 2-4. Constituents Confirmed with Field Sampling and Unreported Constituents

Facility SIC Code	SIC Description	No. Of Constituents Reported in Survey[a]	No. Of Same Constituents Detected in Corresponding EPA Sample	No. Of Additional Constituents Detected by EPA and Not Reported by Facility
2037	Fruit processing	0	0	11
2621	Paper mill	15	8	18
2611	Pulp mill	11	10	30
2821	Nylon manufacturing	8	6	18
2819	Inorganic chemicals	6	4	13
2911	Petroleum refinery #1	55	17	7
2911	Petroleum refinery #2	11	11	13
3087	Rubber mixing	10	5	3
3273	Ready mix concrete	0	0	10
3313	Electrometallurgical products	17	15	13
3353	Aluminum manufacturing	7	7	11
3674	Semiconductors	4	4	9

SIC = Standard Industrial Classification.
[a] Includes concentration values reported as "<", and constituents reported as "present but quantity unknown."

There are a variety of possible reasons for these discrepancies. For example, EPA used high-quality analytical procedures enabling the quantification of constituents that are present at low levels. In addition, impoundment operators may only be required to monitor for a limited number of indicator chemicals and, as a consequence, may only track and therefore report one chemical among a larger class of chemical constituents.

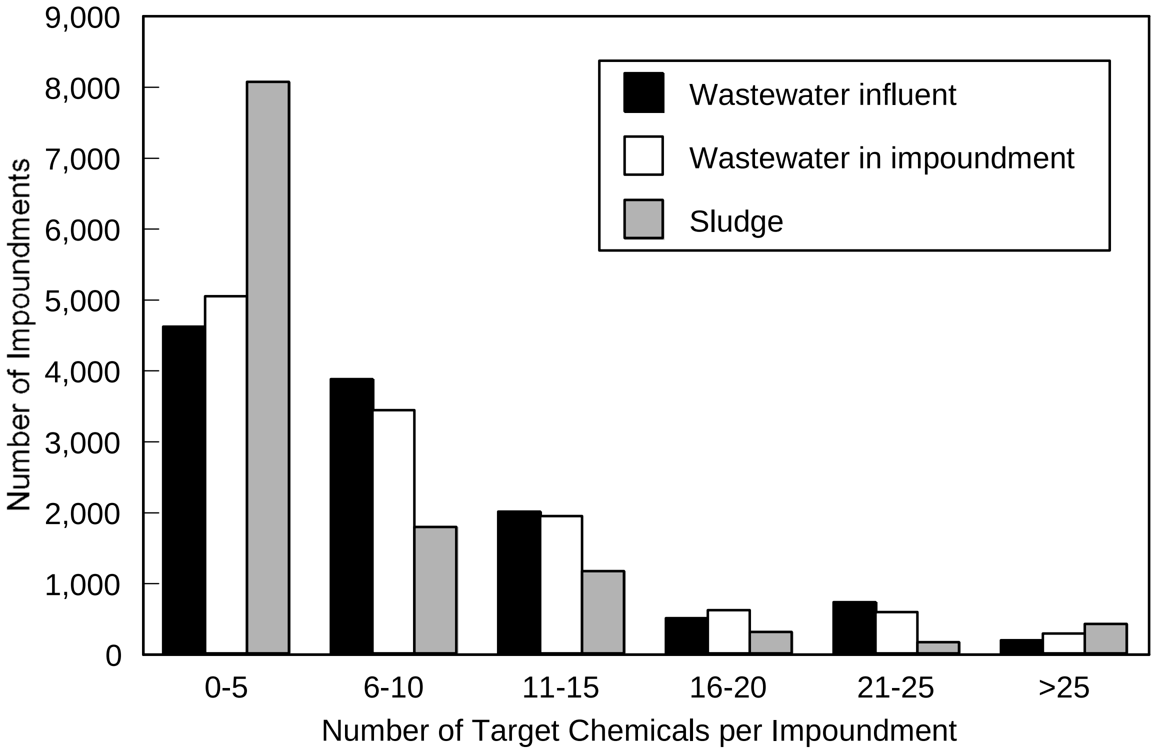
Where chemical data are discussed in the remainder of this chapter, data from the survey database are used. For a more complete discussion of the field sampling data, please see Appendix E of this report.

2.2.2 Chemicals Managed in Surface Impoundments

As stated in Section 2.1.1, the impoundments addressed in this study are those that manage wastewaters that contain chemicals or pH of concern. Of the 11,900 impoundments that meet this criterion, just over 90 percent had chemicals of concern and roughly 10 percent had pH of concern. According to the survey data, approximately half of all facilities (15 percent of wastewater quantity managed) employ impoundments to manage five or fewer chemicals. Figure 2-7 shows the distribution of chemicals present on a per impoundment basis for wastewater influent, wastewater in impoundment, and sludge. The industry sectors that employ impoundments to manage more than 20 chemicals are chemical and allied products, paper and allied products, petroleum and coal products, and primary metals. A more detailed examination of the chemicals found in impoundments across SIC codes is provided in Appendix B.

A breakdown of chemicals present, by chemical category, for wastewaters and sludges is shown in Table 2-5. This table displays chemical presence based on “influent,” “in impoundment,” and “effluent” sampling points. The figures in this table represent the number of impoundments that contain chemicals from the given chemical category (shown under “# Imps”), and the percentage of the total volume of wastewater that contains chemicals from the given chemical category (shown under “% Vol”).

As shown in Table 2-5, metals are the most prevalent chemical category found in wastewaters across the population of impoundments, present in 9,970 impoundments at influent and 7,760 impoundments at effluent sampling points. Furthermore, approximately 85 percent of



Note: For a detailed examination of the number of chemicals found in impoundments by SIC code, see Appendix B.

Figure 2-7. Number of chemicals in wastewater and sludge managed in impoundments.

Table 2-5. Breakdown of Chemical Categories for Wastewater and Sludge (at Different Sampling Points) on Impoundment and Volume Basis

Chemical Categories	Wastewater						Sludge					
	Influent		In Impoundment		Effluent		Influent		In Impoundmen t		Effluent	
	# Imps	% Vol	# Imps	% Vol	# Imps	% Vol	# Imps	% Vol	# Imps	% Vol	# Imps	% Vol
VOCs	5,866	76	5,412	76	4,815	72	1,690	4	2,006	21	1,311	14
SVOCs	3,824	75	3,786	75	3,508	69	863	7	1,261	24	605	3
Metals	9,966	84	9,982	83	7,762	85	3,925	42	5,551	98	3,078	88
Dioxin-like compounds	291	24	218	21	346	22	247	10	861	35	412	41
Mercury	2,483	27	2,479	30	2,235	31	1,061	0.9	1,745	66	826	6
Any chemicals	10,745	96	10,766	97	8,187	92	4,101	45	5,759	100	3,230	89

Imps = number of impoundments.
% Vol = percent of total volume.
SVOCs = Semivolatile organic compounds.
VOCs = Volatile organic compounds.

wastewater volumes contain metals. Dioxin-like compounds are the least common category of chemicals found in wastewaters across the population of impoundments, present in 290 impoundments at influent and 350 impoundments at effluent sampling points. However, just over 20 percent (between 21 and 24 percent) of wastewater volume contains dioxin-like compounds.

Metals are also the most common chemicals present in sludges across the population of impoundments, showing up in 3,930 impoundments at influent and 3,080 impoundments at effluent sampling points. A comparatively higher number of impoundments contain metals in sludge at the "in impoundment" sampling point, approximately 5,500 impoundments. Dioxin-like compounds are the least common category of chemicals in sludge managed in impoundments, present at between 250 impoundments at influent and 410 impoundments at effluent sampling points. There is also a comparatively higher number of units, 860 impoundments, with dioxin-like compounds at the "in impoundment" sampling point.

The most common constituents (by volume) in each chemical category are

- VOCs: methanol, acetone, methyl ethyl ketone, and acetaldehyde
- SVOCs: ethylene glycol, phenol, cresols, and aniline
- Metals: manganese, zinc, barium, and nickel.

In addition, two inorganic chemicals, sulfides and fluoride, are commonly present in wastewater volumes. These data are provided in Appendix B, along with presence and volume estimates for all SIS chemicals.

The pH criteria (pH between 2 and 3 or pH between 11 and 12.5) was not a significant issue at the impoundments addressed in this report. Approximately 3 percent of impoundments were in the acidic range, almost all of which managed never characteristic wastewaters. Roughly 8 percent of impoundments were in the basic range, the vast majority of which never managed characteristic wastes.

Table 2-6 presents data on the wastewater influent concentrations for 11 toxicity characteristic (TC) constituents that are managed in impoundments (see 40 CFR 261.124, Table 1). These 11 constituents are among the most frequently occurring across the population of impoundments, with all but cresol being in the top 25 chemicals; cresol is ranked 35th by presence. Appendix B, Table B-19a shows a complete breakdown of chemicals by presence and by wastewater quantity.

As the data show, arsenic, benzene, and cadmium have 50th percentile concentrations for never characteristic, decharacterized, or all impoundments that are above a screening factor health benchmark for cancer or noncancer effects. For the 90th percentile concentrations, selenium is added to that list. Barium, chloroform, chromium, mercury, and methyl ethyl ketone have 90th percentile concentrations that are within an order of magnitude of a human health screening factor. Benzene is the lone chemical to have 90th percentile wastewater influent concentrations for never characteristic and for all impoundments above the TC level. Arsenic, barium, benzene, cadmium, chloroform, chromium, lead, and selenium show concentrations that are above the TC level at a few impoundments (see Appendix B for histograms of the full concentration distributions for these TC chemicals). The never characteristic and decharacterized concentration breakdowns do not reveal any clear trends regarding chemical concentration.

In Table 2-7, EPA presents data on the facility-level co-occurrence of chemicals in wastewater by human health effect. Facility-level co-occurrence is defined as two or more chemicals with a common target health effect occurring within or across impoundments at a single facility. These figures on co-occurrence of chemicals with a common target health effect do not account for the potential variance of the effects that may result within the same target health effect category, nor does this evaluation consider chemical concentration with regard to co-occurrence. However, EPA did consider chemical concentration and co-occurrence in the risk analysis. Specifically, EPA's risk analysis examined the risks caused by exposure to multiple contaminants from the same impoundment and facility and found only a single instance where co-occurrence led to a risk of concern. (See Appendix C, Section C.1, which provides information on the assessment of cumulative risks.) The evaluation of chemical co-occurrence was specifically called for as a part of the consent decree (*EDF v. Whitman*).

As the data show, the top five target health effect categories for facilities with two or more chemical co-occurrences in wastewater are kidney, liver, neurological, cancer, and hematological. The target health effect categories that have facilities with co-occurrences of

Table 2-6. Comparison of 50th and 90th Percentile Influent Wastewater Concentrations with Toxicity Characteristic (TC) Limits and Health-Based Screening Factors for Selected Chemicals

Chemical	Screening Factor[a] (mg/L)		TC Limit [b] (mg/L)	Influent Wastewater Concentrations (mg/L)					
				50th Percentile			90th Percentile		
	Carc.	Noncarc.		Never Charac-eristic	Decharac-terized	All Impound-ments	Never Charac-teristic	Decharac-terized	All Impound-ents
Arsenic (7440-38-2)	6.6E-04	6.9E-03	5.0	9.0E-03	6.9E-03	9.0E-03	1.3E-02	2.1E-02	2.1E-02
Barium (7440-39-3)	NA	1.6E+00	100.0	1.3E-01	1.0E-01	1.3E-01	3.2E-01	4.5E-01	3.5E-01
Benzene (71-43-2)	1.8E-02	NA	0.5	8.0E-01	1.6E-02	2.1E-02	1.1E+00	9.0E-02	8.0E-01
Cadmium (7440-43-9)	NA	1.2E-02	1.0	1.8E-02	3.1E-03	3.1E-03	7.9E+00	7.0E-03	1.5E-01
Chloroform (67-66-3)	1.6E-01	2.3E-01	6.0	4.0E-03	1.9E-02	4.0E-03	1.1E-02	1.1E-01	3.0E-02
Chromium (7440-47-3)	NA	6.9E-02	5.0	6.0E-03	6.4E-03	6.4E-03	2.5E-02	2.7E-02	2.7E-02
Cresol (1319-77-3)	NA	1.2E+00	200.0	NA	4.1E-02	3.1E-02	NA	1.1E-01	1.1E-01
Lead (7439-92-1)	NA	NA	5.0	2.0E-02	5.7E-03	1.0E-02	2.0E-02	2.0E-02	2.0E-02
Mercury (7439-97-6)	NA	6.9E-03	0.2	6.0E-05	5.9E-04	3.0E-04	6.0E-04	7.5E-03	3.8E-03
Methyl Ethyl Ketone (MEK) (78-93-3)	NA	1.4E+01	200.0	0.0E+00	7.4E-01	6.1E-01	2.5E-02	5.9E+00	5.9E+00
Selenium (7782-49-2)	NA	1.2E-01	1.0	2.0E-03	8.0E-03	5.3E-03	1.4E-01	4.8E-02	1.4E-01

NA = Not available.

[a] Human health screening factors for carcinogens (carc.) and noncarcinogens (noncarc.) in drinking water. See Appendix C, Attachment C-3.

[b] Source: RCRA §261.24, Table 1 – Maximum Concentration of Contaminants for the Toxicity Characteristic

between 11 and 20 chemicals in wastewater within/across impoundments are liver, cancer, kidney, and neurological; liver has the most facilities within this range, at 221. Additional evaluation of the co-occurrence of chemicals in wastewaters and in sludge is shown in Appendix B.

Table 2-7. Co-occurrence of Chemicals in Wastewater by Human Health Effect

Target Health Effect[a]	Estimated Number of Facilities with Co-occurrences[b] in Wastewater				
	Number of Chemicals Co-occurring Within/ Across Impoundments[c]				All Facilities with Two or More Co-ocurrences
	2-3	4-6	7-10	11-20	
Cancer	621	328	390	30	1,369
Adrenal	0	0	0	0	0
Bladder	0	0	0	0	0
Body weight	984	193	13	0	1,191
Brain	0	0	0	0	0
Cardiovascular	0	0	0	0	0
Death	0	0	0	0	0
Developmental	635	11	0	0	646
Eyes	13	0	0	0	13
Forestomach	0	0	0	0	0
Gastrointestinal	0	0	0	0	0
General	0	0	0	0	0
Hematological	1,246	76	11	0	1,334
Kidney	1,099	799	111	11	2,020
Leukemia	0	0	0	0	0
Liver	972	339	212	221	1,743
Lung	766	64	0	0	830
Mammary	0	0	0	0	0
Nasal cavity	0	0	0	0	0
Neurological	873	696	73	10	1,653
Organ weight	13	0	0	0	13
Reproductive	123	0	0	0	123
Respiratory	832	131	0	0	962
Respiratory tract	0	0	0	0	0
Skin	238	0	0	0	238
Spleen	0	0	0	0	0

(continued)

Table 2-7. (continued)

Target Health Effect[a]	Estimated Number of Facilities with Co-occurrences[b] in Wastewater				
	Number of Chemicals Co-occurring Within/ Across Impoundments[c]				All Facilities with Two or More Co-ocurrences
	2-3	4-6	7-10	11-20	
Stomach	0	0	0	0	0
Thyroid	0	0	0	0	0
Vascular	6	0	0	0	6

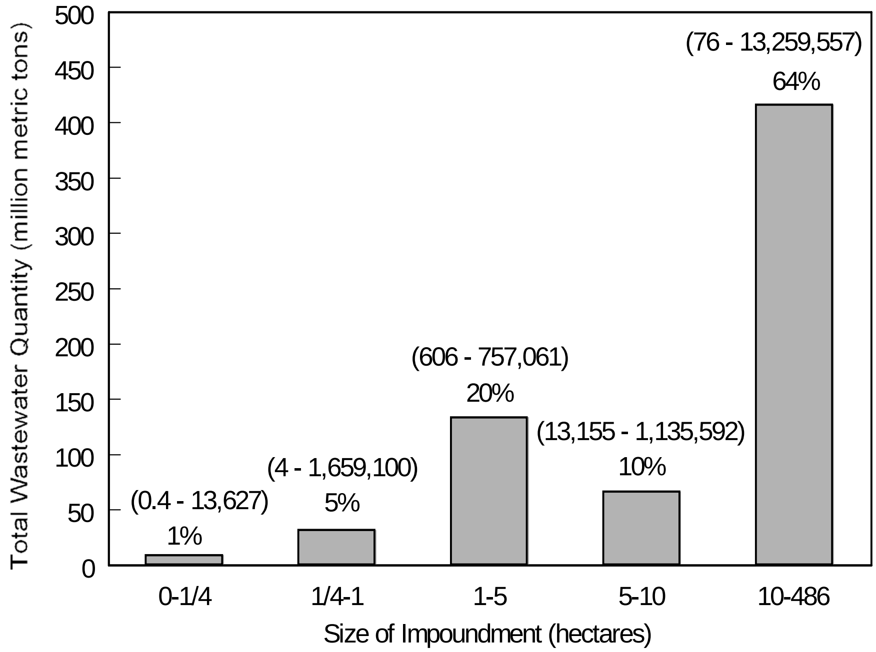
[a] For noncarcinogenic chemicals, target organ on which health benchmark (e.g., RfD) is based. Cancer or leukemia for carcinogenic chemicals. See Appendix C for discussion of health benchmarks.
[b] A facility-level co-occurrence is defined as when two or more chemicals with a common target health effect occur within or across impoundments at a single facility.
[c] Lists of the co-occurring chemicals at each facility in the sample are provided in Appendix B.

2.2.3 <u>Surface Impoundment Size and Wastewater Volume Characteristics</u>

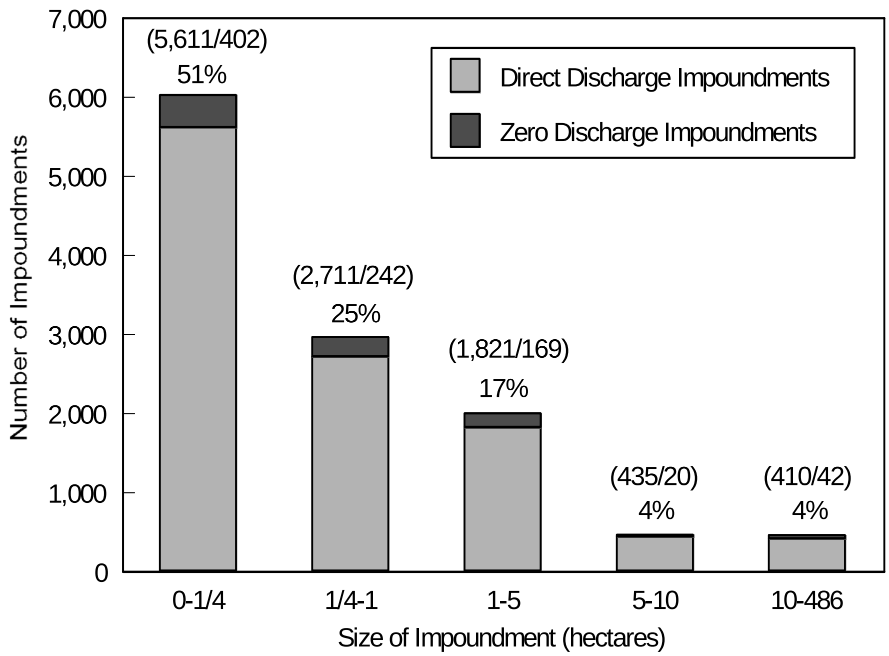
Impoundment size is an important variable in the assessment of wastewater volumes and the potential for environmental releases. As shown in Figure 2-8, approximately 75 percent of the total wastewater quantity for all impoundments exists at roughly 10 percent of the impoundments; these impoundments have surface areas that range from 5 to 500 hectares. Alternatively, approximately half of all impoundments have surface areas under 1/4 hectare; these 6,000 impoundments have a combined total of roughly 1 percent of the wastewater quantity managed in all impoundments.

For a given impoundment surface area, the wastewater quantity in that impoundment will, of course, vary based on depth of the impoundment as well as the potential for partial impoundment dryness on a seasonal basis. Above each bar in the top histogram in Figure 2-8 is the range of wastewater quantities in impoundments in the given size class. A clear example of variance in wastewater quantities is seen for the 1/4- to 1-hectare size range. The wastewater quantity for this group of impoundments varies from roughly 4 metric tons to over 1 million metric tons.

The lower histogram in Figure 2-8 displays the number of impoundments broken out by direct or zero discharge status above each bar. While zero discharge impoundments are present at just over 10 percent of all facilities and make up approximately 7 percent of all impoundments, they represent under 5 percent of the total wastewater quantity. Just over 400 zero discharge impoundments (almost half of the 876 total zero dischargers) are under 1/4 hectare, while just 7 percent of the zero discharge impoundments are over 5 hectares in size.



% = percent of total wastewater managed
(A - B) = range of lowest (A) to highest (B) wastewater quantity (metric tons) per impoundment



% = percent of the total number of impoundments
(A/B) = number of direct discharge impoundments (A)/number of zero discharge impoundments (B)

Figure 2-8. Total wastewater quantity and number of impoundments by impoundment size.

Table 2-8. Facility Breakdown of Treatment Process (Used by at Least One Impoundment)

Facility Status	Treatment Process							
	Aeration		Sedimentation		Other		No Treatment	
	Number of Impoundments	%	Number of Impoundments	%	Number of Impoundments	%	Number of Impoundments	%
Direct dischargers (3,944 facilities)	920	23	1,780	45	1,745	44	2,091	53
Zero dischargers (512 facilities)	160	31	217	42	92	18	232	45
All facilities (4,457 facilities)	1,081	24	1,997	45	1,837	41	2,323	52

% = percent of discharge category.
Several treatment processes may be used at the same facility. Therefore, the sum of the percentages for "all facilities" does not total 100%.

Impoundment size is an important factor in assessing the potential for human exposure to chemicals managed at these facilities. For the air pathway, volatilization potential can increase at larger impoundments due to the increase in surface area exposed to the atmosphere at these impoundments. Alternatively, greater impoundment size can allow for greater dilution of chemicals and thus lower concentrations and reduced emissions (see Section 2.3.1). Similarly, for the groundwater pathway, larger impoundments are less likely to be lined than are smaller impoundments. Additionally, chemical releases to groundwater may be more difficult to detect at larger impoundments due to the greater demand for monitoring well coverage. However, the greater dilution of chemicals that often occurs in larger impoundments is again a mitigating factor, reducing the potential that releases from the unit will be at high concentrations (see Section 2.3.2).

2.2.4 Management Practices at Surface Impoundments

Management practices at impoundments can be broadly classified as aeration, sedimentation, and other (including flocculation, coagulation, precipitation, filtration, biotreatment, denitrification, disinfection, ion exchange, adsorption, and chemical oxidation). Table 2-8 shows a breakdown of management methods at facilities by discharge type. Approximately one-quarter of all facilities performed aeration in at least one impoundment, with a slightly greater percentage of zero dischargers than direct dischargers conducting aeration. Roughly 45 percent of all facilities have sedimentation occurring in an impoundment, while approximately 40 percent of facilities employed some other treatment method. At half of all facilities, no treatment was conducted. See Appendix B, Table B-10, for a detailed list of all treatment types used in the survey.

Many facilities manage wastewaters in multiple impoundments, allowing different methods of treatment to be conducted in different impoundments that are linked in the process (e.g., aeration, biotreatment, and sedimentation). EPA did not assess the occurrence of staged treatment at these facilities. This issue is discussed briefly with regard to transport of chemicals in the atmosphere in Section 2.3.1.

2.3 Factors Related to Transport of Chemicals from Surface Impoundments

This section presents data on factors associated with the transport of chemicals in wastewater from source to receptor via environmental media: air, groundwater, and surface water. The presence of volatile organic compounds (VOCs), the use of aeration, and the size of the impoundment are discussed for the air pathway. The depth to groundwater and presence of liners are discussed for the groundwater pathway. The surface water pathway is treated as a special case of groundwater transport. Therefore, the hydrogeological connectivity of groundwater to surface water is discussed in this section; the possibility of surface water contamination from occurrence of overtopping events is also briefly discussed.

2.3.1 Factors Related to Transport of Chemicals in Air

The uncontrolled release of VOCs from wastewaters is an area of concern. There are many factors that affect the volatilization of a chemical from the water surface of an impoundment and its subsequent transport in the atmosphere. These factors include the properties of the chemical (e.g., its chemical-specific tendency to partition between water and air), the temperature of the air above the impoundment and the wastewater in the impoundment, the local meteorological conditions including wind speed and atmospheric stability class, and the characteristics of the impoundment such as its surface area and aeration level.[7] Additionally, the mass of VOC present in the wastewater has an important influence on the overall emissions from a given unit. The data on VOCs in wastewater, impoundment size, and aeration are discussed below as they relate to potential air contamination.

Approximately 50 percent of impoundments manage wastewaters that contain VOCs (see Table 2-9). However, roughly 75 percent of wastewaters by volume contain VOCs. Additionally, 55 percent of direct dischargers have VOCs present in wastewaters, compared to an estimated 20 percent of zero dischargers. As discussed in Section 2.2.2, the most common VOCs (by volume) present in wastewaters are methanol, acetone, methyl ethyl ketone, and acetaldehyde.

Impoundment size is an important factor influencing the atmospheric contaminant concentration at a receptor point. EPA therefore examined the presence of VOCs by impoundment size in a separate analysis. Approximately 70 percent of the very large impoundments (those in the 5- to 500-hectare category) contain VOCs, while 50 percent of the small impoundments (under 1 hectare) contain VOCs.

[7] Surface impoundments are generally designed as open-air units. Relatively few are known to have a cover or be under a roofed structure.

Table 2-9. VOC/Aeration Status for Impoundments

VOCs/Aeration Treatment	Number of Impoundments	Wastewater Quantity (metric tons)	Percent of Total Wastewater Quantity
No VOCs / aeration	804	44,276,182	6
VOCs / aeration	939	306,608,296	40
VOCs / no aeration	5,350	253,540,050	33
No VOCs / no aeration	4,770	154,075,362	20
All impoundments[a]	11,863	758,499,891	100

[a] The total wastewater quantity shown here for all impoundments does not equal the total wastewater quantity shown in Table 2-1. This is due to the missing data associated with this variable. Please refer to Appendix A for a discussion of how missing data were handled, and Appendix B for information on the standard error associated with the wastewater quantity estimate.

Aeration is a fairly common management practice for these impoundments and is performed for various reasons to improve the efficiency of wastewater treatment. As discussed in Section 2.2.4, aeration is performed at approximately 25 percent of all facilities. Using the figures shown in Table 2-9, EPA estimates that approximately 45 percent of the total wastewater volume is aerated. However, according to the same table, of the 1,743 impoundments where aeration is conducted, 804, or almost half, show no presence of VOCs in wastewater. This is understandable given that aeration may be employed for reasons other than treatment of volatiles, such as for mixing coagulants in the wastewater or promoting aerobic biodegradation (Metcalf and Eddy, 1991).

Of those impoundments conducting aeration, approximately 50 percent are under 1 hectare in size. However, almost 40 percent of impoundments in the 5- to 500-hectare size range are employing aeration practices. These very large impoundments are likely aerated only in particular areas of the impoundment.

As discussed in Section 2.2.4, facilities may employ more than one impoundment in the process of managing industrial wastewaters. Approximately two-thirds of all facilities have more than one impoundment onsite; roughly 5 percent have more than 10 impoundments onsite. In such cases, a facility may have one aerated impoundment in conjunction with an impoundment for sedimentation purposes or some other purpose. Information on the sequencing of impoundments in multistage treatment processes at these facilities was not analyzed in this report. However, any time wastewater containing VOCs experiences turbulence (as when it is pumped from one unit to another), flows through a channel from one unit to another, or at any discharge points in the process, releases to the atmosphere are likely (Metcalf and Eddy, 1991). Therefore, the roughly 5,300 impoundments that contain volatiles but are not performing aeration may still produce air emissions.

2.3.2 *Factors Related to Transport of Chemicals in Groundwater*

Moderate release of chemicals to the subsurface is a design feature of many zero discharge impoundments, which make up just under 10 percent of the population of impoundments addressed in this study. However, releases of chemicals at high enough concentrations can, over time, result in contamination of drinking water supplies or of fishable waterbodies, and thus potential risk to humans. Many factors influence the release and migration of chemicals in groundwater. This section examines depth to groundwater and presence of an impoundment liner for the population of impoundments addressed in this report. In addition, EPA also addresses the discharge of groundwater to surface water, overtopping events, and the data on monitoring wells used to detect releases to groundwater.

2.3.2.1 Depth to Groundwater. The distribution of the depths to groundwater relative to the bottom of the impoundment is shown in Figure 2-9. Approximately 75 percent of impoundments are located in areas where groundwater depth is within 4 meters of the bottom of the impoundment, and almost 90 percent of impoundment bottoms are within 8 meters of groundwater. There are no notable differences in depth to groundwater for the direct and zero discharge subpopulations.

Given that over 90 percent of impoundments in the population are direct dischargers and are located near surface waterbodies, it is not surprising to find that the impoundments are located over relatively shallow groundwater. In fact, as Figure 2-9 shows, almost 20 percent of impoundments have impoundment bottoms that are below the groundwater surface. Given their proximity to surface water, many of these groundwater levels are likely to fluctuate seasonally or with significant precipitation events.

Although the presence of generally shallow groundwater conditions is significant in terms of the potential for groundwater transport of chemical from impoundments, not all shallow groundwater is potable; thus, it is less significant in terms of risk to humans. Approximately one-third of these groundwaters are not potable according to the survey respondents reporting potability status.

2.3.2.2 Presence of Liner. Use of liners is an important method of preventing releases from impoundments to the subsurface. The survey defined the term "liner" as

> a continuous layer of natural or man-made materials, emplaced beneath and/or on the sides of a surface impoundment, that restricts the downward and/or lateral release of waste, waste constituents, or leachate from the surface impoundment. The liner does not include naturally occurring materials (such as a naturally occurring clay layer) that, although effective in controlling the release of leachate from the surface impoundment, were not emplaced intentionally for that purpose.

EPA collected data on the presence of liners at impoundments, as well as the age and type of liner and whether liner failure had occurred. Figure 2-10 displays information on liner usage by impoundment, impoundment size, and wastewater volume. EPA estimates that approximately 5,000 impoundments, or approximately 40 percent of the population, are lined. However, just

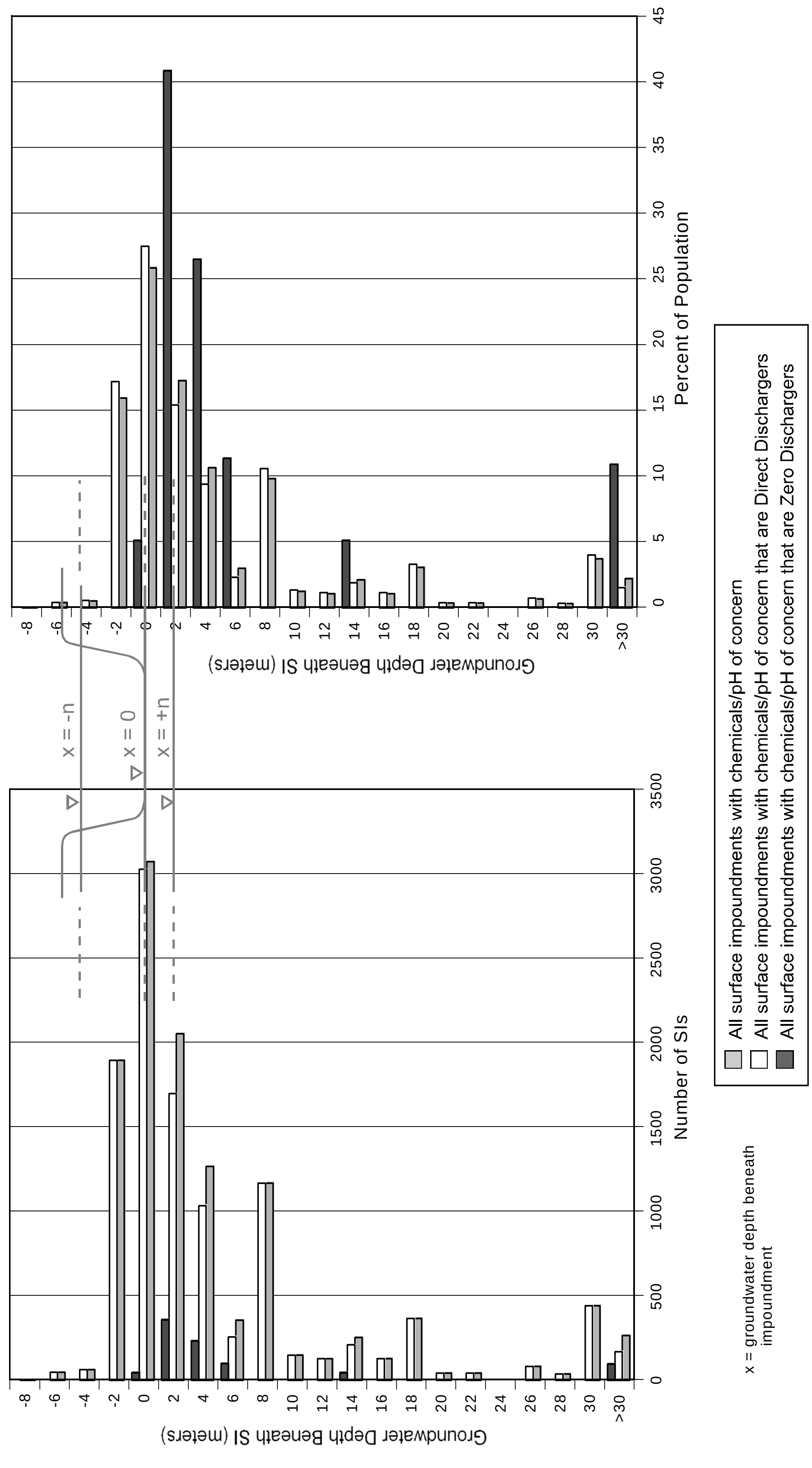
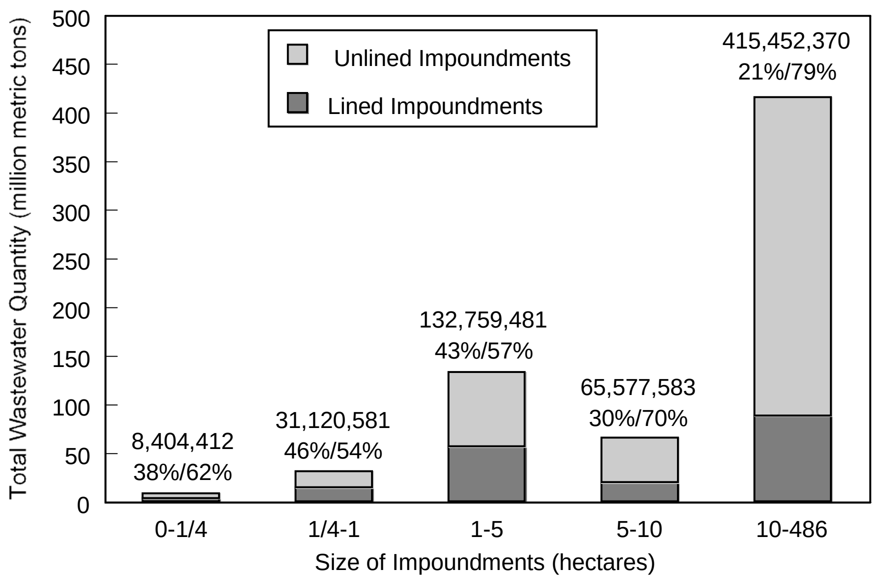


Figure 2-9. Depth to groundwater beneath impoundment by impoundment discharge status.



Total wastewater quantity (from lined and unlined impoundments) is presented above each bar
(A%/B%) = percent of wastewater managed in lined impoundments (A)/percent managed in unlined impoundments (B)

Size of Impoundment (hectares)	0-1/4	1/4-1	1-5	5-10	10-486	All Impoundments
Number of Impoundments	6,013	2,953	1,989	456	452	11,863
Number of Lined Impoundments	2,043	1,878	796	99	139	4,955
Number of Unlined Impoundments	3,970	1,075	1,193	356	314	6,908
Depth to Groundwater (m): median (lowest, highest)	1.1 (-3.8, 64)	1.2 (-6.1, 44)	2.9 (-8.2, 122)	2.9 (-8, 27)	1.2 (-4.6, 41)	1.5 (-8.2, 122)

Figure 2-10. Number of impoundments and wastewater volumes by liner status.

under 25 percent of wastewater volumes are managed in lined units. This difference in the percentage of lined impoundments and the percentage of wastewater quantities managed in lined impoundments is attributable to the fact that larger units are lined less frequently. Just over 40 percent of impoundments under 1 hectare are lined, and 25 percent of those over 5 hectares are lined. One-third of those impoundments with liners were from the chemical and allied products industry sector.

There are a number of possible reasons why liners are used more frequently at smaller units. Obviously, it is more economical and practical to line a smaller unit than to line a larger unit. Additionally, many of the larger impoundments are likely older and were built to provide access to large water supplies that were critical to the manufacturing process at these facilities. They were, therefore, probably constructed in areas that would effectively contain water naturally rather than built to rely on more modern liner technologies.

As engineered structures, liners are susceptible to design and operating flaws and to routine wear and tear that can eventually reduce their ability to restrict flow. However, liner failure can occur in just one layer of the liner at impoundments with multiliner systems or occur in a place in the liner that is above the water surface, which would not necessarily result in a release to groundwater. In addition, liner failure can occur in the freeboard area or next to conveyances, making detection and repair relatively simple. EPA estimates that approximately 12 percent of the impoundments with liners experienced liner failure. Roughly 10 percent of all wastewater volumes are managed in impoundments that have had a liner failure.

The effectiveness of a liner system depends in part on the type of liner installed. The data on liner types are shown in Table 2-10. Almost 80 percent of the lined units have clay, flexible membrane, or composite (flexible membrane and clay) liners. Forty-four percent of the units lined have flexible membrane or composite liners, which are generally more effective than alternative liner types. Asphalt was the least common liner type, employed at less than 1 percent of lined impoundments.

2.3.2.3 Groundwater Discharge to Surface Water. Transport of chemicals from surface impoundments to fishable waterbodies can occur through discharge of groundwater to surface water. In cases where there is a direct hydrogeological connection between groundwater and surface water, contaminant transport in groundwater can impact fishable waterbodies.

Survey data suggest that roughly 80 percent of all impoundments are above groundwater systems that discharge to surface water. In addition, approximately 95 percent of impoundments with a surface area over 5 hectares are above groundwater that discharges to surface water. These larger impoundments constitute only 10 percent of the total impoundment population. In addition, the size of these larger impoundments may allow for greater dilution of chemicals than in smaller impoundments. However, given that only 40 percent of all impoundments are lined, and that these larger impoundments are less likely to be lined than the smaller ones, they may present a greater potential, at the impoundment level, for contamination of adjacent fishable waterbodies.

Table 2-10. Number and Percentage of Impoundments by Liner Status

Liner Status	Number of Impoundments	Percentage of Impoundments
Compacted clay	1,680	14
Flexible membrane (FML)	1,584	13
Composite (FML and clay)	536	5
Concrete	629	5
Asphalt	55	< 1
Other	363	3
Unlined[a]	7,017	59
Total	11,863	100

[a] This estimate differs from the estimate of outlined impoundments shown in Table 2-12. This is due to missing data associated with this variable. Refer to Appendix A on missing data and Appendix B for the standard error associated with this variable.

2.3.2.4 *Overtopping Events*. Overtopping of impoundments can result in contamination of adjacent surface waterbodies through overland transport of wastewaters. EPA estimates that one-quarter of all facilities had an overtopping event, which occurs where there is significant precipitation, or dike or berm failure. An estimated 20 percent of the population of impoundments have fishable waterbodies within 150 meters of the impoundment. And approximately 20 percent of impoundments with fishable waterbodies within 150 meters experienced an overtopping event. EPA did not analyze data on the magnitude of these overtopping events due to concerns with their reliability. Therefore, the potential for impacts to nearby aquatic systems from overtopping is unknown.

2.3.2.5 *Monitoring Wells*. Monitoring wells are installed to detect releases of chemicals from impoundments to groundwater. One-third of the population of impoundments and roughly the same percentage of facilities reported the presence of a monitoring well intended to detect releases. Of these impoundments, 5 percent (189 units) detected a release of chemicals to groundwater, as shown in Table 2-11.

Almost 50 percent of the impoundments with monitoring wells are solid waste management units (SWMUs) at RCRA treatment, storage, and disposal (TSD) facilities (see Section 2.5 for information on SWMUs). However, only one-third of the total population of impoundments are SWMUs at RCRA TSDs. This increased attention to potential releases, evidenced by the greater use of monitoring wells at these SWMUs, is not surprising given the RCRA corrective action program's oversight at these facilities.

Table 2-11. Monitoring Well/Detection of Releases by Discharger Type

Discharger Type	Monitoring Well Present				No Monitoring Well to Detect Release		All Impoundments	
	Detected Release	Did Not Detect Release	Total					
			Number	%	Number	%	Number	%
Direct dischargers	189	3,257	3,446	31	7,541	69	10,987	100
Zero dischargers	0	411	411	47	465	53	876	100
All impoundments	189	3,668	3,856	33	8,007	67	11,863	100

2.4 Proximity of Humans to Surface Impoundments

In this section, EPA examines the potential for human exposure to the chemicals managed in impoundments. First, the general proximity of humans and human activities to surface impoundments is addressed. Then, EPA focuses on the proximity of humans to potential exposure points for air, groundwater, and surface water.

The industrial facilities that employ surface impoundments to manage nonhazardous wastewater are located throughout the United States in a wide array of settings. Some facilities are located in rural areas adjacent to agricultural land use, while other facilities are in heavily populated residential areas or are part of a concentration of industrial activity (see Figures 2-3 and 2-4).

Within this diversity of settings, the potential for human exposure to chemicals managed in these impoundments does exist. EPA estimates that roughly 20 million people (approximately 10 million residences) are located within 2 kilometers of an impoundment (see Table 2-12). Of this population, roughly 50,000 people live within 150 meters of an impoundment. Additionally, an estimated 540 schools are located within 500 meters of an impoundment.

Another indicator of potential exposure is the human activity that occurs near these facilities. EPA's data suggest that farming occurs within 2 km of an impoundment at approximately 40 percent of all facilities. Roughly half of all facilities have fishing within 2 km of an impoundment, and two-thirds of all facilities identified swimming as occurring within 2 km of an impoundment. Hunting is estimated to occur within 2 km of an impoundment at approximately one in five facilities. Each of these activities represents a means by which an exposure pathway could be completed (e.g., indirect exposure through ingestion of produce grown at farms with significant air deposition of chemicals from an adjacent impoundment).

This overview of humans and human activities near surface impoundments suggests that exposure is possible, given the potential for release of contaminants to air, groundwater, or surface water. Section 2.3 of this report discusses several factors related to the possibility of such environmental transport of chemicals from wastewater. In this section, these transport

Table 2-12. Proximity of Surface Impoundments to People, Residences, Drinking Water Wells, and Schools

Distance from Impoundment (m)	People Living within a Given Distance	Residences within a Given Distance	Drinking Water Wells within a Given Distance	Schools within a Given Distance
0 - 150 m	51,579	21,227	888	0
151 - 500 m	663,380	285,411	13,728	541
501 - 1,000 m	3,284,378	1,341,834	56,146	2,390
1,001 - 2,000 m	14,414,175	5,898,810	204,984	8,990

GW= Groundwater.

factors are linked with the human proximity data to provide a closer look at the potential for exposure.

2.4.1 Proximity of Humans to Surface Impoundments by Pathway

EPA has generally observed a significant decline in the concentration of airborne chemicals in a plume as the distance from the source increases. Therefore, in assessing potential exposure to chemicals through the air pathway, EPA examined the proximity of humans within a 150-meter radius of surface impoundments that manage VOCs. EPA estimates that just under 10 percent of all impoundments manage VOCs and have residences within a 150-meter radius (see Table 2-13). Roughly half of these impoundments manage VOCs through aeration.

As discussed in Section 2.3.2 of this chapter, movement of a contaminant plume in groundwater is influenced by a host of factors. These factors must be assessed at the facility level for an accurate determination of the potential for human exposure through groundwater. For the purposes of this chapter, EPA examined the proximity of wells and of fishable waterbodies to impoundments in order to provide an overall picture of the potential for human exposure through groundwater. Approximately 10 percent of all facilities (or 6 percent of all impoundments) are estimated to have a drinking water well within 150 m of an impoundment (see Table 2-14). Fifteen percent of those impoundments (approximately 100) are lined impoundments. At a 2,000-meter radius from the impoundment, the proportion of impoundments with wells jumps to 50 percent (approximately 6,000 out of 11,900), 45 percent (approximately 2,700) of which are lined units.

EPA considered the potential for surface water contamination through groundwater at a 150-meter radius also. As discussed in Section 2.3.2, just over 80 percent of all impoundments are located above groundwater systems that discharge to a fishable waterbody. Furthermore, approximately 20 percent of all impoundments have a fishable waterbody within a 150-meter radius.

Table 2-13. Proximity of Residences to Impoundments Based on Presence of VOCs and Aeration Status

VOC/Aeration Status of Impoundments[a]	Proximity of Nearest Residences to Surface Impoundments (m) 0 - 150	151-1,000	1,001-2,000	No Residences within 2,000	Total
No VOCs in wastewater					
Number of impoundments	3,439	2,173	236	101	5,947
Percent of total wastewater quantity	14%	8%	3%	< 1%	25%
VOCs present in wastewater/no aeration					
Number of impoundments	458	4,123	338	44	4,963
Percent of total wastewater quantity	8	24%	1%	< 1%	33%
VOCs present in wastewater/aeration					
Number of impoundments	406	433	96	18	953
Percent of total wastewater quantity	8%	29%	3%	2%	41%
Total					
Number of impoundments	4,303	6,729	670	162	11,863
Percent of total wastewater quantity	30%	60%	8%	2%	100%

[a] The estimates of the number of impoundments and the percent of total wastewater quantity shown in this table do not agree with those shown in Table 2-9. This is due to the missing data associated with these variables. Please refer to Appendix A for a discussion of how missing data were handled, and Appendix B for information on the standard error associated with these variables.

EPA believes that the data discussed above on the proximity of humans to impoundments with respect to the air, groundwater, and surface water pathways suggest that the potential exists for human exposure to chemicals from these impoundments. The risk assessment work discussed in Chapter 3 of this report evaluates this potential for human exposure.

2.5 Regulatory, Exemption/Exclusion, and Operating Status of Surface Impoundments

The 4,500 facilities examined in this study operate within an overall regulatory context. This context may include permits requiring regular onsite activities, such as periodic sampling of wastewater or routine contacts with regulators, or operational conditions calling for occasional adjustments to treatment processes or monitoring of various aspects of facility operations and monthly flow rates. At any given facility, this regulatory context is made up of federal, state, or local regulations. For example, survey data show that approximately 80 percent of all impoundments are under some level of regulatory oversight, either by virtue of a state or local permit or as an SWMU at a RCRA TSD. Similarly, this regulatory context may include exemptions or exclusions from such regulations. Survey data show that roughly 15 percent of

Table 2-14. Proximity of Nearest Wells to Impoundments Based on Liner Status

	Proximity of Nearest Wells to Surface Impoundments (m)				
Liner Status of Impoundments	**0-150**	**151-500**	**501-2,000**	**No Well within 2,000**	**Total**
Lined impoundments—no liner failures					
Number of impoundments	54	541	1,661	1,809	4,065
Percent of total wastewater quantity	2%	5%	8%	4%	18%
Lined impoundments—with liner failures					
Number of impoundments	40	95	311	38	484
Percent of total wastewater quantity	<1%	<1%	5%	<1%	6%
Unlined impoundments[a]					
Number of impoundments	569	546	2,173	4,026	7,314
Percent of total wastewater quantity	6%	25%	28%	17 %	75%
Total					
Number of impoundments	663	1,182	4,145	5,873	11,863
Percent of total wastewater quantity	8%	30%	41%	21%	100%

[a] The estimates of the number of unlined impoundments shown in this table do not agree with the number shown in Table 2-10. This is due to the missing data associated with these variables. Refer to Appendix A for a discussion of how missing data were handled, and Appendix B for information on the standard error associated with this variable.

impoundments are used to manage wastewaters that are excluded or exempt from RCRA regulations.

EPA collected data on the state, local, and federal regulations that apply at these facilities. Additionally, any exemptions or exclusions that apply at the facility were identified. The survey also requested information on the operating status of the impoundments at the facility. This section presents the main findings from these data.

EPA first examined the data on whether impoundments had a state or local permit for any wastewater or sludge management, groundwater protection activities, and/or air emissions associated with the particular impoundment. As shown in Table 2-15, there are an estimated 3,600 facilities, or 80 percent of all facilities, with at least one impoundment that is under a state or local permit. These 3,600 facilities represent over 95 percent of the wastewater quantities managed in impoundments and are almost entirely NPDES permits for direct discharge to a surface waterbody. Of the facilities that identified permits, 25 percent were chemical and allied product facilities and roughly 15 percent were stone, clay, glass, and concrete product facilities.

The paper and allied product sector and the wholesale trade-nondurable goods sector each accounted for just under 15 percent of these facilities.

Some impoundments examined in this study are solid waste management units at a RCRA TSD facility and are, therefore, subject to federal requirements for remediation of environmental contamination at the facility (40 CFR 264.101). Approximately one-quarter of all facilities (one-third of all impoundments) are RCRA TSD facilities with SWMUs onsite that have been through a RCRA Facility Assessment (RFA), as shown in Table 2-15.[8] Of those impoundments in this group, two-thirds are chemical and allied product impoundments and one-quarter are petroleum and coal product impoundments.

EPA gathered information on the management of exempt/excluded wastewaters in impoundments. As shown in Table 2-15, approximately 15 percent (1,700 impoundments) of the population manage some exempted or excluded wastewaters. Of those impoundments in this group, roughly 35 percent are paper and allied product impoundments, 35 percent are chemical and allied product impoundments, and 20 percent are petroleum and coal product impoundments. These wastewaters are identified as being exempt or excluded from RCRA Subtitle C regulation under a number of possible exemption/exclusion categories. This volume, approximately 98,800,000 metric tons, represents 15 percent of the total wastewater quantity managed in impoundments. As shown in Table 2-16, the exclusions and exemptions cited include those for point source discharges (40 CFR 261.4(a)(2)), mixtures of solid waste and characteristic-only hazardous waste (40 CFR 261.3(a)(2)(iii)), Bevill wastes (40 CFR 261.4(b)(7) and 3001(b)(3)(A)(ii)), coal and fossil fuel combustion wastes (40 CFR 261.4(b)(4) and 3001(b)(3)(A)(i)), and mixtures of solid waste and hazardous waste discharging to Clean Water Act systems (40 CFR 261.3(a)(2)(iv)). For more details on these exclusions and exemptions, please see Appendix A, which contains the survey appendix with the definitions that were provided to survey respondents. Also see Appendix B, which provides a more detailed breakdown of the exempt/excluded wastewaters.

EPA collected data on the operating status of the impoundments in the study. Most impoundments were built more than 20 years ago (see Figure 2-1). Nearly 40 percent of the impoundments operating in the 1990s were constructed in the 1970s and were presumably built in response to environmental programs seeking improved wastewater treatment. The impoundments that were in operation before 1970, approximately one-quarter of the population, were likely employed in some aspect of water supply management associated with the industrial processes at these facilities.

Eventually, impoundments stopped being used for waste management and were closed, with varying degrees of waste removal. As shown in Table 2-15, EPA estimates that, during the 1990s, 16 percent of the industrial impoundments permanently stopped receiving waste. This closure rate is in sharp contrast to the previous decade when a significant percentage of

[8] During an RFA, an overseeing agency typically compiles existing information on environmental conditions at a given facility and, as necessary, gathers additional facility-specific information on solid waste management units and other areas of concern, releases, potential releases, release pathways, and receptors. Information gathered during an RFA usually forms the basis for initiating full-scale site characterization.

Table 2-15. Regulatory, Exempt/Excluded, and Operating Status of Impoundments

	(1) SWMU RCRA Assessment	(2) Manage Excluded/ Exempt Wastewater	(3) Ceased Receiving Waste since June 1, 1990	(4) Are under State/Local Regulations	(5) Meet All (1-4)	(6) Meet None (1-4)
Percent of impoundments (out of 11,863)	33	15	16	86	0.9	5
Percent of facilities with at least one unit in category (out of 4,457)	25	14	22	81	0	7
Percent of total wastewater quantity managed at impoundments (out of 653,796,340 metric tons)[a]	14	15	4	97	0.5	2

[a] The estimate of the wastewater quantity for the total population differs from the estimates shown in Tables 2-1 and 2-2. This is due to missing data associated with this variable. Refer to Appendix A on missing data and Appendix B for the standard error associated with this variable.

Table 2-16. Breakdown of Exempt/Excluded Wastewaters

Exemption/Exclusion Category	Estimated Volume (and Percentage) of Wastewater	
Other (not on specific list of exclusions/exemptions)	40,444,366	(41%)
Mixtures of solid waste and characteristic hazardous waste listed solely because it exhibits a characteristic	16,731,865	(17%)
Point source discharges	13,366,523	(14%)
Bevill wastes	12,537,291	(13%)
Coal and fossil fuel combustion wastes	7,836,906	(8%)
Mixtures of solid waste and hazardous waste discharging to CWA system		
Lab wastes mixed with solid waste	1,852,033	(2%)
De minimis quantities of commercial chemical products mixed with solid waste	1,175,821	(1%)
Heat exchanger bundle cleaning sludge from petroleum refining industry and solvent waste mixtures	105,767	(0.1%)
Domestic sewage and mixtures of domestic sewage	1,606,185	(2%)
Reclaimed pulping liquor	2,016,833	(2%)
Wastes excluded from definition of solid waste	1,000,407	(1%)
Total Volume of Exempt/Excluded Wastewaters	98,768,548	(100%)

hazardous waste impoundments were closed and replaced with tanks. One-quarter of the impoundments that ceased receiving wastes are from the wholesale trade-nondurable goods industry sector. Roughly 35 percent of these impoundments were between 15 and 20 years old and 20 percent were between 35 and 55 years old. These impoundments were predominantly smaller units and account for under 5 percent of the total wastewater quantity.

The data examined above provide a picture of the regulatory and operating status of the population of facilities addressed in this study. As Table 2-15 shows, only 7 percent of the population of facilities fall under none of the regulatory/operating status categories. Furthermore, based on analyses not shown in the table, almost half of the impoundments in the overall population either ceased receiving waste during the 1990s or are at a RCRA TSD facility and are therefore subject to facility-wide corrective action remedial requirements to address potential releases. In addition, approximately 80 percent of all impoundments are under some level of regulatory oversight, either by virtue of a state or local permit or as an SWMU at a RCRA TSD. These facts, to some degree, mitigate the concerns stated in Section 2.4 concerning the potential for human exposure to chemicals from impoundments. Chapter 4 of this report, which investigates the potential gaps that exist in the regulation of surface impoundments, covers these issues in much greater detail.

2.6 Conclusions

Surface impoundments continue to be a prominent feature in the industrial landscape. The overall picture of the U.S. industrial surface impoundment population shows approximately 18,000 impoundments operating in the 1990s; an estimated 11,900 contain at least one or more of the chemical constituents of concern for this study or have high or low pH. The geographic distribution of these impoundments reflects areas with generally higher precipitation levels; that is, they tend to be located in the areas east of the Mississippi River, mainly in Gulf Coast states and along the East Coast. Fewer appear to be located in the more arid states west of the Mississippi. Approximately 90 percent of impoundments are direct dischargers and 10 percent are zero dischargers.

These impoundments serve a variety of beneficial uses. Many facilities employ impoundments to perform necessary wastewater treatment prior to discharge into surface waters. In other cases, industrial facilities may need to control wastewater flows and use impoundments for storing excess wastewater. In still other cases, facilities use impoundments to manage excess wastewaters through evaporation or seepage into the subsurface.

Industrial impoundments vary greatly in size and physical characteristics. Just under 50 percent of impoundments are 1/4 hectare or smaller in size, and, almost 10 percent of the population of impoundments are over 5 hectares in size. These larger impoundments form the bulk of the total national industrial impoundment capacity. Approximately 75 percent of the total wastewater quantity managed exists at only 10 percent of the impoundments. Additionally, about one-third of the facilities that fall into the study population have only one nonhazardous impoundment onsite. Just under 5 percent of facilities have over 10 impoundments for nonhazardous industrial waste management.

The paper and allied products sector accounts for two-thirds of the entire volume of wastewater managed in these impoundments, although representing only 6 percent of the facilities in the population. Over 50 percent of the facilities in the population fall into four industrial sectors: chemical and allied products; stone, clay, glass, and concrete products; wholesale trade-nondurable goods; and primary metals industry. Almost one in four impoundments is located at a chemical and allied products facility.

Although only 15 percent of all facilities manage any decharacterized wastes, the impoundments with decharacterized wastes account for 70 percent of the total industrial wastewater quantity. Approximately 85 percent of impoundments have metals present in the wastewater, and roughly half have volatile organic chemicals present. Approximately half of all facilities use impoundments to manage between one and five chemicals of concern.

Most impoundments were built more than 20 years ago. Nearly 40 percent of the impoundments operating in the 1990s were constructed in the 1970s; presumably in response to environmental programs seeking improved wastewater treatment. Approximately 25 percent of impoundments were in operation before 1970, suggesting that water supply was a critical component of their process.

Impoundments, consistent with their intended purpose, are frequently found in vulnerable environmental settings or use management techniques that increase the potential for chemical releases to the environment. For example, although aeration can have certain benefits, it also increases the potential for airborne contaminant migration. Furthermore, most impoundments are located above shallow groundwater that is located within a few meters of the impoundment bottom, and more than half of the impoundments do not have a liner system to retain the wastes inside the impoundment. Four-fifths of industrial impoundments are located above groundwater that discharges to a fishable waterbody, and approximately one out of five impoundments is within 150 meters of a fishable waterbody. Approximately 20 percent of impoundments with fishable waterbodies within 150 meters had overtopping events.

Regarding the potential for human exposure to constituents of concern, EPA estimates that roughly 20 million people live within 2 kilometers of an industrial impoundment that operated during the 1990s. Approximately one-tenth of the facilities have drinking water wells within 150 meters of at least one of their impoundments. Further, approximately 75 percent of all wastewaters contain volatile organic chemical constituents, which to varying degrees will escape from the impoundments as air emissions (depending on physical properties of the specific constituent and on meteorological conditions). Roughly one-third of impoundments have residences within 150 meters of the impoundment.

Eventually, impoundments cease receiving waste and are closed with varying degrees of waste removal. During the 1990s, EPA estimates that about 15 percent of the industrial impoundments permanently stopped receiving waste. This is in sharp contrast to the previous decade when the majority of hazardous waste impoundments were converted to tanks. Furthermore, EPA estimates that more than three-quarters of industrial impoundments are located at a RCRA permitted interim status facility and, as a result, are within RCRA jurisdiction for corrective action as solid waste management units or operate under a state or local permit such as a wastewater discharge permit.

The figures presented above on the chemicals managed in impoundments, the potential for transport of chemicals in environmental media, and the proximity of residences to impoundments provide an overall picture of the surface impoundment universe. Impoundments are used to manage a host of chemicals of concern. The conditions that exist at these units allow for the possibility of chemical transport from wastewaters. These conditions include the presence of VOCs in aerated impoundments and the absence of liners at units that are located above relatively shallow groundwater. In many cases, there are residences near these units, allowing for the potential of residents' exposure to chemicals. Given these facts, EPA performed an assessment of the risks posed by the population of impoundments. The results of this risk assessment are presented in Chapter 3.

2.7 Reference

Metcalf and Eddy, Inc. 1991. *Wastewater Engineering Treatment, Disposal, and Reuse*. *Third Edition*. Revised by G. Tchobanoglous and F. L. Burton. McGraw-Hill, Inc.

Chapter 3

Human and Ecological Risk Analysis

3.0 Summary of Chapter

The purpose of this chapter is to describe the methodology and provide the results for the screening and assessment of potential risks to human and ecological receptors that may be attributable to surface impoundments managing industrial wastewaters. The methodology and results are summarized for each major pathway assessed, as outlined below. Additional detail on this analysis is provided in Appendix C.

3.1 Introduction and Overview
3.2 Direct Pathways: Inhalation and Groundwater Ingestion
3.3 Indirect Pathways: Groundwater to Surface Water
3.4 Other Indirect Pathways
3.5 Ecological Risk Screening
3.6 Conclusions

3.1 Introduction and Overview

EPA has conducted the risk analysis for surface impoundments in several stages, with the basic objectives of screening all the reported surface impoundments and chemicals, ranking those that warrant additional analysis, and developing risk estimates for chemicals and surface impoundments that may be of higher concern due to concentrations and environmental settings. Throughout this process, the findings reported in the November 1999 survey have been used to identify factors that may contribute to environmental releases or potential chronic risks posed by surface impoundments.

3.1.1 Overview of Methodology

3.1.1.1 Tiered Approach to Risk Assessment Methodology. This analysis has been conducted according to the technical plan submitted for peer review in February 2000, with several additional refinements to the risk screening, ranking, and modeling steps. In general, EPA used a sequential approach to rank facilities to progress through each step of the analysis:

1. **Preliminary Screen:** Conduct direct exposure pathway screenings of all the survey facilities using health-based and ecological screening factors based on precautionary exposure assumptions.

2. **Release Assessment:** Conduct screening-level modeling for direct pathways using health-based screening factors.

3. **Risk Modeling:** Conduct site-based modeling to further refine the initial risk estimates according to the environmental setting described in the survey data.

In essence, the methodology was designed to progress from a very precautionary exposure/risk analysis for all facilities to a more realistic, site-based assessment that takes full advantage of survey and site-specific information on facilities in the final stages of analysis. For each major exposure pathway, EPA used the most appropriate approaches available to screen and rank facilities, impoundments, and constituents for further analysis.

EPA used several different measures of chronic risk and hazard in the risk assessment. Cancer risks were expressed as individual lifetime excess probability of cancer; a threshold of 1 in 100,000 was used as the criteria for determining whether a constituent posed a risk of concern. The hazard associated with exposure to noncancer constituents was measured using a hazard quotient (HQ). The HQ is the ratio of the estimated exposure concentration to an EPA reference dose (RfD) for ingestion or reference concentration (RfC) for inhalation. RfDs and RfCs are threshold measures of hazard that are set at a level that EPA has estimated will not result in adverse effects in humans. The human health threats associated with surface water contamination were evaluated using ratios of estimated surface water concentrations to ambient water quality criteria for human health (HH-AWQC).

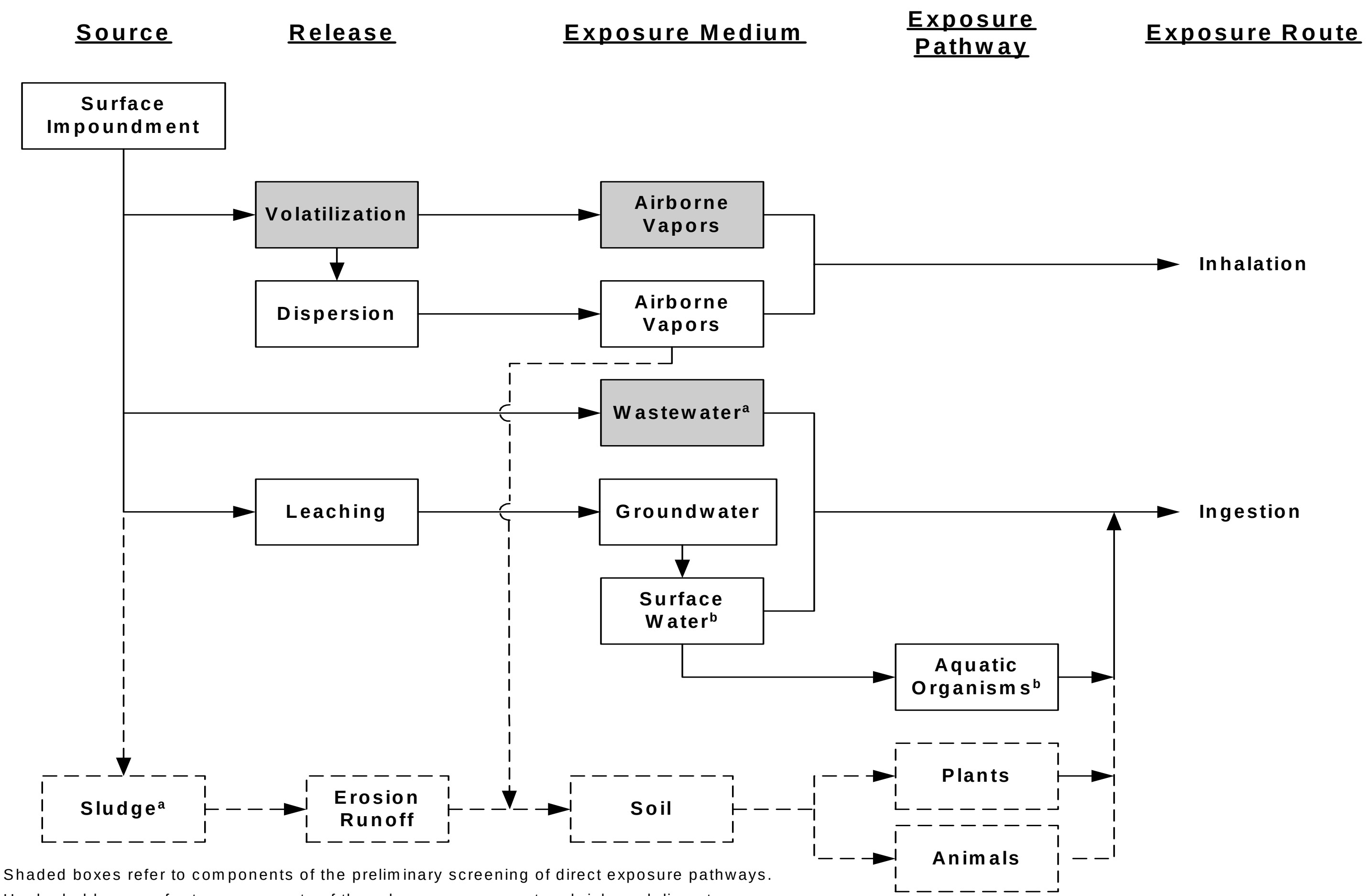
The final risk results for the statistically representative sample were extrapolated to generate national estimates of the number and proportion of facilities and impoundments with potential risks. Throughout this chapter facility proportions are expressed as a percentage of the estimated 4,500 facilities, and surface impoundment proportions are expressed as a percentage of the estimated 11,900 in-scope surface impoundments.

3.1.1.2 *Relevant Exposure Pathways*. EPA structured its risk analysis methodology to identify potential risks posed to people by direct pathways and indirect pathways and to ecological receptors. A pathway is the route a chemical takes from the impoundment to the person or to ecological receptors after release of a chemical from a surface impoundment.

As suggested in Figure 3-1, chemicals may be released from an impoundment by volatilizing from the wastewater into the air, by leaching through the bottom of the impoundment into groundwater, or by erosion/runoff of contaminated sludge particles from an impoundment that has closed.[1] Once released into the environment, chemicals may pose direct exposures, migrate through the groundwater to reach the surface water, or be deposited onto the soil in areas that are close to the facility. Plants and animals that are exposed to these media may accumulate chemicals in their tissues, and human and ecological exposures may occur through the food chain.

People may be exposed to chemicals by many pathways. In **direct** pathways, the person is exposed to the medium, such as air or groundwater, to which the chemical was released. In

[1] Chemicals may also be released through direct discharge to surface water (currently regulated under the Clean Water Act) or through overtopping events. However, these releases were not evaluated in this analysis.



Shaded boxes refer to components of the preliminary screening of direct exposure pathways.
Unshaded boxes refer to components of the release assessment and risk modeling stages.
Dashed lines indicate other indirect exposure pathways that were not modeled quantitatively.
[a] Medium concentration was compared directly to ecological risk screening factors.
[b] This indirect pathway was modeled and the results used in the indirect pathway analysis.

Figure 3-1. Exposure pathways for active surface impoundments considered for human and ecological receptors.

indirect pathways, the person is exposed to a different medium than the one to which the chemical was released. For example, chemicals may be released into the groundwater aquifer and transported to an adjacent surface waterbody by subsurface transport. If the chemical is bioaccumulative, people who eat fish from that waterbody may be exposed to contaminants in their diet.

This study develops quantitative risk estimates for the direct pathways of air inhalation and groundwater ingestion and the indirect pathway of groundwater to surface water. In addition, a screening was conducted of other indirect pathways, such as air deposition or erosion and transport of chemicals across soil, to provide insight into the potential for food chain risks attributable to these types of exposures. The direct discharge of chemicals to surface waters is not considered because this pathway is already regulated by EPA. This study also includes a screening-level assessment of potential ecological risks.

The following sections summarize the methodology and present the risk results for each of the pathways in the human health risk analysis and for the ecological risk screening. For each area of analysis, the screening and ranking stages were based on clear science decision rules related to threshold concentrations of potential concern and the likelihood of exposures. The modeling stages used peer-reviewed modeling tools available for use by the Agency. Appendix C provides a detailed discussion of the methodologies used, including a listing of health-based screening factors, ecological screening factors, and relevant data sources. In addition, Appendix C presents the full analytical results of the assessment.

3.1.2 Overview of Results

Tables 3-1 and 3-2 present the overall results for each of the pathways in the human health risk analysis and for the screening analyses of indirect pathways and potential ecological risks. Sections 3.2 through 3.5 provide more detailed results and discussion for each analysis and pathway. The complete results of the risk analysis are provided in Appendix C. The results for each analytic question are given as the number or percent of facilities or impoundments having the attribute in question. These numbers and percents are weighted national estimates derived from the risk results for the sample population.

The results for the risk analysis are presented in two distinct sets depending on the nature of the information provided in the surveys on chemical concentrations. Chemical concentration data were central to EPA's risk screening and risk analysis of surface impoundments. EPA provided considerable flexibility to survey respondents in submitting concentration data for use in this study. This affects the certainty of the results. Some respondents provided analytical reports; some used professional judgment to identify chemicals likely to be present; some estimated concentrations based on averaged sampling events or other methods; some reported chemicals to be present but did not report a concentration value; and some indicated that concentrations were below detection limits. Survey respondents used many different reporting conventions for detection limits. Sometimes chemicals were reported with very high detection limits, possibly because of analytical interferences. In other cases constituents were reported with very low detection limits. In still other cases facilities that did not expect certain chemicals to be present would report higher detection limits, possibly not wanting to exert the additional

Table 3-1. Overview of Modeling-Level Results

		Facilities That Have Environmental Releases[a, c]		Facilities That May Exceed Risk Criterion[b, c]		Numbers of Chemicals and Impoundments That May Exceed Risk Criterion	
Pathway	**Route**	**RV**	**S/DL**	**RV**	**S/DL**	**Chemicals**	**Impoundments**
Groundwater	Ingestion	641 (14%)	846 (19%)	27 (0.6%)	23 (0.5%)	15 chemicals: 1 inorganic 2 metals 3 SVOCs 9 VOCs	126 impoundments: 114 dechar waste 12 never char waste
Air	Inhalation	173 (4%)	165 (4%)	171 (4%)	55 (1%)	11 chemicals: 1 dioxin-like 5 SVOCs 5 VOCs	236 impoundments: 85 dechar waste 151 never char waste
Groundwater to surface water	Ingestion	790 (18%)	1,079 (24%)	44 (1%)	31 (0.7%)	35 chemicals: 1 dioxin-like 3 metals 24 SVOCs 7 VOCs	142 impoundments: 100 dechar waste 42 never char waste

RV = Reported values.
S/DL = Surrogate values/detection limits.

[a] An impoundment was determined to have an environmental release when there was evidence that contaminants had the potential to migrate from the impoundment into the media of concern at concentrations above health-based levels. The specific definitions vary by media.
[b] A facility was determined to exceed a risk criterion if individual constituents had concentrations in excess of 10^{-5} for cancer, an HQ greater than 1 for noncancer effects, or concentrations in excess of the ambient water quality criteria in the case of surface water. EPA also summed risk across constituents where appropriate to identify any cases where, even though a particular constituent might not exceed a risk criterion, all of the constituents together might exceed a risk level.
[c] Number of facilities (percentages are of the total number of facilities, approximately 4,500).

analytical effort that would be needed to establish a much lower detection limit. EPA observed several cases where facilities reported a rather high limit of detection when, in fact, the chemicals are very unlikely in a particular industrial sector and are probably not present at levels anywhere near the detection limit. When chemicals were reported to be present but the quantity was unknown or when chemicals were reported as being below a detection limit but the respondent did not provide the detection limit, EPA inferred a value for use in the risk analysis as described in Appendix B. When a value was reported to be less than a detection limit and that detection limit was provided, EPA used the reported detection limit in the analysis.

EPA is most confident in those data where repondents reported a value above a limit of detection and far less confident in other values, such as values less than detection limits. EPA took great care to present the results separately based on concentrations actually reported in the surveys because: (1) these values are based on survey respondents' knowledge or estimates of

Table 3-2. Overview of Screening-Level Results

Pathway	Route	Facilities That Are of Lower Concern[a]	Facilities That Are of Potential Concern[a]	Number of Chemicals and Impoundments That Have a Potential Concern	
				Chemicals	Impoundments
Indirect	Ingestion	2,620 (59%)	285 (6%)	37 chemicals: 8 dioxin-like 1 mercury 2 metals 26 SVOCs	NA[b]
Ecological	Ingestion	2,359 (53%)	1,310 (29%)	34 chemicals: 1 dioxin-like 1 mercury 14 metals 7 SVOCs 11 VOCs	2,355 impoundments: 675 dechar waste 1,680 never char waste

[a] Number of facilities (percentages are of the total number of facilities, approximately 4,500).
[b] Not applicable; the indirect pathway analysis evaluates potential exposures for the entire facility.

chemical concentrations and (2) EPA considers these data to have a reasonable degree of certainty. The results based on concentrations that EPA inferred or on detection limits are presented separately, because the Agency believes that these span a greater range of potential uncertainty. These results, nonetheless, may provide an indication of the range of possible environmental releases or exposures for the significant number of surface impoundments for which we lack concentration data.[2] Where concentrations are reported below detection limits, the use of detection limits for risk screening served two purposes: to screen out cases of no concern, and to identify cases where, even at detection limits, there could be exposures of concern depending on environmental settings and management conditions. Some survey respondents who provided a response in the context of detection limits may have intended their responses to represent negligible concentrations or may have intended to convey that the chemical is not present. In these cases, the corresponding risks may be negligible and the risk estimates based on detection limits would clearly be overestimates of potential risk. In summary, the results based on surrogate data and detection limits span a range from negligible risk and no environmental releases of concern to potential risk exceedances and environmental releases. These are all accompanied by a greater level of uncertainty than results based on reported concentrations.

[2] EPA's field sampling provides additional insights concerning the concentration data reported in the surveys. While generally confirming the range of reported concentration values, the field sampling identified many cases where chemicals were not reported and other cases where chemicals were reported that EPA did not detect in its sampling. This suggests that some facility operators do not have full knowledge of the chemicals contained in their impoundments. The EPA field sampling results are discussed further in Chapter 2 and in Appendices C and E.

The results presented for the risk analysis are the national number and percent of all facilities or impoundments that occur in the following categories:

- **Negligible concern:** These are facilities or impoundments for which no pathway exceedances are predicted and/or environmental characteristics prevent the completion of any exposure pathway. Based on the data made available, EPA believes that these facilities or impoundments do not present any concern.

- **Environmental releases:** These are facilities or impoundments at which environmental releases may be occurring because of the concentrations present in the impoundments, and also because of operating conditions such as the presence or absence of liners, the use of aeration, or other factors. However, taking into account actual residential exposures, risks are not anticipated.

- **Potential risk exceedances:** These are facilities and impoundments that potentially pose risks, taking into account actual residential exposures. These tend to be high-end estimates because they are developed for the closest residential exposures.

EPA identified potential environmental releases and risk exceedances, and separately presented results based on reported concentration values, for three pathways: direct inhalation, direct groundwater ingestion, and groundwater discharges to surface water with potential exceedances of HH-AWQC. Tables 3-3 and 3-4 portray the overall results of the risk analysis for these three pathways. Table 3-3 distinguishes results between never characteristic and decharacterized wastes, and Table 3-4 distinguishes results according to the facilities' discharge status under the Clean Water Act. These questions were examined because of the statutory intent, expressed in the 1996 Land Disposal Program Flexibility Act, that decharacterized wastewaters managed in surface impoundments under the scope of the Clean Water Act be assessed in this study. Notable findings are that most facilities do not seem to pose risks or exposures of concern. Twenty-one percent of facilities may have significant environmental releases for at least one of the pathways examined, although not exceeding risk criteria. Five percent of facilities (corresponding to 2 percent of impoundments) may pose potential risk exceedances. Up to 23 percent of facilities may have releases or exposures for at least one of the pathways examined based on surrogate data or detection limits, although the extent to which this may actually be occurring is uncertain due to the lack of concentration data.

The results of EPA's screening level assessments for other indirect pathways and for potential ecological concerns are described in Sections 3.4 and 3.5.

3.2 Direct Pathways (Inhalation and Groundwater Ingestion)

3.2.1 Methodology

Table 3-5 provides an overview of the tiered methodology used to assess potential risks from direct ingestion of groundwater, and Table 3-6 provides an overview of the methodology to assess direct inhalation risks. Appendix C provides complete details on the methodologies used.

Table 3-3. Facility-Level Overview of Human Health Results by Decharacterization Status[a]

Facility Status	Environmental Release[b]	May Exceed Risk Criteria[b]
Risk results based on reported waste concentrations		
Never characteristic	598 (13%)	196 (4%)
Decharacterized	330 (7%)	41 (0.9%)
All facilities with reported values	928 (21%)	237 (5%)
Risk results based on surrogate/DL waste concentrations		
Never characteristic	812 (18%)	0 (0%)
Decharacterized	169 (4%)	66 (1%)
All facilities with surrogate/DL values	981 (22%)	66 (1%)

DL = Detection limit.

[a] Results are for groundwater, air, and groundwater to surface water pathways.
[b] Number of facilities (percentages are of the total number of facilities, approximately 4,500).

Table 3-4. Facility-Level Overview of Human Health Results by Discharge Status[a]

Facility Status	Environmental Release[b]	May Exceed Risk Criteria[b]
Risk results based on reported concentrations		
Direct dischargers	716 (16%)	191 (4%)
Zero dischargers	150 (3%)	27 (0.6%)
All facilities with reported values[c]	865 (19%)	218 (5%)
Risk results based on surrogate/DL concentrations		
Direct dischargers	1,111 (25%)	66 (1%)
Zero dischargers	76 (2%)	0 (0%)
All facilities with surrogate/DL values[c]	1,187 (27%)	66 (1%)

DL = Detection limit.

[a] Results are for groundwater, air, and groundwater to surface water pathways.
[b] Number of facilities (percentages are of the total number of facilities, approximately 4,500).
[c] Note that the facility total for Table 3-4 does not equal the facility total for Table 3-3. This is because the patterns of missing data are different for each of the tables, and the weight adjustments for missing data lead to slightly different estimates.

Table 3-5. Overview of Tiered Risk Assessment Methodology for Direct Ingestion of Groundwater

Analysis Stage	Risk Assessment Methodology - Groundwater/Direct Ingestion Human Health Chronic Risk Measures: (1) Lifetime excess risk of cancer greater than 10^{-5} and (2) Exposure in excess of a reference dose		
	Approach	**Receptor Exposure**	**Key Variables**
Preliminary screen	■ Precautionary screen ■ Eliminate impoundments with no evidence of risk from further evaluation	■ Direct consumption of impoundment water	■ Impoundment chemical concentrations ■ Exposure factors
Release assessment	■ Evaluate facilities, impoundments, and constituents not eliminated in the preliminary screen ■ Use Industrial D Tier I groundwater model lookup tables ■ Impoundments not screened out have release potential; evaluate for risk modeling	■ Drinking water well located at 150 m from unit boundary	■ Liner type ■ Impoundment chemical concentrations ■ Exposure factors
Risk modeling	■ Review site-specific data for all facilities with release potential ■ Select facilities with the greatest potential for risk ■ Conduct site-specific modeling using EPACMTP ■ Conduct Monte Carlo analysis of exposure/risk to capture within-site variability	■ Nearest actual household with a reported domestic well in the direction a plume would migrate ■ Actual exposure to receptor could occur in the future depending on transport time	■ Surface impoundment dimensions ■ Impoundment chemical concentrations ■ Presence and distance to receptor well ■ Subsurface characteristics ■ Infiltration/liner type ■ Groundwater flow direction ■ Exposure factors

EPACMTP = EPA's Composite Model for Leachate Migration with Transformation Products.

Table 3-6. Overview of Tiered Risk Assessment Methodology for the Direct Inhalation of Air

Analysis Stage	Risk Assessment Methodology - Air / Direct Inhalation Human Health Chronic Risk Measures: (1) Lifetime excess risk of cancer greater than 10^{-5} and (2) Exposure in excess of a reference concentration		
	Approach	**Receptor Exposure**	**Key Variables**
Preliminary screen	■ Precautionary screen ■ Eliminate impoundments with no evidence of risk from further evaluation ■ Required reporting of emissions data—few impoundments screened out ■ Promoted impoundments lacking sufficient data to screen to the next tier	■ Direct inhalation of impoundment emissions with zero dispersion	■ Impoundment chemical concentrations ■ Exposure factors
Release assessment	■ Evaluate facilities, impoundments, and constituents not eliminated in the preliminary screen ■ Apply Industrial D air model with a combination of default assumptions and site-specific data	■ Direct inhalation by hypothetical receptor exposed at a fixed distance of 25 m along the centerline of the plume	■ Impoundment chemical concentrations ■ Meteorological conditions ■ Impoundment characteristics such as surface area, aeration status
Risk modeling	■ Review site-specific data for all facilities with release potential, including aerial photographs to identify nearest residence ■ Apply Industrial D air model with a combination of default assumptions and site-specific data	■ Direct inhalation by actual closest resident, assumed to be along the centerline of the plume	■ Impoundment chemical concentrations ■ Meteorological conditions ■ Receptor distance ■ Impoundment characteristics such as surface area, aeration status

In the initial screening stage, EPA compared the reported concentration data (in impoundment water and emissions) collected from the facility survey with threshold concentrations that are protective of human health (residential exposures). EPA made full use of all survey data available to derive concentrations in wastewater and leachate in surface impoundments where values were not reported by respondents. The textbox summarizes the surrogate data protocol used by EPA to infer concentrations when necessary from other reported values. See Appendix B for more discussion on the protocol for inferring concentrations.

EPA Surrogate Data Protocol

EPA relied on the surveys to identify the presence or absence of particular constituents and used the reported concentration data when available. When chemicals were reported present, but concentrations or emission data were not reported, EPA used a number of approaches to derive surrogate values for screening purposes. These included using data from other impoundments at the same facility, using data from other facilities in the same industrial category, or modeling and backcalculating to infer concentrations. In a number of cases, EPA's own sampling identified additional constituents not reported. These data provide an important QA step.

Impoundments with concentrations below the screening factors were below risk criteria for that particular chemical or pathway. Those units that screen out remain an important component of the overall risk profile for the surface impoundment universe. This screening was precautionary because it was based on direct ingestion of the surface impoundment influent and direct inhalation of the emissions.

To remain under consideration at this stage for additional risk screening, a facility must either have at least one constituent in one impoundment that exceeds a risk criterion or present cumulative risks from several constituents and/or impoundments that exceed the risk criteria. Appendix C, Section C.1, provides additional detail on the methodology used for assessing cumulative risks.

In the first modeling stage, EPA used screening-level fate and transport models developed for use under the Industrial D guidance in situations where the major routes of exposure were direct ingestion of drinking water or direct inhalation. These models used some key site-specific data such as unit size, presence or absence of liners, and whether the unit is aerated. Because some chemicals and units were to be screened from further analysis, EPA used precautionary modeling approaches, such as assessing risks for close-in receptors (150 m for groundwater and 25 m for inhalation).[3] Most impoundments reporting volatile constituents did not report emissions data, so the reported wastewater concentrations were used to model emission levels for the air pathway.

Based on the results of the screening-level modeling, EPA identified those chemicals, impoundments, and facilities for which risks could not be ruled out and that, therefore, required

[3] The Industrial D air model (U.S. EPA, 1998) is based on CHEMDAT8 and ISCST3 models for emissions and dispersion factors, respectively. This model uses emissions data from the survey or, if no data are available, estimates emissions from concentration and other site-specific data from the survey. The Industrial D groundwater model is based on the EPACMTP. In this analysis, the Tier I approach was used (U.S. EPA, 1999a, b), using dilution attenuation factors that correspond to a receptor well distance of 150 m.

further analysis. The second modeling stage consisted of site-based modeling of exposures and potential risks to human receptors using more site-based data such as actual receptor locations.

With respect to inhalation, the risk analysis was repeated using the Industrial D air model (U.S. EPA, 1998) and site-specific data were used as before; however, the receptor was placed at the actual distance to the nearest residence for each impoundment (taken from the survey and checked for accuracy against census data and aerial photos). This was typically more than the default distance of 25 m used in the previous step, and, as a result, predicted air risks were almost always lower in this stage.

With respect to groundwater ingestion, EPA reviewed the risk distribution of groundwater ingestion risks after the first two stages of analysis within the context of the site-specific details for those facilities at the high end of that distribution. The conclusions from that review were that EPA could only properly characterize the risk through a more site-specific modeling process. EPA developed numeric ranking criteria based on the potential for receptor well chemical concentrations to exceed risk-based levels of concern. These criteria included site-specific characteristics relevant to completing the groundwater pathway, such as the presence of a confining clay layer in the subsurface. EPA selected 10 facilities with the greatest potential for exposures that could lead to risk and modeled these 10 facilities using more sophisticated tools.

Monte Carlo model simulations were executed using EPA's Composite Model for Leachate Migration with Transformation Products (EPACMTP, U.S. EPA, 1997) for the top-ranked facilities to predict the 90th and 50th percentile risk levels.[4] The simulation varied parameters from site-specific, regional, and national data sources, as appropriate. The groundwater concentrations predicted by EPACMTP were then used to conduct a Monte Carlo simulation of the exposure to contaminated drinking water to generate risk distributions. This assessment focused on chronic cancer risk and noncancer hazard resulting from tap water ingestion. Consequently, the exposure assessment combined modeled residential well concentrations with tap water ingestion rates and exposure durations to predict average daily dose estimates for noncarcinogens and lifetime-averaged daily dose estimates for carcinogens.

At each stage (i.e., screening or modeling), EPA used the same risk criteria to determine when risks to an individual are considered significant:

- For carcinogens: excess lifetime cancer risk = 10^{-5}
- For noncarcinogens: hazard index (HI) = 1.

These criteria were applied to potential risks posed by a specific constituent, unit, and pathway, as well as to summations of risks for a constituent, an impoundment, or a facility.

Once final risk results were generated based on the sample facilities, these were extrapolated using the appropriate facility weights to generate a national estimate of the proportions of facilities and surface impoundments that may pose potential risks.

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[4] The full risk distribution was calculated in the groundwater pathway analysis. This chapter presents results at the 90th and 50th percentiles; the full risk results are presented in Attachment C-11 of Appendix C.

Appendix C provides further discussion of the methodologies and data used for risk analysis, including a listing of the human health and ecological benchmarks used to derive screening factors, the derivation of provisional benchmarks in some cases, the methodologies for deriving surrogate concentration data, and the methodology for representing cumulative risks for constituents, surface impoundments, and facilities. Appendix C also discusses uncertainties associated with the analysis.

3.2.2 Screening Results and Proportions of Facilities that May Pose Risks

Table 3-7 shows the number of facilities and chemicals in the survey sample that were evaluated for potential air and groundwater risks at each stage of the analysis. This table illustrates that, with each stage of the analysis, progressively fewer facilities and constituents continued to the next analytic stage.

3.2.3 Results for Groundwater Ingestion

Based on the precautionary screening stages described above, EPA ranked the facilities that showed risk criteria exceedances in the release assessment phase according to their potential for groundwater concentrations to occur at levels of concern. For each facility that passed an initial decision criterion for potential groundwater flow in the direction of receptor wells, EPA conducted an additional review using data in technical materials submitted by the survey respondents. This review focused on criteria relevant to the completion of the groundwater pathway (e.g., well depth), and was used to determine whether to conduct detailed fate and transport modeling. A narrative was prepared for each facility summarizing all pertinent information according to a series of technical and risk-based criteria. Although the quantitative risk estimates generated in the release assessment were above levels of concern, the review of technical data indicated that, for some facilities, the potential for groundwater contamination at receptor wells was insignificant relative to levels of concern. To ensure consistency during this technical review process, EPA quantified these criteria and adopted a numeric framework to rank the facilities for groundwater contamination potential (see Attachment C-8 of Appendix C). Based on this numeric ranking and the supporting narratives, EPA selected the 10 highest ranked facilities to model for the groundwater pathway. Table 3-8 presents the maximum hazard and risk exceedances for the seven facilities that showed potential risk exceedances; the results based on reported concentrations are distinguished from those based on surrogate data and/or detection

Example of a Site-Specific Narrative

The site is underlain by 260 feet of lacustrine clay. The thickness of the formation, combined with the characteristic low conductivity of clay, suggests that leachate emanating from a surface impoundment would likely not impact drinking water resources. The facility did not indicate that drinking water wells were present within 2 km of the site. This is supported by the fact that the clay formation is not a producing aquifer (i.e., insufficient yield to provide water). Furthermore, the area surrounding the facility is structured in city blocks, suggesting that the populace is supplied with municipal water.

The release assessment indicates that there are seven chemicals of concern at this site. Although the screening suggests that maximum cancer and noncancer risks could be 1.9E-01 and 4.28, respectively, it is highly unlikely that the surrounding populace is at risk from ingestion of groundwater. EPA did not model this facility any further.

Table 3-7. Summary of Screening Process and Risk Analysis Results for Direct Pathways: Groundwater Ingestion and Air Inhalation

Category	Number of Sample Facilities[a]	Number of Chemicals	Number of Impoundment/ Chemical Combinations
Reported in Survey	195	215	
Entered screening assessment (Facilities that reported chemicals to be present)	133	193	8,117
Entered release assessment (Facilities that did not screen out)	116	147	4,097
Considered for risk modeling (Facilities that did not screen out)	75	92[b]	795
Modeled	37	65	359
Evaluated but not modeled	38	66	436
Final Analytic Results[c]			
Results based on reported concentrations			
Environmental release	36	53	202
May exceed risk criteria	8	6	16
Results based on surrogate/DL concentrations			
Environmental release	24	68	519
May exceed risk criteria	7	20	59

DL = Detection limit.

[a] The number of actual facility responses analyzed in the study that were used to perform the national extrapolations presented throughout this report. There are no nationally extrapolated estimates in this table.

[b] Some chemicals were modeled for only one of the two direct pathways; in addition, some chemicals were modeled for several impoundments at the same facility. Therefore, the number of chemicals in subsequent stages does not add to 92.

[c] These results were subdivided according to whether the concentration data used were reported values or were based on surrogate data and detection limits.

Table 3-8. Summary of Chemicals and their Maximum of Hazard and Risk Exceedances for Groundwater Pathway[a]

Summary of HQ Exceedances 90th Percentile (50th Percentile)[a]	Summary of Risk Exceedances 90th Percentile (50th Percentile)[a]
Risk exceedances based on reported concentrations	
Acetone - 13 (0.02) **Fluoride** - 59 (12)	
Risk exceedances based on surrogate/DL chemical concentrations	
Allyl alcohol - 26 (0.06) Chloroform[b] - 50 (0.09) Pyridine - 1.7 (0.003) Methanol - 1.7 (0.004) Methylene chloride[b] - 8.2 (0.01) Thallium - 4.5 (0.03) Toluene - 1.8 (0.004)	Acrylonitrile - 2.5E-5 (1E-6) Arsenic - 1.6E-5 (8E-9) Benzidine - 1.6E-03 (3E-4) Chloroform[b] - 1.5E-4 (2E-7) Methylene chloride[b] - 1.8E-4 (3E-7) N-Nitrosodi-n-propylamine - 4.5E-5 (1E-5) N-Nitrosodimethylamine - 3.3E-4 (7E-5) Vinyl chloride - 1.1E-5 (2E-6)

DL = Detection limit.

[a] Risk estimates and HQ values at the 90th percentile are shown first, and those at the 50th percentile are shown in parentheses.
[b] Agency had both cancer and noncancer endpoints for these constituents.

limits. Several of these facilities showed potential exceedances at more than one impoundment. The complete impoundment level results are presented in Appendix Table C-3-20.

Table 3-9 portrays the groundwater ingestion risk analysis results for decharacterized and never characteristic wastes and further distinguishes these according to whether the results derive from reported concentrations or from surrogate data and detection limits. For each category of interest, Table 3-9 portrays the proportion of the surface impoundment universe that may exceed risk criteria because of the direct ingestion of groundwater and those that may have environmental releases to groundwater that do not exceed risk criteria.

3.2.3.1 Quantitative Risk Estimation for the Groundwater Pathway. Notable findings in Table 3-9 are that very few facilities seem to show risks due to groundwater ingestion, less than 1 percent of reported concentrations. The majority of potential risk exceedances may be associated with decharacterized wastes, although the total numbers are too small to generalize with confidence. Fourteen percent of facilities (based on reported concentration data) may have environmental releases, that is, the potential to generate groundwater plumes that extend 150 meters or more beyond the impoundment boundary. These releases are evenly split between decharacterized and never characteristic wastes. As described in Attachment C-12 to Appendix C, the rates of potential risk exceedances and environmental releases are higher for decharacterized wastes than for never characteristic wastes. About 20 percent of facilities cannot be assessed with confidence because the results are based on surrogate concentration data and

Table 3-9. Facility-Level Results for Groundwater Pathway by Decharacterization Status

Facility Status	Environmental Release[a]	May Exceed Risk Criteria[a]
Risk results based on reported concentrations		
Never characteristic	341 (8%)	9 (0.2%)
Decharacterized	300 (7%)	18 (0.4%)
All facilities with reported values	641 (14%)	27 (0.6%)
Risk results based on surrogate/DL concentrations		
Never characteristic	714 (16%)	0 (0%)
Decharacterized	132 (3%)	23 (0.5%)
All facilities with surrogate/DL values	846 (19%)	23 (0.5%)

DL = Detection limit.

[a] Number of facilities (percentages are of the total number of facilities, approximately 4,500).

detection limits. Some of these facilities may have negligible concentrations and others may have environmental releases or risk exceedances.

Not surprisingly, the highest risks for the groundwater pathway on an impoundment basis correlate strongly with the absence of a liner. The liner status reported in the survey responses provided the necessary data to make this determination, and, as shown in Table 3-10, the number of risk criteria exceedances observed in unlined impoundments is twice the number for those that are lined. Similarly, the number of unlined impoundments that indicate the potential for environmental releases is almost three times the number for lined impoundments. These results strongly suggest that (1) the modeling is sensitive to the presence and type of liner, and (2) the contaminant release into the environment tends to be much higher for unlined impoundments.

Two chemical constituents with reported concentrations exceeded the risk criteria for the groundwater ingestion pathway: acetone and fluoride.

Acetone is a non-cancer-causing chemical that has been associated with increased liver and kidney weights and nephrotoxicity in rats via oral administration. The RfD of 0.1 mg/kg-d for ingestion was identified in IRIS and used in the risk modeling. This benchmark represents a health benchmark suitable for evaluating chronic exposures.

Fluoride is a noncarcinogen that, at elevated doses, may cause objectionable dental fluorosis in children. The RfD of 0.06 mg/kg-d used in the risk modeling was based on fluorine, as soluble fluoride, currently found in IRIS. EPA has determined that dental fluorosis is a cosmetic effect, not a toxic or adverse health effect. However, it is important to note that, at somewhat higher levels of exposure, the endpoint of concern is crippling skeletal fluorosis. Although an RfD for skeletal fluorosis is not available, EPA has determined that a safe exposure level for this more severe endpoint in adults is twice the RfD for dental fluorosis, or 0.12 mg/kd-d.

Table 3-10. Impoundment-Level Results for Groundwater Pathway by Liner Status

Impoundment Status	Environmental Release[a]	May Exceed Risk Criteria[a]
Risk results based on reported concentrations		
Lined	449 (4%)	8 (0.07%)
Not lined	850 (7%)	36 (0.3%)
All impoundments with reported values	1,299 (11%)	44 (0.4%)
Risk results based on surrogate/DL concentrations		
Lined	461 (4%)	32 (0.3%)
Not lined	1,939 (16%)	47 (0.4%)
All impoundments with surrogate/DL values	2,400 (20%)	79 (0.7%)

DL = Detection limit.

[a] Number of impoundments (percentages are of the total number of in scope impoundments, approximately 11,900).

3.2.3.2 *<u>Discussion of Uncertainties Associated with Groundwater Analysis</u>*. In its assessment of the groundwater pathway, EPA relied on modeling tools that have been peer-reviewed and used in previous analyses, as much site-specific data as possible from the surveys, and standard EPA sources for important data such as exposure factors and health benchmarks. All of these factors contributed to a relatively robust analysis that met the study objectives of the Surface Impoundment Study. This section identifies the primary sources of uncertainty and qualitatively describes how each may influence the results of the risk assessment. Additional details on these uncertainties are presented in Appendix C of this report.

Parameter Uncertainties. The critical parameters required for the screening of groundwater pathway included the distribution coefficients (K_d) and model parameter inputs.

- **Distribution Coefficients.** Empirical data were used to characterize partitioning of chemical contaminants between the aqueous phase and soil and aquifer materials. The K_d values used in the SI Study are based on values found in the literature. Uncertainty associated with these values could result in either an underestimation or an overestimation of risk.

- **Model Input Parameters.** Application of the EPACMTP model requires input values for the source-specific, chemical-specific, unsaturated zone-specific, and saturated zone-specific model parameters. For this analysis, facility-specific values for impoundment location and waste, soil, and aquifer characteristics were used to the extent possible. Where facility-specific data were not available, regional databases were used to obtain the parameter values for soil and aquifer conditions. The use of facility-specific data reduces but does not eliminate uncertainty. Use of regional databases may result in a greater spread of risks in Monte Carlo analyses.

Model Uncertainties. Model uncertainty is associated with all models used in all phases of a risk assessment because models and their mathematical expressions are simplifications of reality that are used to approximate real-world conditions, processes, and their relationships. These simplifications generally rely on precautionary assumptions and, as a result, the modeling approach tends to overpredict the potential effects on water quality.

- **Model Simplifications.** In modeling the fate and transport of chemicals in groundwater, complex hydrogeology such as karst or highly fractured aquifers was not directly assessed. A small fraction of the groundwater settings in this analysis are located in hydrogeologic environments where fracturing is likely. EPACMTP also does not model colloidal transport nor does it model possible geochemical interactions among different contaminants in the leachate and the subsurface environment. In addition, some precautionary assumptions are made that allow for the saturated zone to be modeled as having a uniform thickness. The use of these simplifications may result in a greater spread of concentrations in the groundwater in the Monte Carlo analysis.

- **Recharge Rates.** The recharge rates used in this analysis rely on regionalized climatic data and generalized soils types. These are not site-specific data, but are intended to represent the range of conditions expected in the area. Although the model accounts for uncertainty using a probabilistic simulation, the recharge rates are not site-specific and may over- or underpredict the contaminant flux to groundwater.

- **Timeframe of Exposure.** There is uncertainty in predicting the movement of contaminants over long periods of time. The risk to receptors for the groundwater pathway was evaluated over a time period of 10,000 years. There are significant uncertainties concerning how exposure and environmental assumptions will change over time, and the modeling methodology does not change these assumptions over this 10,000-year period.

Uncertainty in Results. It is important to consider several key uncertainties in interpreting the significance of the groundwater pathway results. The greatest uncertainty relates to assumptions made in defining the geometric configuration of the modeled system, specifically concerning the groundwater flow direction, well construction, and aquifer mounding.

- **Groundwater Flow Direction.** The direction of groundwater flow was not provided in the survey responses. Because the exact direction of the groundwater flow was unknown, the actual receptor well locations in the general the direction of the groundwater flow, as well as the physiography of the site were used to define the angle “THETA.” For each surface impoundment, THETA sets the bounds for the true direction of groundwater flow and, therefore, captures the uncertainty in centerline for groundwater flow and contaminant movement relative to the nearest receptor well to the impoundment. The error margin for THETA was based on professional judgement, and was set to 5 degrees for all facilities evaluated in the risk modeling. The impact of this geometrical inexactitude is considered to be small compared to several other uncertainties in the groundwater pathway analysis.

- **Well Construction.** The aquifer from which receptor wells drew water was not consistently reported in survey results. In the absence of technical information from the survey respondents indicating a site-specific well depth, it was assumed that the receptor wells considered in this analysis drew water from the uppermost unconfined saturated zone. This is a protective assumption and would tend to overestimate risk.

3.2.4 Results for Direct Inhalation Pathway

Table 3-11 identifies the chemicals that showed potential risk exceedances for the direct inhalation pathway. The more reliable findings based on reported values are distinguished in the table from those based on use of surrogate values and detection limits as modeling inputs. Eleven chemicals show a potential risk of 1E-5 or more or an HQ of 1 or more. Two of these chemicals show potential risks based on reported values.

Table 3-12 provides national estimates of the number of facilities that may have risk exceedances by the direct inhalation pathway, distinguishing those results in which we have more confidence because they are based on reported concentration data from those less reliable results based on inferred concentrations or detection limits. Table 3-12 further distinguishes results for decharacterized wastewaters and for never characteristic wastewaters.

> Two chemical constituents with reported concentrations exceeded the risk criteria for the air inhalation pathway: alpha-hexachlorocyclohexane and chlorodibromomethane.
>
> **alpha-Hexachlorocyclohexane** is considered a probable human carcinogen (Class B2) and has been shown to cause hepatic nodules and hepatocellular carcinomas in male mice when administered orally. The cancer slope factor for inhalation of 6.3 $(mg/kg\text{-}d)^{-1}$ was identified in IRIS and used in the risk modeling. The inhalation CSF found in IRIS is based on the oral ingestion study on male mice.
>
> **Chlorodibromomethane** is considered a possible human carcinogen (Class C); oral administration to female mice resulted in an increased incidence of hepatocellular adenomas and carcinomas. The CSF for inhalation of 8.4E-02 $(mg/kg\text{-}d)^{-1}$ was extrapolated from the CSF for ingestion identified in IRIS and used in the risk modeling. This provisional inhalation benchmark was derived from the oral ingestion study described in IRIS; however, this benchmark has not undergone EPA-wide review.

Table 3-13 shows the proportion of impoundments by aeration status. Aeration greatly facilitates emissions to air. The majority (86 percent) of impoundments are not aerated, thus most of the exceedances are for nonaerated impoundments.

3.2.4.1 Quantitative Risk Estimation for Air Pathway. Table 3-12 shows that 4 percent of facilities potentially exceed risk criteria (based on reported wastewater concentrations.) Most

Table 3-11. Maximum Hazard and Risk Exceedances for Air Pathway

Summary of HQ Exceedance	Summary of Risk Exceedance
Risk exceedances based on reported concentrations	
	Chlorodibromomethane - 1E-05 **alpha-Hexachlorocyclohexane** - 3E-05
Risk exceedances based on surrogate/DL chemical concentrations	
Acetonitrile - 57 Acrolein[b] - 11 Chloroform - 2 Hexachlorocyclopentadiene - 1.5	Bis (chloromethyl) ether - 4E-01 n-Nitrosodiethylamine[b]- 5 E-05 n-Nitrosodi-n-butylamine[b] - 2 E-05 Tetrachlorodibenzofurans - 3 E-05 Toxaphene - 4E-03
Risk exceedances based on summed risks for the facility	
	Facility level sum - 1.5E-05 **Acetaldehyde**[a] - 6 E-06 Tetrachlorodibenzodioxins - 9E-06

DL = Detection limit.

[a] Constituent risk was based on a reported value. However, the individual risk did not exceed the risk criterion.

[b] Industry representatives, subsequent to completion of the survey, have indicated that this constituent is not expected to be present at the facility. These constituents were reported to EPA in response to the Survey of Surface Impoundments in November 1999 as less than a specified limit of detection. When this constituent was evaluated in our risk analysis at the reported detection limit the concentrations were high enough to predict the indicated risk/hazard of concern. EPA included the results in this table because of the methodology used throughout the study to evaluate less than detection limit data.

Table 3-12. Facility-Level Results for Air Pathway by Decharacterization Status

Facility Status	Environmental Release[a]	May Exceed Risk Criteria[a]
Risk results based on reported concentrations		
Never characteristic	105 (2%)	158 (4%)
Decharacterized	69 (2%)	13 (0.3%)
All facilities with reported values	173 (4%)	171 (4%)
Risk results based on surrogate/DL concentrations		
Never characteristic	31 (0.7%)	0 (0%)
Decharacterized	134 (3%)	55 (1%)
All facilities with surrogate/DL values	165 (4%)	55 (1%)

DL = Detection limit.

[a] Number of facilities (percentages are of the total number of facilities, approximately 4,500).

Facility-Level Risk Summation

The risks presented in the exceedance tables in this section reflect risks for individual chemicals in individual impoundments. However, an aggregate facility-level risk was also calculated and was used to determine whether a facility exceeded the risk criterion or not.

- For carcinogens, the aggregate risk for a facility was calculated by taking the maximum risk for each chemical across all impoundments at the facility and summing these.

- For noncarcinogens, the aggregate risk for a facility was calculated by taking the maximum hazard index for each chemical across all impoundments at the facility, summing those that act on the same target organ, and taking the maximum of the target organ-specific sums.

In only one case did a facility have an aggregate risk that exceeded the risk criterion and no individual impoundment-chemical results that exceeded the risk criterion. This was via the air pathway. This aggregate, however, is a combination of reported data and less reliable surrogate or detection limit data. That exceedance is listed in Table 3-11 with all the individual impoundment chemical components as well as the aggregate facility-level risk.

See Attachment C-6 in Appendix C for the full impoundment-level results that were used to generate facility-level risk summations.

Table 3-13. Impoundment-Level Results for Air Pathway by Aeration Status

Impoundment Status	Environmental Release[a]	May Exceed Risk Criteria[a]
Risk results based on reported concentrations		
Aerated	78 (0.7%)	8 (0.06%)
Not aerated	297 (3%)	154 (1%)
All impoundments with reported values	375 (3%)	161 (1%)
Risk results based on surrogate/DL concentrations		
Aerated	195 (2%)	60 (0.5%)
Not aerated	207 (2%)	26 (0.2%)
All impoundments with surrogate/DL values	402 (3%)	85 (0.7%)

DL = Detection limit.

[a] Number of facilities (percentages are of the total number of facilities, approximately 4,500).

of these manage never characteristic wastes. The trend is reversed for facilities and impoundments that show environmental releases, with a higher rate of these releases associated with decharacterized wastes. From an impoundment standpoint, Table 3-13 shows that a significantly higher number of impoundments that may exceed risk criteria are not aerated. These data are somewhat misleading because the number of non-aerated impoundments (10,193) far exceeds the number of aerated impoundments (1,670). The relative proportion of aerated impoundments that are classified as "may exceed risk criteria" is much higher than the relative proportion of not aerated impoundments classified as "may exceed risk criteria." Approximately one-third of the total risk exceedances are attributable to aerated impoundments even though less than one-fifth of the sample population consists of aerated impoundments. (See Attachment C-7 to Appendix C for additional detail.) Chemicals of interest included primarily volatile organic compounds (VOCs), although several semivolatile organic compounds (SVOCs) and one dioxin-like chemical showed potential risk exceedances; both cancer risks and noncancer risks were predicted.

Table 3-12 also shows that 4 percent of facilities may have environmental releases, i.e., exposures of potential concern at a distance of 25 meters from the facility boundary. An additional 5 percent of facilities cannot be assessed with certainty because of lack of information on concentrations. Some of these facilities may have negligible concentrations, and others may have environmental releases or risk exceedances.

3.2.4.2 *Discussion of Uncertainties for Air Analysis*. In its assessment of the air pathway, EPA relied on modeling tools that have been peer-reviewed and used in previous analyses, as much site-specific data as possible from the surveys, and standard EPA sources for important data such as exposure factors and health benchmarks. All of these factors contribute to an analysis that met the study objectives of precautionary screening at earlier stages for the many impoundments and constituents and more robust modeling at the final stages of analysis. However, there are several key uncertainties that should be considered in interpreting the results of the air analysis. These are grouped under parameter uncertainties, modeling uncertainties, and results uncertainties. This section identifies these sources of uncertainty and qualitatively describes how each may influence the results. Additional details on these uncertainties are presented in Appendix C.

Parameter Uncertainties. The key parameters required for the air pathway modeling included impoundment characteristics, receptor location, and exposure parameters.

- **Impoundment Characteristics.** Impoundment characteristics needed for the modeling were taken from the survey responses whenever possible; however, when this was not possible, assumptions or estimates were made that introduce uncertainty into the results. Assumptions and estimates were generally chosen to be somewhat conservative (i.e., to overpredict risk).

- **Receptor Location.** To the extent that receptor locations were based on old or inaccurate maps, there is some uncertainty introduced in the risk estimates, which could be either over- or underestimated. However, conclusions regarding whether or not the risk may exceed the risk criteria are more robust, because, in cases where this conclusion was sensitive to receptor location, the location was verified using recent aerial photos.

- **Exposure Parameters.** The air model used in this analysis, is called the IWAIR, the Industrial Waste Air Model (IWAIR) (U.S. EPA, 1998) and was developed for EPA's draft industrial nonhazardous waste guidelines and used standard EPA exposure factors, such as inhalation rate, body weight, and exposure duration. Exposure factors have been chosen to be somewhat conservative; therefore, this uncertainty will typically result in an overestimate of risk.

- **Volatilization.** Our evaluation of the groundwater pathway was focused only on the ingestion of contaminated groundwater. We did not address volatlization of chemical constituents in groundwater that may result in inhalation exposures during showering. Because the inhalation pathway associated with shower exposure was not modeled, the groundwater pathway risk results may underestimate the total risk from leaching to groundwater. This contributes to the uncertainty in the risk estimates in the direction of underprotection.

Modeling Uncertainties. The modeling for the air pathway simplifies the fate and transport of chemicals from an impoundment through air to a receptor. Many of these simplifications could result in either over- or underprediction of risk.

- **Hydrolysis.** IWAIR cannot model hydrolysis. To the extent that constituents modeled do hydrolyze, IWAIR will overpredict risks. For constituents that hydrolyze quickly, this could be significant. For others, it will be less significant.

- **Biodegradation Losses.** IWAIR models biodegradation losses using conservative biodegradation rate constants. However, biodegradation is heavily influenced by site-specific factors. Therefore, the emissions estimates are uncertain. This uncertainty could result in either over- or underprediction of emissions and risks.

- **Receptor Location Relative to Plume.** The receptor is assumed to be located at the centerline of the plume, where air concentrations are highest. Depending on site-specific meteorology, particularly prevailing wind directions, the nearest receptor may not be located in the centerline of the plume. This uncertainty tends to overpredict air concentration at the nearest receptor, and thus the risk.

- **Coverage of Meteorological Data in IWAIR**. The version of IWAIR used for this study uses dispersion factors for 41 meteorological stations. Use of these meteorological stations introduces uncertainty to the extent that they may not fully represent all possible impoundment locations. However, this uncertainty is believed to be small. The direction of this uncertainty is not known.

- **Interpolation of Dispersion Factors in IWAIR Based on Impoundment Area.** IWAIR uses dispersion factors generated for a fixed set of impoundment areas and interpolates results for other areas. This will result in the underprediction of risk; however, this underprediction is expected to be modest.

Results Uncertainites. As with any risk assessment, there is uncertainty in the risk results associated with simplifying assumptions and data limitations. Several key uncertainties to consider in interpreting the risk results are presented below.

- **Chemical-Physical Properties.** Adequate chemical-physical properties to run IWAIR were not available for 12 constituents of interest in this study for the air pathway. To the extent that these constituents pose risks, this results in an underestimate of risk.

- **Health Benchmarks.** It was not possible to assess inhalation risks for many constituents in the scope of this study becasue they do not have health benchmarks for inhalation. If inhalation health benchmarks were available for all constituents of interest, a few more might be found to pose risks; therefore, this uncertainty tends to result in an underestimate of risk.

3.3 Indirect Pathways: Groundwater to Surface Water

Many impoundments are located near surface waterbodies and their direct discharges are subject to regulatory standards. However, there is the potential for indirect discharge to surface waters when chemicals are released through the bottom of the impoundment, travel through the subsurface, and impact nearby waterbodies. The intersection of groundwater flow with surface water is often referred to as groundwater discharge to surface water. Through this pathway, contaminant discharge into a pond or stream has the potential to affect water quality adversely.

For chemicals that are bioaccumulative, chemical concentrations in fish may approach or exceed levels of concern for the segment of the population that ingests fish from the nearby waterbody. For convenience, we will refer to the release, transport, and accumulation of chemicals in fish and other aquatic organisms as the groundwater to surface water (gw-sw) pathway.

3.3.1 Methodology for Groundwater to Surface Water Pathway

Table 3-14 provides an overview of the methodology for assessing the groundwater to surface water pathway. The basic approach to evaluating the potential for risks by this pathway was first to identify candidate sites through a screening process that considered groundwater concentrations, proximity to surface waterbodies, and the magnitude of potential dilution. For these candidate sites, screening-level modeling was conducted to generate flux rates from the surface impoundments, estimate groundwater concentrations that might contaminate the surface waterbody, and estimate the ensuing dilution. This analysis was conducted on all facilities that reported the presence of in-scope constituents. The basic steps in the screening process were to

- Identify sites near (within 1 km) one or more fishable waterbodies
- Screen out some sites based on a comparison of wastewater concentrations to the human health ambient water quality criteria for the ingestion of surface water and aquatic organisms (HH-AWQC)
- For those that did not screen out, estimate groundwater concentrations (from dilution attenuation factors [DAFs]) and compare these to the HH-AWQC. The DAFs used were intended to provide conservative estimates of groundwater concentrations
- Using site-specific data (such as surface impoundment area) and reviewing topographical maps, identify sites with a potential to impact surface water. Typically, this was based on a low probability of dilution by the surface waterbody based on flow data for the closest waterbody.

After the screening process, EPA conducted screening-level modeling to generate more refined estimates of chemical concentrations in the receiving waterbody and compared the resulting values to the HH-AWQC.[5]

[5] In cases in which the receiving waterbody was brackish (e.g., in an estuary), the HH-AWQC for ingestion of contaminated aquatic biota only was used (i.e., no drinking water ingestion).

Table 3-14. Overview of Tiered Risk Assessment Methodology for Potential for Adverse Effects on Surface Water Quality

Analysis Stage	Risk Assessment Methodology—Groundwater to Surface Water Human Health Chronic Risk Measure: Surface water concentrations in excess of AWQC for protection of human health for ingestion of aquatic organisms and surface water		
	Approach	**Receptor Exposure**	**Driving Variables**
Preliminary Screen	■ Precautionary screen ■ Determine potential for a groundwater to surface water pathway as a function of distance (surface waterbody within 1 km) ■ Eliminate impoundments with wastewater concentrations below HH-AWQC from further evaluation	Ingestion of aquatic organisms and surface water (as defined by the HH-AWQC)	■ Wastewater leachate concentrations
Release Assessment	■ Evaluate facilities, impoundments, and constituents not eliminated in the preliminary screen ■ Use Industrial D Tier I groundwater model lookup tables to estimate groundwater concentrations ■ Eliminate impoundments with leachate concentrations below HH-AWQC from further evaluation ■ Impoundments not screened out have release potential and are evaluated for screening risk modeling	Ingestion of aquatic organisms and surface water (as defined by the HH-AWQC)	■ Impoundment wastewater concentrations ■ Liner type ■ Distance to surface waterbody (groundwater concentration was not diluted if waterbody was within 150 km of impoundment)

(continued)

Table 3-14. (continued)

Analysis Stage	Risk Assessment Methodology—Groundwater to Surface Water Human Health Chronic Risk Measures: Surface water concentrations in excess of AWQC for protection of human health for ingestion of aquatic organisms and surface water		
	Approach	**Receptor Exposure**	**Driving Variables**
Risk modeling (screening)	■ Evaluate characteristics of impoundments (e.g., surface area) and receiving waterbodies (e.g., flow rate) that drive this pathway ■ Develop numeric ranking scheme to identify impoundments with potential to adversely affect surface water quality ■ Using EPACMTP, calculate infiltration rate and contaminant flux from impoundment to surface water ■ Determine surface water concentrations using instantaneous dilution and full mixing assumptions ■ Compare surface water concentrations with HH-AWQC for the impoundments modeled	Ingestion of aquatic organisms and surface water (as defined by the HH- AWQC)	■ Impoundment leachate concentrations ■ Surface area of surface impoundment ■ Meteorological conditions that affect infiltration (e.g., precipitation) ■ Type of receiving waterbody (flowing versus quiescent) ■ Flow rate ■ Liner type ■ Distance to surface waterbody

EPACMTP = EPA's Composite Model for Leachate Transformation Products.
HH-AWQC = Human health ambient water quality criteria.

3.3.2 Results for Indirect Pathway—Surface Water

After completion of this screening-level modeling, EPA found 158 potential risk exceedances (35 constituents) at 27 impoundments at nine facilities in the survey sample. In summary, EPA found

- 30 exceedances of the HH-AWQC by a factor of over 100—of these 30 exceedances, 7 are based on reported values for arsenic at a single facility.
- 38 exceedances of the HH-AWQC by a factor between 10 and 100—none are based on reported values.
- 90 exceedances of the HH-AWQC by a factor between 1 and 10—of these 90 exceedances, only thallium and arsenic are based on reported values.

Table 3-15 identifies the maximum exceedances for reported values at each of the nine facilities with respect to the ratio of the surface water concentration to the HH-AWQC. Where a reported value was not identified, the maximum exceedance based on a surrogate/detection limit (DL) value, in which there is less confidence, is presented.

Tables 3-16 and 3-17 illustrate the proportion of the surface impoundment universe that show potential exceedances of HH-AWQC and those that show potential environmental release to surface water. Table 3-16 shows the proportion of facilities by decharacterization status; Table 3-17 shows the proportion of impoundments by liner status.

3.3.2.1 Quantitative Risk Estimation for Surface Water Pathway. Based on screening level modeling, Table 3-16 shows that very few facilities—about 1 percent—may exceed risk criteria using reported concentration data. Eighteen percent of facilities may have environmental releases into surface water that are higher than HH-AWQC at the point of discharge before dilution occurs. An additional 25 percent of facilities cannot be assessed with certainty because of incomplete information on concentrations; some of these facilities may have negligible concentrations, and others may have environmental releases or risk exceedances. The number of potential risk exceedances is roughly similar for decharacterized and never characteristic wastes; however, the rate of potential risk exceedance is higher for decharacterized wastes. (See Attachment C-15 of Appendix C.) Table 3-18 shows the risk results by discharge status. For the groundwater pathway, no zero discharge facilities exceeded the risk criteria; however, for the surface water pathway, it can be inferred that roughly 37 percent[6] of all facilities that exceeded the risk criteria were zero dischargers. The value of liners for protecting the surface water pathway was pronounced (see Table 3-17); no impoundments with liners show potential exceedances of the human health ambient water quality criteria, whereas unlined impoundments do show potential risk exceedances.

[6] There are approximately 73 total facilities with 27 zero dischargers listed as "May Exceed Risk Criteria." The complete analytical results for this pathway are shown in Attachment C-15 in Appendix C.

Table 3-15. Maximum Exceedances for Groundwater to Surface Water Pathway

Constituent of Concern	C_{leach}[a] (mg/L)	C_{gw}[b] (mg/L)	C_{river}[c] (mg/L)	HH-AWQC (mg/L)	C_{river}/ HH-AWQC[d]
Risk exceedances based on reported chemical concentrations					
Thallium	2.40E-01	3.29E-03	3.29E-03	1.70E-03	1.93E+00
Arsenic	1.95E-01	1.95E-01	1.95E-01	1.80E-05	1.08E+04
Risk exceedances based on surrogate/dl chemical concentrations					
Antimony	6.00E-02	6.00E-02	3.74E-04	1.40E-04	2.67E+00
3,3'Dichlorobenzidine	2.00E-02	2.00E-02	9.02E-05	4.00E-05	2.26E+00
4,4-DDD	3.67E-04	3.67E-04	1.65E-06	8.30E-07	1.99E+00
4,4-DDE	3.67E-04	3.67E-04	1.65E-06	5.90E-07	2.80E+00
4,4-DDT	3.67E-04	3.67E-04	1.65E-06	5.90E-07	2.80E+00
Heptachlor epoxide	2.93E-03	2.93E-03	1.32E-05	1.00E-07	1.32E+02
Hexachlorobenzene	1.00E-02	1.00E-02	4.51E-05	7.50E-07	6.02E+01
PCBs	1.65E-02	1.65E-02	7.45E-05	1.70E-07	4.38E+02
Benzo(a)anthracene	1.00E-02	1.00E-02	1.44E-04	4.40E-06	3.28E+01
Benzo(a)pyrene	1.00E-02	1.00E-02	1.44E-04	4.40E-06	3.28E+01
Benzo(b)fluoranthene	1.00E-02	1.00E-02	1.44E-04	4.40E-06	3.28E+01
Chrysene	1.00E-02	1.00E-02	1.44E-04	4.40E-06	3.28E+01
Dibenzo(a,h)anthracene	1.00E-02	1.00E-02	1.44E-04	4.40E-06	3.28E+01
Ideno 1,2,3-cd pyrene	1.00E-02	1.00E-02	1.44E-04	4.40E-06	3.28E+01
1,1,2,2-Tetrachloroethane	5.00E-03	5.00E-03	4.87E-04	1.70E-04	2.86E+00
1,1-Dichloroethylene	5.00E-03	5.00E-03	4.87E-04	5.70E-05	8.54E+00
1,2-Dichloroethane	5.00E-03	5.00E-03	4.87E-04	3.80E-04	1.28E+00
1,2-Diphenylhydrazine	1.00E-02	1.00E-02	9.73E-04	4.00E-05	2.43E+01
2,4-Dinitrotoluene	1.00E-02	1.00E-02	9.73E-04	1.10E-04	8.85E+00
Acrylonitrile	1.00E-02	1.00E-02	9.73E-04	5.90E-05	1.65E+01
Aldrin	5.00E-05	5.00E-05	4.87E-06	1.30E-07	3.74E+01
Benzidine	1.00E-02	1.00E-02	9.73E-04	1.20E-07	8.11E+03
Bis(2-chloroethyl) ether	1.00E-02	1.00E-02	9.73E-04	3.10E-05	3.14E+01
Carbon tetrachloride	5.00E-03	5.00E-03	4.87E-04	2.50E-04	1.95E+00
Chlordane	5.00E-05	5.00E-05	4.87E-06	2.10E-06	2.32E+00

(continued)

Table 3-15. (continued)

Constituent of Concern	C_{leach}[a] (mg/L)	C_{gw}[b] (mg/L)	C_{river}[c] (mg/L)	HH-AWQC (mg/L)	C_{river}/ HH-AWQC[d]
Chlorodibromomethane	5.00E-03	5.00E-03	4.87E-04	4.10E-04	1.19E+00
Dieldrin	2.00E-04	2.00E-04	1.95E-05	1.40E-07	1.39E+02
Heptachlor	5.00E-05	5.00E-05	4.87E-06	2.10E-07	2.32E+01
Hexachlorobutadiene	1.00E-02	1.00E-02	9.73E-04	4.40E-04	2.21E+00
N-Nitrosodimethylamine	1.00E-02	1.00E-02	9.73E-04	6.90E-07	1.41E+03
N-Nitrosodi-n-propylamine	1.00E-02	1.00E-02	9.73E-04	5.00E-06	1.95E+02
Pentachlorophenol	1.00E-02	1.00E-02	9.73E-04	2.80E-04	3.48E+00
Toxaphene	5.00E-03	5.00E-03	4.87E-04	7.30E-07	6.67E+02

HH-AWQC = Ambient Water Quality Criteria for human health.

[a] The estimated concentration in the leachate as it leaves the unit boundary.
[b] The estimated concentration in the groundwater as it enters the surface water; if this value exceeds a HH-AWQC then the facility is considered to have the potential for an environmental release.
[c] The estimated concentration in the surface water after complete mixing.
[d] The ratio of the surface water concentration to the HH-AWQC; if this ratio exceeds 1, then the facility is considered to pose a potential risk to surface water quality.

Table 3-16. Facility-Level Results for Groundwater to Surface Water Pathway by Decharacterization Status

Facility Status	Environmental Release[a]	May Exceed Risk Criteria[a]
Risk results based on reported concentrations		
Never characteristic	479 (11%)	29 (0.7%)
Decharacterized	311 (7%)	14 (0.3%)
All facilities with reported values	790 (18%)	44 (1.0%)
Risk results based on surrogate/DL concentrations		
Never characteristic	918 (21%)	9 (0.2%)
Decharacterized	161 (4%)	22 (0.5%)
All facilities with surrogate/DL values	1,079 (24%)	31 (0.7%)

DL = Detection limit.

[a] Number of facilities (percentages are of the total number of facilities, approximately 4,500).

Table 3-17. Impoundment-Level Results for Groundwater to Surface Water Pathway by Liner Status

Impoundment Status	Environmental Release[a]	May Exceed Risk Criteria[a]
Risk results based on reported concentrations		
Lined	1,123 (9%)	0 (0%)
Not lined	1,028 (9%)	64 (0.5%)
All impoundments with reported values	2,150 (18%)	64 (0.5%)
Risk results based on surrogate/DL concentrations		
Lined	426 (4%)	0 (0%)
Not lined	1,121 (9%)	74 (0.6%)
All impoundments with surrogate/DL values	1,547 (13%)	74 (0.6%)

DL = Detection limit.

[a] Number of impoundments (percentages are of the total number of in scope impoundments, approximately 11,900).

Table 3-18. Facility-Level Results for Groundwater to Surface Water Pathway by Discharge Status[a]

Facility Status	Environmental Release[a]	May Exceed Risk Criteria[a]
Risk results based on reported concentrations		
Direct dischargers	622 (14%)	14 (0.3%)
Zero dischargers	115 (3%)	27 (0.6%)
All facilities with reported values[b]	738 (17%)	42 (0.9%)
Risk results based on surrogate/DL concentrations		
Direct dischargers	906 (20%)	31 (0.7%)
Zero dischargers	76 (2%)	0 (0%)
All facilities with surrogate/DL values[b]	982 (22%)	31 (0.7%)

DL = Detection limit.

[a] Number of facilities (percentages are of the total number of facilities, approximately 4,500).
[b] Note that the facility totals for Tables 3-16 through 3-18 do not match. This is because the patterns of missing data are different for each of the tables, and the weight adjustments for missing data lead to slightly different estimates.

3.3.3 Discussion of Uncertainties

There are several key uncertainties that should be considered in interpreting the results of the surface water quality screening assessment. These are grouped under parameter uncertainties, modeling uncertainties, and results uncertainties. This section identifies these sources of uncertainty and qualitatively describes how each may influence the results. Additional details on these uncertainties are presented in Appendix C to this report.

3.3.3.1 Parameter Uncertainties. The critical parameters required for the screening modeling of surface waterbodies included flow rates and dilution/attenuation factors.

- **Flow Rates.** Flow rates were a potentially significant source of uncertainty; the low flow rate (7Q10) was often greater than the average flow rate, suggesting that the data sources were highly variable. In addition, many flow rate estimates are based on end-of-stream locations, which could be a substantial distance from the point at which the groundwater could reasonably be expected to intersect with the surface waterbody. Consequently, the river dilution factor calculated from the flow rate may be highly uncertain.

- **Dilution/Attenuation Factors.** For surface waterbodies within 150 meters, a default DAF of 1.0 was chosen. This value tends to overestimate the contaminant flux in groundwater that reaches the surface waterbody. The DAFs in Industrial Waste Evaluation Model (IWEM) were used for waterbodies beyond 150 meters and, as with the default DAF, these were developed for a groundwater screening tool. The resulting groundwater concentrations will generally lead to an overprediction of the contaminant concentration in the surface waterbody.

3.3.3.2 Modeling Uncertainties. The screening modeling for the groundwater to surface water pathway simplifies the fate and transport of chemicals from groundwater to surface water and is based on several assumptions. These simplifications generally rely on precautionary assumptions and, as a result, the modeling approach tends to overpredict the potential effects on water quality.

- **Groundwater Flow Direction.** For the surface water screening, groundwater flow direction was inferred from the topography and a plausible groundwater flow direction was established perpendicular to the receiving waterbody—either a flowing waterbody or a quiescent system such as a small pond. In addition, the plume was assumed to completely intersect with the waterbody so that the groundwater would exert the maximum impact on the surface waterbody. The combination of these assumptions creates a bias toward higher surface water concentrations.

- **Designation of Fishable Waterbody.** The closest fishable waterbody was identified for each impoundment based on both survey responses and simple decision rules. However, there may be substantial uncertainty in this selection because, in many instances, survey responses were not useful in identifying the closest fishable waterbody.

- **Infiltration Rates.** The infiltration rates used in this analysis were developed with the EPACMTP model using generalized soils data. These are not site-specific data but are intended to represent the conditions expected in the area. The infiltration rates are not site-specific and may over- or underpredict the contaminant flux to groundwater.

3.3.3.3 *Results Uncertainties*. It is important to consider several key uncertainties in interpreting the significance of the surface water pathway results. The modeling approach is based on the assumption of instantaneous and thorough dilution throughout the surface waterbody, which would create a constant exposure profile for human usage throughout the entire receiving waterbody. In reality, contaminant release into the surface waterbody through this pathway would likely be associated with a concentration gradient that would vary the exposure pattern throughout the length of the waterbody. In many instances, only a small portion of the receiving waters may actually maintain chemical concentrations above the HH-AWQC. For the highest area of contamination (perhaps a "favorite" fishing spot), the dilution may mask potentially adverse impacts on surface water quality. Nevertheless, the results of this analysis suggested that, despite the proximity of receiving waterbodies to surface impoundments, the risks from adverse effects to surface water quality are generally low nationwide.

- **Data Gaps.** The screening criteria (HH-AWQC) selected for this analysis were identified in EPA's compilation of national recommended water quality criteria developed pursuant to section 304(a) of the Clean Water Act. An HH-AWQC was not available for all of the constituents that failed the preliminary screen; therefore, the results may not capture impacts from all chemicals that may be released through this pathway.

- **Additive/Synergistic Effects.** The screening modeling does not address the possibility that other contaminant sources may be releasing similar chemical constituents into the same waterbody. For waterbodies that are already receiving significant contaminant loads of similar chemicals (or synergistic chemicals), the chemical release from an impoundment may be a significant contributor to water quality degradation.

- **Surface Water as a Drinking Water Source.** Some facilities were located next to freshwater systems and others were located adjacent to saline estuarine systems. In freshwater systems EPA used HH-AWQC that assume both fish consumption and use of the waterbody as a drinking water source without treatment. Because few people use untreated surface water as a source of drinking water, some of the results are overestimates of the potential groundwater to surface water risk. In estuarine systems, EPA assumed the water would not be used as a source of drinking water and only used the HH-AWQC that are based on fish consumption.

3.4 Other Indirect Pathways

3.4.1 Methodology

The potential for industrial sites with surface impoundments to pose a risk to surrounding populations through indirect exposure pathways was evaluated using a screening analysis that was implemented in two stages. Table 3-19 provides an overview of the methodology used.

In reviewing the indirect pathway methodology and results it is important to consider the limited nature and explicit purpose of this risk screening. This analysis ranks and orders facilities and impoundments based on whether they have the potential to generate an indirect risk. Unlike the previous risk analysis of groundwater, air and groundwater to surface water this analysis does not use models to predict the movement of chemicals through indirect pathways and therefore this analysis never measures the actual degree of indirect risk, this analysis only identifies the potential for risk. It is likely that many of the facilities in this screening analysis that are indicated to have the potential for an indirect risk would not actually indicate a risk of concern if modeling were conducted. This was certainly observed in the risk analysis of groundwater, air, and groundwater to surface water. Since indirect pathways often involve even more complex and highly site specific movement of contaminants through several different environmental compartments (e.g., sludge to wind blown dust to crops to cattle to humans) it is even more likely that many potential indirect exposure pathways would not be completed and as a result the proportion of facilities with actual indirect risk are likely to be far less than those with only the potential for risk.

In the first stage of the indirect screening, EPA reviewed the constituents reported in the surveys to identify a short list of constituents of focused concern for indirect exposure. The tendency to bioaccumulate is a chemical property that is considered especially relevant for indirect pathways of exposure where accumulation occurs in food chains and humans ingest these foods. This screening-level assessment of indirect pathways focused on those chemicals having a significant potential to bioaccumulate. The first step was to rank order all the constituents reported in the surveys, irrespective of their concentrations, according to their potential to bioaccumulate considering chemical-specific data on bioaccumulation. Based on this rank ordering, 37 constituents were included in our assessment of indirect exposure pathways. These chemicals are shown in Table 3-20.

The second stage of the screening analysis was to identify all facilities that reported managing these constituents and to screen these facilities according to their potential for indirect exposures. This potential was evaluated by examining facility-specific data and environmental settings, including probable proximity to receptors such as residents, farmers, and fishers. The release scenarios considered were volatilization of constituents from wastewater, particulate entrainment or erosion of constituents from exposed sludge, and leaching of constituents from wastewater into groundwater with subsequent transport and release to surface water.

The criteria considered in the ranking process included size of the surface impoundment, distance from the impoundment to the nearest receptor, slope of the terrain in the vicinity of the site (which impacts the degree of erosion/runoff that may occur in some cases after closure), size

Table 3-19. Overview of Tiered Risk Assessment Methodology for Indirect Pathway Assessment

Analysis Stage	Risk Assessment Methodology—Indirect Pathway Human Health Chronic Risk Measure: Numeric ranking scheme for potential completion of indirect pathways		
	Approach	**Receptor Exposure**	**Key Variables**
Preliminary screen	■ Precautionary screen for indirect exposure potential conducted at the facility-level ■ Focus on bioaccumulative chemical constituents that may pose risk via indirect exposures ■ Eliminate facilities from further evaluation that do not manage bioaccumulative chemicals	■ Indirect exposures (e.g., food chain) are considered to be a function of the presence or absence of bioaccumulative chemicals	■ Source concentration data indicating that the facility manages bioaccumulative chemicals
Release Assessment	■ Take full advantage of site-specific information on physiography, residences, presence of farms, location of nearest waterbody ■ Consider potential from exposures associated with active impoundments as well as for postclosure scenario ■ Scoring criteria include impoundment characteristics such as surface area, proximity to receptors, and groundwater-surface water modeling results ■ Use the numeric ranking criteria to identify facilities with the highest potential to complete indirect pathways	■ Ingestion of fruits and vegetables grown in local gardens or on local farms ■ Ingestion of animals and animal products raised on local farms ■ Ingestion of fish caught in fishable waterbodies located near the facility ■ Receptors and farms located at actual distances reported in the survey responses or identified using GIS tools	■ Impoundment characteristics (e.g., size) ■ Distance to farms, residences ■ Distance to fishable waterbodies ■ Results from gw-sw pathway screening modeling ■ Impoundment characteristics ■ Physiographical characteristics indicating potential for erosion/runoff of soil particles

GIS = Geographic information system.

Table 3-20. Chemicals Selected for Inclusion in Indirect Exposure Pathway Ranking Analysis

p,p'-DDT	Fluorene	Polychlorinated biphenyls
Dibenz[a,h]anthracene	Hexachloro-1,3-butadiene	2,3,7,8-TCDD
3-Methylcholanthrene	1,2,4,5-Tetrachlorobenzene	Lead
Chlordane, alpha & gamma isomers	2,4,5-Trichlorophenol	Mercury
7,12-Trimethylbenz[a]anthracene	Endosulfan	Cadmium
Lindane	Hexachlorobenzene	Toxaphene
Dieldrin	1,2,4-Trichlorobenzene	Pentachlorodibenzofurans
Endrin	Kepone	Hexachlorodibenzo-p-dioxins
Methoxychlor	Indeno(1,2,3-cd) pyrene	Pentachlorodibenzo-p-dioxins
p,p'-DDD	Benzo(b)fluoranthene	Tetrachlorodibenzo-p-dioxins
p,p'-DDE	Aldrin	Hexachlorodibenzofurans
Heptachlor	Pentachlorobenzene	Tetrachlorodibenzofurans
	Heptachlor epoxide, alpha, beta, and gamma isomers	

of the waterbody (which can influence the degree of dilution following deposition of bioaccumulative chemicals into waterbodies such as lakes, rivers, or creeks). These criteria were quantified and integrated into a numerical ranking framework designed to provide a consistent protocol to determine the potential for complete exposure pathways. The decision to list a facility as potential concern, lower concern, or least concern is based on the outcome of the numeric scheme.

The rankings assigned to facilities are based exclusively on an assessment of current site-conditions, including both impoundment status and environmental setting criteria in the vicinity of the facilities. However, a future closure scenario was also included in the analysis to address potential risks following impoundment closure. The future closure scenario is based on the precautionary assumption that all impoundments close without taking action to mitigate environmental releases such as dredging of residual sludge and capping to prevent erosion/runoff. Because of the precautionary assumptions underlying the future closure scenario, the results of this portion of the analysis are used to qualify the overall rankings given to individual facilities, but are not considered explicitly in assigning those rankings. Appendix C provides additional detail on the methodology, and Attachment 17 of Appendix C presents the full ranking results.

Once the screening had been completed to identify facilities where indirect pathways are of potential concern, EPA generated national estimates of the proportion of facilities that could pose concerns due to indirect pathway exposures. The measures used to portray the results in Tables 3-1 and 3-2 (overview of results) and in the tables described below, are as follows:

- Potential Concern: This risk metric is an indicator of the potential for completion of more than one indirect exposure pathway at the facility.

- Lower Concern: This risk metric is an indicator of the potential for completion of one indirect exposure pathway at the facility and, therefore, of relatively lower concern.

- Least Concern: This risk metric is an indicator of low potential to complete even one indirect exposure pathway at the facility.

3.4.2 Results

The screening analysis generated a number of results that provide a different perspective on whether facilities have the potential to pose indirect exposures of concern to surrounding populations. These include: (1) overall rankings, which summarize the overall facility-rankings across the entire set of facilities that manage bioaccumulative chemicals, (2) results presented according to which receptor population and exposure pathways are of concern. Appendix C provides additional detail on these results and additional perspectives of potential interest.

3.4.2.1 Overall Results. Table 3-21[7] summarizes the overall results by characterization status of the indirect pathway screening analysis, expressed as national estimates. Six percent of facilities fall into the potential concern category for indirect exposure. Table 3-22 presents the overall results by regulatory status, also expressed as national estimates, and indicates that all facilities classified as of potential concern are direct dischargers.

3.4.3 Discussion of Uncertainties

The qualitative character of the indirect exposure pathway analysis leads to several major areas of uncertainty that affect interpretation of the results. These are grouped under parameter uncertainties, modeling uncertainties, and results uncertainties. Additional details on these uncertainties are presented in Appendix C to this report.

Table 3-21. Facility-Level Results for Indirect Pathways by Decharacterization Status

Facility Status	Lower Concern[a]	Potential Concern[a]
Never characteristic	2,153 (48%)	116 (3%)
Decharacterized	466 (10%)	169 (4%)
All facilities	2,620 (59%)	285 (6%)

[a] Number of facilities (percentages are of the total number of facilities, approximately 4,500).

[7] Because specific chemical concentrations are not used in the indirect assessment, these results are not divided into reported vs. surrogate DL as other results are.

Table 3-22. Facility-Level Results for Indirect Pathways by Discharge Status[a]

Facility Status	Lower Concern[a]	Potential Concern[a]
Direct dischargers	2,487 (56%)	272 (6%)
Zero dischargers	181 (4%)	0 (0%)
All facilities[b]	2,668 (60%)	272 (6%)

[a] Number of facilities (percentages are of the total number of facilities, approximately 4,500).
[b] The facility total for Table 3-22 does not equal the facility total for Table 3-21 because the patterns of missing data are different for each of the tables, and the weight adjustments for missing data lead to slightly different estimates.

3.4.3.1 Parameter Uncertainties. Key parameters required for this analysis fall into one of two broad categories, including facility performance parameters and environmental setting parameters. Various sources of uncertainty can impact each of these parameters. The following parameter uncertainties are believed to have the greatest potential impact on the indirect exposure pathway screening assessments.

- **Distance to Nearest Receptor.** The distance between specific impoundments and the nearest receptor (i.e., residential areas, farms, or fishable waterbodies) was estimated using a combination of aerial photos and topographic maps. Although these measurements were made using the most up to-date photos and maps available, some of the photos and maps were somewhat dated and possibly inaccurate. This introduces uncertainty in the distance-to-nearest-receptor measurements because land use change could result in a receptor either being added to or removed from a given study area. This is less of an issue in identifying fishable waterbodies.

- **Assessment of Potential for Erosion/Runoff.** Topographic maps used to assess slope and the potential for sheet versus channel flow may not be current, in which case significant changes in land use (which would not show up on older maps) could introduce uncertainty into the characterization of this parameter.

3.4.3.2 Modeling Uncertainties. The indirect exposure pathway screening assessment is a facility-level evaluation intended to rank facilities according to their potential for complete indirect exposure pathways. This analysis uses a ranking algorithm together with facility-specific and environmental setting criteria to generate overall ranking scores for individual exposure pathways. The criteria used in this analysis were selected as surrogates for key factors related to human health risk (e.g., impoundment surface area was used as a surrogate for level of chemical emissions, distance to receptor was used as a surrogate for level of dispersion following source release). The use of these surrogate parameters as criteria in the ranking algorithms for individual exposure pathways, while appropriate given the screening nature of the analysis, does introduce modeling uncertainty into the analysis. In addition, there are uncertainties associated with the ranking algorithms used in the analysis.

- **Use of ranking algorithms.** The ranking algorithm used in this analysis assumes an additive relationship between the criteria that are considered. However, in relation to actual risk, these criteria may have multiplicative or other nonlinear relationships to each other, in which case the overall importance of individual criteria could be misrepresented in the ranking algorithm.

- **Use of surface area as a surrogate parameter.** Total aggregated impoundment surface area for a given facility was used as a surrogate for the level of constituent emissions from that facility. However, a wide range of factors can influence the degree of source emissions from an impoundment including chemical composition of the wastewater/sludge and other environmental setting/impoundment characteristics. Consequently, use of surface area as a surrogate for emissions levels does introduce uncertainty into the analysis.

- **Use of distance to receptor as a surrogate parameter.** The shortest distance from any of the impoundments at a facility to the nearest offsite receptor (i.e., resident, farmer, or fisher) was used as a surrogate for the degree of chemical dispersion that would occur following release. However, a wide range of factors in addition to distance-to-receptor can impact dispersion including meteorology, topography, and the specific characteristics of the source release.

3.4.3.3 Results Uncertainties. The indirect exposure screening analysis is designed to identify which facilities have the potential to pose an indirect exposure pathway risk to surrounding populations. Given this scope, the analytical framework for the screening analysis uses a combination of surrogate criteria and simple additive ranking algorithms in place of a formal site-specific risk assessment framework to generate ranking results. While this semi-quantitative approach does support ranking of facilities with regard to the potential for indirect exposure pathway risk, care should be taken not to overextend conclusions drawn from the analysis. A similar issue applies to results produced for the current status scenario versus future closure scenario.

- **Drawing Conclusions from the Analysis.** Because the indirect exposure screening analysis uses surrogate criteria combined with simple additive algorithms to rank facilities, there is significant uncertainty associated with the overall analysis that should be considered in interpreting results. While this degree of uncertainty is considered acceptable for a first-pass assessment as to whether individual facilities have the potential for indirect exposure pathway risk, it precludes drawing any conclusions regarding the potential magnitude of risk that these facilities could pose.

- **Current Status Scenario Versus Future Closure Scenario Results.** There is significantly greater uncertainty associated with results generated for the future closure scenario than for the current status scenario. This discrepancy results from the fact that the current status scenario is based on best available data regarding the current status of modeled facilities, while the future closure scenario is not intended as a "best guess" of future closure conditions at sites, but rather as a precautionary analysis of the potential for indirect exposure pathway risk should impoundments close without sufficient postclosure actions being taken to limit constituent mobility. Reflecting this discrepancy in uncertainty, overall rankings for the indirect exposure screening analysis are based only on results for current status scenario—results from the future closure scenario are not considered in assigning these rankings. However, the results of the future closure scenario could be used to qualify the results of the current status scenario since they provide perspective on how many facilities could pose an indirect exposure pathway risk should impoundment closure occur without remediation.

3.5 Ecological Risk Screening

Industrial wastes managed in surface impoundments can potentially cause adverse effects on flora and fauna in natural systems. Many impoundments are located near rivers and waterbodies and are freely accessible to wildlife. Moreover, some chemicals are more toxic to wildlife than to humans; wildlife species generally have higher metabolic rates than humans and, therefore, eat, drink, and breathe proportionately more contaminants than humans. In addition, nonhuman organisms live in closer association with their immediate environment and often cannot avoid contamination or replace destroyed food sources as humans can. For this study, EPA assessed the potential for impoundments to pose risks to populations and communities of ecological receptors that live in and near surface impoundments.

3.5.1 Methodology

Table 3-23 provides an overview of the methodology used to assess potential ecological risks. The ecological risk screening was similar to the first screening stage of the human health risk analysis, but did not go beyond that stage to consider actual exposures and did not rely on fate and transport modeling. The assessment strategy is intended to represent only the potential for adverse ecological effects, not the actual risk posed to wildlife.

In reviewing the ecological risk screening methodology and results it is important to consider the limited nature and explicit purpose of this evaluation. This analysis ranks and orders facilities and impoundments based on their potential to generate an ecological threat. Unlike the previous risk analysis of groundwater, air, and groundwater to surface water, this analysis does not use models to predict the movement of chemicals through the environment and actual exposure through the food chain. In this way the ecological risk screening analysis never measures the actual degree of ecological risk; this analysis only identifies the potential for risk. It is likely that many of the facilities in this analysis that are indicated to have the potential for an ecological risk would not actually indicate a risk of concern if modeling were conducted. This was certainly observed in the risk analysis of groundwater, air, and groundwater to surface water. Because the ecological pathways often involve even more complex and highly site-specific movement of contaminants through several different environmental compartments and food chains (e.g., sludge to windblown dust to flora to fauna to other fauna), it is even more likely that

Table 3-23. Overview of Tiered Risk Assessment Methodology for Screening Ecological Risk Assessment

Analysis Stage	Risk Assessment Methodology Ecological Receptors Chronic Risk Measures: (1) Media concentrations in excess threshold concentration and (2) Exposure in excess of a reference dose		
	Approach	**Receptor Exposure**	**Key Variables**
Preliminary Screen	■ Screen using protective ecological screening factors for range of taxa ■ Use endpoints relevant to population sustainability and community structure/function ■ Eliminate impoundments with no evidence of risk from further evaluation ■ Ascertain potential for adverse ecological effects across habitats ■ Divide facilities into two categories based on the number of receptor exceedances: potential concern or lower concern ■ Identify sensitive and protected ecosystems in the proximity of facilities with chemicals that exceed risk criteria	■ Direct consumption of impoundment water ■ Direct contact with contaminants in sludge and impoundment water ■ Direct ingestion of sludge and plant/animals in contact with the sludge ■ Receptors presumed to have complete access to impoundment and rely on immediate area as major food source	■ Impoundment chemical concentrations ■ Ecological benchmarks including NOAELs ■ Ecological exposure factors

NOAEL = No observed adverse effect level.

many potential ecological pathways would not be completed; as a result, the proportion of facilities with actual ecological risk is likely to be far smaller than the proportion with only the potential for risk.

A screening assessment was performed to estimate the potential risk for a wide variety of plants and animals. EPA assigned receptors to each facility based on regional data sources and land use characteristics at each facility. EPA screened for ecological risk in a manner similar to that used in the preliminary screening stage for noncancer risks for humans. The assessment compares chemical concentrations in surface impoundment water and sludge to concentrations that are considered protective of animals and plants. When this ratio, or hazard quotient, exceeds 1, there is the potential for adverse effects; if the result is less than 1, adverse effects are not expected for a particular ecological receptor. The ecological screening assessment is precautionary because it is based on direct ingestion or uptake of the surface impoundment influent. Risk was assessed for birds, mammals, and amphibians as well as for organisms that live in the soil, water, and sediment (e.g., worms, fish, and insect larvae). Plants that grow in water and those that grow on land were also assessed. By including many different types of ecological receptors, EPA can infer a degree of protection to ecosystems as a whole.[8] An additional element of the ecological screening considered whether surface impoundments are located near sensitive ecosystems such as wetlands, wildlife refuges, or national forests.

The final stage of the screening-level assessment was to compare the number of each facility's risk exceedances[9] to the median number of exceedances (38 exceedances) for all the facilities that did not screen out. Using this standard, facilities were placed in two categories:

- Potential concern: Facilities having at least the median number of exceedances for ecological receptors (i.e., 38 or more exceedances).
- Lower concern: Facilities having fewer than the median number of exceedances for ecological receptors.

Note that the selection of the median number of exceedances does not guarantee that an equal number of facilities will be assigned to the two risk categories. The risk results from the sample population are weighted-up to produce the national risk estimates; therefore, the percentages for each risk category reflect the weights and missing data patterns as well as the exceedance rate.

3.5.2 <u>Results</u>

Based on the comparison with screening factors, a total of 34 chemicals exceeded the risk criteria for at least one receptor at one impoundment, and 54 of the more than 62 ecological receptors considered in this assessment showed potential risk exceedances. These receptor taxa include mammals, birds, and plants, as well as organisms living in the soil, water, and sediment. Wildlife species for which potential risks were indicated cover a variety of taxa and feeding strategies, from species that depend on aquatic systems for food (e.g., mink, river otter, kingfisher, great blue heron) to those typical of terrestrial systems (e.g., terrestrial plants, coyote, white tailed deer, cerulean warbler). These results were not based on modeling; they represent a screening-level exposure assessment that implies direct usage of the impoundment by wildlife. EPA recognizes that, although direct usage is possible, surface impoundments are not designed to provide habitat and it is highly unlikely that many receptors would rely on an impoundment exclusively to provide shelter, food sources, and other attributes of functioning habitats. Nevertheless, these results do measure the potential ecological impacts at a national level.

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[8] Regionally unique species occurring in coastal areas of the southeastern United States (e.g., Florida manatee) and other species listed as threatened and endangered were not evaluated in the analysis. However, the precautionary nature of the screening factors, which are based on standards such as EPA ambient water quality criteria and no observed effects levels, implies some degree of protection for species already considered to be under stress.

[9] Risk exceedances are defined as the ratio of the chemical concentration in the medium of interest to the ecological screening factors for surface water, sludge, and soil, as appropriate.

Figure 3-2 presents the nationally weighted facility results correlated with potentially sensitive ecosystems such as wetlands and managed areas (e.g., national wildlife refuges, national forests). Approximately 25 percent of all facilities that show screening-level risk exceedances are located within 1 km of a permanently flooded wetland or 3 km of a managed area. Figure 3-2 illustrates the relative level of exceedances for lower concern (light shading) and potential concern (dark shading). At facilities identified as of potential concern, 19 percent are located within 1 km of a wetland and 7 percent are located within 3 km of a managed area. At facilities listed as lower concern, 19 percent are located within 1 km of a wetland and 14 percent are located within 3 km of a managed area. Slightly more than 3 percent of these facilities have both a wetland within 1 km and a managed area within 3 km.

3.5.2.1 *Quantitative Risk Estimation for Ecological Risk Screening*. Tables 3-24 and 3-25 summarize the ecological screening results. Because of the screening nature of the assessment and the precautionary exposure assumptions used, these results are associated with a high level of uncertainty. As shown in Table 3-24, 29 percent of facilities may pose potential concern for ecological receptors. Table 3-24 distinguishes the facilities according to whether they manage decharacterized wastes, and Table 3-25 distinguishes facilities according to their discharge status. Most of the facilities of potential concern manage never characteristic wastes and are direct dischargers. This is consistent with the fact that 80 percent of facilities manage never characteristic wastes and the vast majority of facilities are direct dischargers.

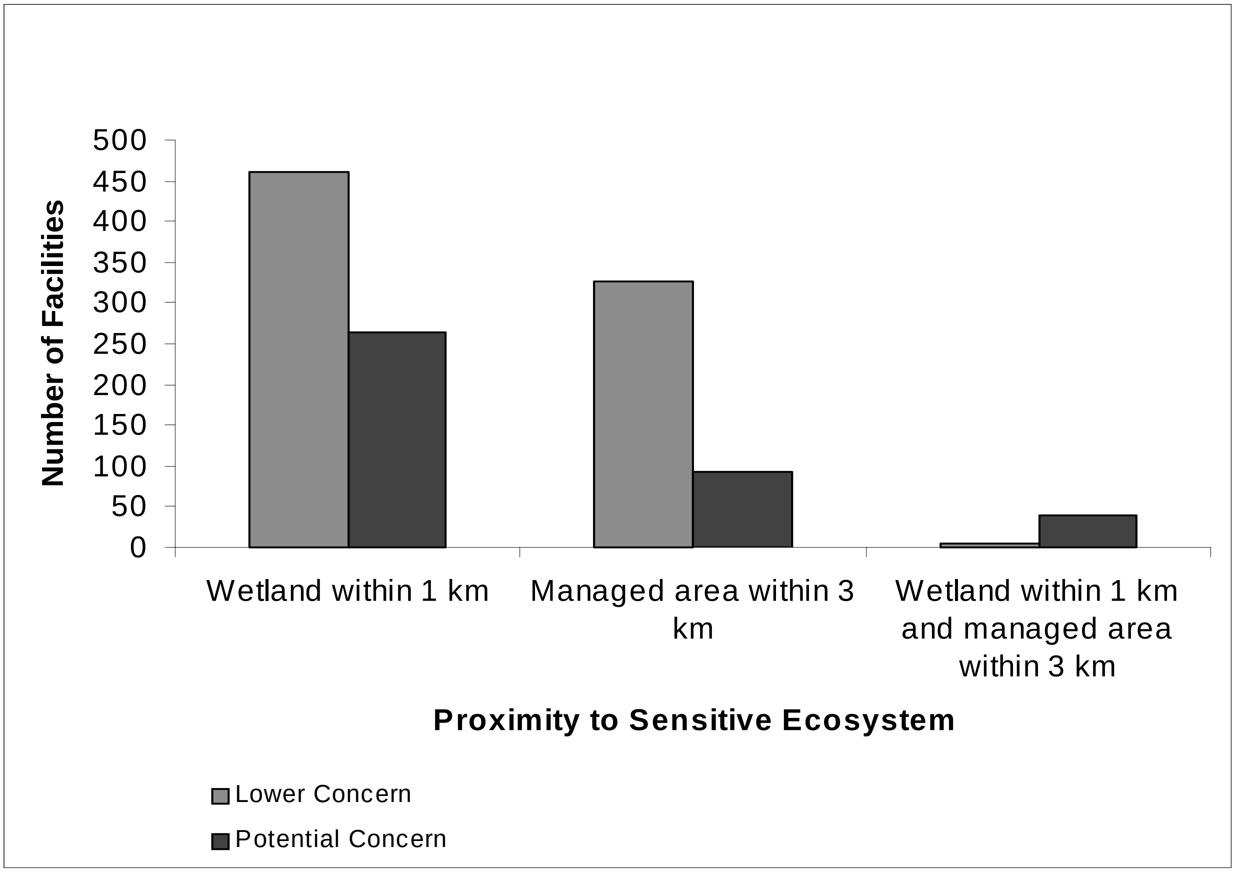

Figure 3-2. Summary of sensitive ecosystem analysis.

Table 3-24. Facility-Level Results for Ecological Risk by Decharacterization Status

Facility Status	Lower Concern[a]	Potential Concern[a]
Never characteristic	2,007 (45%)	1,037 (23%)
Decharacterized	352 (8%)	273 (6%)
All facilities	2,359 (53%)	1,310 (29%)

[a] Number of facilities (percentages are of the total number of facilities, approximately 4,500).

Table 3-25. Facility-Level Results for Ecological Risk by Discharge Status[a]

Facility Status	Lower Concern[a]	Potential Concern[a]
Direct dischargers	2,058 (46%)	1,072 (24%)
Zero dischargers	101 (2%)	160 (4%)
All facilities[b]	2,160 (48%)	1,232 (28%)

[a] Number of facilities (percentages are of the total number of facilities, approximately 4,500).
[b] The facility total for Table 3-25 does not equal the facility total for Table 3-24 because the patterns of missing data are different for each of the tables, and the weight adjustments for missing data lead to slightly different estimates.

3.5.3 Discussion of Uncertainties Associated with Screening Ecological Risk Analysis

The screening nature of the analysis leads to several major areas of uncertainty that affect interpretation of the results. These are grouped under parameter uncertainties, modeling uncertainties, and results uncertainties. Additional details on these uncertainties are presented in Appendix C to this report.

3.5.3.1 Parameter Uncertainties. The key parameters required for the ecological risk screening include the list of ecological receptors assigned to each facility, dietary assumptions, and ecological screening factors. As appropriate for screening-level analyses, the selection of parameter values tends to support a precautionary assessment.

- **Ecological Receptor Assignments.** Ecological receptors were assigned at each facility as a function of the land use patterns and presence of wetlands and/or fishable waterbodies. This adds to the protective nature of the screening assessment because not all facilities are located in areas of sufficient ecological quality to sustain those receptors.

- **Assumptions on Dietary Exposure.** Screening-level assessments typically assume exclusive intake of contaminated prey in the diets of primary and secondary consumers (i.e., 100 percent of the diet originates from the contaminated area), providing a very conservative estimate of potential risks.

- **Conservatism of Screening Factors.** Because the screening factors were generally based on benchmarks for very low levels of effect for sensitive endpoints, these factors tend to be precautionary of wildlife species and natural communities.

3.5.3.2 *Modeling Uncertainties*. The screening ecological risk assessment did not involve fate and transport modeling of chemical movement and uptake into plants and prey items. Consequently, this direct exposure approach is precautionary in the sense that it implies actual usage of the impoundment as habitat.

- **Spatial Scale of Exposure.** The screening level of resolution does not provide insight into the scope/size of ecological impacts. The size of the contaminated area is a critical determinant of the risk results because larger areas dilute chemical concentrations. Restricting the area to the impoundment tends to bias the results toward an overestimate of risk.

- **Temporal Scale of Exposure.** The timing is assumed to include the entire life stage of the wildlife species evaluated or, in the case of community-type receptors (e.g., soil biota), a period that is relevant to the structure and function of the community. The chronic, low-level exposure that this implies may be underprotective of some species during sensitive lifestages or of short-lived species.

- **Constant Chemical Concentration.** The chemical concentration was assumed to be constant for the screening analysis when, in reality, the chemical concentrations in plants, prey, and media will vary over time and space. A constant chemical concentration will tend to overpredict the potential risks to wildlife.

- **Chemical Behavior.** For screening purposes, all forms of a constituent are assumed to be equally bioavailable and toxic. This assumption may either overestimate or underestimate the actual exposures, depending on the environmental characteristics. For example, the form of arsenic (i.e., elemental, ionic, and methylated) has been shown to influence toxicity profoundly.

- **Single Chemical Exposures.** The risk of each constituent is considered separately in this analysis, and this may overlook possible synergistic effects. This is one example of a potential underestimation of adverse effects.

3.5.3.3 *Results Uncertainties*. As with any screening ecological risk assessment, there is considerable uncertainty in the risk results associated with simplifying assumptions and data limitations such as ecological benchmarks. Moreover, the screening analysis does not address the potential significance of predicted ecological impacts. Although the ecological risk results indicate that the potential for adverse ecological effects exists at these facilities, it is not possible to quantify that potential within the broader context of ecological health and sustainability. Key uncertainties to consider in interpreting the risk results are as follows:

- **Concentration Data Source.** A portion of the risk findings are based on surrogate data and detection limits, rather than on reported concentrations, which contributes to the overall uncertainty in the results.

- **Data Gaps.** Protective ecological screening factors were developed for constituents when sufficient data were available, which, for this analysis, included 41 chemicals. The absence of benchmarks may lead to the underestimation of risks associated with stressors for those chemicals that could not be evaluated.

- **No Additional Stressors.** The only stressor assumed in the screening analysis is the introduction of chemicals into the environment. In the field, wildlife may be exposed to a variety of stressors (e.g., habitat alteration) and, therefore, the risk results may underestimate the potential for adverse effects.

- **Threatened/Endangered Species.** Only common species were evaluated in this analysis. The sensitivity of endangered species that are already under substantial stress is not accounted for explicitly. Although the selection of screening approach and parameters is inherently precautionary, it is possible that the results do not capture the risks to sensitive species and habitats.

3.6 Summary and Conclusions

This section summarizes several key findings of the risk assessment and highlights findings that address the statutory requirements for the scope of the study.

The assessment of potential risks posed by surface impoundments was based on a tiered approach designed to address comments from EPA's Science Advisory Board and external peer review comments on the technical plan. The first stage of this tiered approach was an initial screening based on precautionary exposure assumptions. Subsequent stages increased the level of realism through the use of increasing levels of facility-specific data, screening-level models, and site-based models. At each stage in the analysis, EPA was able to identify chemicals at particular surface impoundments and facilities that did not require further analysis. Given the design of the overall approach, which proceeds from precautionary exposure scenarios to realistic exposure scenarios, and based on the data available to EPA, the Agency has concluded that those constituents and impoundments do not pose significant risks to human health or the environment.

The risk estimates developed in this study for human health and the screening conducted for indirect exposures and ecological risks are based on an extensive analysis of the survey data reported for a wide array of chemicals and impoundments of potential concern. EPA acknowledges the uncertainties in the predicted risks and considers the following findings to be representative of the population of industrial surface impoundments managing wastewaters.

3.6.1 Summary of Major Risk Analysis Findings

- Most facilities and impoundments nationally do not appear to pose risks to human health through environmental releases. Two percent of impoundments and 5 percent of facilities show potential risk exceedances for at least one pathway, based on reported concentration data.

- Twenty-four percent of impoundments (21 percent of facilities) have the potential for environmental releases to occur from impoundments by at least one pathway, considering the chemical concentrations present in the impoundments and site-specific attributes such as the presence or absence of liners and proximity to surface water. These releases do not appear to pose risks to human health; however, some degradation of the environment is possible.

- For 23 percent of facilities and impoundments overall, EPA was not able to estimate potential risks with any confidence due to lack of chemical concentration data. This study portrays a range of possible findings, limited to the extent they are based on inferred data and detection limits, that may provide insights into potential risks or environmental releases for some portion of these facilities.

3.6.2 Findings by Pathway Based on Risk Analysis

- **Direct inhalation** risks can occur if a toxic chemical volatilizes from the impoundment's water surface, is carried by air dispersion to nearby residences, and then is inhaled by residents. EPA developed risk estimates for the closest residences, based on locations reported in the surveys or identified through census information, and generated national estimates of the proportion and number of facilities and impoundments exceeding levels of concern. Most facilities (87 percent) and impoundments (92 percent) appear to pose no concern. Four percent of facilities and three percent of impoundments do not pose risks, but do show releases that exceed levels of concern within 25 meters from impoundments. Four percent of facilities and one percent of impoundments are estimated to have a potential for risk exceedances to occur. Five percent of facilities and 4 percent of impoundments cannot be assessed with confidence due to incomplete reporting of concentration data. For those chemicals with reported concentration values, only chlorodibromomethane and alpha-hexachlorocyclohexane exceeded risk criteria and only acetaldehyde contributed to a calculated facility risk of potential concern.

- **Groundwater** ingestion risks can occur if impoundments release toxic chemicals through the bottom or sides of the impoundment and these chemicals enter groundwater and move through the subsurface to a drinking water well. EPA developed risk estimates that could occur at the closest drinking water wells reported in the surveys. If survey data were not available, EPA used census information and assigned the receptor well to the nearest residence identified with a census block that reports drinking water well usage. The majority of facilities and impoundments appear to pose no concerns. A very small percentage of facilities and impoundments have the potential for risk exceedances to occur at the time the impacted groundwater reaches the closest well. Fourteen percent of facilities and eleven percent of impoundments do not appear to pose risks but are predicted to generate groundwater releases that will exceed levels of concern at or beyond 150 meters of the unit boundary. About 19 percent of facilities and 22 percent of impoundments cannot be assessed with confidence due to the lack of concentration data.

- **Groundwater to surface water** risks can occur if impoundments release toxic chemicals through the bottom or sides of the impoundment and these chemicals migrate through groundwater, discharge into nearby surface water, and contaminate fish and drinking water supplies. EPA identified exceedances of human health ambient water quality that could occur to surface waterbodies that were reported in the surveys and generated national estimates. Fifty-six percent of facilities do not appear to pose concerns by this pathway. About 18 percent of facilities may produce contaminated groundwater concentrations that exceed the HH-AWQC at the point of entry into the surface waterbody. One percent of facilities may contribute to exceedances of EPA's HH-AWQC by this pathway. About 25 percent of facilities could not be assessed with confidence because of the lack of concentration data.

3.6.3 <u>Findings Based on Risk Screening</u>

EPA also screened for potential risks to human health through other indirect pathways and screened for potential risks to ecological receptors.

- **Indirect pathway** risks can occur when humans ingest food sources that have been contaminated indirectly by surface impoundment releases. For example, toxic chemicals can evaporate, move by dispersion through air, and then deposit on nearby crops and contaminate food sources. Another example may occur when impoundments close with sludge left in place; chemicals present in those sludges can move with stormwater, or by erosion, onto nearby soil and crops or can be dispersed as dust. Based on a screening analysis and precautionary assumptions, an estimated 6 percent of facilities nationally may pose the greatest potential concern through indirect pathways.

- **Ecological** risks are possible for flora and fauna in natural systems located near impoundments. Many impoundments are located near rivers and waterbodies and are freely accessible to wildlife. The objective of the ecological screening was to characterize the national potential for adverse ecological effects associated with the management of chemicals in impoundments considered within the scope of this study. Although the screening methods imply that the impoundment is used directly as habitat, the intent of the screen is to characterize the potential for adverse ecological effects at the site, not simply from direct use of the impoundment. The measure of this potential was based on ecotoxicological endpoints relevant to the sustainability of wildlife populations (e.g., reproductive effects) and the structure and function of communities (e.g., growth and survival of key species). Based only on this initial screening level analysis and using precautionary assumptions, no more than 29 percent of facilities nationally may pose potential concerns to ecological receptors that live near, or make direct use of, surface impoundments.

3.6.4 *Additional Findings of Interest*

EPA examined potential risks for decharacterized wastes separately from never characteristic wastes and also examined potential risks depending on discharge status. This was to address the statutory intent in the 1996 Land Disposal Program Flexibility Act that the study assess decharacterized wastewaters managed in surface impoundments subject to the Clean Water Act.

- The results suggest that impoundments managing decharacterized waste may be associated with higher risks than those managing never characteristic waste for two pathways of concern. For one pathway, direct inhalation, the trend is reversed, with never characteristic waste representing two-thirds of the overall risk. This is largely because most impoundments (about 80 percent) manage never characteristic wastes. However, for all pathways, including direct inhalation, the rates of risk exceedances for decharacterized wastes were higher than for never characterized wastes.

- The bulk of facilities are direct dischargers; consequently, most of the potential risk exceedances and environmental releases are associated with direct dischargers. For the groundwater to surface water pathway, the rates of potential HH-AWQC exceedances are much higher for zero dischargers even though the national numbers in that group are relatively small.

Reference

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U.S. EPA (Environmental Protection Agency). 1998. *Industrial Waste Air Model Technical Background Document*. EPA-530-R-99-004. Washington, DC: U.S. Government Printing Office.

U.S. EPA (Environmental Protection Agency). 1999a. *Technical Background Document: Industrial Waste Management to Support the Guide for Industrial Waste Management.* EPA530-R-99-002. Washington, DC: U.S. Government Printing Office.

U.S. EPA (Environmental Protection Agency). 1999b. *User's Guide for the Industrial Waste Management Evaluation Model (IWEM): Tier 1 Look-up Tables and Tier 2 Neural Networks.* EPA530-R-99-003. Washington, DC: U.S. Government Printing Office.

Chapter 4

Regulatory/Program Coverage and Gaps Analysis

4.0 Introduction and Background

This chapter presents EPA's regulatory/program coverage and gaps analysis in support of the Surface Impoundment Study. The regulatory/program coverage and gaps analysis was conducted to satisfy provisions of (1) the Land Disposal Program Flexibility Act of 1996 and (2) a consent decree in the matter of *EDF v. Whitman*. The methodology and regulatory coverage findings are summarized under the following sections:

4.1 Regulatory/Program Analysis Methodology

4.2 Coverage and Potential Gaps in Existing Programs and Regulations Addressing Air Risks

4.3 Coverage and Potential Gaps in Existing Programs and Regulations Addressing Nonair Risks

4.4 The Role of EPA's Multimedia Strategy for PBT Pollutants in Reducing Risks from Surface Impoundments.

4.1 Regulatory/Program Analysis Methodology

The general approach for conducting the regulatory coverage and gaps analysis for this study required a detailed review of provisions in applicable federal and state programs that address surface impoundments, an evaluation of the extent to which the constituents of concern are specifically addressed by such programs, and the extent to which the industry categories covered by this study are addressed by the programs. The regulatory coverage and gaps were identified and evaluated based on potential risks found by the human health and ecological risk screening analyses, as described in Chapter 3. The regulatory gaps analysis addresses coverage for each of the two human direct exposure pathways of concern (i.e., air and groundwater), indirect pathways including groundwater releases to surface water, and other indirect pathways. The information reflects risk results with varying levels of certainty. The level of certainty depends, in part, on the extent to which the results were based on (1) reported concentration values, and (2) surrogate data (including detection limit values). Regulatory gaps identified based on this information thus carry the same level of varying certainty.

4.1.1 *Approach for Conducting Regulatory/Program Coverage and Gaps Analysis for Air Risks*

To evaluate regulatory coverage and potential gaps in regulations addressing air releases from surface impoundments, EPA identified existing federal and state programs that potentially address such releases. Federal programs evaluated included RCRA hazardous and nonhazardous waste programs and the Clean Air Act. The specific activities and related analyses are summarized below. The detailed analysis is presented in Section 4.2.

Existing RCRA Regulations/Programs That Can Address Air Risks from Non-Hazardous Surface Impoundments. EPA evaluated existing RCRA regulations and programs that address air emissions from nonhazardous waste surface impoundments. RCRA programs (both federal and state) are included in this part of the analysis primarily to address the requirement of the LDPFA to evaluate the extent to which existing federal and state programs address risks posed by decharacterized wastes in surface impoundments. The coverage analysis also applies to never characteristic wastes managed in surface impoundments, thereby providing additional information to support EPA's obligations under the EDF consent decree. Programs evaluated were:

- RCRA Subtitle C corrective action program (and the authority under RCRA section 3005) to address air risks from nonhazardous surface impoundments located at RCRA interim status and permitted facilities,
- RCRA Subtitle D (nonhazardous) waste regulations and state programs that address air emissions from nonhazardous waste surface impoundments,
- EPA's draft *Guide for Industrial Waste Management* (U.S. EPA, 1999a),
- Toxicity characteristic (TC) (to assess whether the management of impoundment wastewaters not classified as hazardous by the TC could still result in environmental air releases), and
- Other nonregulatory programs including the use of Supplemental Environmental Projects (SEPs) and EPA's Multimedia Strategy for Persistent, Bioaccumulative, and Toxic Pollutants.

Existing RCRA Subtitle C Hazardous Waste Regulations and Programs That Address Air Emissions from Hazardous Waste Surface Impoundments. Even though the focus of the surface impoundment study is on nonhazardous wastes, hazardous waste requirements were included in this part of the analysis to address the extent to which regulations can address air risks from wastes in impoundments if these wastes were newly characterized or listed as hazardous wastes. If a waste were classified as hazardous, then it would be subject to current Subtitle C requirements.

The following provisions within the Subtitle C program were evaluated to determine the extent to which these programs can address potential air risks: requirements for hazardous waste management units (e.g., Subpart K, Surface Impoundments), RCRA air emission control standards (e.g., Subpart CC—Air Emission Standards for Tanks, Surface Impoundments, and Containers), land disposal restrictions, the omnibus permitting authority under RCRA section 3005(c)(3), and the RCRA corrective action program.

This discussion assumes these wastes will continue to be managed in surface impoundments even if they became subject to the Subtitle C requirements. It is perhaps more realistic to assume that these wastes would be managed in tanks if they became subject to the Subtitle C requirements (such that the LDR requirements would not apply). The tank management scenario was evaluated as part of EPA's Air Characteristics Study (U.S. EPA, 1998, 1999b).

Existing Clean Air Act Programs. The primary focus of the air pathway analysis was the CAA requirements. Identifying potential gaps in current CAA regulations was required to fulfill one of the obligations in the EDF consent decree. The analysis also provided information needed to satisfy the requirements of the LDPFA. The analysis involved three interrelated elements: (1) a waste management unit analysis to identify provisions within the CAA that can address surface impoundments, (2) a constituent coverage analysis that focused on the constituents of concern from the risk assessment, and (3) an industry coverage analysis that focused on the industry categories within the scope of this study.

The outputs of the waste management unit, constituent, and industry analyses were integrated with the findings of the risk assessment to identify those constituents and industry categories for which regulations or programs may not adequately address potential risks.

4.1.2 Approach for Conducting Regulatory Program Coverage and Gaps Analysis for Nonair Risks Found from Managing Nonhazardous Waste in Surface Impoundments

In addition to examining potential air risks, EPA investigated risks to other media as well. In this portion of the analysis, EPA assessed program coverage of (1) risks resulting from consumption of groundwater containing constituents released from surface impoundments, (2) risks resulting from the contamination of surface water (from the groundwater pathway), (3) risks posed via other indirect pathways (e.g., erosion runoff and deposition), and (4) ecological risks, collectively identified as "nonair risks." EPA evaluated the extent to which these predicted risks are adequately addressed under existing federal and state programs.

4.1.2.1 Approach for Conducting Regulatory/Program Coverage and Gaps Analysis for Groundwater and Surface Water Risks Found from Managing Nonhazardous Waste in Surface Impoundments. Leachate from a nonhazardous waste surface impoundment can potentially migrate through the subsurface and affect groundwater and surface water quality. Therefore, it was necessary to identify existing regulations and programs that address the release of constituents from nonhazardous waste surface impoundments to groundwater and surface water.

The general approach for identifying regulatory coverage by federal and state programs comprises four general steps:

1. Use the risk analysis results to identify constituents posing potential risks to groundwater.

2. Identify federal regulations and programs that address releases to groundwater from nonhazardous waste surface impoundments.

3. Identify state regulations and programs that address releases to groundwater from nonhazardous waste surface impoundments.

4. Determine if gap exists.

4.1.2.2 *Approach for Conducting Regulatory Program Coverage and Gaps Analysis for Risks Associated with Other Indirect Pathways*. As discussed in Chapter 3, EPA evaluated potential risk scenarios from indirect pathways, including air deposition to surrounding crops and exposures resulting from runoff and erosion of contaminated sludge particles onto local farms and gardens. Runoff and erosion of contaminated sludge was assumed to occur after closure; therefore, EPA evaluated regulations and programs addressing industrial runoff, corrective action, and postclosure care. EPA did not evaluate regulatory coverage of indirect risk posed by air deposition separately; it is included in the air pathway coverage analysis.

4.1.2.3 *Approach for Conducting Regulatory Program Coverage and Gaps Analysis for Ecological Risks*. The approach for evaluating regulatory coverage and gaps for any ecological risks focused on reviewing regulations, programs, and guidance on location standards for new units and other provisions in federal and state programs designed to protect endangered and threatened species and habitats.

4.2 Coverage and Potential Gaps in Existing Programs and Regulations Addressing Air Risks

> The intent of this chapter is to identify existing programs/regulations that are used to address risks from surface impoundments and to identify possible gaps in them based on the results of the risk assessment. If EPA determines these gaps must be addressed, then the Agency may either: (1) use existing programs as tools to address the gaps or (2) propose changes to existing regulations or propose new regulations to address the gaps, such as new LDR requirements, a new hazardous waste characteristic, a new hazardous waste listing, or perhaps investigate the protectiveness of some of the hazardous waste exclusions/exemptions.

One of the primary objectives of the surface impoundment study was to investigate gaps in the current hazardous waste characteristics and CAA programs for air risks associated with managing never characteristic wastes in surface impoundments. A related objective was to address the requirements of section 3004(g)(10) of RCRA, as amended by the LDPFA, which required EPA to evaluate the extent to which risks posed from decharacterized wastes in surface impoundments are adequately addressed under existing state and federal programs. This part of the study, which in part fulfills EPA's obligation under both the EDF consent decree and the LDPFA, describes the Agency's analysis of coverage by regulations that address air risks posed by wastes managed in surface impoundments.

The regulatory coverage and gaps analysis for the air pathway addresses relevant RCRA, CAA, and state regulations and programs; however, emphasis is placed on those constituents that did not screen out of the study upon completion of the risk assessment for the air pathway. The direct inhalation risk assessment determined that air emissions from surface impoundments can, in some cases, potentially exceed the specified risk threshold. Specifically, the risk assessment identified the possibility of risks associated with 13 chemicals. Refer to Chapter 3 for more detailed information on the risk assessment findings.

4.2.1 Existing RCRA Rules and Programs That Address Air Risks

Existing RCRA Subtitle C and Subtitle D programs include various provisions that, when implemented, can limit air emissions from nonhazardous waste surface impoundments. This section includes the following:

- An analysis of the ability of the RCRA Subtitle C corrective action program (and the authority under RCRA section 3005) to address air risks from nonhazardous surface impoundments located at RCRA interim status and permitted facilities (Section 4.2.1.1).

- An analysis of Subtitle D (nonhazardous) RCRA waste regulations and state programs that address air emissions from nonhazardous waste surface impoundments (Section 4.2.1.2).

- An analysis of coverage by EPA's draft *Guide for Industrial Waste Management* (Section 4.2.1.3).

- An analysis of the TC regulatory levels to determine if the management of impoundment wastewaters not classified as hazardous by the TC (e.g., decharacterized wastewaters or wastewaters that have never been hazardous waste) could still result in environmental air releases (Section 4.2.1.4).

- A description of EPA's enforcement program for SEPs and how it may be used to address risks posed by nonhazardous waste surface impoundments. Note that the use of SEPs is discretionary, and their potential application for addressing risks posed by surface impoundments would be determined on a case-specific basis (Section 4.2.1.5).

Finally, EPA's Multimedia Strategy for Persistent, Bioaccumulative, and Toxic (PBT) Pollutants (PBT Strategy) has the goal of reducing risks to human health and the environment from current and future exposure to priority PBT pollutants. See Section 4.4 for an evaluation of how the PBT initiative may affect constituents that may be found in surface impoundments.

4.2.1.1 RCRA Corrective Action Program, Permitting Authority under RCRA 3005, and RCRA 7003. Facilities that treat, store, or dispose of hazardous waste (TSDFs) must apply for a RCRA Subtitle C permit. Under RCRA 3004(u), RCRA permits must require corrective action for releases of hazardous waste or constituents from any solid waste management units

(SWMUs) as necessary to protect human health and the environment. TSDFs that have not yet received permits and have been authorized to operate under interim status may be compelled to conduct corrective action under section 3008(h). Under the RCRA corrective action program, a surface impoundment containing nonhazardous waste located at a TSDF is considered an SWMU. Therefore, releases from these impoundments, including air emissions, are subject to corrective action requirements on a site-specific basis.[1] EPA can incorporate specific corrective action requirements into the permit during the permitting process or when a permit is already in place. Corrective action requirements could include interim measures (e.g., use of a temporary cover), institutional controls (such as deed restrictions or access controls), and application of remediation technologies designed to contain, remove, and/or destroy contamination.

The survey indicates that about 33 percent of the surface impoundments nationwide that fall within the scope of this study have been designated as SWMUs pursuant to the RCRA corrective action RCRA Facility Assessment (RFA) process (see also Chapter 2, Section 2.5, for additional information on the permit and corrective action status of impoundments within the scope of this study). This indicates that a significant number of nonhazardous surface impoundments are located at RCRA TSD facilities; these impoundments are being addressed by EPA and the states on a priority basis, and thus no regulatory gaps should exist for these impoundments.

RCRA contains various additional permitting requirements for facilities. The omnibus permitting authority at RCRA section 3005(c)(3) requires EPA to include in permits any requirements necessary to protect human health and the environment. For impoundments containing nonhazardous waste, permit writers may use their omnibus permitting authority under RCRA 3005(c)(3) to impose additional standards to achieve the health-based requirements of RCRA 3004(n).

RCRA section 3005(h) mandates, as a permit condition, that TSDFs that are also generators must have a program in place to reduce the volume and toxicity of the waste they generate. These waste minimization requirements, to the extent they are used to minimize concentrations of constituents of concern that might be released to the air pathway, provide some potential for control of air emissions.

Note that the imminent and substantial endangerment provision of RCRA section 7003 allows EPA, upon evidence of past or present handling of solid or hazardous waste, to require any action necessary if a situation presents an imminent and substantial endangerment to health or the environment. This authority applies to all facilities that manage solid waste, whether or not they have a RCRA permit, and could be used at any impoundment that is within the scope of this study if the situation meets the statutory threshold.

4.2.1.2 *Coverage by State Waste Programs*. Historically, regulation of nonhazardous waste has been provided by the states; however, state nonhazardous waste regulations typically

[1] See also EPA's policy on integrating RCRA corrective action with requirements imposed in permits issued pursuant to other environmental laws at 55 FR 30798, 30808 (July 27, 1990), and 61 FR 19423, 19442 (May 1, 1996).

do not include provisions that address inhalation risks from nonhazardous waste surface impoundments. Previous studies summarizing state nonhazardous waste regulations, including ASTSWMO (1996), ICF (1993), and U.S. EPA (1995a, 1995b), provide limited information on programs for controlling air emissions from industrial nonhazardous waste surface impoundments.

EPA's own analysis for this study indicates that, of the 50 states, only six have waste regulations or other waste programs in place that address, to some degree, air emissions from industrial nonhazardous waste surface impoundments. These states are California, Colorado, Delaware, Louisiana, Maryland, and Pennsylvania (see also Appendix D, Section D-1, Summary of State Regulations and Programs Covering Nonhazardous Industrial Waste Surface Impoundments). The type of regulatory coverage varies considerably among these states. For example, some states require monitoring and reporting of emissions and some require permits. Another state regulates both fugitive dust and gas emissions. Note that this program coverage discussion applies to waste programs (i.e., RCRA) and not air programs. State air regulations should provide more extensive coverage for air releases from surface impoundments.

Note that EPA's analysis of state waste regulations and programs in Appendix D is based on publicly available information rather than a survey of state regulators. EPA did not review state air programs. Therefore, the analysis may not have identified all state regulations and programs that address nonhazardous waste industrial surface impoundments. Furthermore, the state regulatory coverage may change in the future.

Federal regulations for solid waste disposal facilities (including nonhazardous waste surface impoundments) are given in 40 CFR Part 257, Criteria for Classification of Solid Waste Disposal Facilities and Practices. Regulations that specifically address potential impacts to air are identified in 40 CFR 257.3-7. However, the Part 257 applicability to air emissions from surface impoundments of this study is limited to restrictions on open burning and referencing applicable State Implementation Plan (SIP) requirements (see Part 257.3-7(a) and (b)). The regulatory coverage of the Part 257 requirements does not provide additional restrictions beyond those provided by the SIPs. Due to the complexity and potential for change, as noted above, SIPs were not evaluated as part of this study.

4.2.1.3 Coverage by EPA's Draft Guide for Industrial Waste Management. In 1999, EPA's Office of Solid Waste, in collaboration with states, industry, and environmental groups, published the draft *Guide for Industrial Waste Management* (U.S. EPA, 1999a). The document, which is voluntary and commonly referred to as the "Industrial D Guidance," evaluates all aspects of the design and operation of industrial waste management facilities to enable these facilities to protect human health and the environment. It is designed primarily for new units and can be used by state regulatory programs to evaluate their existing programs. The approach taken in the guide is site-specific to help communities and facility managers identify a protective facility site, design, and operation that fits their needs.

The draft guide recommends a three-part strategy for addressing potential air risks from waste management units (including surface impoundments). First, the guide helps the user determine whether the waste management unit(s) is already subject to requirements under the

Clean Air Act. Second, the guide provides a tool (the IWAIR model software) to assess risks associated with toxic air emissions. Third, the guide suggests the user implement pollution prevention, treatment, or controls to reduce risks, if appropriate. For the protection of air, 95 constituents are addressed in the draft guide.

The extent to which risk assessment constituents of concern are addressed by this guide is discussed in Section 4.2.3.2.

4.2.1.4 *Toxicity Characteristic Regulatory Levels*. Under RCRA regulations, a solid waste is defined as a hazardous waste if it either is listed as a hazardous waste or exhibits one of the four characteristics of a hazardous waste (i.e., toxicity, ignitability, corrosivity, or reactivity). Wastes are listed as hazardous based on the criteria set forth in 40 CFR 261.11. Once listed, the waste is presumed hazardous regardless of the concentration of hazardous constituents present (unless the generator has successfully petitioned EPA to delist the waste) and must be managed in accordance with Subtitle C standards. In contrast to hazardous waste listings, the toxicity characteristic provides concentration-based regulatory thresholds used to identify wastes that present significant hazard and therefore should be managed under Subtitle C. The regulations defining the other three characteristics (ignitability, corrosivity, and reactivity) do not generally address specific constituents and are not addressed in this analysis.

The TC was designed to protect against human health risks from exposure to hazardous waste constituents released to groundwater. EPA's current definition of toxicity was promulgated in 1990, replacing the Extraction Procedure (EP) leach test with the Toxicity Characteristic Leaching Procedure (TCLP). The final TC rule added 25 organic chemicals to the eight metals and six pesticides on the existing list and established regulatory levels for these constituents. All 39 TC constituents (40 including total cresols) are also on the list of 256 constituents of interest for this study.

Wastewaters with TC constituent concentrations meeting or exceeding the TC regulatory levels would be hazardous, subject to the protective measures required under RCRA Subtitle C regulations (unless exempted or excluded from regulation), and thus are not within the scope of this study. To determine if wastewater concentrations at or below TC levels could still result in environmental releases to the air pathway, a direct comparison was made between the milligram/liter TC levels in the regulations (40 CFR 261.24) and waste concentrations in surface impoundments predicted to cause environmental air releases. For purposes of this analysis, environmental air releases are defined as air releases from surface impoundments that result in predicted risks as indicated by the screening-level Industrial D risk model for receptors at a default distance of 25 meters rather than site-specific distances to receptors. This comparison is presented in Appendix D, Section D-2.

The wastewater concentrations (presented as ranges in Appendix D) are divided into three categories: concentrations with predicted inhalation risks less than the risk criteria, concentrations with predicted risks in the range of 10E-5 to 10E-4 or HI of 1 to 10, and concentrations with predicted risks greater than 10E-4 or HI greater than 10. It is appropriate to report a range of concentration values because risk results for a given constituent varied significantly due to factors such as the concentration of the constituent in the wastewater, the size of the impoundment, where it is located, and whether it is aerated.

The comparison indicates that concentrations of 10 TC constituents in surface impoundment wastewater may result in environmental air releases at concentrations less than their respective TC regulatory levels. As mentioned above, this conclusion is based on the use of a screening-level risk model employing conservative assumptions (i.e., chronic exposure at 25 meters). The 10 constituents include nine volatile organics plus mercury. For the remaining nine volatiles on the TC list, there were no concentration data that yielded predicted environmental releases. This does not mean, however, that the TC regulatory levels for these constituents prevent environmental air releases (we did not evaluate whether environmental air releases would occur if concentrations of these constituents increased). The remaining 21 non-volatiles on the TC list are constituents that would not likely cause environmental air releases, and risk estimates were not conducted for these constituents.

The TC constituents that show the potential for environmental air releases in Appendix D-2 reflect risk results with varying levels of certainty. The level of certainty depends, in part, on the extent to which the results were based on (1) reported concentration values and (2) surrogate data (including detection limit values). For this analysis, we did not determine the extent to which predicted environmental air releases were based on reported or surrogate data.

4.2.1.5 <u>Use of Supplemental Environmental Projects to Address Risk from Surface Impoundments</u>. If EPA or a state believes that an individual or company has failed to comply with federal environmental laws, it may initiate an enforcement action. Enforcement actions are taken to require an individual or company to return to compliance and deter others from violating these laws. Enforcement settlements may also include Supplemental Environmental Projects (U.S. EPA, 2001). EPA's SEP Policy encourages the use of environmentally beneficial projects as part of the settlement of an enforcement action. Through SEPs, the settlement of an enforcement action can result in environmental and public health protections beyond that specifically required by law. There must be some connection between the SEP and the kinds of concerns addressed by the statute or statutes that were violated (EPA SEP Policy, May 1, 1998). The SEP Policy provides criteria to guide when and how SEPs may be included as part of a settlement. SEPs may not be appropriate in the settlement of all cases, but they are an important part of EPA's enforcement program.

SEPs are actions taken by an individual or company that are in addition to what is required to return to compliance with environmental laws. A SEP is an environmentally beneficial project that a violator voluntarily agrees to perform. When volunteering to perform a SEP, a company must show that it can and will complete the project and must provide all funds used to finance the project. EPA provides oversight to ensure that the company does what it promises to do. EPA, however, does not manage or control the funds.

EPA has seven specific categories of projects that can be acceptable SEPs. These include Pollution Prevention, Pollution Reduction, Public Health, Environmental Restoration and Protection, Assessments and Audits, Environmental Compliance Promotion, and Emergency

Planning and Preparedness. Other acceptable SEPs would be those that have environmental merit but do not fit within the categories above (U.S. EPA, 2000b).

In the context of a nonhazardous waste surface impoundment, a violation of existing regulations affecting a facility could result in an enforcement action and then, as a condition of the settlement, EPA and the defendant could agree upon a SEP that is related to reducing the risks posed by a surface impoundment at the facility. A SEP related to a surface impoundment could include closure, installation of a liner, or implementation of some other measure that would eliminate or reduce risk to the environment and/or public health.

4.2.2 Extent to Which Current RCRA Subtitle C Regulations Address Risks from Wastes Newly Classified as Hazardous

Subtitle C of RCRA established management practices to safely control hazardous wastes from the point of generation to final disposal. If a waste stream that is within the scope of this study was newly classified as hazardous based on a new characteristic or listing, then it would be subject to current Subtitle C requirements for hazardous waste surface impoundments (assuming the waste stream continued to be managed in a surface impoundment). Therefore, the RCRA hazardous waste regulations relevant to the regulatory analysis include those that limit air emissions from surface impoundments. Several RCRA Subtitle C regulations and RCRA statutory provisions have this effect, including

- Requirements for hazardous waste management units (e.g., Subpart K—Surface Impoundments)
- RCRA air emission control standards (e.g., Subpart CC—Air Emission Standards for Tanks, Surface Impoundments, and Containers)
- Land disposal restrictions
- Omnibus permitting authority under RCRA section 3005(c)(3)
- RCRA corrective action program.

These regulations and provisions are discussed in Sections 4.2.2.1 through 4.2.2.5.

4.2.2.1 Subpart K—Surface Impoundments. RCRA standards for hazardous waste TSDFs include specific requirements for surface impoundments. Because a new characteristic or listing could subject additional wastes to RCRA Subtitle C standards, it would also subject surface impoundments managing the waste to Subtitle C standards and permitting as well, if such units do not currently manage hazardous wastes (and the wastes are continued to be managed in the impoundments). Thus, affected surface impoundments would be subject to the requirements at 40 CFR Parts 264 and 265, Subpart K. These requirements include the use of double liners, leachate collection, leak detection, inspection, waste analysis, financial responsibility, closure, and postclosure. In addition, there are special requirements restricting the placement of ignitable and reactive wastes in surface impoundments. To control air emissions, Subpart K requires the owner or operator to manage all hazardous waste placed in a surface impoundment in accordance with the requirements of Subparts CC—Air Emission Standards for Tanks, Surface Impoundments, and Containers.

4.2.2.2 <u>Subpart CC—Air Emission Standards for Tanks, Surface Impoundments, and Containers</u>. Section 3004(n) of RCRA authorizes EPA to regulate air emissions from hazardous waste TSDFs. Under this authority, EPA issued air emission standards under 40 CFR Part 264 and 265, Subpart CC—Air Emission Standards for Tanks, Surface Impoundments, and Containers. Subpart CC applies to tanks, surface impoundments, containers, and certain miscellaneous units that

- Are not expressly exempted from the rule.
- Are subject to permit standards (40 CFR 264) or interim status standards (40 CFR 265)
- Manage hazardous wastes that have an average volatile organic concentration at the point of waste origination equal to or greater than 500 parts per million by weight (ppmw).

These requirements do not apply to surface impoundments in which all the hazardous waste entering the surface impoundment meets one of the following (40 CFR 264.1082(c) and 265.1083(c)):

- The average volatile organic concentration of the hazardous waste at the point of waste origination is less than 500 ppmw (as noted above)
- The organic content of the hazardous waste has been reduced by an organic destruction or removal process. For example, organic destruction can be achieved by waste incineration or biodegradation. Organic removal must achieve the treatment level specified for the process.
- The waste meets the treatment standards for hazardous waste as specified in 40 CFR 268.40 or has been treated by the treatment technology established by EPA for the waste in 268.42(a) or by an equivalent method.

To control air emissions from a surface impoundment managing a hazardous waste with a volatile organic concentration greater than 500 ppmw, an owner or operator must install and operate either a floating membrane cover or a cover that is vented through a closed-vent system to a control device. The floating membrane cover must meet certain design and inspection requirements including use of materials that meet standards for organic permeability and compatibility with the waste, weather conditions, and operating conditions. The facility must also perform periodic (once per year) inspections for membrane defects.

The technical requirements for the RCRA air rules in Subpart CC as amended are essentially the same as those adopted by EPA under the MACT program (e.g., requirements in

Subparts OO, PP, and QQ of Part 63). A unit controlled under one or the other set of requirements would achieve the same emission reduction and performance level; the various requirements thus provide the same level of protection (61 FR 59939, November 25, 1996).

Due to the exclusion for wastes below the 500-ppmw threshold for volatile organic content, any wastes subject to the Subpart CC requirements that potentially pose air risks at concentrations less than 500 ppmw might not be controlled by the Subpart CC air emission standards for surface impoundments.

4.2.2.3 Land Disposal Restrictions Treatment Requirements. RCRA LDRs limit the placement of untreated hazardous waste in all land-based waste management units, including landfills, wastepiles, land application units, and surface impoundments. Under 40 CFR 268.1, characteristic wastes may not be land disposed unless (1) the wastes are treated in a Clean Water Act or equivalent treatment system, and (2) the wastes no longer exhibit the characteristic at the point of land disposal. Listed waste must meet treatment standards defined in 40 CFR Part 268, Subpart D, prior to land disposal.

Note that RCRA section 3005(j)(11) and 40 CFR Part 268.4 (which implements that provision) provide an exclusion allowing treatment of otherwise prohibited wastes (i.e., listed or characteristic hazardous wastes that do not meet the otherwise applicable treatment standard) in surface impoundments provided that treatment occurs in the impoundment, the treated residues are removed at least annually, sampling and testing and recordkeeping requirements are met, and evaporation of hazardous constituents is not used as a means of treatment. Because the LDR treatment requirements would not apply to these wastes, the LDR treatment requirements would not mitigate risks to the air pathway. Nonetheless, such surface impoundments must meet the Subpart K and Subpart CC design and operating requirements for hazardous waste surface impoundments.

The LDR treatment standards—when they apply—are based on the performance of best demonstrated available technology (BDAT) and are deemed sufficient to minimize threats to human health and the environment posed by land disposal of the waste. In fact, the standards for most organics reflect the performance of combustion technology, which destroys organics to nondetectable levels, so that the treatment standard is actually the analytical detection limit for the organic chemical times a factor that reflects technological variability. Consequently, EPA has found that units receiving wastes that satisfy these standards for organics need not be controlled further, since the organics in the wastes are already reduced to levels at which threats posed by release of the organics have been minimized (see 61 FR 59941, November 25, 1996).

4.2.2.4 EPA's Permitting Authority under RCRA 3005. If a waste is newly subject to Subtitle C, then EPA's permitting authority under RCRA 3005 is another statutory control that could be used to address air risks posed by surface impoundments. See Section 4.2.1.1 for a detailed explanation of EPA's omnibus permitting authority at RCRA section 3005(c)(3).

4.2.2.5 RCRA Corrective Action Program. If a waste is newly subject to Subtitle C, then EPA's corrective action authority is another control that could be used to address air risks posed by surface impoundments. See Section 4.2.1.1 for a detailed explanation of EPA's corrective action authority under RCRA section 3004(u) for permitted facilities and under section 3008(h) for interim status facilities.

4.2.3 Analysis of Coverage and Potential Gaps in CAA Requirements

This section focuses on relevant federal programs under the Clean Air Act to determine the extent of coverage of air emissions from surface impoundments. This analysis was conducted in four steps. First, a general analysis of relevant CAA programs was conducted (Section 4.2.3.1). Second, an evaluation of the risk assessment constituents of concern was conducted to determine the extent to which they are covered by existing programs (Section 4.2.3.2). The third part of the analysis focused on the CAA NESHAP program since it was identified as the primary program to address air releases from industrial surface impoundments (Section 4.2.3.3). This section provides a list of NESHAP requirements that may apply to surface impoundments and industry sectors that are within the scope of this study. The fourth part of the analysis focuses on the Criteria Air Pollutant Program, which may, to a lesser extent, also address air releases from surface impoundments (Section 4.2.3.4).

4.2.3.1 Overview of Relevant Clean Air Act Programs. The 1990 Amendments to the CAA substantially enhanced existing air quality programs. These enhancements include new attainment provisions for National Ambient Air Quality Standards (NAAQS) and substantial changes to the NESHAP program including control of HAPs using MACT standards. These programs can, to varying degrees, address air emissions from industrial surface impoundments.

Most of the CAA programs regulate significant sources of air pollution; these sources are defined as major sources of air pollution. A major source generally includes all of the individual emission points within a plant complex or facility; emissions from the source would be the sum of emissions from all the individual emission points. Typical sources include petroleum refineries, power plants, and manufacturing facilities. Whether a source meets the definition of major depends on the type and amount of air pollutants it emits.[2]

The following subsections summarize the relevant CAA programs that address air emissions from industrial surface impoundments.

Regulation of Hazardous Air Pollutants

Air Toxics Program. Prior to the 1990 CAA amendments, a few HAPs were regulated using risk-based standards under the NESHAP program. These NESHAPs appear at 40 CFR Part 61. Section 112 of the 1990 amendments to the CAA authorized EPA to set technology-based standards to reduce HAP emissions. While both the risk-based standards (i.e., those enacted prior to 1990) and the technology-based standards (i.e., those enacted after 1990) are all considered NESHAPs, the risk-based standards are generally referred to as original NESHAPs and the technology-based standards are referred to as MACT standards.

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[2] As discussed later, the definition of major source differs for the NESHAP and Criteria Air Pollutant Program.

The following is a brief overview of the pertinent subsections of section 112 applicable to this study:

- List of Hazardous Air Pollutants
- MACT Emissions Standards
- Residual Risk Program
- Area Source Standards
- Urban Air Toxics Program.

List of Hazardous Air Pollutants. Section 112(b)(1) established the list of HAPs to which the air toxics program applies. Currently EPA is required to regulate 188 HAPs.[3] While broad in nature, the statutory list may be modified by adding or deleting pollutants. The CAA also allows outside parties to request an addition or deletion to the list of HAPs. EPA may, after notice and comment, add or delete a pollutant. Section 112(b)(3)(B) lists the following criteria for adding a pollutant to the list:

> ...determination that the substance is an air pollutant and that emissions, ambient concentrations, bioaccumulation or deposition of the substance are known to cause or may reasonably be anticipated to cause adverse effects to human health or adverse environmental effects.

MACT Standards. The technology-based MACT program and the related residual risk program are key elements of the CAA air toxics provisions. Under section 112, EPA is required to list all categories of major sources emitting HAPs and such area sources warranting regulation and to promulgate MACT standards to control, reduce, or otherwise limit the emissions of HAPs from these categories. To the extent possible, this list of source categories is consistent with the list of source categories listed pursuant to New Source Performance Standard (NSPS) requirements. EPA has identified 83 source categories requiring MACT standards and has promulgated 47 MACT standards to date. The remaining standards are in various stages from proposal to under development. As discussed in Section 4.2.3.3, many industry categories that are within the scope of this surface impoundment study are, or will be, covered by a MACT rule.

A major source is defined as a facility with the potential to emit 10 tons per year or more of any one HAP or 25 tons per year or more of a combination of HAPs. Under section 112(a)(1), EPA is authorized to reduce the 10-ton/yr threshold upon a demonstration that a lesser quantity cutoff is warranted.

MACT standards must require the maximum degree of emission reduction that EPA determines to be achievable by each particular source category. Different criteria for MACT standards apply for new and existing sources. In setting MACT standards, EPA does not generally prescribe a specific control technology. Instead, whenever feasible, EPA sets a performance level based on the performance of technology or other practices already used by the

[3] The original list contained 189 chemicals; however, EPA removed caprolactam from the list in 1996 after a review of the most current scientific information.

industry. Facilities are free to achieve these performance levels in whatever way is most cost-effective for them. Eight years after each MACT standard is issued, EPA must assess the remaining health risks from source categories through the residual risk program.

Residual Risk Program. To ensure that MACT regulations protect public health and the environment, Congress included section 112(f) in the 1990 CAA Amendments, which requires a human health risk-based and adverse environmental effects-based "needs test" in the second regulatory phase of the air toxics program. In this phase, referred to as residual risk standard setting, EPA is required to promulgate additional standards for those source categories that, after imposition of MACT standards, are emitting HAPs at levels that present a potential unacceptable risk to the public or the environment. Congress directed that such residual risk standards should "provide an ample margin of safety to protect public health."

Section 112(f) specifically gives EPA the mandate to consider environmental health assessment. Although not very explicit as to how this should be done, Congress does say that EPA shall promulgate standards to provide an ample margin of safety to protect public health unless the Administrator determines that a more stringent standard is necessary to prevent "an adverse environmental effect." The statute directs that consideration of adverse environmental effects must take into account "costs, energy, safety, and other relevant factors" in deciding what level is protective. Adverse environmental effect is defined in section 112(a)(7) as "any significant and widespread adverse effect, which may reasonably be anticipated to wildlife, aquatic life, or other natural resources, including adverse impacts on populations of endangered or threatened species or significant degradation of environmental quality over broad areas."

EPA has developed the residual risk strategy to implement the requirements of CAA sections 112(f)(2) through (6). Goals of the residual risk strategy include (1) assessing any risks remaining after MACT standard compliance, (2) determining if additional emission reductions are necessary and, if so, for which source categories, (3) setting a standard that protects the public with an "ample margin of safety," and (4) setting a more stringent standard, if necessary, to protect the environment. (See U.S. EPA, 1999c, *Residual Risk, Report to Congress*, EPA-453/R-99-001, for a more detailed description of the residual risk program.)

Area Source Standards. Area sources are smaller sources, such as dry cleaners and gas stations, that release smaller amounts of toxic pollutants into the air than major sources. Area sources are defined as sources that emit less than 10 tons per year of a single air toxic and less than 25 tons per year of a mixture of air toxics. Though emissions from individual area sources are often relatively small, collectively their emissions can be of concern. The CAA provides EPA with broad authority to control HAP emissions from area sources. EPA is authorized to develop technology-based standards for area sources when such sources present a threat of adverse effects to health or the environment (this is often referred to as a "positive area source finding" that is issued pursuant to CAA 112(c)(3)). These technology-based standards are to be based either on MACT or generally achievable control technology (GACT). For example, hazardous waste incinerators, cement kilns, and lightweight aggregate kilns are required to comply with MACT standards, regardless of whether they are major or area sources.

Urban Air Toxics Program. The National Urban Air Toxics Strategy aims to reduce the health risks associated with air toxics exposures affecting populations in urban areas (metropolitan areas with population greater than 250,000) by developing a number of national standards for stationary and mobile sources to reduce HAP risks. The strategy includes a description of risk reduction goals; a list of 33 HAPs judged to pose the greatest potential threat to public health in the largest number of urban areas, including 30 HAPs specifically identified as being emitted from area sources; and a list of area source categories that emit a substantial portion of these HAPs and that are being considered for regulation under section 112(d). The goal of the strategy is to attain a 75 percent reduction in incidence of cancer attributable to exposure to HAPs emitted by stationary sources. This is relevant to all HAPs from both major and area stationary sources in all urban areas nationwide.

The list of area source categories includes 29 categories: 13 new categories being listed for regulation and 16 categories already subject to standards or for which standards are under development. The area source categories include industrial organic and industrial inorganic chemical manufacturing.

Section 112(k)(3)(b) of the CAA requires that the Urban Air Toxics program ensure that area sources that account for 90 percent of the aggregate emissions for each of the 30 area source HAPs are subject to standards. The program has developed MACT standards for these 30 area source HAPs for those area sources whose emissions pose the greatest threat to urban areas under section 112(k). Section 112(k) requires that area source categories be subject to standards under section 112(d). Section 112(d) standards are national standards that generally apply everywhere in the country. Consistent with this approach, EPA expects to apply section 112(k) standards nationally. This approach may also result in reductions of emissions from facilities with surface impoundments not located in urban areas.

Additionally, if further analyses reveal that an area source category that is currently unregulated or unlisted poses a public health risk, the Urban Air Toxics program will list that source category under authority of section 112(c) and develop the necessary regulation under 112(d), or they may address it through other activities like pollution prevention or voluntary programs. Similarly, if a specific source is contributing to a local risk problem, then it may be more appropriate for the state, local, or tribal program to address it.

Regulation of Volatile Organic Compounds

Criteria Air Pollutant Program. The CAA authorizes EPA to protect human health and the environment from criteria air pollutants, including ozone, lead, sulfur dioxide (SO_2), nitrogen oxides (NO_x), particulate matter, and carbon monoxide (CO). Few sources emit ozone directly; rather ozone is formed in the atmosphere through the reaction of VOCs and NO_x. To attain the ozone standard, EPA typically requires VOC and NO_x emission reductions. The definition of VOCs according to the CAA regulations (40 CFR Part 51.100), while complex, is basically any compound of carbon (excluding CO, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium) that participates in atmospheric photochemical reactions. Essentially all organic compounds are considered VOCs except those with negligible photochemical reactivity. The definition specifically excludes methane, ethane, methyl chloride, methyl chloroform, and many chlorofluorocarbons (CFCs), and hydrochlorofluorocarbons (HCFCs). Most of these are halogenated compounds (i.e., refrigerants) and do not take part in the photochemical reactions that cause ozone formation. CAA provisions that reduce VOCs to address ozone formation thus have the potential to limit VOC emissions from surface impoundments.

As required by the CAA, EPA established NAAQS for the criteria air pollutants. NAAQS are ambient concentrations above which the air is deemed unhealthy. Geographic areas (e.g., counties and urban areas) in which ambient concentrations exceed the NAAQS are referred to as nonattainment areas, and areas in which ambient concentrations are below the NAAQS are called attainment areas.

Under the Criteria Air Pollutant Program, major sources are stationary facilities that emit 100 tons or more per year of a criteria air pollutant. For purposes of this study, this would mean any source that emits greater than 100 ton/yr VOCs. Two of the major components of criteria air pollutant control programs are New Source Review (NSR) and control programs under State Implementation Plans that require reasonably available control technology (RACT) on existing sources. In attainment areas, new and modified major sources must install best available control technology (BACT) under the Prevention of Significant Deterioration (PSD) permit program, which is an NSR program. Within nonattainment areas, states must require emissions reductions beyond those called for in attainment areas to bring the area back into attainment. New and modified major sources in nonattainment areas must be equipped with technology representing lowest achievable emissions rate (LAER) as part of NSR permitting.

As previously discussed, existing sources in nonattainment areas must be equipped with technology representing RACT. Although EPA publishes guidance for RACT, SIPs are designed to meet local and regional problems and vary substantially between states. Smaller sources are considered major in areas that are not meeting the NAAQS for a particular pollutant. For example, VOC sources emitting 50 ton/yr are considered major for SIP and NSR programs in areas in serious ozone nonattainment areas. The amount goes down to 25 ton/yr in severe nonattainment areas and to 10 ton/yr in extreme nonattainment areas.

A federal program requiring emission reductions in both attainment and nonattainment areas is the NSPS program. This program, as authorized by section 111 of the Clean Air Act, requires EPA to identify source categories emitting criteria pollutants or their precursors and to establish emissions limits for new, modified, and reconstructed sources of emissions. Emissions limits must be based on the best demonstrated technology. To date, EPA has promulgated 77 NSPSs. As discussed in Section 4.2.3.4, several industry categories that fall within the scope of this study have applicable VOC NSPS requirements; sources in these industry sectors would thus be subject to the requirements if they met the definition of new, modified, or reconstructed source.

4.2.3.2 *Constituent Coverage Analysis*. Under the CAA, constituents could be regulated under the Air Toxics Program as HAPs or under the Criteria Air Pollutant Program pursuant to NAAQS. For the purposes of evaluating emissions from surface impoundments, the relevant criteria pollutants are VOCs. Note that some coverage may be provided by the draft *Guide for*

Industrial Waste Management (U.S. EPA, 1999a) as discussed in Section 4.2.1.3. This section thus evaluates whether the risk assessment constituents of concern in this study are HAPs or VOCs or are covered by the draft *Guide for Industrial Waste Management*.

The risk assessment identified 13 constituents of concern for the air pathway based on reported data as well as surrogate data. Table 4-1 lists the 13 constituents and indicates if they are CAA HAPs or VOCs.[4] Table 4-1 also indicates whether the constituent is addressed in EPA's draft *Guide for Industrial Waste Management* and the companion Industrial Waste Air Model.

As explained earlier, the constituents of concern listed in Table 4-1 reflect risk results with varying levels of certainty. The level of certainty depends, in part, on the extent to which the results were based on (1) reported concentration values and (2) surrogate data (including DL values). Constituents of possible concern that were reported at specific concentration values (above the detection limit) are identified in the table. Of the 13 constituents, only 3 represent reported values. The 10 surrogate values were not detected, and, if present in the samples, were at levels less than the detection limits. For these 10 constituents, modeling risk at the detection limit provided a conservative and protective basis for analysis of regulatory gaps.

<u>*HAP Constituents*</u>. Of the 13 constituents of concern that show potentially elevated risk, four are not HAPs. These four constituents cannot be directly controlled by MACT standards unless they are added to the list of HAPs pursuant to section 112 (b)(3)(B). These constituents may, however, be indirectly co-controlled by MACT standards if control of other, perhaps similar, regulated constituents also results in control of the non-HAP (see discussion below on draft *Guide for Industrial Waste Management* constituents for additional details on co-control). Instances where non-HAPs pose risk can thus be considered a limitation of current CAA requirements.

Nine of the 13 risk assessment constituents are CAA HAPs. These nine HAPs thus fall within the jurisdiction of the MACT program. A HAP-emitting facility, however, must first be subject to a specific MACT standard in order to be regulated under section 112 under the CAA. Section 4.2.3.3 discusses the extent to which surface impoundments and industry sectors that are within the scope of this study are, or will be, covered by MACT rules.

<u>*VOC Constituents*</u>. Table 4-1 identifies all 13 constituents of concern as VOCs under the CAA. VOC regulations may fill regulatory gaps for those constituents not regulated as HAPs. For example, NSPS Subpart QQQ regulates wastewater for petroleum refineries. Constituents that are not HAPs but are VOCs could be controlled by oil/water separators or other NSPS requirements under this subpart. One disadvantage of NSPS requirements is that they apply to new and modified sources. This leaves a potential gap because the control requirements are not applied to "grandfathered" sources. The same issue occurs with NSR program requirements. Although BACT is applied to major modifications and new sources, grandfathered sources may remain uncontrolled.

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[4] This risk assessment differentiated between volatile and semivolatile organic compounds as a result of different analytical methods. 40 CFR Part 51.100 defines VOCs differently for the Criteria Air Pollutant Program. Table 4-1 reflects the Part 51.100 definition.

Table 4-1. Extent That Constituents Exceeding Risk Criteria for Air Pathway Are HAPs, VOCs, or Covered by Draft *Guide for Industrial Waste Management*

Chemical Name	CAA HAP	Criteria Pollutant (VOC)	Addressed by *Guide for Industrial Waste Management*
alpha-Hexachlorocyclohexane [alpha-BHC][b]		•	
Acetaldehyde [b, c]	•	•	•
Chlorodibromomethane [dibromochloromethane][b]		•	•
Acetonitrile [methyl cyanide] [a]	•	•	•
Acrolein [2-propenal] [a]	•	•	•
Bis(chloromethyl) ether [sym-dichloromethyl ether] [a]	•	•	
Chloroform [trichloromethane] [a]	•	•	•
Hexachlorocyclopentadiene [a]	•	•	•
N-Nitrosodi-n-butylamine [a]		•	•
N-Nitrosodiethylamine [a]		•	•
Tetrachlorodibenzodioxins [TCDDs] [a, c]	•	•	•
Tetrachlorodibenzofurans [TCDFs] [a]	•	•	•
Toxaphene [chlorinated camphene] [a]	•	•	
Totals	**9**	**13**	**10**

CAA = Clean Air Act.
HAP = Hazardous air pollutant.
VOC = Volatile organic compound as defined by criteria air pollutant program.
[a] Indicates risk estimate was based on surrogate or detection limit value.
[b] Indicates risk estimate was based on reported concentrations.
[c] Indicates no individual chemical combination exceeds the risk criteria, but the aggregate facility-level risk does.

It is not clear to what extent SIP regulations will provide coverage. Although state regulations may reduce emissions from surface impoundments, the regulations are likely to apply only to major sources located in urban areas with photochemical smog problems. Because of this, SIP programs were not included as a potential mechanism for gap filling even though they may regulate surface impoundment emissions in some areas.

Draft *Guide for Industrial Waste Management Constituents*. The draft *Guide for Industrial Waste Management* identifies 95 constituents for the protection of air (see Section 4.2.1.3). Ten of the 13 compounds that showed the potential for risk are addressed by the guide. These 10 constituents included three of the four non-HAPs (chlorodibromethane, N-nitrosodi-n-butylamine, and N-nitrosodiethylamine).

The three non-HAP, draft *Guide for Industrial Waste Management* constituents are also considered VOCs, and any source emitting them would be subject to applicable VOC regulations. If a source emits one of these three compounds along with any HAP, there could be a co-control benefit. Co-control occurs when measures taken to reduce HAP emissions under the MACT standards also reduce emissions of non-HAPs. Co-control is likely to occur at facilities that are major HAP sources and that also emit non-HAP chemicals. Most of the technology-based controls prescribed for HAPs will reduce emissions of all organic chemicals, including non-HAPs. Similarly, most MACT requirements to reduce emissions of specific HAPs, or to reduce total HAP emissions by specific amounts, imply or identify control technologies that are also effective for non-HAP pollutants. Thus, co-emitted HAPs and non-HAPs could receive roughly equivalent levels of control. For example, if a source generates wastewater containing both chlorodibromomethane and a regulated HAP and is required to meet wastewater concentration limitations pursuant to MACT, then the source's efforts to reduce the wastewater HAP concentration could also reduce chlorodibromomethane concentrations. Lower chlorodibromomethane wastewater levels would subsequently reduce chlorodibromomethane emissions from any impoundment that receives that wastewater.

4.2.3.3 NESHAP Program Coverage. The primary regulatory program that addresses air releases from industrial surface impoundments is the CAA NESHAP program. Under this third step of this analysis, specific NESHAP regulations were examined to determine the extent to which these requirements address air releases from surface impoundments.

Waste Management Unit Coverage. NESHAP rules that directly regulate surface impoundments were examined. CAA regulations are not typically adopted for waste management units such as surface impoundments—instead the emission limits are targeted at specific source categories that may include surface impoundments as a regulated emission unit. Generally speaking, most NESHAP standards tend to focus on HAP levels in wastewater generated in the production process, which eventually could be treated/stored in the surface impoundment unit (e.g., MACT standards may control HAP levels in wastewater as opposed to requiring emission controls, such as a cover, on surface impoundments). However, there are some NESHAP regulations that specifically address surface impoundments. Table 4-2 lists these regulations.

Although there is a MACT standard for surface impoundments (40 CFR 63, Subpart QQ), it is only applicable to facilities subject to other MACT or NESHAP requirements that also reference subpart QQ. This subpart is listed only as an administrative convenience. The requirements include standards for floating membrane covers and closed-vent systems venting to a control device. The subpart also includes requirements for test methods, inspection procedures, monitoring, recordkeeping, and reporting.

Industry Coverage. As previously discussed, MACT standards are typically issued for specific industries. Table 4-3 lists the in-scope industry categories (by four-digit SIC code) and the extent to which they are, or will be, covered by MACT standards (e.g., proposed, completed, and upcoming). The table also notes if there is no existing, proposed, or scheduled MACT standard for the industry sector. The four-digit SICs are ranked by estimated wastewater volume managed in descending order. For example, Table 4-3 indicates that pulp mills (1) manage the highest estimated volume of wastewater and (2) have an applicable MACT standard.

Table 4-3 shows that MACT requirements exist, or will exist, for the majority of the SIC codes that manage the largest wastewater volume in surface impoundments. For example, the paper and allied products industry, which EPA estimates manages roughly 67 percent of the wastewater capacity, is subject to the Pulp and Paper Cluster rule (see Chapter 2, Table 2-2).

Table 4-2. Potential MACT and NESHAP Requirements Applicable to Surface Impoundments

MACT/NESHAP	Regulatory Citation	Waste Streams Covered
National Emission Standard for Benzene Waste Operations	40 CFR Part 61 Subpart FF	Benzene-containing waste from chemical manufacturing plants, coke byproduct recovery plants, and petroleum refineries, individual drain systems, wastewater treatment system
National Emission Standard for Organic Hazardous Air Pollutants from the Synthetic Organic Chemical Manufacturing Industry for Process Vents, Storage Vessels, Transfer Operations, and Wastewater Operations	40 CFR Part 63 Subpart G	Wastewater streams
National Emission Standard for Hazardous Air Pollutants from Off-Site Waste and Recovery Operations	40 CFR 63 Subpart DD, including 10 CFR 63 Subpart QQ	Waste and recoverable materials from offsite for treatment, storage, disposal, recovery, or recycling
National Emission Standards for Pharmaceuticals Production	40 CFR Part 63 Subpart GGG	Wastewater
National Emission Standards for Pesticide Active Ingredient Production	40 CFR Part 63 Subpart MMM	Wastewater
National Emission Standards for Polyether Polyols Production	40 CFR Part 63 Subpart PPP	Wastewater

Table 4-3. List of In-Scope 4-Digit SICs and Extent to Which They are Covered by MACT

SIC (Ranked by Estimated Wastewater Volume Managed)	SIC Title	Potentially Applicable MACT Standard	Regulatory Citation	Completed/ Proposed/ Upcoming
2611	Pulp mills	Pulp and Paper Cluster Rule	40 CFR Part 63 Subparts S and MM	Completed
2631	Paperboard mills			
2621	Paper mills			
2911	Petroleum refining	Petroleum Refineries	40 CFR 63 Subpart CC	Completed
		Petroleum Refineries- Catalytic Cracking, Catalytic Reforming & Sulfur Plant Unit	40 CFR Part 63 Subpart UUU	Proposed
5171	Petroleum bulk stations and terminals	Gasoline Distribution	40 CFR Part 63 Subpart R	Completed

(continued)

Table 4-3. (continued)

SIC (Ranked by Estimated Wastewater Volume Managed)	SIC Title	Potentially Applicable MACT Standard	Regulatory Citation	Completed/ Proposed/ Upcoming
3313	Electrometallurgical products	Wool Fiberglass Manufacturing	40 CFR Part 63 Subpart NNN	Completed
		Ferroalloys Production	40 CFR Part 63 Subpart XXX	Completed
		Metal Coil (Surface Coating)	40 CFR Part 63 Subpart SSSS	Proposed
3312	Blast furnaces and steel mills	Integrated Iron & Steel	40 CFR Part 63 Subpart FFFFF	Upcoming
		Steel Pickling-HCl Process	40 CFR Part 63 Subpart CCC	Completed
		Metal Coil (Surface Coating)	40 CFR Part 63 Subpart SSSS	Proposed
		Coke Oven Batteries	40 CFR Part 63 Subpart L	Completed
		Coke Oven Batteries: Pushing, Quenching and Battery Stacks	40 CFR Part 63 Subpart CCCCC	Upcoming
2821	Plastics materials and resins	Polymers and Resins I	40 CFR Part 63 Subpart U	Completed
		Polymers and Resins II	40 CFR Part 63 Subpart W	Completed
		Polymers and Resins III	40 CFR Part 63 Subpart OOO	Completed
		Polymers and Resins IV	40 CFR Part 63 Subpart JJJ	Completed
		Generic MACT	40 CFR Part 63 Subpart YY	Proposed
		Amino/Phenolic Resins Production	40 CFR Part 63 Subpart OOO	Completed
		Miscellaneous Organic Chemical Production and Processes (MON)	40 CFR Part 63 Subpart FFFF	Upcoming
		Polyvinyl Chloride and Copolymers Production	40 CFR Part 63 Subpart J	Proposed
		Cellulose Product Manufacture	40 CFR Part 63 Subpart UUUU	Proposed

(continued)

Table 4-3. (continued)

SIC (Ranked by Estimated Wastewater Volume Managed)	SIC Title	Potentially Applicable MACT Standard	Regulatory Citation	Completed/ Proposed/ Upcoming
2819	Industrial inorganic chemicals, not elsewhere classified	Hydrochloric Acid Production Industry	Rules not yet proposed or promulgated	Upcoming
		Generic MACT	40 CFR Part 63 Subpart YY	Proposed
		Cellulose Product Manufacture	40 CFR Part 63 Subpart UUUU	Proposed
		Uranium Hexafluoride Production	Rules not yet proposed or promulgated	Upcoming
2092	Food and kindred products (fish)	No existing, proposed, or scheduled MACT standard		
2874	Phosphatic fertilizers	Phosphoric Acid Manufacturing Plants/ Phosphate Fertilizer Plants	40 CFR Part 63 Subpart AA and BB	Completed
2436	Softwood veneer & plywood	Plywood & Composite Wood Products	40 CFR Part 63 Subpart ZZZ	Upcoming
		Wood Building Products	40 CFR Part 63 Subpart QQQQ	Upcoming
2063	Food and kindred products (beet sugar)	No existing, proposed, or scheduled MACT standard		
3273	Ready-mixed concrete	No existing, proposed, or scheduled MACT standard		
2022	Food and kindred products (cheese)	No existing, proposed, or scheduled MACT standard		
2873	Nitrogenous fertilizers	No existing, proposed, or scheduled MACT standard		
2035	Food and kindred products (pickles, sauces, salad dressing)	No existing, proposed, or scheduled MACT standard		
4953	Refuse systems	MSW Landfills	40 CFR Part 63 Subpart AAAA	Proposed
2869	Industrial organic chemicals, not elsewhere classified	Synthetic Organic Chemical Manufacturing Industry (SOCMI) Manufacture	40 CFR Part 63 Subpart F	Completed
		SOCMI for Process Vents, Storage Vessels, Transfer Operations, and Wastewater	40 CFR Part 63 Subpart G	Completed

(continued)

Table 4-3. (continued)

SIC (Ranked by Estimated Wastewater Volume Managed)	SIC Title	Potentially Applicable MACT Standard	Regulatory Citation	Completed/ Proposed/ Upcoming
2869 (cont.)		SOCMI for Equipment Leaks	40 CFR Part 63 Subpart H	Completed
		SOCMI for Negotiated Regulation for Equipment Leaks	40 CFR Part 63 Subpart I	Completed
		Generic MACT	40 CFR Part 63 Subpart YY	Proposed
		Polyether Polyols Production	40 CFR Part 63 Subpart PPP	Completed
		Cellulose Product Manufacture	40 CFR Part 63 Subpart UUUU	Proposed
3353	Aluminum sheet, plate, and foil	Metal Coil (Surface Coating)	40 CFR Part 63 Subpart SSSS	Proposed
2653	Corrugated and solid fiber boxes	No existing, proposed, or scheduled MACT standard		
3339	Primary nonferrous metals, not elsewhere classified	Wool Fiberglass Manufacturing	40 CFR Part 63 Subpart NNN	Completed
		Primary Magnesium Refining	Rules not yet proposed or promulgated	Upcoming
3351	Copper rolling and drawing	No existing, proposed, or scheduled MACT standard		
3334	Primary aluminum	Primary Aluminum Production	40 CFR Part 63 Subpart LL	Completed
		Metal Coil (Surface Coating)	40 CFR Part 63 Subpart SSSS	Proposed
2824	Organic fibers, noncellulosic	Generic MACT	40 CFR Part 63 Subpart YY	Proposed
		Miscellaneous Organic Chemical Production and Processes (MON)	40 CFR Part 63 Subpart FFFF	Upcoming
2899	Chemical preparations, not elsewhere classified	Misc. Organic Chemical Production & Processes (MON)	40 CFR Part 63 Subpart FFFF	Upcoming
2833	Medicinals and botanicals	No existing, proposed, or scheduled MACT standard		
3229	Pressed and blown glass, not elsewhere classified	Wet Formed Fiberglass Mat Production	40 CFR Part 63 Subpart HHHH	Proposed

(continued)

Table 4-3. (continued)

SIC (Ranked by Estimated Wastewater Volume Managed)	SIC Title	Potentially Applicable MACT Standard	Regulatory Citation	Completed/ Proposed/ Upcoming
3624	Carbon and graphite products	No existing, proposed, or scheduled MACT standard		
2435	Hardwood veneer & plywood	Plywood & Composite Wood Products	40 CFR Part 63 Subpart ZZZ	Upcoming
		Wood Building Products	40 CFR Part 63 Subpart QQQQ	Upcoming
2843	Surface active agents	Polyether Polyols Production	40 CFR Part 63 Subpart PPP	Completed
4952	Sewerage systems	Publicly Owned Treatment Works (POTW)	40 CFR Part 63 Subpart VVV	Completed
		Sewage Sludge Incinerators	Rules pending	Upcoming
2251	Women's hosiery, except socks	Fabric, Printing, Coating and Dyeing	40 CFR Part 63 Subpart OOOO	Upcoming
2834	Pharmaceutical preparations	Pharmaceuticals Production	40 CFR Part 63 Subpart GGG	Completed
3011	Tires and inner tubes	Tire Manufacturing	40 CFR Part 63 Subpart XXXX	Proposed
3341	Secondary nonferrous metals	Secondary Lead	40 CFR Part 63 Subpart RRR	Completed
		Secondary Brass and Bronze	40 CFR Part 63 Subpart SSSS	Proposed
3761	Guided missiles and space vehicles	Aerospace Industry	40 CFR Part 63 Part GG	Completed
		Rocket Engine Test	Rules not yet proposed or promulgated	Upcoming
2865	Cyclic crudes and intermediates, and organic dyes and pigments	Miscellaneous Organic Chemical Production and Processes (MON)	40 CFR Part 63 Subpart FFFF	Upcoming
		Fabric, Printing, Coating and Dyeing	40 CFR Part 63 Subpart OOOO	Upcoming
3399	Primary metal products, not elsewhere classified	Taconite Iron Ore Processing	Rules not yet proposed or promulgated	Upcoming
9711	National security	No existing, proposed, or scheduled MACT standard		
2211	Broadwoven fabric mills, cotton	No existing, proposed, or scheduled MACT standard		
3321	Gray and ductile iron foundries	Iron & Steel Foundries	40 CFR Part 63 Subpart EEEEE	Upcoming

(continued)

Table 4-3. (continued)

SIC (Ranked by Estimated Wastewater Volume Managed)	SIC Title	Potentially Applicable MACT Standard	Regulatory Citation	Completed/ Proposed/ Upcoming
3087	Custom compound purchased resins	No existing, proposed, or scheduled MACT standard		
3674	Semiconductors and related devices	Semiconductor Production	40 CFR Part 63 Subpart BBBB	Upcoming
3462	Iron and steel forgings	No existing, proposed, or scheduled MACT standard		
3317	Steel pipe and tubes	Metal Coil (Surface Coating)	40 CFR Part 63 Subpart SSSS	Proposed
		Steel Pickling-HCl Process	40 CFR Part 63 Subpart CCC	Completed
2011	Food and kindred products (meat packing)	No existing, proposed, or scheduled MACT standard		
3324	Steel investment foundries	Iron & Steel Foundries	40 CFR Part 63 Subpart EEEEE	Upcoming
2679	Converted paper products, not elsewhere classified	No existing, proposed, or scheduled MACT standard		
3316	Cold finishing of steel shapes	Metal Coil (Surface Coating)	40 CFR Part 63 Subpart SSSS	Proposed
3499	Fabricating metal products, not elsewhere classified	Metal Coil (Surface Coating)	40 CFR Part 63 Subpart SSSS	Proposed
		Metal Furniture (Surface Coating)	40 CFR Part 63 Subpart RRRR	Upcoming
		Misc. Metal Parts & Products (surface coating)	40 CFR Part 63 Subpart MMMM	Upcoming
3069	Fabricated rubber products, not elsewhere classified	No existing, proposed, or scheduled MACT standard		
3089	Plastics products, not elsewhere classified	Plastic Parts (surface coating)	40 CFR Part 63 Subpart PPPP	Upcoming
		Reinforced Plastics Components Production	40 CFR Part 63 Subpart WWWW	Upcoming
3731	Shipbuilding and repairing	Shipbuilding & Ship repair	40CFR Part 63 Subpart II	Completed
		Boat Manufacturing	40 CFR Part 63 Subpart VVVV	Proposed

(continued)

Table 4-3. (continued)

SIC (Ranked by Estimated Wastewater Volume Managed)	SIC Title	Potentially Applicable MACT Standard	Regulatory Citation	Completed/ Proposed/ Upcoming
3357	Nonferrous wiredrawing & insulating	No existing, proposed, or scheduled MACT standard		
3398	Metal heat treating	No existing, proposed, or scheduled MACT standard		
2952[a]	Asphalt felts and coatings	Asphalt Roofing and Processing	40 CFR Part 63 Subpart LLLLL	Upcoming
3052[a]	Rubber & plastics hose and belting	Plastic Parts (surface coating)	40 CFR Part 63 Subpart PPPP	Upcoming
3081[a]	Unsupported plastics film & sheet	Metal Coil (Surface Coating)	40 CFR Part 63 Subpart SSSS	Proposed
		Plastic Parts (surface coating)	40 CFR Part 63 Subpart PPPP	Upcoming

[a] Survey data not available to adequately quantify wastewater volumes for ranking purposes.

This set of rules is an innovative regulatory effort to address both air and water releases from pulp and paper mills. The air rule covers MACT I emissions (noncombustion sources from pulping and bleaching operations at chemical and semichemical wood pulping mills); MACT II emissions (chemical recovery combustion areas of mills); and MACT III emissions (noncombustion sources from mills that mechanically pulp wood, pulp secondary fibers, or pulp nonwood materials and those that use paper machine additives and solvents). The final water rule applies to mills in Subpart B (Bleached Papergrade Kraft and Soda) and Subpart E (Papergrade Sulfite) Subcategories and includes best available technology (BAT) limitations and Best Management Practice (BMP) requirements. The implementation of the cluster rule will eliminate the use of chlorine or hypochlorite in the pulp bleaching process or require the facility to meet the revised effluent limitation guidelines and standards. This rulemaking will also achieve 99 percent reduction in chloroform in the wastewater discharged.

It is important to note that this industry coverage analysis did not focus on the industry types that showed potential risks. There were not enough risk exceedances in any one industry sector that warranted a more detailed industry-specific regulatory analysis. A review of those industry sectors that did show the potential for risk, however, indicated that the majority of those industry sectors are, or will be, covered by MACT regulations.

A HAP-emitting facility must first be part of a source category that is subject to a specific MACT standard in order to be regulated under section 112 of the CAA. If a surface impoundment emits a HAP but is not part of a listed source category for which there is an applicable MACT standard, then it is not an affected source subject to MACT requirements. Situations where nonaffected HAP-emitting sources pose unacceptable risk could thus also be considered a limitation in current MACT requirements, since these types of sources should be regulated pursuant to section 112. This could potentially occur in two different scenarios.

First, MACT standards may not exist for a source category that emits HAPs (and are not on the list of upcoming MACT rules). As noted previously, a review of industry sectors that showed the potential for risk indicated that the majority (but not all) of those industry sectors are, or will be, covered by MACT regulations. Second, a source category that is covered by an existing MACT rule may not be considered an affected source if it does not meet the definition of a major source. A facility emitting HAPs is considered a major source if it emits or has the potential to emit 10 tons per year or more of any listed HAP or a combination of listed HAPs of 25 tons or more. This study did not investigate what fraction of the facilities that were within the scope of this study would meet the definition of a major source.

In addition, MACT regulations for each source category do not always address all the HAPs listed in section 112 of the CAA. For example, the Petroleum Refinery MACT (40 CFR 63 Subpart CC) is limited to organic HAPs as defined by the regulation. The regulation includes only 28 of the 188 HAPs. In some cases, this occurs because the source category emits only a subset of CAA HAPs. In other cases, this may have occurred because the best performing sources were uncontrolled and EPA therefore concluded that the MACT standard for that pollutant was no control. A recent court decision (National Lime Association v. *EPA*, 99-1325 (DC Cir)) clarifies that, even if no controls are found to be in use, other means of reduction must also be evaluated and that MACT represents the performance level of lowest emitting facilities and a MACT standard must address all HAPs emitted by the industrial category. For the instances where an unacceptable risk is identified as a result of a constituent of concern in this study being a HAP but not addressed in an existing MACT regulation, it is assumed that this will be addressed by the residual risk program. Therefore, for those constituents that are HAPs, there is not a regulatory gap because the Air Toxics Program should, in time, address HAPs that pose unacceptable threats to human health.

Other air toxics regulations may achieve some emissions reductions for HAPs. Section 112(j) contains the MACT "hammer" requirement. This requires facilities and states to establish MACT equivalent standards should EPA fail to meet congressionally mandated MACT schedule deadlines. Prior to the 1990 CAA and MACT programs, individual states had a variety of air toxics programs. Although these programs may control emissions from industrial surface impoundments, they have not been included in this regulatory/program analyses because these provisions vary significantly from state to state.

4.2.3.4 Other CAA Coverage—Criteria Air Pollutant Program. We also evaluated applicability of VOC regulations. All of the 13 constituents of potential concern in this study are VOCs. As VOCs, the constituents of concern may be regulated indirectly as part of a national program to reduce ozone. Although VOC regulations have resulted in substantial reductions in emissions of air toxics, it is important to note that NSPS requirements apply only to new and newly modified sources. This means that older "grandfathered" sources may not be required to comply with the standards.

NSPS Waste Management Unit and Industry Coverage. There are no NSPS requirements that directly regulate surface impoundments. However, NSPS regulations that control, for example, VOCs generated in the manufacturing process and ultimately in the wastewater generated can serve to limit VOC emissions from surface impoundments that manage such wastewaters. For example, NSPS Subpart QQQ regulates VOC emissions from petroleum refinery wastewater systems. Appendix D, Section D-3, lists the in-scope industry sectors and potentially applicable NSPS VOC standards. The appendix lists several NSPS regulations that can potentially limit VOC emissions from surface impoundments within the scope of this study (provided the source has been modified as defined by the NSPS requirements).

Many ozone problems are regional in nature; thus additional VOC requirements may be in place pursuant to SIPs at the state and local level. There are SIP programs that specifically regulate surface impoundments; however, control of criteria pollutants under the CAA is based on local, state, and regional air quality programs and regulations. A detailed analysis of SIPs was not conducted for this study. EPA may issue guidance, such as control technology guidelines (CTGs) and alternative control technique guidance (ACTs) for VOC sources, to assist states in designing control programs to meet local air quality needs. The Office of Air Quality Planning and Standards developed a CTG in 1993 and released an ACT guidance in 1994 for VOCs in industrial wastewater.

4.2.3.5 Summary of Potential Regulatory Program Coverage and Gaps in CAA Regulations. The analysis of potential regulatory gaps under the Clean Air Act examined constituents of concern and the regulatory applicability under Air Toxics and Criteria Pollutant Control programs. The analysis looked at regulations that directly control constituents of concern (e.g., MACT regulations) as well as regulations that indirectly control constituents of concern (e.g., VOC regulations). This subsection outlines the nature and extent of potential regulatory/program gaps.

The analysis showed that MACT requirements exist, or will exist, for the majority of the SIC codes that manage the largest wastewater volume in surface impoundments. The analysis also indicates that the majority of industry categories that showed the potential for risk were covered by MACT standards. However, potential exists for a particular source category not to be covered by a MACT rule. Under the CAA, MACT categories are supposed to include all source categories that emit HAPs and pose risks to human health. Thus, source categories that emit HAPs at levels of concern but are not currently regulated, regardless whether they are major or area sources, are supposed to be regulated when MACT is fully implemented. Section 112(c) of the CAA gives EPA the authority to list additional source categories that emit HAPs but are not currently subject to existing or proposed MACT standards.

Another type of gap under this analysis may occur when a MACT standard exists for an industrial category that exceeds the risk threshold, but does not specifically address surface impoundments or the constituents of concern that are HAPs. A review of the industry sectors that showed the potential for risk found two instances in which an industry category was covered by MACT standards, but the MACT standard did not directly address the HAP constituent of concern. It must be noted, however, that both of these risk estimates were based on DL values as opposed to reported concentration values, and both of these constituents would have benefitted from co-control of similar HAPs that are covered by the MACT standard. Thus, it is not clear that the risks are real, and, if they are, they may well be addressed by the MACT standard. Regardless, gaps associated with unaddressed HAPs at sources that are covered by MACT standards should be addressed by the Residual Risk Program.

It must be noted, however, that MACT typically applies only to major sources. Although major sources account for most of the pollution (e.g., traditionally less than 20 percent of the sources are considered to emit over 80 percent of the pollution), there is still the potential for elevated exposure from small sources. The area source program for HAPs is designed to address this issue. EPA is authorized to develop technology-based standards for area sources when such sources present a threat of adverse health effects. One important qualification for coverage under the area source program is that the residual risk program cannot address area sources unless they have been listed in accordance with section 112(c)(3) and have been included in regulations under section 112(d).[5] This study did not investigate what fraction of the facilities that were within the scope of this study would meet the definition of a major source.

These limitations are supposed to be addressed when MACT is fully implemented. For those constituents of concern that are non-HAPs, there are still potential regulatory gaps. Table 4-1 lists the four constituents of concern that are not regulated as HAPs and show the potential for elevated risks. They are

- Alpha-hexachlorocyclohexane
- N-Nitrosodi-n-butylamine
- N-Nitrosodiethylamine
- Chlorodibromomethane.

Non-HAP constituents were evaluated to determine if they are regulated as VOCs. Alpha-hexachlorocyclohexane, chlorodibromomethane, N-nitrosodi-n-butylamine, and N-nitrosodiethylamine are VOCs and would potentially be subject to VOC requirements for wastewater treatment for some NSPS industrial categories. NSPS standards for VOCs only address new or newly modified sources in certain industrial categories and would not apply to "grandfathered" sources that had not made modifications that triggered NSPS requirements. Because the NSPS requirements do not address "grandfathered" sources, there is no certainty that a regulatory gap would be closed. However, as previously discussed, additional VOC requirements may be in place pursuant to SIPs at the state and local level.

The likelihood of these four constituents presenting a problem should also be considered. Risk results for both N-nitrosodi-n-butylamine and N-nitrosodiethylamine were not based on reported values. This means that concentration values used in the risk assessment were a function of the detection levels. Both chlorodibromomethane and alpha-hexachlorocyclohexane were only detected at one facility each. The limited verification of the hazard posed by these constituents suggests that any gap is likely to be small.

[5] The Residual Risk Program is not required to cover area sources that are subject to GACT rather than MACT.

4.3 Coverage and Potential Gaps in Existing Programs and Regulations Addressing Nonair Risks

Although the EDF consent decree was limited to examining the air risks from never characteristic wastes in surface impoundments, EPA investigated risks associated with other media as well in response to the requirements of the LDPFA. In this portion of the analysis, EPA assessed program and regulatory coverage for

- Risks resulting from consumption of groundwater containing constituents released from surface impoundments (Section 4.3.1)
- Indirect risks resulting from contaminated groundwater leaching into surface waterbodies (Section 4.3.2)
- Risks posed via other indirect pathways (Section 4.3.3)
- Ecological risks (Section 4.3.4).

EPA evaluated the extent to which these predicted risks are adequately addressed under existing federal and state programs.

4.3.1 Groundwater Risks Found from Managing Nonhazardous Waste in Surface Impoundments

Leachate from a nonhazardous waste surface impoundment can potentially migrate through the subsurface and affect groundwater quality. Therefore, EPA identified existing federal and state regulations and programs that address the release of constituents from nonhazardous waste surface impoundments to groundwater.

In this part of the analysis, EPA used the results of the groundwater risk assessment to illustrate regulatory coverage and potential gaps. The risk assessment evaluated risks from specific facilities, constituents, and impoundments resulting from ingestion of groundwater that had been contaminated with impoundment leachate. The results of the risk assessment indicate that groundwater contamination from surface impoundments may potentially pose a risk (see also Section 3.2 for a discussion of groundwater risks). Specifically, the risk assessment identified 15 constituents that potentially exceed the specified risk threshold of this study for the groundwater pathway.

4.3.1.1 Existing Federal RCRA Regulations and Programs that Control Releases to Groundwater from Nonhazardous Industrial Waste Surface Impoundments. This section describes the federal solid waste regulations and programs that may address potential risks to groundwater posed by the management of nonhazardous wastes in surface impoundments. State programs are described in Section 4.3.1.2. Federal regulations and programs that address groundwater risks at nonhazardous waste impoundments include the following:

- RCRA Subtitle C—Corrective Action Program

- Omnibus permitting authority under RCRA section 3005(c)(3)
- SEPs conducted in connection with an enforcement action
- RCRA Subtitle D Regulations
- EPA's draft *Guide for Industrial Waste Management*.

In addition, EPA's multimedia strategy for persistent, bioaccumulative, and toxic (PBT) pollutants could potentially reduce risks to groundwater from surface impoundments in the future. EPA's PBT strategy is described in detail in Section 4.4.

Potential regulatory coverage and gaps in these programs, as they pertain to protection of groundwater at nonhazardous waste surface impoundments, are discussed below.

Potential Coverage by RCRA 7003 and Subtitle C Corrective Action Program. As described in Section 4.2.1.1, releases from SWMUs can be addressed under the RCRA corrective action program if a facility has a RCRA permit or is an interim status facility. For facilities with RCRA permits, the RCRA corrective action program provides extensive regulatory and program coverage to address any releases to groundwater from nonhazardous waste surface impoundments that pose unacceptable risks.

Also, as previously discussed, the imminent and substantial endangerment provision of RCRA section 7003 allows EPA, upon evidence of past or present handling of solid or hazardous waste, to require any action necessary when a situation may present an imminent and substantial endangerment to health or the environment.

The survey indicates that about 33 percent of the surface impoundments nationwide that fall within the scope of this study have been designated as solid waste management units pursuant to the RCRA corrective action RFA process (see also Chapter 2, Section 2.5 for additional information on the permit and corrective action status of impoundments within the scope of this study). This indicates that a significant number of nonhazardous surface impoundments are located at RCRA TSD facilities; these impoundments are being addressed by EPA and the states on a priority basis, and thus no regulatory gaps should exist for these impoundments.

EPA's Permitting Authority under RCRA 3005. EPA's permitting authority under RCRA 3005 is another statutory control that could be used to address groundwater risks posed by surface impoundments if they are located at a RCRA TSD facility. See Section 4.3.1.1 for a detailed explanation of EPA's omnibus permitting authority at RCRA section 3005(c)(3).

Use of SEPs to Address Surface Impoundments at Facilities Subject to Enforcement Actions. As discussed in Section 4.2.1.5, a SEP is one program that could be used to address contamination problems found at a nonhazardous waste surface impoundment if the facility is subject to a related enforcement action. As a condition of the settlement, EPA and the defendant could agree upon a SEP that is related to reducing groundwater risks posed by a surface impoundment at the facility. A SEP related to a surface impoundment could include closure, installation of a liner, or implementation of some other measure that would eliminate or reduce risk to the environment and/or public health.

Coverage by RCRA Subtitle D Regulations. RCRA sections 1008(a)(3) and 4004(a) required EPA to develop criteria for states to use in determining which facilities would be classified as open dumps and thus be required to be closed or upgraded. EPA promulgated 40 CFR Parts 256 and 257 to partially fulfill the Agency's obligations under the Act. Part 256 establishes guidelines for the states to use in the development and implementation of their solid waste management plans and includes provisions related to the scope of the plan, the identification of the responsibilities for state and substate agencies, the requirements for state legal and regulatory authorities, and planning and implementation. The federal regulations at Part 257 were EPA's primary mechanism for controlling open dumps prior to promulgation of municipal solid waste landfill regulations at Part 258. The Part 257 standards provide siting restrictions, limited performance standards, and references to other applicable federal programs (e.g., CWA). Table 4-4 is provided in this report for completeness; the regulations have limited ability to address potential risks, as identified in our study, posed by surface impoundments. Although the Part 257 regulations typically are administered and enforced by the states, and state regulations generally are more stringent than the Part 257 regulations, the federal Part 257 regulations may still apply to surface impoundments that are in the scope of this study.

Table 4-4 describes the Part 257 criteria that potentially apply to industrial surface impoundments.

The regulations that specifically address potential impacts to groundwater are identified in 40 CFR 257.3-4. This regulation identifies a list of contaminants (appearing at 40 CFR 257 Appendix I) and maximum concentration limits (MCLs) that cannot be exceeded in groundwater. Table 4-5 compares the risk assessment constituents of concern for the groundwater pathway to the Part 257 constituent list. Note that the information in the table reflects risk results with varying levels of certainty. The level of certainty depends, in part, on the extent to which the results were based on (1) reported concentration values and (2) surrogate data (including DL values). (See discussion in Chapter 3.) Constituents of possible concern that were reported at specific concentration values (above the detection limit) are identified in the table. Regulatory gaps identified based on this information thus carry the same level of varying certainty.

Table 4-5 indicates that only 3 of the 15 constituents potentially exceeding the risk criteria (flouride, arsenic, and vinyl chloride) are covered under 40 CFR Part 257.3-4. Thus, coverage of the constituents of potential concern for groundwater risks must be provided by other programs such as state programs (see Section 4.3.1.2) or EPA's voluntary draft *Guide for Industrial Waste Management*. Two of the potential constituents of concern (allyl alcohol and flouride) are not covered by the draft guidance. Allyl alcohol is not covered by either 40 CFR Part 257.3-4 or the draft guidance. The groundwater tool in the draft guidance allows the user to enter additional constituents that are not specifically listed in the guidance. Because the guidance is in draft form, the constituent list may change in the future.

Description of EPA's Draft *Guide for Industrial Waste Management* as It Relates to Coverage of the Groundwater Pathway. EPA's draft *Guide for Industrial Waste Management* (U.S. EPA, 1999a) includes three categories of groundwater protection guidelines: risk assessment, liner design and installation, and long-term operations. See Section 4.2.1.3 for a more generalized description of the draft guide.

Table 4-4. Summary of 40 CFR Part 257 Criteria That Potentially Apply to Surface Impoundments

Regulatory Citation	Summary of Requirement
§257.3-1 Floodplains	Facilities located in the 100-year floodplain must not restrict the flow of the flood, reduce water storage of the floodplain, or result in a washout of solid waste.
§257.3-2 Endangered or Threatened Species	Facilities must not cause or contribute to the taking of endangered or threatened species nor destroy or adversely modify their critical habitat.
§257.3-3 Surface Water	Facilities must not cause a discharge of pollutants or dredged or fill material in violation of the requirements of the Clean Water Act or cause nonpoint source pollution that violates an area or statewide water quality management plan under the Clean Water Act.
§257.3-4 Groundwater Protection	Facilities must not contaminate underground drinking water sources beyond the solid waste boundary unless it can be shown that an alternative boundary would not result in the contamination of water that may be needed for human consumption.
§257.3-7 Air	Facilities must not engage in the open burning of waste unless it is the infrequent burning of agricultural wastes in the field, silvicultural wastes for forest management purposes, land-clearing debris, diseased trees, debris from emergency cleanup operations, and ordinance and must not violate requirements developed under a State Implementation Plan under the Clean Air Act.
§257.3-8 Safety	Facilities must not generate high concentrations of explosive gases, pose a fire hazard, be located within 10,000 feet of a jet aircraft runway or 5,000 feet of a piston-type aircraft runway, or allow uncontrolled public access.

- ***Assessing Risk.*** Chapter 7a of the draft guide provides a tool for assessing risks associated with waste management practices and for tailoring management controls accordingly. The guidance employs a three-tiered evaluation approach to determine recommended liner systems and whether land application is appropriate. The chapter is intended for use at new units.

- ***Designing and Installing Liners.*** Chapter 7b of the draft guide discusses different types of liner systems that can be used to protect groundwater from contamination. Liner recommendations may include clay liners, synthetic liners, composite liners, leachate collection systems, and leak detection systems as appropriate. The chapter is intended for use at new units.

- ***Long-Term Operation.*** Chapter 9 of the draft guide includes recommendations for groundwater monitoring, Chapter 10 includes guidance on taking corrective action, and Chapter 11 provides guidance on closure/postclosure care. While the draft guide focuses primarily on new units, information in these chapters can be applied to existing industrial waste units.

Table 4-5. Federal Regulatory or Program Coverage of Constituents with Predicted Risks Exceeding Risk Criteria for Groundwater Pathway

CAS Number	Constituent	40 CFR Part 257 Constituent	*Guide for Industrial Waste Management* Constituent
107-13-1	Acrylonitrile [a]		•
107-18-6	**Allyl alcohol** [a]		
110-86-1	Pyridine [a]		•
16984-48-8	Fluoride [a,b]	•	
621-64-7	N-Nitrosodi-n-propylamine [di-n-propylnitrosamine] [a]		•
62-75-9	N-Nitrosodimethylamine [a]		•
67-56-1	Methanol [a]		•
67-64-1	Acetone [2-propanone] [a,b]		•
67-66-3	Chloroform [trichloromethane] [a]		•
7440-28-0	Thallium [a]		•
7440-38-2	Arsenic [a]	•	•
75-09-2	Methylene chloride [dichloromethane] [a]		•
75-01-4	Vinyl chloride [a]	•	•
8001-35-2	Toluene [a]		•
92-87-5	Benzidine [a]		•

[a] Risk estimate was based on surrogate or detection limit value.
[b] Risk estimate was based on a reported waste concentration.
Note: **Bold** indicates the constituent is not specifically addressed by either program.

Corrective action can include use of interim measures, institutional controls (such as deed restrictions or access controls), and application of remedial technologies designed to contain, remove, and/or destroy contamination.

4.3.1.2 Existing State Regulations and Programs that Control Releases to Groundwater at Nonhazardous Waste Surface Impoundments. States typically regulate nonhazardous waste surface impoundments under their more general solid and industrial waste management regulations for nonhazardous waste or pursuant to their water programs. This section provides an overview of state regulations that are applicable to nonhazardous waste management in general or nonhazardous waste surface impoundments in particular. The following types of state programs and regulations may address potential groundwater risks from in-scope surface impoundments:

- States may have regulations or programs addressing the groundwater pathway, such as monitoring or unit design requirements.

- A facility may have a permit for the surface impoundment issued by the state that addresses potential groundwater risks.

- States may make specific exclusions to their requirements for certain facilities. Such facilities, therefore, would not be subject to otherwise stricter state requirements.

Key Components of State Regulations and Programs that Address Releases to Groundwater at Nonhazardous Waste Surface Impoundments. Based on available information, most states have a program that includes provisions for controlling or addressing releases to groundwater from industrial nonhazardous waste surface impoundments (see Appendix D, Section D-1). The level of controls, however, varies across states. Many provisions are not formally adopted regulations; rather, they are imposed through permits, on a case-by-case basis at the discretion of the regulators, or via nonmandatory guidance. Note that EPA's analysis of state waste regulations and programs in Appendix D is based on publicly available information rather than on a survey of state regulators. Therefore, the analysis may not have identified all state waste regulations and programs that address nonhazardous waste industrial surface impoundments.

State programs may include some or all of the following key components, many of which are for the protection of groundwater:

- ***Location standards.*** Location standards generally address both potential effects a waste management unit may have on the surrounding environments and the effect that natural and man-made conditions may have on the performance of the unit. Location standards may include provisions such as airport safety; restrictions on placement of a unit in flood plains and wetlands; and design, construction, or siting requirements for placement in a fault area, seismic impact zone, or unstable areas. Note that the federal Part 257 location restrictions apply in all states and territories, even if such restrictions are not covered by state regulations.

- ***Design criteria***. Design criteria typically include design standards for liners and leachate collection or performance standards for maintaining contaminant concentrations in groundwater at protective levels at a point of compliance.

- ***Operating criteria.*** State programs for nonhazardous waste surface impoundments may include criteria pertaining to routine operation, management, and environmental monitoring. Operating criteria may include provisions for preventing disposal of hazardous or special waste, access and security, stormwater runon/runoff controls, freeboard requirements, nuisance controls, inspection, and reporting and recordkeeping.

- ***Monitoring.*** Monitoring programs may be required to evaluate whether a unit meets performance objectives and whether there are releases of constituents to and impacts on the surrounding environment that need to be corrected. Monitoring requirements typically emphasize groundwater monitoring; however, states may require monitoring of air, surface water, and sludge or soil.

- ***Corrective action.*** If monitoring indicates that performance objectives are not being met, then a state program may require corrective measures. Under a remedial program, a facility may be required to assess the nature and extent of the releases of waste or constituents; to evaluate unit characteristics; and to identify, evaluate, and implement an appropriate corrective measure or measures to protect human health.

- ***Closure and postclosure care.*** A state may have requirements for unit closure to minimize or eliminate potential threats and the need for future corrective action at a site. Closure measures may include removal of wastewater, treatment of wastes, and/or containment. For postclosure care, the overall goal is to minimize the infiltration of water into a unit after closure by providing maintenance of the final cover until such time as it is determined that care is no longer necessary.

Figure 4-1 summarizes the number of states that have various programs in place for the protection of groundwater at nonhazardous industrial waste surface impoundments. A comprehensive summary of state waste regulations applicable to nonhazardous waste surface impoundments is included in Appendix D, Section D-1.

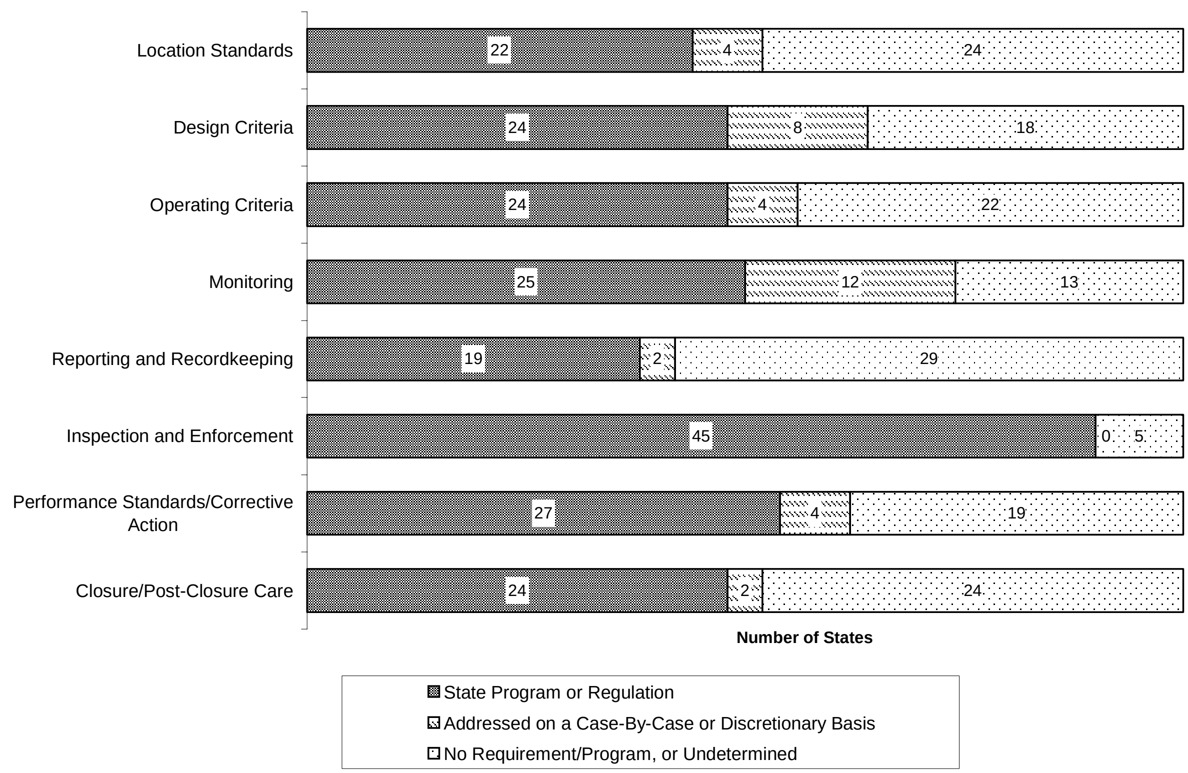

Figure 4-1. State programs or regulations for the protection of groundwater at nonhazardous waste surface impoundments.

In conclusion, many, but not all, states have regulatory or other programs in place designed to address groundwater risks posed by nonhazardous waste surface impoundments. While these programs provide an important level of protection, they do not, at least by regulation, address all potential releases of concern.

4.3.1.3 Existing Programs Under the Safe Drinking Water Act that Address Releases to Groundwater from Surface Impoundments. Programs under the SDWA Amendments of 1996 also provide coverage at the national level and state level.

To determine the susceptibility of all public water supplies in the nation through source water assessments, EPA published guidance for state source water assessment and protection programs in 1997, under section 1453 of the SDWA. Each state, using the national guidance and funding under the Drinking Water State Revolving Fund (SRF) (section 1452 of the SDWA), developed and has started to implement a Source Water Assessment Program (SWAP) approved by EPA. Each SWAP includes delineation or mapping of the areas around drinking water sources, an inventory of potential contamination sources (such as Class 5 wells, landfills, surface impoundments), assessment of risks or likelihood of contamination, and reports to the public. While SWAPs do not control releases to groundwater or provide for remediation of any releases, they are part of EPA's overall strategy, Source Water Contamination Prevention.

Nationally, by the end of 2003, all 170,000 public water systems should have a completed assessment showing their relative susceptibility to potential sources of contamination, including surface impoundments. To the extent a surface impoundment is in a delineated source water protection area geospatially mapped by a state, it will be part of an assessment. Whether or not an impoundment is mapped and determined to be a significant potential source of contamination for a water supply depends on the factual situation for any such water supply and the approved state methodology for determining a public water system's susceptibility.

In addition, 49 states are implementing EPA-approved Wellhead Protection Programs (WHP) under section 1428 of the Safe Drinking Water Act to protect public water wells from identified potential sources of contamination. While many states do not require local governments and public water systems to develop and implement these programs, about 6,000 public water systems as of September 30, 1999, are in communities where some management measures have been implemented to protect the systems (measures could be nonregulatory or regulatory).

Also, the Groundwater Report to Congress in October 1999 (U.S. EPA, 1999e), required by section 1429 of the SDWA, reported that every state is "undertaking some component of a comprehensive groundwater protection program, including enacting protection legislation and regulations, coordinating activities of various agencies responsible for groundwater management, performing groundwater mapping and classification, monitoring ambient quality, developing data management systems, and implementing remediation and prevention programs." Although the report pointed out that there are many sources threatening groundwater contamination, there were no national data ranking sources from more to less threatening.

In the *1998 National Water Quality Inventory, Report to Congress* (U.S. EPA, 2000c) requested by Clean Water Act section 305(b), states report the major sources of groundwater contamination in their states. Nineteen states reported that surface impoundments ranked only ninth as a contamination source of groundwater. Potential sources of contamination that were reported to be more prevalent than surface impoundments were underground storage tanks, septic systems, landfills, large industrial facilities, fertilizer applications, spills, pesticide applications, and hazardous waste sites.

4.3.2 <u>Risks to Surface Water from Releases of Contaminated Groundwater to Surface Water</u>

EPA evaluated the potential for risks and performed an indirect exposure pathway screening analysis and quantitative modeling to estimate risks from surface water contaminated by releases from groundwater to surface water (see also Section 3.3).

By design, surface impoundments are often located near receiving waterbodies. Impoundments designed for final treatment are intended to produce effluent that meets regulatory standards (e.g., NPDES) and, therefore, discharges directly into the waterbody. Many impoundments, however, are designed as part of a treatment train and are not intended to produce effluent of sufficient quality to meet regulatory standards. Although these impoundments do not discharge directly to surface water, chemicals may be released through the bottom or sides of the impoundment, travel through the subsurface, and adversely impact the quality of nearby waterbodies.

The risk analysis identified 35 constituents of concern for the groundwater to surface water pathway. Of the 35 constituents estimated to pose potential risks to surface water from groundwater releases, five are regulated under 40 CFR Part 257 as constituents whose concentrations must not exceed MCLs in groundwater. Thirty-one of the constituents are addressed in EPA's draft *Guide for Industrial Waste Management*. Only two constituents of concern are not addressed by either program. These constituents are dibenz[a,h]anthracene and 1,2-diphenylhydrazine. The 35 constituents and their program coverage by 40 CFR Part 257 regulations and EPA draft *Guide for Industrial Waste Management* are presented in Table 4-6.

Note that the information in the table reflects risk results with varying levels of certainty. The level of certainty depends, in part, on the extent to which the results were based on (1) reported concentration values and (2) surrogate data (including DL values). (See discussion in Chapter 3.) Constituents of possible concern that were reported at specific concentration values (above the detection limit) are identified in the table. Regulatory gaps identified based on this information thus carry the same level of varying certainty.

Regulations and programs designed to control releases to groundwater or to address groundwater contamination at or near a unit's boundary (as discussed previously in Section 4.3.1) should, in turn, control any potential releases from groundwater to downgradient surface water. Based on research of federal and state regulations, there do not appear to be any programs or requirements specifically intended to control releases from groundwater to surface water. EPA's longstanding interpretation of the Clean Water Act, however, is that the discharge of a pollutant from a point source to a navigable water via groundwater that has a direct

Table 4-6. Federal Regulatory or Program Coverage of Constituents with Predicted Risks Exceeding the Risk Criteria for Groundwater to Surface Water Releases

Constituent	40 CFR Part 257 Constituent	*Guide for Industrial Waste Management* Constituent
Arsenic [a,b]	•	•
Thallium [a,b]		•
Acrylonitrile [a]		•
Aldrin [a]		•
Antimony [a]		•
Benzidine [a]		•
Benzo(a)anthracene [benz[a]anthracene] [a]		•
Benzo(a)pyrene [a]		•
Benzo(b)fluoranthene [a]		•
Bis(2-chlororethyl)ether [a]		•
Carbon tetrachloride [a]	•	•
Chlordane [a]		•
Chlorodibromomethane [a]		•
Chrysene [a]		•
4,4-DDD [a]		•
4,4-DDE [a]		•
4,4-DDT [a]		•
Dibenz[a,h]anthracene [a]		
3,3-Dichlorobenzidine [a]		•
1,2-Dichloroethane [a]	•	
1,1-Dichloroethylene [a]	•	
Dieldrin [a]		•
2,4-Dinitrotoluene [a]		•
1,2-Diphenylhydrazine [a]		
Heptachlor [a]		•
Heptachlor epoxide [a]		•
Hexachlorobenzene [a]		•
Hexachlorobutadiene [hexachloro-1,3-butadiene] [a]		•
Ideno (1,2,3-cd) pyrene [a]		•
Pentachlorophenol [a]		•
PCBs [a]		•
1,1,2,2-Tetrachloroethane [a]		•
Toxaphene [a]	•	•
N-Nitrosodimethylamine [a]		•
N-Nitrosodi-n-propylamine [a]		•

[a] Risk estimate was based on surrogate or detection limit value.
[b] Risk estimate was based on a reported waste concentration.
Note: **Bold** indicates the constituent is not specifically addressed by either program.

hydrologic connection to that water is subject to regulation under the NPDES. EPA and states with authorized NPDES programs have issued permits addressing the discharge or potential discharge of pollutants to surface water via hydrologically connected groundwater to a number of facilities including those involved in

- Concentrated animal feeding operations (CAFOs)
- Waste disposal
- Site remediation
- Mining
- Petroleum refining
- Aircraft production.

In those cases where these facilities may impact a waterbody not meeting state water quality standards, their impacts could be addressed through the Total Maximum Daily Load (TMDL) program.

Also, EPA has recently proposed that CAFOs that discharge or have the potential to discharge wastes to navigable waters via groundwater with a direct hydrologic connection must apply for an NPDES permit. See, generally, 66 FR 2960, 3015-3020, 3138, and 3144 (January 12, 2001).

4.3.3 Risks Associated with Other Indirect Pathways

The risk assessment evaluated indirect pathways other than the groundwater to surface water pathway. This involved numerically ranking facilities that manage bioaccumulative chemicals based on criteria relevant to release, transport, and exposure to farmers, home gardeners, and fishers (see also Section 3.4 in Chapter 3). The release scenarios considered included volatilization of constituents from wastewater and particulate entrainment or erosion of constituents from exposed sludge. In addition, the possibility that postclosure exposures could occur through any of these release scenarios was also considered.

To address postclosure exposure to sludge, the regulatory/program coverage and gaps analysis focused on federal and state programs and regulations that address closure and post-closure care requirements for nonhazardous waste surface impoundments (see Section 4.3.3.1). The analysis also evaluated CWA programs that can address erosion and runoff (see Section 4.3.3.2). Program coverage for air deposition indirect pathway risks is identical to programs discussed in Section 4.2.

4.3.3.1 Programs That Address Closure and Postclosure Care of Nonhazardous Waste Surface Impoundments. The RCRA corrective action program and EPA's draft *Guide for Industrial Waste Management* (U.S. EPA, 1999a) are two federal programs that may be used to address closure and postclosure care of nonhazardous waste surface impoundments. Note that the Subtitle D regulations at 40 CFR Part 257 (Subpart A) addressing solid waste disposal units do not address closure and postclosure care. In addition, closure of nonhazardous waste impoundments also could be addressed under various state programs, as voluntary actions, or under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as Superfund.

RCRA Corrective Action. As discussed previously, the RCRA corrective action program provides authorized states or the EPA Regions with the authority to address potential risks from nonhazardous waste surface impoundments located at TSDFs. This provides a regulatory mechanism to address any risks that may be posed by sludge left in place after closure.

Draft *Guide for Industrial Waste Management*. As discussed previously, EPA has developed the draft *Guide for Industrial Waste Management* (U.S. EPA, 1999a) to address multiple aspects of industrial waste management in land-based units. The guide, as currently drafted, includes detailed information on closure and postclosure care of nonhazardous waste surface impoundments. The document currently includes guidance on

- Developing a closure plan
- Selecting a closure method
- Closure by use of a final cover system
- Closure by waste removal
- Postclosure care monitoring and financial assurance.

Implementation of the practices recommended in the guidance, when finalized, would provide substantial reduction in potential risks associated with sludges left in place after closure of a nonhazardous waste surface impoundment.

State Programs. State regulations and programs relevant to closure and postclosure care typically address potential risks posed by exposure to sludge after closure of an impoundment. Based on available information, approximately 26 states have regulations that address closure and postclosure care of nonhazardous waste surface impoundments.

4.3.3.2 CWA Coverage of Erosion/Runoff of Sludges. Once a surface impoundment is closed, the sludge left in the impoundment may contain significant concentrations of chemical contaminants. In some cases, impoundments may be completely filled (or nearly so) with sludge upon closure. If the impoundment sludge is not capped following closure (perhaps pursuant to the previously discussed programs), the potential for runoff and erosion of contaminated sludge particles exists.

EPA's NPDES Program for Storm Water Discharges Associated with Industrial Activity may provide a regulatory mechanism by which erosion/runoff of contaminated sludge particles can be controlled. Under 40 CFR Part 122.26, EPA or authorized states regulate storm water discharges associated with a variety of industrial activities, including discharges associated with those activities from the portions of such "sites used for residual treatment, storage, or disposal" including surface impoundments.

4.3.4 *Ecological Risks*

Federal regulations applicable to nonhazardous waste surface impoundments that may reduce risks posed to ecological receptors include the provisions at 40 CFR Part 257.3-2 for the protection of endangered or threatened species and critical habitats at nonhazardous waste disposal facilities. For facilities that have or are seeking RCRA permits, clearly identified ecological risks may be addressed under the RCRA corrective action program. In addition, the imminent and substantial endangerment provision of RCRA section 7003, allows EPA, upon evidence of past or present handling of solid or hazardous waste, to require any action necessary when a situation may present an imminent and substantial endangerment to health or the environment. This authority applies to all facilities, whether or not they have a RCRA permit, in those specific situations where the statutory threshold is met.

Approximately 26 of 50 states have siting requirements to prevent adverse effects on endangered or threatened species from surface impoundments.

In addition, EPA's draft *Guide for Industrial Waste Management* suggests buffer zones to help prevent the destruction or adverse modification of a critical habitat and minimize harm to endangered or threatened species. The guidance also indicates the need to check with state and local officials in the area to determine if buffer zones are required for industrial waste management units.

4.4 Role of EPA's Multimedia Strategy for PBT Pollutants in Reducing Risks from Surface Impoundments

EPA has a multimedia strategy in place to address the challenges associated with priority persistent, bioaccumulative, and toxic pollutants in the environment. The purpose is to create a mechanism that will enable EPA to better address the cross-media issues associated with reducing priority PBT pollutants in the environment. PBT chemicals pose risks because they are toxic, persist in ecosystems, and accumulate in fish and other organisms.

A set of 12 chemicals is the initial focus of EPA's PBT Strategy. These pollutants are the Level 1 chemicals identified in the United States - Canada Binational Toxicity Strategy (BNS). It is these chemicals, listed in Table 4-7, that are the subject of national action plans, currently in various stages of development. When priority PBTs are selected for the development of national action plans, a comprehensive analysis is conducted to identify, among other things, chemical characteristics, release patterns, uses, sources, multimedia fate and transport, geographic hot spots, sensitive populations, and impacts to human health and the environment. A pesticide action plan will cover aldrin/dieldrin, chlordane, DDT (DDE, DDD), mirex, and toxaphene.

Table 4-7 indicates that, out of the 12 priority PBT chemicals, eight showed the potential for risk for one or more pathways. No groundwater risks were predicted for any of the PBT chemicals listed in the table. Note that all predicted risks for these listed chemicals were based on detection limit/surrogate data, not reported concentrations.

Table 4-7. List of Priority PBT Chemicals and Extent to Which They Showed Potential for Risk

Level 1 PBT Chemicals		**Potential Risk Predicted for One or More Pathways?**
CAS Number	**Chemical Name**	
309-00-2/60-57-1	Aldrin/dieldrin [b]	Yes (gw-sw)[a]
	Alkyl-lead	Not evaluated
50-32-8	Benzo(a)pyrene	Yes (gw-sw)
57-74-9	Chlordane	Yes (gw-sw)
50-29-3 (72-54-8 & 72-55-9)	DDT (DDD & DDE)[b]	Yes (gw-sw)
110-00-9	Dioxins and furans	Yes (gw-sw, air)[a]
118-74-1	Hexachlorobenzene	Yes (gw-sw)
7439-97-6	Mercury and its compounds	No
2385-85-5	Mirex	Not evaluated
29082-74-4	Octochlorostyrene	Not evaluated
1336-36-3	PCBs	Yes (gw-sw)
8001-35-2	Toxaphene	Yes (gw-sw, air)

[a] "Air" and "gw-sw" (groundwater to surface water) indicate the pathways for which risks were predicted for the identified PBT chemical.
[b] PBT chemicals listed together, such as aldrin/dieldrin and DDT (DDD&DDE), are listed separately on the Surface Impoundment Study list of constituents.

The Surface Impoundment Study seeks to evaluate the risks posed by managing wastewaters in surface impoundments and to determine whether existing state or federal programs adequately address those risks. If, through the action plan development process, EPA decides to address PBT risks through any of the various regulatory and nonregulatory mechanisms that are appropriate, any subsequent reductions to the generation of PBT pollutants can, in turn, reduce the quantity of PBT chemicals sent to surface impoundment units, thereby indirectly reducing risk from this source.

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Chapter 5

Summary and Conclusions

5.1 Scope of Surface Impoundment Study

This study is of industrial surface impoundments located in the United States that operated during the 1990s and managed nonhazardous wastes. This study does not address management of hazardous wastes in surface impoundments. For this study, the term "industrial" refers to manufacturing, chemical and petroleum storage, waste management, transportation, and national security activities. The term "surface impoundment" means a natural topographic depression, artificial excavation, or diked arrangement for storing, treating, or disposing of wastewater. It may be constructed above ground, below ground, or partly above and partly below ground.

5.2 SIS Requirements

EPA undertook this study to satisfy two separate requirements: (1) a consent decree between EPA and the Environmental Defense Fund (EDF) resulting from EDF vs. Whitman, D.C. Circuit, 89-0598; and (2) the March 26, 1996, amendment to the Solid Waste Disposal Act (see section 3004(g)(10)), also known as the Land Disposal Program Flexibility Act of 1996 (LDPFA). These requirements are described in detail in Chapter 1.

5.3 Survey and Risk Assessment Findings

5.3.1 Survey of Industrial Impoundments

Chapter 2 of this report discusses the findings of the survey of industrial impoundments. EPA's best estimate is that no more than two-thirds of the 18,000 industrial impoundments in the United States contain one or more of the chemical constituents that were of interest for this study or contain either high (11-12.5) or low (2-3) pH wastewater. More than half of the impoundments with chemical constituents or pH of interest are in the chemical, concrete, paper, and petroleum industries.

Industrial impoundments vary greatly in size, from less than a quarter hectare to several hundred hectares. The larger impoundments form the bulk of the total national industrial impoundment capacity. On a volume basis, the paper and allied products sector manages roughly two-thirds of the total quantity of wastewater—this represents more wastewater than all categories combined.

Industrial impoundments frequently use management techniques that increase the potential for chemical releases and frequently are found in environmental settings that increase the potential for impacts to humans or ecosystems in the event of a chemical release. For example, in this study, EPA found that most industrial impoundments are located only a few meters above groundwater and that, in most cases, shallow groundwater discharges to a nearby surface waterbody. More than half of the impoundments do not have liner systems to prevent releases of wastes to soil or groundwater.

There is also significant potential for people to be exposed to chemical constituents released from industrial impoundments. EPA estimates that 20 million people live within 2 kilometers (about 1.2 miles) of an industrial impoundment that was in operation during the 1990s. Additionally, about 10 percent of impoundments have a drinking water well located within 150 meters of the impoundment's edge.

5.3.2 Risk Assessment

This section summarizes key findings of the risk assessment, which included a risk analysis quantifying risks associated with exposure to contaminated groundwater, air, and surface water and a risk screening ranking the risks associated with indirect pathways and ecological threats. This discussion also highlights findings that address the statutory requirements for the scope of the study. A detailed discussion of the risk screening and risk analysis is included in Chapter 3 of this report.

The analysis to characterize potential risks posed by surface impoundments was based on a tiered approach designed to screen the large number of constituents and impoundments in order to focus subsequent analysis. The first stage of this tiered approach was an initial screening based on very protective exposure assumptions; subsequent stages increased the level of realism through the use of increasing levels of facility-specific data, screening-level models, and site-based models. At each stage in the analysis, EPA was able to identify combinations of facility, impoundment, and chemical that did not require further analysis. Given the design of the overall approach–proceeding from a very protective exposure scenario to a realistic exposure scenario–EPA is confident that combinations that were omitted from further consideration, or screened out, do not pose significant risks to human health or the environment.

The risk estimates developed in this study for human health and the screening conducted for ecological risks are based on an extensive analysis of the survey data reported for a wide array of chemicals and impoundments of potential concern. While there are elements of uncertainty in this analysis, EPA has increased confidence in the results by emphasizing those risk findings that are based on concentration data reported in the survey as being above a limit of detection.

Our major risk analysis findings, as they apply to the 11,900 surface impoundments containing constituents or exhibiting a pH within the scope of this study, can be summarized as follows:

- Most facilities and impoundments nationally do not appear to pose risks to human health or environmental releases of concern.

- Twenty-one percent of facilities nationally—corresponding to 24 percent of impoundments—have the potential for environmental releases above health-based levels to occur from impoundments. While these releases do not appear to pose risk to human health (because of limited exposure), the results do indicate that, at these facilities, selected contaminants have the potential to move beyond the surface impoundment confines and through the environment in excess of health-based levels.

- Five percent of facilities nationally, corresponding to 2 percent of impoundments, may pose potential risks by at least one pathway.

- For 23 percent of impoundments and facilities, EPA was not able to estimate potential risks with confidence because the chemical concentration data were based on inferred or detection-limit data.

Our major risk screening findings for the in-scope surface impoundments can be summarized as follows:

- Based on a screening analysis and protective assumptions, 6 percent of facilities nationally may pose potential concerns through indirect pathways such as contamination of croplands.

- Based on a screening analysis and protective assumptions, 29 percent of facilities nationally may pose potential localized ecological impacts to receptors that inhabit the impoundment area or the nearby areas affected by undiluted impoundment runoff.

EPA also examined potential risks according to whether wastewaters are decharacterized or never characterized and according to their discharge status. This examination was to address the requirement of the 1996 LDPFA that EPA assess decharacterized wastewaters that are managed in surface impoundments under the scope of the Clean Water Act. The findings may be summarized as follows:

- Only about 20 percent of impoundments manage decharacterized wastewaters. Because of this, a relatively small number of the total potential risk exceedances or environmental releases are attributable to decharacterized wastes. However, the rates of risk exceedances and releases generally are higher for decharacterized than for never characterized wastes.

- There are relatively few zero dischargers compared to direct dischargers. For certain pathways, notably the groundwater to surface water pathway, the zero dischargers have a higher rate of potential risk exceedances and environmental releases.

5.4 Regulatory Analysis Findings

As is discussed in detail in Chapter 4, EPA performed a regulatory and program analysis specific to each risk pathway. For the air pathway, EPA conducted a generic program analysis and then a more detailed analysis based on the constituents that showed the potential for risk. Programs that were analyzed include: Clean Air Act (e.g., MACT, residual risk, NSPS), RCRA (e.g., corrective action, permitting, solid waste program), and state regulations and programs. Similarly, for the groundwater and surface water pathways, EPA conducted a RCRA coverage analysis, a review of state programs, and a review of the Clean Water Act and Safe Drinking Water Act.

5.4.1 Air Pathway Regulatory Analysis

5.4.1.1 Summary of Clean Air Act Coverage. As discussed in previous chapters, the risk analysis showed with that, with relatively few exceptions, the impoundments in the scope of the study do not pose risks from air emissions.

The primary regulatory program that addresses potential air risks from industrial surface impoundments is the CAA NESHAP program. Our regulatory analysis found that MACT requirements exist, or will exist, for the majority of industries managing the largest estimated wastewater volume in surface impoundments. Also, a review of the industry sectors that showed the potential for risk did show that the majority, but not all, of the industry sectors are covered by MACT regulations or will be covered by upcoming MACT standards. Further, most of the pollutants that may cause concern are hazardous air pollutants. EPA recognizes that some of these NESHAP rules have not yet reached their compliance dates, so some releases identified in these findings reflect the preregulatory status. Also, the NESHAPs issued after 1990 CAA (commonly referred to as MACT standards) are technology based and, therefore, may not completely restrict releases to levels below the EPA identified risk level. However, under the Clean Air Act, sources subject to MACT standards must be evaluated to determine if “residual risk” remains; if so, additional controls may be imposed.

The study also found that most industry-level NESHAPs do not directly address surface impoundments. A few industry NESHAPs require covers on surface impoundments only if wastewater exceeds a certain threshold concentration value for particular constituents (e.g., benzene loading, total organic concentration). Generally, however, most NESHAP standards tend to focus on HAP levels in the wastewater generated in the production process, which eventually could be treated/stored in the surface impoundment unit (e.g., MACT standards may control wastewater concentration HAP levels as opposed to requiring emission controls, such as a cover, on surface impoundments). However, when a technology standard addresses and reduces or removes pollutants upstream of the surface impoundment, this reduces the load entering the impoundment and, ultimately, emitted to the environment.

5.4.1.2 Possible Limitations in Air Regulatory Coverage. Even though coverage of the air pathway is fairly complete, coverage may not address all surface impoundments in all situations (i.e., in different industries or with different pollutants of concern). Current limitations in regulatory coverage may include situations in which a source category is not covered and, therefore, is not subject to a NESHAP. If an industry is not listed as a source category under section 112 of the CAA, the source would not be subject to a NESHAP or, therefore, a residual risk analysis. As explained previously, this situation is the exception based on the results of this survey and risk analysis.

Another potential gap in coverage is the limited situation in which pollutants of concern are not HAPs. As discussed in Chapter 3, this study suggested only four non-HAP constituents that potentially exceed risk thresholds. It should be noted that there are uncertainties with the identification of a regulatory gap for these four constituents. Risk results for two of the four constituents were not based on reported values; that is, the concentration values used in the risk assessment were a function of the detection levels. Clearly, the other two constituents were detected at only one facility each. The limited verification of the hazard posed by these constituents suggests that any gap is likely to be small. Furthermore, non-HAPs that cannot be addressed directly with NESHAPs and subsequent residual risk determinations still may be indirectly "co-controlled" through use of pollution abatement technologies for other, similar HAPs.

Another type of existing CAA limitation may occur when a MACT rule exists for an industrial category that exceeds the risk threshold, but the MACT rule does not directly address surface impoundment emissions or the risky constituents of concern that are HAPs. As discussed previously, MACT rules typically address the emissions of HAPs generated facility-wide; therefore, few MACT rules require air emission controls specifically for the surface impoundment. Also, based on a review of the industry sectors that showed the potential for risk, EPA found two instances suggestive of industry categories covered by MACT standards, but where the MACT standard did not directly address the HAP constituent of potential concern. Because both of these risk estimates were based on detection limit values as opposed to reported concentration values, and both of these constituents would benefit from co-control of similar HAPs that are covered by the MACT standard, it is not clear that a regulatory gap, in fact, exists.

It should be noted that the NESHAP program only automatically applies to facilities that are considered "major sources," as determined by quantitative measure of the facilities' HAP emissions. Facilities that release less than 10 tons per year of a single HAP or less than 25 tons of more than one HAP are not major sources, and are defined as "area sources." Area sources have special designation under the NESHAP program and their emissions may not be controlled to the same degree as major sources or they may not be controlled at all. To issue equivalent controls for area sources, EPA must either: (1) find that the source presents a threat to human health or the environment warranting regulation, which may or may not be as stringent as major source regulations;[1] or (2) determine that MACT standards are necessary to fulfill the requirements of the Urban Air Toxics Program pursuant to CAA 112(c)(3) and 112(k). One important aspect of the area source program is that the residual risk program cannot address area sources unless they have been listed in accordance with section 112(c)(3) and have been included

[1] "Positive area source determinations" are rarely made and, if not made, area sources are not subject to the MACT controls that apply to major sources for the same source category.

in regulations under section 112(d). EPA did not evaluate the extent to which surface impoundments are located at facilities that meet the definition of a NESHAP major source.

5.4.1.3 <u>Whether Unaddressed Risks Could Be Better Addressed under Existing Programs</u>. Overall, the study shows that coverage of potential air risks is fairly complete, and any gaps in coverage appear, at most, to be limited to specific industry sectors, individual facilities that meet certain exemptions in the NESHAP program, or specific HAPs. This regulatory analysis has determined that, for the air risks that may be present from impoundments, EPA and states have the following tools that could be used more expansively to better address the few risks identified. Most of these tools are currently available, without any regulatory or statutory changes. Voluntary and site-specific tools are included on this list because the potential risks are not widespread.

- Clean Air Act NESHAPs: The CAA requires air emission standards for certain source categories under section 112, i.e., Hazardous Air Pollutants. Additionally, the CAA has residual risk evaluations associated with the 112 MACT standard.

- Clean Air Act Criteria Air Pollutant Program: New or modified sources may be subject to NSPS requirements that could limit VOC emissions from surface impoundments.

- RCRA: For those facilities that are subject to permitting under Section 3005, EPA has the authority to address releases from nonhazardous waste impoundments under the corrective action provisions of section 3008(h) and 3004(u). The "omnibus" permit provision of section 3005 also requires that any RCRA permit issued be protective of human health and the environment and, therefore, can be used to address any identified risks. Further, EPA retains authority to address any solid waste unit, including nonhazardous waste impoundments, under RCRA section 7003 to the extent that "an imminent and substantial endangerment" to human health and the environment may exist.

- State regulation programs: This study determined that a few state solid waste programs address, to varying degrees, air releases from surface impoundments. States also may have additional authorities they can bring to bear at the site-specific level (e.g., through the state's Air Toxics Program or State Implementation Plan). Such programs may be able to target facilities that have the potential to exceed risk thresholds for the air pathway. EPA also has issued draft guidance for state Industrial D programs that identify ways air risks can be evaluated and addressed.

- Voluntary Waste Minimization Programs: Federal and state agencies have a number of waste minimization programs that may address the pollutants of concern. Process changes made upstream of impoundments may reduce or eliminate the pollutants of concern to prevent them from even reaching the impoundments. These programs generally rely on voluntary actions by private parties.

- Supplemental Environmental Programs: When enforcement actions are taken under RCRA or other authorities at facilities with impoundments, EPA or the states may negotiate supplemental agreements or compliance orders to address releases from impoundments.

- New controls: Under RCRA, EPA has considerable authority to develop new regulations that would address possible gaps. These regulations might identify additional wastes as hazardous under 40 CFR Part 261, either through additional waste listings or characteristics. Wastes identified as hazardous would then be subjected to all Subtitle C requirements, which include controls on air emissions. Also, for the decharacterized waste, EPA can issue additional rules under the Land Disposal Restrictions (see 40 CFR Part 268). These controls may require treatment of the pollutants of concern prior to placement in the impoundment so that the pollutants would either be eliminated or reduced to levels that minimize threats to human health and the environment.

- New controls: The CAA provides the ability to add industrial source categories and HAPs to the section 112 and 129 evaluations. (See sections 112 (c)(5) and (b)(3)(B), respectively.)

In summary, a number of tools exist to better address any risks that may be present from impoundment air emissions. Some of the tools are already being used as a matter of course to address impoundments and pollutants of concern.

5.4.2 Groundwater and Surface Water Pathway Analysis

5.4.2.1 Summary of State and Federal Coverage. For the groundwater pathway, several metal and organic constituents were identified as potentially posing risks above the EPA threshold at 1E-05 cancer risk or 1 HQ noncancer risk. As discussed above, in general, releases to groundwater from nonhazardous surface impoundments are controlled under state programs. This study found that regulatory and nonregulatory coverage of potential groundwater risks is fairly complete, but may still have some limited gaps. Based on available information, most states have a program(s) that includes provisions for controlling or addressing groundwater releases from industrial nonhazardous waste surface impoundments. The level of regulatory control or ability to address these releases, however, varies from state to state. These state regulations may be implemented under either general solid and industrial waste management authority or under water program authority. Note that EPA's analysis of state regulations and programs is based on publicly available information rather than on a survey of state regulators. Therefore, the analysis may not have identified all state regulations and programs that address nonhazardous waste industrial surface impoundments.

Additionally, there are RCRA, CWA, and SWDA programs that also, to varying degrees, address groundwater releases or assess the susceptibility of drinking water sources to contamination. These programs, for example, include the SDWA Source Water Assessment Program (SWAP), SDWA Wellhead Protection Programs, RCRA corrective action, reliance on the voluntary Guide for Industrial Waste Management as it is being developed, NPDES program (including the Program for Storm Water Discharges Associated with Industrial Activity), and federal or state waste minimization programs. Where these facilities may impact a waterbody not meeting state water quality standards, their impacts could be addressed through the total maximum daily load program.

5.4.2.2 Limitations in State and Federal Coverage. As noted in Chapter 4, coverage under the various state programs varies, and some impoundments posing potential risks may not currently be addressed. Further, as discussed elsewhere in this report, should land use patterns change and populations increase around impoundments, additional impoundments could pose risks in the future that are not currently addressed by state programs.

5.4.2.3 Whether Unaddressed Risks Could Be Better Addressed under Existing Programs. Many of the same RCRA and state tools described for the air pathway are also applicable to the groundwater and surface water pathways:

- RCRA: The same RCRA tools that exist for the air pathway also exist for the groundwater and surface water pathway.
- State non-RCRA regulations: State NPDES programs and solid waste programs may be able to target facilities that have the potential to exceed risk thresholds for the groundwater and surface water pathway. EPA also has issued draft guidance for State Industrial D programs that identify ways groundwater and surface water risks can be evaluated and addressed.
- Voluntary Waste Minimization Programs: Same as discussed for the air pathway.
- Supplemental Environmental Programs: Same as discussed for the air pathway.
- New RCRA Controls: Same as discussed for the air pathway.

In summary, a number of tools exist to better address any risks that may be present from impoundment groundwater releases. Some of the tools are already being used as a matter of course to address impoundments and pollutants of concern.

5.5 Surface Impoundment Study Conclusions

5.5.1 Our General Findings

This study satisfies both the requirements of the consent decree and the LDPFA with regard to evaluating the risks and regulatory programs for surface impoundments receiving "decharacterized" wastewaters and never characteristic wastewaters. In both cases, EPA has conducted an extensive analysis of the in-scope surface impoundment universe to better understand the risks that may be posed, and the extent that risks are addressed by current and emerging federal and state programs.

5.5.2 *Specific Findings to Satisfy Consent Decree Resulting from EDF v. Whitman*

In conducting the study pursuant to the EDF consent decree, EPA has obtained the information necessary to determine whether a rulemaking to promulgate a hazardous waste characteristic should be initiated. Specifically, EPA examined the universe of impoundments that manage nonhazardous wastewaters; characterized the pollutants of concern, likely releases, and pathways from these impoundments; and assessed potential risks to human health and the environment. Little risk was found and, such as it is, any risk is not widespread. However, risks may, at most, exist in certain industrial sectors or at a facility-specific level, which needs to be verified more specifically. Further, EPA examined the regulations that may apply to impoundments under the variety of federal and state authorities and found that coverage is extensive, but may not be complete in all cases. EPA also identified a number of tools that may be used more expansively to better address risks.

5.5.3 *Specific Findings to Satisfy LDPFA—RCRA Section 3004 (g)(10)*

In conducting the study pursuant to the LDPFA, EPA has completed a study of “decharacterized” wastewaters that characterizes the risks to human health or the environment associated with such management. The findings of the risk assessment, and its limitations, are discussed at length in Chapter 3 of this study. Further, EPA examined existing federal and state programs to evaluate the extent that risks are adequately addressed under those programs. EPA also looked at whether the risks could be better addressed under such laws or programs. These analyses, including a “gap analysis,” are discussed in detail in Chapter 4 of this study. EPA concluded that there are some limited gaps in regulatory coverage, but did not find any serious risks that are not addressed by existing programs.

5.5.4 *Study Conclusion*

The completed surface impoundment study will undergo a formal peer review process similar to the one EPA conducted after completion of the first phase of the consent decree study. Consequently, any technical data in the report should be used with appropriate caveats and cautions. The Agency has not yet determined whether any specific regulatory actions are appropriate to mitigate the potential risks identified in the study.