Economic Analysis for Listing of Inorganic Chemicals, Notice of Proposed Rulemaking

Final Report

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CHAPTER 1

EXECUTIVE SUMMARY

The U.S. Environmental Protection Agency (EPA) is directed by Congress in Section 3001(e)(2) of the Resource Conservation and Recovery Act (RCRA) (42 U.S.C §6921(e)(2)) to determine whether to list as hazardous waste a number of different wastes including those from the inorganic chemicals industry. A lawsuit by the Environmental Defense Fund in 1989 resulted in a consent decree approved by the court that sets out an extensive series of deadlines for making the listing determinations required by Section 3001(e)(2). The deadlines include those for making final listing determinations as well as for concluding various related studies or reports on the industries of concern. The antimony oxide, titanium dioxide, sodium chlorate, sodium phosphates, and inorganic hydrogen cyanide production processes are five of the 14 specific production processes identified within the inorganic chemicals industry in the consent decree and are the only five processes that generate wastes that EPA, based on its risk assessment, found reason to model for risks. The production processes generate numerous different wastes for which the Agency is required to make specific listing determinations. This report provides analytic support to the Agency's notice of proposed rulemaking effort.

After sampling and analyzing the wastes generated by these inorganic chemical producers, the Agency examined two regulatory scenarios for the proposed listing. The first, Scenario 1, consists of wastes that EPA has proposed to list as hazardous wastes. Scenario 1 lists specified wastes from the antimony oxide sector and the titanium dioxide sector. Scenario 2 includes not only wastes that EPA has proposed to list but also any waste that has exceeded risk screens (or other screening criteria) and has had quantitative risk assessment completed. These include all of the specified wastes listed in Scenario 1 and specified wastes generated in the production of sodium chlorate, sodium phosphate, and inorganic hydrogen cyanide and additional specified wastes generated in the production of titanium dioxide. The individual wastes are listed in Table 2-13 in Chapter 2 of this report. EPA has selected Scenario 1 over Scenario 2 because the wastes specified in Scenario 1 either present individual risks that warrant hazardous waste listing or warrant additional controls than those provided under RCRA because of their hazardous characteristics.

EPA studied the production processes, waste management practices, and market and financial conditions in each affected industry sector. The Agency analyzed the costs that each affected industry sector would incur as a result of listing the waste. These costs include new capital expenditures and the incremental treatment, transportation, and disposal costs that firms would incur because of the listing. To make the best use of the nonconfidential data it had available, the Agency chose to use a "typical facility" approach to model the average quantities of saleable final product and waste produced by facilities in each sector. Revenues and costs of compliance were then calculated according to the amount of saleable final product and waste produced by this typical facility. Finally, the total costs and expected economic impacts on the affected sectors of the inorganic chemicals industry were calculated. Economic impacts were measured by comparing the costs of compliance to baseline sales of affected inorganic chemicals and the baseline sales and profits for the typical companies owning affected facilities.

Based on the economic impact analysis, the Agency believes that neither scenario of this proposed listing will have any significant economic impact on firms in the inorganic chemical industry, with the exception, under Scenario 2, of firms that produce titanium dioxide using the sulfate process. Affected facilities generally face costs that will result in very small impacts on them and their owner companies, as defined by cost-to-sales or cost-to-profits ratios. Thus, the costs of these regulations are not expected to be burdensome to most inorganic chemical producers. Only firms using the sulfate process to produce titanium dioxide incur costs (under Scenario 2) that could be considered significant, and they measure only slightly over one percent of the typical owner company's baseline sales.

Tables 1-1 and 1-2 summarize the expected costs of implementing this ruling for Scenario 1 and Scenario 2, respectively. The tables are broken down by sector, the range of cost-to-sales ratios, and total annualized costs. The totals at the bottom of each table sum the expected national costs of implementing this ruling.

Table 1-1. National Costs of Implementing the Proposed Listing: Scenario 1

Industry sector	Cost-to-sales ratio (%)	Total annualized costs ($\$10^6$)
Antimony oxide	0.00004 to 0.048	0.005
Titanium dioxide	0.011	2.898
Total		2.903

Table 1-2. National Costs of Implementing the Proposed Listing: Scenario 2

Industry sector	Cost-to-sales ratio (%)	Total annualized costs ($\$10^6$)
Antimony oxide	0.00001 to 0.025	0.005
Titanium dioxide	0.008 to 1.02	47.937
Sodium chlorate	0.0005	0.223
Sodium phosphate	0.0007	0.063
Inorganic hydrogen cyanide	0.00001 to 0.0002	0.093
Total		48.320

CHAPTER 2

INTRODUCTION, BACKGROUND, AND ORGANIZATION OF THIS REPORT

2.1 Introduction

EPA is directed by Congress in Section 3001(e)(2) of RCRA (42 U.S.C §6921(e)(2)) to determine whether to list as hazardous waste a number of different wastes including those from the inorganic chemicals industry. A lawsuit by the Environmental Defense Fund in 1989 resulted in a consent decree approved by the court that sets out an extensive series of deadlines for making the listing determinations required by Section 3001(e)(2). The deadlines include those for making final listing determinations as well as for concluding various related studies or reports on the industries of concern. This document, an economic impact analysis of the affected industries, is one of the documents supporting the listing determination.

2.2 Organization of the Economic Impact Analysis

This report is organized into six chapters. The first chapter (the Executive Summary) provides an overview to the report and summarizes the study's conclusions. Chapter 2 (this chapter) provides an introduction to the report and presents background information on the industries that will be affected by the proposed listing. It presents an industry profile of the five sectors of the inorganic chemicals industry that will be affected by the proposed listing, discussing supply-side and demand-side dynamics, industry organization, and the markets for each of the chemicals. It also discusses the two possible scenarios the Agency has considered for implement the listing, and it delineates which specific wastes would be listed under each scenario. Scenario 1 consists of wastes that EPA has proposed to list as hazardous wastes. Scenario 2 includes not only wastes that EPA has proposed to list but also any waste that has exceeded risk screens (or other screening criteria) and has had quantitative risk assessment completed. Chapter 3 explains the methodology used by the Agency to facilitate the economic analysis. The "typical facility" and "typical company" models for each sector of the industry are explained, as well as the baseline and compliance waste management practices for each of the scenarios. The economic analysis methodology is explained in detail and the limitations of both the "typical facility" modeling and the economic analysis methodology are discussed. Chapter 4 analyzes the costs and the economic impacts of the proposed listing for each of the affected sectors. Cost analyses and economic impacts are provided separately for both Scenario 1 and Scenario 2. This chapter presents the national costs of the proposed listing for both scenarios. Chapter 5 considers the impact of this listing in light of other regulatory requirements. Chapter 6 presents the conclusions of the economic analysis. It includes tables that break down and summarize the sector by sector and national costs for the two scenarios of the proposed listing. Under Executive Order 12866, economic analyses of Agency rulemakings are to address both the costs and benefits of regulation and alternative approaches. Because of data limitations, the

Agency was unable to quantify all benefits associated with this regulatory proposal and alternatives. The reader is referred to the background document *Risk Assessment for Listing Determination of Inorganic Chemical Manufacturing Wastes*[1] for a description of individual risks posed by wastes proposed for listing under this proposal. The appendices discuss formulas for waste analysis and cost analysis that are too cumbersome to be included in the main body of the report.

2.3 The Inorganic Chemicals Industry

A variety of waste materials are generated in the manufacturing of inorganic chemicals. The original lawsuit resulting in the consent decree identified 14 specific production processes in the inorganic chemicals industry for which EPA was required to do risk assessments on the wastes generated. Of those 14, the antimony oxide, titanium dioxide, sodium chlorate, sodium phosphates, and inorganic hydrogen cyanide production processes generate wastes that EPA, based on its risk assessment, found reason to model and thus consider listing as hazardous wastes. This section profiles these five sectors of the industry and includes extensive information on each industry's supply, production processes, demand, market structure, and product markets.

2.3.1 Industry Profile for Antimony Oxide

Characterizing the antimony oxide industry involves describing the supply of antimony oxide, including production processes, production facilities, and the firms that own them. Demand for antimony oxide, the market structure of the industry, and markets for the product are also a part of the profile.

2.3.1.1 The Supply of Antimony Oxide

In the United States, six facilities engage in antimony oxide production. This section examines the raw materials used, production processes employed, and the costs of production. Antimony oxide can be produced commercially from either antimony sulfide ore or antimony metal.[2] Antimony oxide can be produced using four different processes:

- direct process (roasting),
- indirect process,
- recovery from lead smelting, and
- hydrolysis of antimony trichloride (only demonstrated on a laboratory scale to date).

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[1] U.S. Environmental Protection Agency. August 2000. *Risk Assessment for Listing Determination of Inorganic Chemical Manufacturing Wastes*.

[2] Science Applications International Corporation (SAIC). 1997. "Industry Overview for the Inorganic Chemicals Listing Determination DRAFT." Prepared for the U.S. Environmental Protection Agency. Reston, VA: SAIC. Pg. 59.

These processes are described in detail below.

Direct Method. The direct method involves roasting antimony oxide or sulfide ore in the presence of air (or oxygen). The chemical reaction is as follows:

$$2Sb_2S_3 + 9O_2 \rightarrow 2Sb_2O_3 + 6SO_2$$

The antimony oxide is formed as a fume, cools, and is condensed in a baghouse or similar dry collection device. At this stage, the antimony oxide is usually too impure and must undergo further roasting steps.

Indirect Method. The indirect method of antimony oxide production reduces the raw ore to antimony metal prior to the recovery of antimony oxide. In the blast furnace, oxide-based antimony ore, coke, iron oxide, limestone, and silica are combined, and the antimony present in the ore is converted to its metallic state. Next, the extracted molten antimony is refined using proprietary fluxes. The refined antimony metal is then volatilized and reacted with oxygen in the vapor phase to produce the product. The antimony oxide cools, condenses, and is collected in a dry collection device. The chemical reaction is as follows:

$$4Sb + 3O_2 \rightarrow 2Sb_2O_3.$$

Recovery. The final commercial means of antimony oxide production is through recovery as a by-product of secondary lead refining. Most of the antimony oxide is recovered from lead scrap, particularly batteries.

Hydrolysis. Antimony oxide can also be produced by a wet chemical process that entails the hydrolysis of antimony trichloride solutions under alkaline solutions. Although this method produces a pure product in the laboratory, it is not an economical method for the commercial production of antimony oxide.[3]

In addition to other standard variable input costs, firms incur costs associated with waste disposal. At baseline, the production of antimony oxide generates two nonhazardous wastes, baghouse filters and antimony sludge, that are subject to this proposed rulemaking under RCRA. Typically, the nonhazardous waste is disposed of without treatment or it is recycled.

2.3.1.2 The Demand for Antimony Oxide

Characterizing the consumption of antimony oxide involves describing antimony oxide's uses and consumers and possible substitutes in consumption. Antimony oxide's primary use is as a flame retardant in plastics and textiles. It is also used as a smoke suppressant; as a stabilizer for plastics; in chromate pigment manufacture; as an opacifier in glass, ceramics, and vitreous

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[3] Science Applications International Corporation (SAIC). 1997. "Industry Overview for the Inorganic Chemicals Listing Determination DRAFT." Prepared for the U.S. Environmental Protection Agency. Reston, VA: SAIC. Pg. 59-60.

enameIs; and as a coating for titanium dioxide pigments.[4] Substitutes exist for its use as a flame retardant. Hydrated aluminum oxide and certain organic compounds are considered acceptable substitutes.[5]

2.3.1.3 Industry Organization

The organization of the antimony oxide industry is an important component of the industry profile because the organization provides insights into how the industry will respond to increased costs.

Five companies produce antimony oxide: Amspec Chemical Corp.; GLCC-Laredo, owned by Great Lakes Chemical; Laurel Industries; Schumacher, owned by Air Products and Chemicals, Inc; and U.S. Antimony. Each company operates one facility. Two of the facilities have had recent changes in ownership, but overall production capacity has not been affected. Table 2-1 shows the company, the facility location, and production at each facility. Capacity information was unavailable, so the table lists current production as provided by RCRA 3007 surveys.

Table 2-1. Characteristics of Major Antimony Oxide Producers

Company	Facility location	Production (MT/yr)
Amspec Chemical Corp.	Gloucester City, NJ	CBI
GLCC-Laredo	Laredo, TX	10,890
Laurel Industries	LaPorte, TX	9,133
U.S. Antimony	Thompson Falls, MT	CBI

CBI = confidential business information
Source: Company Surveys

The ownership of several antimony oxide producers has changed in recent years. GLCC-Laredo was formerly Anzon, Inc. Great Lakes Chemical reached a deal to buy the facility

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[4] Science Applications International Corporation (SAIC). 1997. "Industry Overview for the Inorganic Chemicals Listing Determination DRAFT." Prepared for the U.S. Environmental Protection Agency. Reston, VA: SAIC. Pg. 58.

[5] U.S. Geological Survey. "Antimony." *Mineral Commodity Summaries*. January 1999. <www.usgs.gov>. As accessed September 1999.

from Cookson in 1997. In addition, Laurel Industries, which produces approximately one-third of the antimony for the U.S. market,[6] recently acquired Elf-Atochem's facility, marginally increasing its production capabilities. Finally, U.S. Antimony recently dissolved its partnership with Pressure Vessel Services and now realizes 100 percent of the profits and reports 100 percent of sales.[7]

Table 2-2 provides financial information at the company level for antimony oxide. Of the five companies for which data are available, two companies have fewer than 1,000 employees and therefore meet the Small Business Administration's (SBA's) definition of small for this industry.

Table 2-2. Company-Level Financial Information: Antimony Oxide

Companies	Facilities	Profits ($1999 10^6)	Sales ($1999 10^6)	Employees
APOA (Amspec)[a]	Gloucester City, NJ	NA	$50.0	65
Great Lakes[b] Chemical	Laredo, TX	$139.6	$1,453.3	5,800
Occidental (Laurel)[b]	LaPorte, TX	$448	$7,610	8,701
U.S. Antimony[c]	Thompson Falls, MT	$0.304	$4.7	31

NA = Not available

[a] Amspec Chemical Corp. <www.amspecorp.com>. As accessed June 16, 2000.

[b] Hoover's Online. <www.hoovers.com>. Company Capsule. As accessed June 16, 2000.

[c] U.S. Securities and Exchange Commission. July 2000. EDGAR database. <http://www.sec.gov/cgi-bin/srch-edgar>.

2.3.1.4 Markets

Conditions in the markets for antimony oxide help indicate the effect the regulation will have on antimony oxide producers. As previously stated, antimony oxide is used primarily as a flame retardant; in fact, in 1990, 20,000 metric tons were used for this purpose.[8] Overall,

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[6] Scheraga, Dan. "OxyChem's Laurel Buys Elf Line in Flame Retardant Consolidation." *Chemical Market Reporter*; New York; December 22, 1997. www.chemexpo.com/schnell/cmr.html. Accessed June 11, 1999.

[7] U.S. Antimony. <www.usantimony.com>. As accessed April 2000.

[8] Science Applications International Corporation (SAIC). 1997. "Industry Overview for the Inorganic Chemicals Listing Determination DRAFT." Prepared for the U.S. Environmental Protection Agency. Reston, VA: SAIC. Pg. 58-59.

domestic production met consumer demand in 1980 and was expected to continue to meet demand as production increased with economic growth.[9]

Between 1985 and 1990, domestic production doubled. To accommodate production, the United States imports a large amount of antimony and metal ore. Domestic sources are considered inferior to imports because U.S. sources contain high arsenic levels. In 1988, 33,106 tons of ore were imported into the United States, while only 1,353 tons were exported.[10]

In January 1999, the price of antimony oxide was $1.65 to $1.70 per pound. With only five firms, producers (especially the larger ones) may have the power to influence price. Because of this market power and the large growth in demand between 1985 and 1990, antimony oxide producers may be able to shift some of the costs associated with new regulations on to their customers. However, because substitutes do exist, they will not be able to shift all of the costs on to consumers.

2.3.2 Industry Profile for Titanium Dioxide

This profile of the titanium dioxide segment of the inorganic chemicals industry describes the supply of titanium dioxide, including production processes, production facilities, and the firms that own them. Demand for titanium dioxide, the market structure of the industry and markets for the product are also a part of the profile.

2.3.2.1 The Supply of Titanium Dioxide

This section provides an overview of titanium dioxide production in the United States and examines the raw materials used, production processes employed, and the costs of production. The titanium dioxide industry comprises 64 percent of products produced under SIC code 2816. Currently, five companies with 11 facilities produce titanium dioxide. These facilities use three different processes to produce titanium dioxide. These are known and described as the sulfate process, the chloride process, and the chloride-ilmenite process. These three processes are described sequentially.

Sulfate Process. The sulfate process is complex and includes numerous stages and intermediate steps. Producing titanium dioxide via the sulfate process requires sulfuric acid and naturally occurring ilmenite ore ($FeTiO_3$) or manufactured titanium-bearing slag as the major material inputs. Titanium-bearing slag is an ilmenite/hematite mixture. This mixture of ores is smelted, leaving iron and a slag that is rich in titanium.[11] For the sulfate process, sulfuric acid is

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[9] Ibid.

[10] Science Applications International Corporation (SAIC). 1997. "Industry Overview for the Inorganic Chemicals Listing Determination DRAFT." Prepared for the U.S. Environmental Protection Agency. Reston, VA: SAIC. Pg. 58-59.

[11] Science Applications International Corporation (SAIC). 1997. "Industry Overview for the Inorganic Chemicals Listing Determination DRAFT." Prepared for the U.S. Environmental Protection Agency. Reston, VA: SAIC. Pg. 98.

used to dissolve the titanium dioxide out of this pulverized slag. Additional refinement is required to produce different grades of the finished product.[12]

Chloride Process. In the chloride process, rutile or high grade ilmenite ore is reacted with chlorine gas at high temperatures to produce titanium tetrachloride. The titanium tetrachloride is then oxidized at high temperature, forming titanium dioxide and recyclable chlorine.[13] In the discussion that follows, this process is referred to as the "chloride-only" process to distinguish it from the chloride-ilmenite process. In reality, both processes are chloride processes, but they differ in important ways, as discussed below.

Chloride-Ilmenite Process. The chloride-ilmenite process is very similar to the chloride process but uses low-grade ilmenite ore as an input. This low-grade ore has a much higher iron content than the grade of ore used in the chloride process. The pulverized ore is reacted with chlorine gas at high temperature with coke added as a reducing agent. In the first step of this two-step reaction, the iron oxides in the ore react with the chlorine, forming iron chlorides that are condensed and then sold or disposed of in the waste stream. What remains is enriched ilmenite ore. In the second step, this ore is converted, as in the chloride process, to titanium tetrachloride. The titanium tetrachloride is then oxidized to form titanium dioxide and recyclable chlorine. Refinement steps within the process remove contaminants and improve the purity of the finished product.[14]

Of these three methods of production, the chloride processes are newer and more widely used. A comparison of the sulfate and chloride-only processes reveals that the sulfate process creates large amounts of dilute acid effluent, whereas the chloride-only methods produces a more toxic waste, but in lower volumes. A key difference is that chloride process facilities can recover and recycle chlorine when either of the chloride methods is used.[15] For instance, producing 1 ton of titanium dioxide results in 12 tons of wastes material from the sulfate process and only 4 tons from the chloride-only process. However, iron chloride makes up a large amount of the chloride-only process waste. Iron chloride is both acidic and hazardous; thus, facilities using the chloride-only process minimize the amount of iron chloride waste by using higher grade, higher cost rutile or other purified titanium-containing materials in production.[16] The chloride-ilmenite process

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[12] Heil, Scott, and Terrance W. Peck, eds. 1998. *Encyclopedia of American Industries, Second Edition*. Vol. 1: Manufacturing Industries. Detroit: Gale Research, Inc. Pg. 510.

[13] Ibid.

[14] Letter from C. Goldstein, Covington & Burling, Washington, D.C., to Randolph L. Hill, U.S. Environmental Protection Agency, Office of General Counsel, November 16, 1990, p.2.

[15] Science Applications International Corporation (SAIC). 1997. "Industry Overview for the Inorganic Chemicals Listing Determination DRAFT." Prepared for the U.S. Environmental Protection Agency. Reston, VA: SAIC. Pg. 97.

[16] Heil, Scott, and Terrance W. Peck, eds. 1998. *Encyclopedia of American Industries, Second Edition.* Vol. 1: Manufacturing Industries. Detroit: Gale Research, Inc. Pg. 510.

uses lower grade ores with higher iron content, producing higher quantities of wastewater treatment solids than the chloride-only process.

The costs of producing titanium dioxide include the costs of obtaining variable inputs, such as the raw materials, labor, transportation, and energy, and fixed capital expenditures. Most of these costs are assumed, under the current methodology, to be unaffected by the regulation. The incremental costs of the rulemaking result from changes in waste management practices. Baseline waste management practices and costs are discussed in Section 4.2.

2.3.2.2 The Demand for Titanium Dioxide

This section characterizes the consumption of titanium dioxide. It describes the characteristics of titanium dioxide, its uses and consumers, as well as possible substitutes in consumption. The three titanium dioxide production processes result in titanium dioxide having slightly different characteristics. Titanium dioxide produced using the sulfate process uses more common raw materials and produces a less abrasive pigment product, while the chloride processes result in a pigment with a better dry brightness.[17] The chloride processes can produce higher grades of titanium dioxide without additional handling. Furthermore, titanium dioxide produced using the chloride processes uses less labor and equipment and is produced continuously, as opposed to by the batch.[18] These differences in the finished product affect the commercial applications in which it is used.

Over 50 percent of the titanium dioxide produced is used in paints, varnishes, and lacquers. In paints, titanium dioxide is used primarily to whiten and opacify polymeric binder systems. Even mid to deep shades of paint usually contain some titanium dioxide. It is also used in coatings where exterior durability is needed.

Approximately one-third of the titanium dioxide produced is used in the paper and plastics industries. The paper industry uses titanium dioxide in two different applications: as a direct addition to whiten and opacify the paper stock and in the manufacture of coatings that are applied to the paper product. Titanium dioxide is used in plastics to impart whiteness and opacity. It is used by the ink printing industry to control the optical properties and abrasivity of the inks. It is used in a wide range of synthetic fibers (such as rayon, crepe, and taffeta) for delustering. Titanium dioxide is also used in significant quantities by the rubber industry in the manufacture of whitewall tires.

Finally, titanium dioxide is used in the manufacture of numerous other products including enamel and glaze for ceramics, pharmaceuticals, thermoplastic roadline compounds, putties, mastics, fillers, white shoe cleaners, leather coatings, roofing granules, correction fluids,

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[17] Science Applications International Corporation (SAIC). 1997. “Industry Overview for the Inorganic Chemicals Listing Determination DRAFT.” Prepared for the U.S. Environmental Protection Agency. Reston, VA: SAIC. Pg. 100.

[18] Ibid.

bitument and bituminous mastic, concrete-curing membranes, wire-drawing lubricants, lens polishes, lapidary polishes, welding rod coatings, titanium chemicals, and catalysis.[19]

According to the U.S. Geological Survey, there are no cost-effective substitutes for titanium pigment.[20] However, in paper production, calcium carbonate can be used as a filler that is both less expensive and that protects against cellulose degradation by acids in the air.[21]

2.3.2.3 Industry Organization

Titanium dioxide producers are categorized under SIC code 2816, inorganic pigments. The SIC code represents numerous types of inorganic pigment producers, but titanium dioxide producers overwhelmingly comprise the majority of the SIC code, making up 64 percent of the products produced in SIC 2816.

Although the Herfindahl index is only available at a four-digit SIC code level, it may provide a meaningful picture of the titanium dioxide industry in the United States. The index indicates a highly concentrated industry with a value of 1,910 and only 73 producers in the entire SIC code.

Eleven facilities produce titanium dioxide in the United States, representing only five companies. In addition, two facilities in Canada produce a total of 63,636 tons of titanium dioxide, 18,185 tons of which are produced using the sulfate method. DuPont operates a chloride facility in Mexico that produces 100,000 tons. Of the ten U.S. facilities, only two companies—Kemira Oyj and Millennium Inorganics—produce titanium dioxide using the sulfate method.

Table 2-3 presents characteristics of titanium dioxide producers. The table is organized into three sections: facilities that use the chloride process and low-grade ilmenite ore (chloride-ilmenite), facilities that use the sulfate process, and facilities that use the chloride process and high grade ores (chloride-only). This organization facilitates the discussion of the regulations in the following sections. It should be noted that the two facilities that use the sulfate process are paired with adjacent chloride-only process facilities. The paired facilities, currently owned by the same firm but analyzed based on 1999 ownership, mix some of their waste streams. In the analysis and discussion, when these processes and waste streams are combined, they are referred to as “chloride/sulfate...” In modeling the waste production of typical facilities, the Agency took this into account by assuming that one of the typical facilities is a “chloride/sulfate” facility.

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[19] Ibid.

[20] U.S. Geological Survey. <www.usgs.com>. *Mineral Commodity Summaries, January 1999.* Accessed July 1999.

[21] Swaddle, T.W. 1997. *Inorganic Chemistry: An Industrial and Environmental Perspective*. San Diego: Academic Press. Pg. 199.

Table 2-3. Characteristics of Titanium Dioxide Producers

Company	Facility location	Capacity in 2000 (Mt)	Production (Mt)
Chloride-Ilmenite Facilities			
DuPont (C)	DeLisle, MS	280,000	266,000[a]
DuPont (C)	Edge Moor, DE	130,000	123,500[a]
DuPont (C)	New Johnsonville, TN	320,000	304,000[a]
Chloride/Sulfate Facilities			
Kemira (S)	Savannah, GA	60,000	57,000[a]
Kemira (C)	Savannah, GA	100,000	95,000[a]
Millenium Inorganics (C)	Baltimore, MD	51,000	48,450[a]
Millenium Inorganics (S)	Baltimore, MD	44,000	41,800[a]
Chloride-only Facilities			
Kerr-McGee (C)	Hamilton, MS	190,000	180,500[a]
Louisiana Pigment (C)	Lake Charles, LA	110,000	121,956[a]
Millenium Inorganics (C)	Ashtabula, OH	104,000	98,800[a]
Millenium Inorganics (C)	Ashtabula, OH	86,000	81,700[a]
Total		1,475,000	1,401,250[a]

[a] Plant production data were either CBI or not available. Production was estimated for these facilities, using a 95% industry-wide capacity utilization rate. Source: ChemExpo. "Chemical Profile for Titanium Dioxide." <http://www.chemexpo.com> Accessed June 16, 2000.

C = chloride method

S = sulfate method

Overall, titanium dioxide facilities are generally in the mid-90 percent capacity utilization range, regardless of method.[22] The industry is facing some changes in its structure. On April 1, 2000, Kemira transferred ownership of its Savannah plants to Kerr-McGee.[23] This change will affect Kerr-McGee's sales, income, and employment information. The change will also result in Kemira dropping out of scope and in Kerr-McGee incurring all the costs associated with compliance at the Savannah facilities as well as at its Mississippi plant. However, the only data available to characterize the industry pre-date this sale. Thus, Kemira remains in the analysis and Kerr-McGee's data are pre-transfer.

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[22] Ibid; ChemExpo. "Chemical Profile for Titanium Dioxide." <http://www.chemexpo.com> Accessed May 8, 2000.

[23] Kemira Oyj. "Kemira and Kerr-McGee Finalised Sale Contract on Kemira Pigments Titanium Dioxide Pigment Plant in the U.S." <www.kemira.com>. Accessed April 2000.

Table 2-4 provides company-level financial information. None of the five firms meets the SBA's criteria as a small business.

Table 2-4. Company-Level Financial Information: Titanium Dioxide

Companies	Facilities	Profits[a] ($1999 10^6)	Sales[a] ($1999 10^6)	Employees[a] (1999)
DuPont	DeLisle, MS Edge Moor, DE New Johnsonville, TN	$7,690.0	$26,918.0	94,000
Kemira[b]	Savannah, GA (2)	$28.6	$2,416.0	10,743
Kerr-McGee	Hamilton, MS	$142.0	$2,696.1	3,653
Millennium Inorganics	Ashtabula, OH (2) Baltimore, MD (2)	$288.0	$1,589.0	4,400
Valhi, Inc (Louisiana Pigment)	Lake Charles, LA	$49.4	$1,145.2	7,115

[a] Hoover's Online Company Data. <www.hoovers.com>. Accessed June 16, 2000.
[b] Converted from Eurodollars based on 1 EUR$ = 1.045 US$. Universal Currency Converter. <http://www.xe.net/ucc/>. Accessed June 16, 2000.

2.3.2.4 Markets

This section summarizes conditions in the market for titanium dioxide. Between 1994 and 1996, production of titanium dioxide fell 36,000 tons to 1,217,800 tons. Total shipments, including interplant transfers, fell by 40,909 tons to 1,229,818 tons. However, the total value of shipments increased $14.6 million to $2.3 billion.[24] In 1997, estimated capacity was 1,474,545 tons; capacity recently decreased for the sulfate process, while increases are expected for chloride-produced titanium dioxide.[25] In 1997, titanium dioxide production reached 1,342,952 tons.[26]

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[24] U.S. Department of Commerce. *1996 Manufacturing Profiles*. <www.census.gov>. Accessed June 1999.

[25] ChemExpo. *Chemical Profiles*. <www.chemexpo.com>. Accessed June 1999.

[26] U.S. Department of Commerce. *1997 Current Industrial Reports*. <www.census.gov>. Accessed June 1999.

Meanwhile, 1997 domestic demand was 1,068,000 tons.[27] In 1996, with titanium dioxide production at 1,217,800 tons, the United States exported 332,200 tons and imported 167,100 metric tons. Thus, U.S. apparent consumption was 1,052,700 tons of titanium dioxide.[28]

Demand was strong enough for the industry to raise prices at least twice in 1997 (another increase was expected in the near future at the time of the report).[29] The price improvement represents a partial recovery from 1995-1996 when global prices fell 15 percent. In September 1997, the price for titanium dioxide ranged between $0.92 and $0.94 per pound. Between 1981 and 1996, the market high was $1.04 per pound, and the market low was $0.69 per pound.[30]

Growth is projected in this industry in the range of 2 to 4 percent per year through the year 2001. Prices should continue to rise to their 1995 levels. Several capacity expansions put on hold in 1997 are likely to be put into place as the market continues to look positive.

Given the recent increases in price, the limited availability of substitutes, and the positive outlook for the industry, it seems likely that the titanium dioxide producers will be able to pass some share of the costs of new regulations onto consumers.

2.3.3 Industry Profile for Sodium Chlorate

This profile of the sodium chlorate industry describes conditions in the sodium chlorate industry, including production processes, facilities and companies owning sodium chlorate production facilities, and uses and consumers of sodium chlorate. It also provides details on the industry organization and markets.

2.3.3.1 The Supply of Sodium Chlorate

This section provides an overview of sodium chlorate production in the United States and examines the raw materials used, production processes employed, and the costs of production. There are currently ten sodium chlorate production facilities owned by eight companies.

The primary raw material used in the production of sodium chlorate is salt. Sodium chlorate is manufactured by the electrolysis of sodium chloride solution in electrochemical cells without diaphragms. The sodium chlorate manufacturing process can be divided into six steps: (1) brine treatment, (2) electrolysis, (3) crystallization and salt recovery, (4) chromium removal, (5) hydrogen purification and collection, and (6) electrical distribution.

The production of sodium chlorate is very energy intensive, requiring between 4,950 and 6,050 kW hours of electricity per metric ton of product. More than 95 percent of the energy is

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[27] ChemExpo. *Chemical Profiles.* <www.chemexpo.com>. Accessed June 1999.

[28] U.S. Department of Commerce. *1996 Manufacturing Profiles.* <www.census.gov>. Accessed June 1999.

[29] ChemExpo. *Chemical Profiles.* <www.chemexpo.com>. Accessed June 1999.

[30] Ibid.

used in the electrolysis step. The newer processes incorporate a low chloride-chlorate solution coupled with a chromium removal system, or the use of a crystallizer to produce crystal chlorate as the final product. Increases in energy costs have resulted in the use of highly efficient noble metal-coated titanium anodes and elimination of the less efficient graphite anodes.[31]

In addition to the energy cost mentioned above, sodium chlorate production costs include a combination of variable inputs such as raw materials, labor, transportation and waste disposal, and fixed capital expenditures. The regulation is expected to affect waste disposal; baseline waste management and costs are discussed in Section 4.3.

2.3.3.2 The Demand for Sodium Chlorate

This section characterizes the consumption of sodium chlorate. It describes the characteristics of sodium chlorate, its uses and consumers, as well as possible substitutes in consumption. "Sodium Chlorate, $NaClO_3$, is a cubic cyrstalline solid at room temperature and has a molecular weight of 106.44 g/mol. Sodium chlorate melts at 248 ˚C and degrades before any boiling point is reached."[32] The major use of sodium chlorate is as an input to the production of chlorine dioxide, a bleach used in paper production.

Sodium chlorate is the preferred raw material for production of chlorine dioxide in quantity. Chlorine dioxide is finding increasing use as an oxidizing bleaching agent in the pulp and paper industry, replacing chlorine and sodium hypochlorite. Chemical wood pulp bleached with chlorine dioxide has superior brightness over pulps bleached with other reagents, and it is more environmentally friendly than chlorine dioxide (regarding dioxin formation in pulp production). Ninety-seven percent of the demand for sodium chlorate is in the generation of chlorine dioxide for the bleaching of chemical pulp. Canada is the largest producer of sodium chlorate in the world.

Table 2-5 summarizes the uses for sodium chlorate. The second most important (approximately 3 percent) use of sodium chlorate in 1990 was as an intermediate in the production of other chlorates and/or perchlorates. Lesser uses include agricultural application as a herbicide and as a defoliant for cotton. About 9,000 metric tons of sodium chlorate were used

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[31] Science Applications International Corporation (SAIC). 1997. "Industry Overview for the Inorganic Chemicals Listing Determination DRAFT." Prepared for the U.S. Environmental Protection Agency. Reston, VA: SAIC. Pg. 53.

[32] Science Applications International Corporation (SAIC). 1997. "Industry Overview for the Inorganic Chemicals Listing Determination DRAFT." Prepared for the U.S. Environmental Protection Agency. Reston, VA: SAIC. Pg. 52.

Table 2-5. North American Uses of Sodium Chlorate (10^3 tons/yr)

Use	1983	1987	1990
Chemical pulp bleaching	513	644	921
Perchlorates and sodium chlorite manufacturing	25	27	30
Uranium production	17	12	9
Agricultural herbicide	6	8	7
Other	4	2	0

Source: Science Applications International Corporation (SAIC). 1997. "Industry Overview for the Inorganic Chemicals Listing Determination DRAFT." Prepared for the U.S. Environmental Protection Agency. Reston, VA: SAIC. Pg. 52.

for uranium production during 1990 in North America. Minor uses of sodium chlorate include the preparation of certain dyes and the processing of textiles and furs.[33]

The demand for sodium chlorate has only grown as the pulp industry has moved away from elemental chlorine. Other uses, which account for very small shares of total sodium chlorate production, have remained steady or declined since 1983. Paper producers may choose to produce sodium chlorate in-house or they may purchase it from commercial sodium chlorate producers.

In the face of increased costs due to compliance costs, sodium chlorate producers could probably pass much of the cost along to their customers. It is possible that a large increase in the price of sodium chlorate would result in firms choosing to produce the sodium chlorate in-house. In-house production of sodium chlorate would require costly process modifications and capital investment. Elemental chlorine is not a viable bleaching agent since EPA's cluster pulp and paper rule calls for elemental chlorine-free pulp bleaching by 2001.

2.3.3.3 Industry Organization

Sodium chlorate producers are included in SIC code 2819, industrial inorganic chemicals not specified elsewhere. The SIC classification represents a broad range of chemical producers. In 1999, ten facilities produced sodium chlorate.

A concentration ratio is only available at the four-digit SIC code and is unapplicable to the much narrower sodium chlorate industry. The United States is home to ten sodium chlorate producers representing eight different companies. There are an additional 16 facilities in Canada representing seven companies, three of which are among the eight companies producing in the

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[33] Science Applications International Corporation (SAIC). 1997. "Industry Overview for the Inorganic Chemicals Listing Determination DRAFT." Prepared for the U.S. Environmental Protection Agency. Reston, VA: SAIC. Pg. 52.

United States. The companies with facilities in the United States are CXY, Eka, Elf Atochem, Georgia Gulf, Huron Tech, Kerr-McGee, Sterling Pulp Chemicals, and Western Electrochemical.

These eight companies have facilities located around the country. Table 2-6 shows the company, the facility location, and capacity and or production at each facility. Three of these firms also operate sodium chlorate facilities in Canada. CXY has one plant operating in Taft, LA, and five additional facilities in Canada. Eka operates two U.S. facilities and two Canadian facilities. Finally, Sterling Pulp Chemicals operates one U.S. and five Canadian facilities.

Table 2-6. Characteristics of Sodium Chlorate Producers

Company	Facility location	Capacity (tons)	Production (tons)
CXY	Taft, LA	121,818	116,558
Eka	Columbus, MS	199,090	181,570[a]
Eka	Moses Lake, WA	57,273	57,133
Elf Atochem	Portland, OR	52,727	48,087[a]
Georgia Gulf	Plaquemine, LA	24,545	18,866
Huron Tech	Purdue Hill, AL	36,363	33,163[a]
Huron Tech	Augusta, GA	131,818	120,218[a]
Kerr-McGee	Hamilton, MS	130,000	120,000
Sterling Pulp Chemicals	Valdosta, Ga	100,000	91,280[a]
Western Electrochemical	Cedar City, UT	6,364	5,804[a]

[a] Plant production data were either CBI or unavailable. Production was estimated for these facilities using the average capacity utilization for the facilities with production data.

Three of the eight companies have recently made significant changes in their production capacities. Elf Atochem's U.S. production capacity dropped significantly in September 1997 when it closed a 25,000-ton plant in Tacoma, WA. Huron Tech was scheduled to open a new 90,000-ton plant in March 1999 in Eastover, SC. In July 1997, Kerr-McGee closed a 13,000-ton chlorate plant in Henderson, NV, leaving only its facility in Hamilton, MS. Finally, Sterling Pulp Chemicals' facility in Valdosta, GA, opened in 1997 and has a production capacity of 100,000 tons of sodium chlorate.[34]

Table 2-7 provides financial information at the company level for firms owning sodium chlorate plants. Two of the companies are small businesses by SBA's definition: Huron Tech and Western Electrochemical.

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[34] ChemExpo. *Chemical Profiles.* <www.chemexpo.com>. Accessed June 1999.

Table 2-7. Company-Level Financial Information: Sodium Chlorate

Companies	Facilities	Profits ($1999 10^6)	Sales ($1999 10^6)	Employees
Canadian Occidental Petroleum Ltd (CXY Chemicals, USA)[a,b]	Taft, LA	$69.1	$1,113.5	1,620
Eka[a,c]	Columbus, MS Moses Lake, WA	$206.0	$14,565.0	34,080
Elf Atochem[a]	Portland, OR	NA	$10,326.0	34,080
Georgia Gulf[a]	Plaquemine, LA	$33.0	$858.0	1,440
Huron Tech	Purdue Hill, AL Augusta, GA	NA	NA	NA
Kerr-McGee[a]	Hamilton, MS	$142.0	$2,696.0	3,653
Sterling Pulp Chemicals[a]	Valdosta, GA	$110.0	$721.0	1,180
American Pacific Corp. (Western Electrochemical)[a]	Cedar City, UT	$11.4	$72.8	222

NA = Not available

[a] Hoover's. <www.hoovers.com> Accessed July 2000.

[b] CXY Chemicals is a partnership between Occidental Chemical Corp. and Canadian Occidental Petroleum Ltd. Canadian Occidental owns 85 percent and is the managing partner of CXY. Information on Occidental Chemical is available in the sodium chlorate section. Occidental Chemical does not meet the SBA's standards as a small business for this industry.

[c] Eka Chemicals is a subsidiary of Akzo Nobel N.V.

2.3.3.4 Markets

This section summarizes conditions in the market for sodium chlorate. As of February 1999 total U.S. sodium chlorate capacity was 860,000 tons. Meanwhile, Canadian capacity stood at a slightly higher 1,084,545 tons. While there is a mixture of closures and expansions in this industry, overall the trend seems to be for capacity to increase at a higher rate than demand. This situation is leading to falling capacity utilization rates.[35]

In 1996 the total production of sodium chlorate increased to 598,140 tons.[36] This represents a 6.5 percent increase in production over 1 year. Total shipments including interplant

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[35] ChemExpo. *Chemical Profiles.* <www.chemexpo.com>. Accessed June 1999.

[36] U.S. Department of Commerce. *1996 Manufacturing Profiles.* <www.census.gov>. Accessed June 1999.

transfers increased 38,740 tons, while the value of shipments increased $12,665, an increase of 6.1 percent.[37]

In 1997, U.S. total production of sodium chlorate reached 568,984 tons. Much of the difference between demand and supply was made up for with imports. In 1997, the United States exported 65,680 tons and imported 411,637, leaving apparent U.S. consumption at 913,754 tons. Meanwhile, 1998 North American demand was 1.85 million tons. Still, demand was well below North American capacity.

The recent increases in capacity have put downward pressure on prices and margins. However, prices seem to be historically high. In 1998, 1 ton of sodium chlorate cost $450, a market high between 1983 and 1998. The low during the same period was $320.[38]

As a result of excess capacity, close substitutes, and high international production, it is unlikely that U.S. sodium chlorate producers will be able to pass much of the costs of new waste treatment procedures on to consumers.

Future growth is expected to fall from the 8 percent level between 1988 and 1997 to 5 percent per year through 2002. North American demand is expected to peek at more than 2 million tons in 2001, when EPA's cluster rules calling for elemental chlorine-free pulp bleaching are fully implemented. Growth is then expected to fall to 2 to 3 percent per year.[39] However, even 2 million tons fall short of current capacity.

2.3.4 Industry Profile for Sodium Phosphates

This section provides a profile of the sodium phosphates industry, which describes the supply of sodium phosphates, including production processes, production facilities and the firms that own them, and demand and consumption of sodium phosphates.

2.3.4.1 The Supply of Sodium Phosphates

This section provides an overview of sodium phosphates production in the United States. Only two producers in the U.S. sodium phosphates industry are expected to be affected by this regulation. This section examines the raw materials used, production processes employed, and the costs of production

Sodium phosphates are actually a class of chemicals that include sodium and phosphorous. Sodium phosphate is a general name for a variety of chemicals including Na_3PO_4, HNa_2PO_4, and H_2NaPO_4. These compounds also have many hydrated forms that are very

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[37] U.S. Department of Commerce. *1997 Current Industrial Reports*. <www.census.gov>. Accessed June 1999.

[38] ChemExpo. *Chemical Profiles.* <www.chemexpo.com>. Accessed June 1999.

[39] ChemExpo. *Chemical Profiles.* <www.chemexpo.com>. Accessed June 1999.

common. Physical properties vary with each variation of the compound.[40] Sodium phosphates are a co-product of phosphoric acid produced using the wet process.

Sodium phosphate from the wet feedstock method is produced by a series of precipitation reactions followed by a final neutralization step to release the product. Wet phosphoric acid is fed into the system with sodium carbonate to give a pH of approximately 2. This step will precipitate sodium fluorosilicate. The precipitant is then removed by centrifugation and the remaining solution is then sent to a secondary precipitation train to remove iron and aluminum phosphates as well as arsenic salts by neutralization to a pH of approximately 5 and treatment with sodium sulfide (arsenic precipitant). This step also removes any remaining fluorides that escaped the previous precipitation step. These are sent to the secondary crystallizer and then filtered to remove the precipitants. The remaining acid is sent to final neutralization with sodium carbonate. The pH is neutralized to approximately 8.5 if the desired product is disodium monohydrogen phosphate or to approximately 10 if the desired product is trisodium phosphate. The final neutralization also produces some monosodium dihydrogen phosphate and some monosodium monohydrogen phosphate. The process described here requires an estimated 4.5×10^4 Btu per ton.[41]

Each of these sodium phosphate salts is produced commercially in the anhydrous state, although HNa_2PO_4 and Na_3PO_4 are also produced commercially as hydrates of different forms.[42]

In addition to other standard variable input costs, costs are associated with waste disposal. At baseline the production of sodium phosphates results in the generation of nonhazardous wastes that are subject to this proposed rulemaking under RCRA. Typically, the nonhazardous wastes are transported to a Subtitle D landfill for disposal without treatment. Incremental costs of the rulemaking result in changes in management practices. Specific management steps are described in Section 4.4.

2.3.4.2 The Demand for Sodium Phosphates

This section characterizes the consumption of sodium phosphates. It describes the characteristics of sodium phosphates, its uses and consumers, as well as possible substitutes in consumption. A variety of sodium phosphates are used for a wide range of products. As a result of confidential business concerns, the Bureau of the Census is not able to publish all possible

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[40] Science Applications International Corporation (SAIC). 1997. "Industry Overview for the Inorganic Chemicals Listing Determination DRAFT." Prepared for the U.S. Environmental Protection Agency. Reston, VA: SAIC. Pg. 47.

[41] Science Applications International Corporation (SAIC). 1997. "Industry Overview for the Inorganic Chemicals Listing Determination DRAFT." Prepared for the U.S. Environmental Protection Agency. Reston, VA: SAIC. Pg. 48.

[42] Science Applications International Corporation (SAIC). 1997. "Industry Overview for the Inorganic Chemicals Listing Determination DRAFT." Prepared for the U.S. Environmental Protection Agency. Reston, VA: SAIC. Pg. 47.

data. However, an estimate of the distribution of industrial phosphates by end use is detergent builders and cleaners, 44 percent; miscellaneous, 26 percent; food and beverage, 19 percent; metal treatment, 6 percent; and water treatment, 5 percent.[43]

EPA is only considering listing wastes from the production of sodium phosphates produced using wet process phosphoric acid. This includes $Na_4P_4O_{12}$, $Na_5P_3O_{10}$, HNa_2PO_4, and Na_3PO_4. However, information concerning $Na_4P_4O_{12}$ and $Na_5P_3O_{10}$ was not available for much of this report; thus, unless otherwise specified, the information in this report concerns HNa_2PO_4 (dibasic) and Na_3PO_4 (tribasic).

Wet process sodium phosphates are used to create detergent-grade products and are typically not used to produce food-grade products.[44] Thus, while several of the following uses of sodium phosphates are in food-grade products, those sodium phosphates are not from the process that will be affected by this listing. Specifically, $Na_4P_4O_{12}$ is used for water softening, sequestering, peptizing, and deflocculating, and as a food additive and texturizer. $Na_5P_3O_{10}$ is used as a water softener, corrosion inhibitor in deicing salt preparations, frozen dessert additive, pretanning agent for hides, dispersant for clays and pigments, and a corrosion preventative. "HNa_2PO_4 is most frequently used in food processing as an emulsifier. HNa_2PO_4 is also used in a wide variety of dye and pigment applications as well as detergents and chemical glazes. Na_3PO_4 is used in a wide variety of cleaning products and operations including automatic dish washing detergents, paint remover, and disinfectant cleaners. Na_3PO_4 uses depend directly on the form of Na_3PO_4 being used. Na_3PO_4 is sold commercially in many hydrated forms including some chlorinated forms."[45]

2.3.4.3 Industry Organization

Two companies currently produce sodium phosphates from wet process phosphoric acid: Rhodia Inc. and Solutia. Both have two facilities using this method. Table 2-8 provides information on the location of the four U. S. facilities manufacturing sodium phosphates from wet process phosphoric acid.

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[43] U.S. Geological Survey. "Soda Ash." <www.usgs.gov> Accessed October, 1999.

[44] Science Applications International Corporation (SAIC). 1997. "Industry Overview for the Inorganic Chemicals Listing Determination DRAFT." Prepared for the U.S. Environmental Protection Agency. Reston, VA: SAIC. Pg. 47.

[45] Science Applications International Corporation (SAIC). 1997. "Industry Overview for the Inorganic Chemicals Listing Determination DRAFT." Prepared for the U.S. Environmental Protection Agency. Reston, VA: SAIC. Pg. 47.

Table 2-8. Characteristics of Sodium Phosphates from Wet Process Producers

Company	Facility location	Production
Rhodia, Inc.	Chicago, IL	NA
Rhodia Inc.	Chicago Heights, IL	CBI
Solutia	Augusta, GA	CBI
Solutia	St. Louis, MO	CBI

NA = Not available
Source: Company surveys

Table 2-9 describes the companies owning plants producing sodium phosphates from wet process phosphoric acid. Neither of the companies qualifies as a small business under SBA guidelines (fewer than 1,000 employees).

Table 2-9. Company-Level Financial Information: Sodium Phosphates, 1998

Companies	Facilities	Profits ($$10^6$)	Sales ($$10^6$)	Employees
Rhodia Inc.[a]	Chicago, IL Chicago Heights, IL	$229.0	$5,576.0	23,500
Solutia[a]	Augusta, GA St. Louis, MO	$206.0	$2,830.0	10,600

[a] Hoover's Online <www.hoovers.com>. Company Capsule. Accessed July 2000.

2.3.4.4 Markets

This section describes conditions in the markets for sodium phosphates. In 1996, 19,000 tons of dibasic (HNa_2PO_4) and 18,000 tons of tribasic sodium phosphate (Na_3PO_4) were produced. The total value of shipments was $27,205,000 ($71.60 per 100 pounds) and $15,305,000 ($42.51 per 100 pounds), respectively. Both tribasic value and production increased slightly from 1995, while dibasic value and production decreased slightly. For tribasic sodium phosphate, exports were 0.6 tons and imports were 3.3 tons.[46]

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[46] U.S. Department of Commerce. *1996 Manufacturing Profiles*. <www.census.gov>. Accessed June 1999.

The June 1999 market price was $72.50 per 100 pounds for dibasic sodium phosphate and $73.00 per 100 pounds for tribasic.[47] "Market conditions for sodium phosphates began to improve by year end 1996 and were expected to continue to rise [in] 1997 and 1998."[48] Strengthening demand and the fact that there are only four wet process sodium phosphates producers in the United States, even if some substitutes exist for some uses, suggest sodium phosphate producers are likely to be able to pass at least part of the regulatory costs on to consumers. Furthermore, imports were a small portion of domestic consumption, so foreign competition should not put undue pricing pressure on the companies. At the same time, the sales of both companies are very large compared to sodium phosphates' value of shipments, so they can absorb small cost increases without significant problems.

2.3.5 Industry Profile for Inorganic Hydrogen Cyanide

This profile of the inorganic hydrogen cyanide section of the inorganic chemicals industry describes the supply, demand, and consumption of hydrogen cyanide. The profile includes a description of production processes, production facilities, and the firms that own them. It also provides details on the industry organization and markets.

2.3.5.1 The Supply of Inorganic Hydrogen Cyanide

The United States currently has eight producers of primary inorganic hydrogen cyanide. This section provides an overview of industrial inorganic hydrogen cyanide production by examining the raw materials used, the production processes employed, and the costs of production.

There are four inputs needed to synthesize hydrogen cyanide: energy, hydrogen, nitrogen, and carbon.[49] In practice, over 50 percent of total inorganic hydrogen cyanide output is produced through the Andrussow process. This process synthesizes hydrogen cyanide by reacting ammonia, methane, and air over a platinum catalyst. Another 40 percent is produced as a by-product from acrylonitrile manufacture. The balance is assumed to be produced using other processes.[50] This report will not focus on the production of HCN as a by-product because of the scope of the listing. Thus, the two processes of interest are the Andrussow and Blausäure-Methan-Ammoniak (BMA) processes.

Andrussow Process. In the Andrussow process, the oxidation of the hydrogen is not complete, so the converter off-gas contains hydrogen. The overall reaction is carried out

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[47] ChemExpo. *Chemical Profiles.* <www.chemexpo.com>. Accessed June 1999.

[48] U.S. Geological Survey. "Soda Ash." <www.usgs.gov> Accessed October 1999.

[49] *Kirk-Othmer 1977 Encyclopedia of Chemical Technology.* 2nd Ed. Vol. 20. New York: John Wiley & Sons. Pg 161.

[50] Science Applications International Corporation (SAIC). 1997. "Industry Overview for the Inorganic Chemicals Listing Determination DRAFT." Prepared for the U.S. Environmental Protection Agency. Reston, VA: SAIC. Pg 90-91.

adiabatically by adding air (O_2). The air oxidizes a portion of the methane, making the overall reaction exothermic, even though the reaction of methane with ammonia to form HCN is endothermic. There are two processes for recovering the HCN from the converter off-gases. One process recovers unreacted ammonia for recycling to the converter, and the other scrubs the ammonia out of the gas using sulfuric acid and produces ammonium sulfate as a by-product.[51]

The BMA process. The BMA process, developed by Degussa in Germany, reacts ammonia and methane without air. The reaction is carried out in tubes that are heated externally. Hydrogen cyanide yield is above 90 percent.[52] Two other processes are used to produce hydrogen cyanide, but they are not discussed because they are not used in the United States and are thus outside the scope of the listing.

The cost of producing inorganic hydrogen cyanide includes the costs of the variable inputs including raw materials, labor, transportation, and energy, along with fixed capital expenditures. There are also costs associated with waste disposal. Transportation costs for wastes involve treating them as a poisonous and flammable gas. Transportation containers must be tested before shipment to ensure that there is no leakage.[53]

2.3.5.2 The Demand for Inorganic Hydrogen Cyanide

Characterizing the demand for inorganic hydrogen cyanide involves describing its uses and consumers, as well as possible substitutes in consumption. Hydrogen cyanide is a colorless gas having an odor similar to bitter almonds.[54] It is used in the manufacture of many important chemicals, including adiponitrile (to produce nylon), methyl methacrylate (to produce clear acrylic plastics), sodium cyanide (for the recovery of gold), triazines (for agricultural herbicides), methionine (for animal food supplements), chelating agents (for water treatment), and many others.[55] Table 2-10 compares hydrogen cyanide uses between 1993 and 1996.

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[51] Science Applications International Corporation (SAIC). 1997. "Industry Overview for the Inorganic Chemicals Listing Determination DRAFT." Prepared for the U.S. Environmental Protection Agency. Reston, VA: SAIC. Pg 90-91.

[52] Science Applications International Corporation (SAIC). 1997. "Industry Overview for the Inorganic Chemicals Listing Determination DRAFT." Prepared for the U.S. Environmental Protection Agency. Reston, VA: SAIC. Pgs. 90-92.

[53] *Kirk-Othmer 1977 Encyclopedia of Chemical Technology*. 2nd Ed. Vol. 20. New York: John Wiley & Sons. Pg 164.

[54] *Kirk-Othmer 1977 Encyclopedia of Chemical Technology*. 2nd Ed. Vol. 20. New York: John Wiley & Sons. Pg 159.

[55] Science Applications International Corporation (SAIC). 1997. "Industry Overview for the Inorganic Chemicals Listing Determination DRAFT." Prepared for the U.S. Environmental Protection Agency. Reston, VA: SAIC. Pg. 89.

Table 2-10. Comparison of Uses for Hydrogen Cyanide

Use	1993 (%)	1996 (%)
Adiponitrile for nylon	41	43
Methyl methacrylate	NA	32
Acetone cyanohydrin for acrylic plastics	28	NA
Sodium cyanide for gold recovery	13	10
Cyanuric chloride for pesticides and other agricultural products	9	5
Chelating agents such as EDTA	4	5
Miscellaneous (includes methionine and nitrolotriacetic acid)	NA	5
Methionine for animal feed	2	NA

NA = Not available

Source: Science Applications International Corporation (SAIC). 1997. "Industry Overview for the Inorganic Chemicals Listing Determination DRAFT." Prepared for the U.S. Environmental Protection Agency. Reston, VA: SAIC. Pg. 89.

While there are numerous uses for hydrogen cyanide, several new processes create hydrogen cyanide derivatives directly, forgoing use of hydrogen cyanide as an input. This has reduced the demand for primary inorganic hydrogen cyanide.[56] Furthermore, inorganic hydrogen cyanide faces two perfect substitutes in the forms of organic hydrogen cyanide and hydrogen cyanide produced as a by-product of other processes.

2.3.5.3 Industry Organization

As with other industries, the organization of the hydrogen cyanide industry is an important factor in understanding how the industry will respond to increased costs of production stemming from a new listing. Hydrogen cyanide producers are identified by SIC code 2819, industrial inorganic chemicals not specified elsewhere. The SIC classification represents a broad range of chemical producers. In 1999, 15 facilities produced hydrogen cyanide, including those that produced it as a by-product. Five facilities produce hydrogen cyanide as a by-product of acrylonitrile production.

While a concentration ratio is not available at this level of detail, it is known that these 15 facilities represent 11 companies. If those facilities producing hydrogen cyanide as a by-product or through the organic method are excluded, there are ten facilities owned by eight companies. The companies with facilities producing inorganic hydrogen cyanide as a primary product are Cyanco (a joint venture between Mining Services International and Degussa), Degussa, Dow, DuPont, FMC, Novartis (Ciba), Rhone-Poulenc (now Rhodia), and Rohm and Haas. The

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[56] ChemExpo. *Chemical Profiles*. <www.chemexpo.com>. Accessed May 2000.

facilities are located around the country and have varying capacities. Table 2-11 shows the company, the facility location, capacity, and production at each facility.

Table 2-11. Characteristics of Hydrogen Cyanide Producers

Company	Facility location	Capacity (MT)	Production (MT)
Cyanco	Winnemucca, NV	21,778	13,535
Degussa	Theodore, LA	34,474	23,375
Dow	Freeport, TX	9,072	5,897[a]
Dupont	Memphis, TN	99,792	64,864[a]
Dupont	Orange, TX	145,152	94,348[a]
Dupont	Victoria, TX	181,440	117,936[a]
FMC	Green River, WY	14,969	9,399
Novartis	St. Gabriel, LA	40,824	26,535[a]
Rhodia	Institute, WV	6,804	4,423[a]
Rohm and Haas	Deer Park, TX	90,720	58,968[a]

[a] Production figures for these facilities were confidential business information. The provided numbers were estimated based on the capacity utilization rates of the other facilities (65 percent).

Source: ChemExpo. *Chemical Profiles*. <www.chemexpo.com>. (11/98 data)

Table 2-12 provides financial information at the company level. Only one of the companies for which there are data meets SBA's definition of small for this industry. Mining Services International, 50 percent owner of Cyanco, employs 244 people.

2.3.5.4 Markets

Conditions in the market for hydrogen cyanide provide insights into the effect the regulation will have on hydrogen cyanide producers. The hydrogen cyanide industry produced 521,614 metric tons in 1997, a 9.1 percent increase in production from 1996. On the other hand, total shipments including interplant transfers only increased 2 percent, to 139,041 metric tons. However, the total value of shipments rose 14 percent from $98,932,000 to $112,403,000.[57] Total hydrogen cyanide capacity is 828,727 metric tons. When hydrogen cyanide produced as a by-product is excluded, capacity is 674,503 metric tons. In general, capacity seems to be increasing.[58]

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[57] U.S. Department of Commerce. *1997 Current Industrial Reports*. <www.census.gov>. Accessed May 2000.

[58] ChemExpo. *Chemical Profiles*. <www.chemexpo.com>. Accessed May 2000.

Table 2-12. Company-Level Financial Information: Hydrogen Cyanide

Companies	Facilities	Profits ($1999 10^6)	Sales ($1999 10^6)	Employees
Degussa	Theodore, AL	$279.0	$13,267.0	45,355
Dow	Freeport, TX	$1,331.0	$18,929.0	39,239
Dupont	Memphis, TN Orange, TX Victoria, TX	$7,690.0	$26,918.0	94,000
FMC	Lawrence, KS	$213.0	$4,111.0	15,609
Mining Services International (Cyanco)	Winnemucca, NV	$0.7	$26.8	244
Novartis	St. Gabriel, LA	$4,098.0	$19,979.0	81,854
Rhodia	Morrisville, PA	$229.0	$5,556.0	23,500
Rohm and Haas	Deer Park, TX	$249.0	$5,339.0	21,500

Source: Hoover's Online. <www.hoovers.com>. Accessed July 2000.

Although production data are available, information concerning hydrogen cyanide exports and imports is not. Data are available for exports and imports of hydrogen cyanide and mixed inorganic acids. For the two groups together, 23,400 tons (worth $27,700) were exported and 19,000 tons (worth $16,900) were imported. Even if none of the exports were hydrogen cyanide and all of the imports were, this would only represent a 3.6 percent increase over total U.S. capacity. Thus, imports and exports should not have a large impact on this industry, even though "strong exports of adiponitrile and sodium cyanide have been key growth factors for hydrogen cyanide in recent years."[59] Finally, U.S. demand for hydrogen cyanide was 636,363 tons in 1997 and increased slightly to 654,545 tons in 1998.[60]

The current price of hydrogen cyanide is $0.60 per pound. During the period 1988 through 1997, the low price was $0.41 per pound.[61] Demand for hydrogen cyanide is strong, equaling approximately 79 percent of capacity in 1998. This suggests that inorganic hydrogen cyanide producers may be able to pass some of the costs of new waste regulations on to consumers. On the other hand, the existence of organic hydrogen cyanide producers, whose

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[59] ChemExpo. *Chemical Profiles*. <www.chemexpo.com>. Accessed June 1999.

[60] U.S. Department of Commerce. *1996 Manufacturing Profiles.* <www.census.gov>. Accessed June 1999.

[61] ChemExpo. *Chemical Profiles*. <www.chemexpo.com>. Accessed June 1999.

costs will be unaffected by the rulemaking, limits the inorganic producers' ability to raise their prices.

According to ChemExpo, demand for HCN should parallel or slightly exceed gross domestic product growth.[62] Growth through 2002 is expected to be 2 percent per year, slightly down from the period between 1988 and 1997 when the industry grew at 3 percent per year.

2.4 Proposed Listings of Inorganic Chemical Industry Wastes

The Agency collected data from producers of antimony oxide, titanium dioxide, sodium chlorate, sodium phosphate, and inorganic hydrogen cyanide under Section 3007 of RCRA. Using these data on current production residuals and residual management practices, EPA estimated the incremental costs of listing 16 specific residuals generated in the above five production processes as hazardous wastes. The residuals considered for listing for antimony oxide production are baghouse filters and low-antimony slag. The residuals considered for listing for the three titanium dioxide production processes include combined ilmenite wastewaters, chloride ilmenite wastewater treatment solids, sulfate process digestion sludge, combined chloride/sulfate wastewaters, combined chloride/sulfate wastewater treatment solids, co-mingled chloride-only wastewater, and secondary gypsum. The residuals considered for listing for sodium chlorate production are process sludges without chromium and spent filters without chromium. The residuals considered for listing for sodium phosphate production are filter press cake and dust collection filter bag residuals. Finally, the residuals considered for listing for the hydrogen cyanide production process are hydrogen cyanide wastewaters and ammonium recycle filtration residuals.

Not all of the manufacturers of a particular product produce all of these wastes in their production process. Some produce none of the wastes and are thus exempt from the listing. Others produce only one or a few of the total number of wastes to come under the proposed listing for any particular sector. This means that the number of companies affected by the proposed listing is only a subset of the total number of producers of that particular product.

Currently, producers of these wastes typically treat them as nonhazardous. In practice, this means that the wastes may not be treated prior to impoundment and/or disposal to a Subtitle D landfill. If these wastes were to be listed, producers would have to both handle them as hazardous wastes and treat some of them to mitigate their hazardous characteristics. Disposal in a more stringent Subtitle C landfill or hazardous waste incinerator would be required. Residuals that are currently stored in open air, unlined impoundments would need to be stored in tanks or treated before disposal. Additional costs for transport as a hazardous waste would also be incurred.

2.4.1 Scenario 1 and Scenario 2 Listings

EPA is developing a notice of proposed rulemaking for Scenario 1 that lists the following wastes generated in the production of antimony oxide and titanium dioxide as hazardous:

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[62] ChemExpo. *Chemical Profiles*. <www.chemexpo.com>. Accessed June 1999.

- baghouse filters (antimony oxide),
- low-antimony slag (antimony oxide), and
- chloride ilmenite nonexempt nonwastewaters (titanium dioxide).

The proposed listing under Scenario 2 includes all of the wastes listed above along with

- sulfate process digestion sludge (titanium dioxide),
- combined chloride/sulfate waterwater treatment solids (titanium dioxide),
- secondary gypsum (titanium dioxide),
- combined chloride/sulfate wastewater (titanium dioxide),
- commingled chloride-only wastewaters (titanium dioxide),
- combined ilmenite wastewater (titanium dioxide),
- process sludge without chromium (sodium chlorate),
- filter wastes without chromium (sodium chlorate),
- filter press cake residuals (sodium phosphates),
- dust collection filter bag residuals (sodium phosphates),
- ammonium recycle filtration residuals (inorganic HCN), and
- hydrogen cyanide combined wastewaters (inorganic HCN).

Table 2-13 shows the facilities that would be affected under each regulatory scenario. A facility that produces antimony oxide could exempt itself from the antimony oxide listings if it chose to recycle rather than dispose of the waste. A facility that currently produces secondary gypsum could exempt itself from the listing for this specific waste if it chose to produce some other mineral salt with its process waste acid.

Table 2-13. Wastes and Facilities Affected Under Each Regulatory Scenarios

Product	Waste to be listed	Scenario 1	Scenario 2	Companies affected and waste volume (Mt/y)
Antimony Oxide	Low-antimony slag	Yes	Yes	U.S. Antimony (20)
	Baghouse filters	Yes	Yes	Laurel Industries (4) Amspec (3)
Titanium Dioxide	Sulfate process digestion sludge	No	Yes	Kemira (34,000) Millenium Baltimore (CBI)
	Combined chloride-sulfate wastewater treatment solids	No	Yes	Kemira (66,000) Millenium Baltimore (CBI)
	Secondary gypsum	No	Yes	Millenium Baltimore (CBI) Kemira (9,600,000)
	Combined chloride/sulfate wastewater	No	Yes	Millenium Baltimore (CBI) Millenium Ashtabula 1 & 2 (CBI)
	Commingled chloride-only wastewaters	No	Yes	Louisiana Pigments (70,670) Kerr-McGee (477,000)
	Chloride-ilmenite nonexempt nonwastewaters	Yes	Yes	DuPont DeLisle, EdgeMoor, and New Johnsonville (NA)
	Combined ilmenite wastewater	No	Yes	DuPont DeLisle, EdgeMoor, and New Johnsonville (NA)
Sodium Chlorate	Process sludge without chromium	No	Yes	Georgia Gulf (CBI) Huron Tech (CBI) Eka Columbus & Moses Lake (CBI) Elf Altochem (CBI) Huron Tech (CBI)
	Spent filters without chromium	No	Yes	Eka Moses Lake (0.5)
Sodium Phosphate	Filter press cake	No	Yes	Rhodia Chicago Heights (108)
	Dust collector filter bags	No	Yes	Rhodia Chicago Heights (1.07) & Waterway (0.287) Solutia St. Louis (0.05) & Augusta (0.7)
Hydrogen Cyanide	HCN combined wastewaters	No	Yes	DuPont Memphis (3,550,000) DeGussa (88,300) Rohm & Haas (318,900)
	Ammonia recycle filtration residuals (landfill)	No	Yes	DuPont Memphis (24) Rohm & Haas (21.5)
	Ammonia recycle filtration residuals (incinerate)	No	Yes	DuPont Orange (11) & Victoria (458)

CHAPTER 3

METHODOLOGY AND DATA LIMITATIONS

3.1 Introduction

This report estimates the economic impacts of the listings proposed by EPA on certain sectors of the inorganic chemicals industry. To determine the costs and economic impacts of the proposed hazardous waste listings sector by sector, the Agency chose to use a model facility approach. This approach involves creating a "typical facility," representative of facilities using a particular production process. This approach to modeling uses all of the publicly available and nonconfidential information available about the firms and the industry in the construction of the model to create estimates of industry costs for waste treatment and disposal under the proposed listing.

The typical plants were developed using only nonconnfidential data sources, including data provided by the industry through RCRA 3007 questionnaires or obtained from publicly available sources. Resulting estimates are examined to ensure that the final results do not compromise any particular firm's CBI. Although using only non-CBI limits the data used in the analysis and thus the precision of the cost estimates for a particular plant, EPA does not believe the analysis is significantly affected.

This chapter summarizes the methods used to characterize plants and companies expected to be affected by the listing, to estimate the costs they will incur, and to analyze the impacts of the costs on their plant and company profits. Limitations of the typical plant approach and the economic modeling methodology are identified. As described in Chapter 1, EPA is analyzing the costs and economic impacts of two regulatory scenarios. All of the wastes considered for listing under either scenario were modeled using the typical facility approach, although only a subset of them may be listed under Scenario 1. These models are described below.

3.2 Creation of Typical Plants for Each Industry Sector

There are two basic ways that the typical plant capacities and waste stream numbers were developed. The first uses both existing capacity/production data and waste data to develop a typical plant and estimate waste treatment costs, while the second uses only waste data to develop a typical plant and estimate the waste treatment costs.

In situations where specific information on plant production or capacity for a particular sector is publicly available, this number, coupled with non-CBI information on wastes, was used to create a typical facility. For each production process and waste type, the typical facility was assumed to produce certain amounts of waste as a factor of its production capacity. The production capacity of the typical facility was most often estimated as the average capacity for facilities using that production process and generating that type of waste. The waste quantity data are based on RCRA 3007 questionnaires or from mass balance engineering calculations. The amount of waste "generated" by the typical facility was usually estimated as the average of the waste quantities generated by plants using that process. The typical plant's waste quantities were scaled to its plant capacity. In cases where not all plants in the sector use the same production process or produce the same wastes, separate typical plants were created for each process or each waste stream.

In sectors for which no plant capacity or production data were available, typical plants are based entirely on waste generation data. The typical plant for each production process/waste type in these sectors was created by averaging (in general) the waste quantities generated by facilities for which nonconnfidential data were available. In some cases, waste quantities for the typical plant were estimated based on engineering mass-balance calculations.

The rest of this section presents the typical plants for each industry sector. Tables are given for each separate typical plant used in the cost analysis of this report. The cost analysis for the listing of these wastes is given in detail in Chapter 4.

For each sector, typical plants and companies are created, based on averaging data for existing plants and the companies that own them.

3.2.1 Typical Facility for Antimony Oxide

Data on plant capacity and production for firms in the antimony oxide industry are not available for all firms. Data on wastes are available and were used in creating the cost model.

The wastes considered for listing (Scenarios 1 and 2) are low-antimony slag and baghouse filters. Only U.S. Antimony does not already recycle low-antimony slag; its current baseline (pre-listing) management of this waste is on-site storage in containers. Laurel Industries and Amspec do not recycle baghouse filters or incinerate them on-site. The current baseline management of baghouse filter wastes for these two firms involves off-site disposal in a Subtitle D landfill or disposal in a nonhazardous waste incinerator, respectively.

The disposal practices associated with these two wastes were used to create two typical plants: one that produces 20 metric tons of low-antimony slag and another that produces 4 metric tons of baghouse filters. Information on capacity for these typical plants is unavailable for plants producing low-antimony slag, so no capacity figures are included. Information on capacity is available for only one of the plants that produces baghouse filters, so this plant's capacity and waste numbers were used to create the model of the typical plant producing baghouse filters.

Table 3-1 shows the capacity and waste numbers for the two typical facilities producing antimony oxide and generating wastes that could be affected by either Scenario 1 or 2 of the proposed listing.

Table 3-1. Antimony Oxide: Typical Facilities Capacity

	Typical Facility 1 (one facility) Production: NA	Typical Facility 2 (two facilities) Production: 9,133 Mt/yr
Type of waste generated	Low-antimony slag	Baghouse filters
Amount of waste (Mt/yr)	20	4

NA = Not available

Under either Scenario 1 or Scenario 2 of the proposed listing, disposal practices would need to be upgraded to reflect the hazardous nature of the wastes. These costs are calculated in Chapter 4 and would include disposal in a Subtitle C landfill and transport via hazardous waste hauler. Firms affected by this listing could avoid these additional costs by recycling their wastes, a practice common to the other firms in this sector. Table 3-2 summarizes baseline practices and changes that would be required as a result of the listing.

Table 3-2. Summary of Baseline and Listing Compliance Waste Management Practices (Scenarios 1 & 2) for a Typical Antimony Oxide Facility

Baseline practice	Compliance management practice (treatment and disposal)	Compliance management practice (recycling)
Loading as nonhazardous waste	Loading as hazardous waste	Loading as nonhazardous waste
Transportation to landfill as nonhazardous waste	Transportation to landfill as hazardous waste	Transportation to smelter as nonhazardous waste
	Off-site stabilization	Smelter charges
Off-site disposal in Subtitle D landfill	Off-site disposal in Subtitle C landfill	Recovery of antimony values
	RCRA recordkeeping	
	Incremental administrative costs	

3.2.2 Typical Facility for Titanium Dioxide

The titanium dioxide industry is represented by three different typical facilities. These three typical facilities reflect the three different processes used to produce titanium dioxide. These are the sulfate process, the chloride process, and the chloride-ilmenite process. Since data for production/capacity and wastes are known and/or publicly available, all of these typical facilities use production capacity in their modeling of waste output. Under Scenario 1, the proposed listing will only affect facilities using the chloride-ilmenite process. Under Scenario 2, the proposed listing will affect facilities using any of the three titanium dioxide processes.

At baseline, facilities manage most wastes as nonhazardous wastes. After the listing, the plants would typically substitute tanks for surface impoundments used to store and treat liquids and implement Subtitle C transportation and disposal of solids. In determining whether treatment of solids is necessary prior to disposal, EPA looked at concentrations and compared them to UTS levels. If leachate concentrations were less than UTS, no treatment is needed. If leachate concentrations exceed UTS, appropriate treatment is modeled. For titanium dioxide wastes, no treatment is believed necessary.

3.2.2.1 Titanium Dioxide: Chloride Sulfate Process

The typical facility capacity for the sulfate process was derived by taking the numeric average of production for the two plants that produce titanium dioxide using this method. Each facility is colocated with a chloride process facility, and the wastes from the two processes are commingled. Thus, these are referred to as chloride/sulfate facilities. The wastes considered for listing for this process under Scenario 2 are sulfate process digestion sludge, combined chloride sulfate wastewaters, combined chloride sulfate wastewater treatment solids, and secondary gypsum.

Table 3-3 shows the plant capacity and waste amounts for the typical facility producing titanium dioxide via the sulfate process. Plant capacity for a typical chloride/sulfate producer was taken from the average of the estimated capacity for Kemira and Millennium Baltimore in Table 2-3 in Chapter 2. Waste quantities are based on non-CBI data from the facilities' 3007 questionnaires, scaled to the typical plant capacity. Only CBI data are available for secondary gypsum, so the typical plant quantity cannot be estimated.

Table 3-3. Titanium Dioxide: Chloride Sulfate Process—Typical Facility (plant capacity: 127,500 Mt/yr)

Type of waste generated	Secondary gypsum (one facility)	Sulfate digestion sludge (two facilities)	Combined chloride/sulfate wastewater treatment solids (two facilities)	Combined chloride/sulfate wastewaters (two facilities)
Amount of waste generated (Mt/yr)	NA	29,467	26,297	10,176,891

NA = Not available

Current baseline practices for disposal of wastes at chloride/sulfate process plants are as follows. Secondary gypsum is currently managed in on-site piles prior to disposal or resale. Sulfate process digestion sludge is dewatered and stored in on-site tanks or disposed of in an on-site Subtitle D landfill, respectively. Combined chloride/sulfate wastewaters are stored in unlined settling ponds on-site. The combined chloride/sulfate wastewater treatment solids are the materials that settle to the bottom of the ponds. They are periodically dredged and sent to a Subtitle D landfill.

Under Scenario 2 of the proposed listing, waste management, handling, and disposal practices would need to be upgraded to reflect the hazardous nature of the wastes. These are the costs calculated in Chapter 4 and would include tank storage of wastewaters and container storage of solids. Disposal of liquids and solids would be to a Subtitle C landfill with transport via hazardous waste hauler. This would involve significant additional costs and is more thoroughly discussed in Chapter 4. Table 3-4 summarizes the baseline practices and the changes that would be necessitated by listing the wastes. These changes would only be necessitated under Scenario 2 of the proposed listing.

Table 3-4. Summary of Baseline and Listing Compliance Waste Management Practices (Scenario 2 only) for a Typical Titanium Dioxide Facility—Chloride/Sulfate Process

Baseline practice	Compliance management practice (treatment and disposal)
Sulfate Digestion Sludge	
Loading as nonhazardous waste from impoundment	Send to tank system for listed portion of waste
Transportation as nonhazardous waste	Loading as hazardous waste from tank system
Off-site disposal in Subtitle D landfill	Transportation as hazardous waste
	Off-site disposal in Subtitle C landfill
Secondary Gypsum	
Managed in piles on-site prior to disposal or resale	Storage in on-site containers
Transportation as nonhazardous waste	Loading as hazardous waste from containers
Disposal to Subtitle D landfill or sale to off-site users	Transportation as hazardous waste
	Off-site disposal in Subtitle C landfill
Combined Chloride/Sulfate Wastewaters	
Treatment in impoundment	Construction of tank system
Discharge to NPDES outfall	Neutralize and clarify in tank system; dewater sludge
	Discharge to NPDES outfall
Combined Chloride/Sulfate Wastewater solids	
Settling in impoundment	Construction of tank system
Periodic dredging	Loading as hazardous waste from tank system
Transportation as nonhazardous waste	Transportation as hazardous waste
Disposal to captive Subtitle D landfill	Disposal to Subtitle C landfill
	Administrative costs

3.2.2.2 Titanium Dioxide: Chloride-Only Process

The typical facility capacity for the chloride-only process was derived by taking the numeric average of production for the four plants that produce titanium dioxide using this method. The waste considered for listing for Scenario 2 only is commingled chloride-only wastewater. The waste amount number used in the analysis is based on one facility's non-CBI data, scaled to the typical plant capacity. Table 3-5 shows the numbers for the typical facility producing titanium dioxide via the chloride-only process.

Table 3-5. Titanium Dioxide: Chloride-Only Process—Typical Facility (plant capacity: 122,500 Mt/yr) (four facilities)

Type of waste generated	Commingled chloride-only wastewaters
Amount of waste generated (Mt/yr)	657,656

Current baseline practices for the management of commingled chloride-only wastewaters involves impoundment in settling ponds. Three of the four facilities that would be affected by Scenario 2 of this ruling further treat the wastewater and discharge it to local bodies of water via National Pollutant Discharge Elimination System (NPDES). Compliance with a listing of this waste would involve the storage of wastewater in a tank system prior to treatment and NPDES discharge. Table 3-6 summarizes the baseline practices and the changes that would be necessitated by listing the wastes. These changes would only be necessitated under Scenario 2 of the proposed listing.

Table 3-6. Summary of Baseline and Listing Compliance Waste Management Practices (Scenario 2 only) for a Typical Titanium Dioxide Facility—Chloride-Only Process

Baseline practice	Compliance management practice (treatment and disposal)
Commingled Chloride-Only Wastewaters	
Treatment in impoundment	Construction of tank system
Discharge to NPDES outfall	Neutralize and clarify in tank system; dewater sludge
	Discharge to NPDES outfall
	Administrative costs

3.2.2.3 Titanium Dioxide: Chloride-Ilmenite Process

The typical facility capacity for the chloride-ilmenite process was derived by taking the numeric average of published capacity for the three plants that use this method to produce titanium dioxide and then multiplying it by a factor of 0.95, which is the average industry capacity utilization rate.[1]

The wastes considered for listing under Scenario 1 for this process are nonwastewaters not otherwise exempt from titanium dioxide production—chloride-ilmenite process (hereafter chloride-ilmenite nonexempt nonwastewaters). The wastes considered for listing under Scenario 2 for this process are both chloride-ilmenite nonexempt nonwastewaters and combined chloride-ilmenite wastewaters. Waste amounts are scaled to typical plant capacity. Data on amounts of treatment solids are confidential or not available, so the numbers used in the typical plant were derived using chemical and engineering formulas that represent production conversion from one possible grade of input ilmenite ore, figuring the amount of solids produced as a factor of titanium dioxide production and estimating that 90 percent or more of the solids are subject to the Bevill exclusion. The complete formula is enumerated in detail in Appendix A. Because of the uncertainty surrounding volumes and treatment requirements for nonexempt nonwastewaters, the Agency completed a sensitivity analysis of this material for both volume and treatment method. This analysis appears in Appendix E of this document. Wastewater volumes were derived by taking non-CBI data from two plants and scaling it to the typical plant capacity. Table 3-7 shows the numbers for the typical facility producing titanium dioxide via the chloride-ilmenite process.

Table 3-7. Titanium Dioxide: Chloride-Ilmenite Process—Typical Facility (plant capacity: 243,333 Mt/yr)

Type of waste generated	Chloride-ilmenite nonexempt nonwastewaters (three facilities)	Combined ilmenite wastewater (three facilities)
Amount of waste generated (Mt/yr)	2,200	347,739

The typical baseline waste disposal practices for these three wastes are as follows: chloride-ilmenite wastewater treatment solids are settled in impoundments and then disposed of

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[1] ChemExpo. <www.chemexpo.com> Accessed June 2000.

in on-site Subtitle D landfills.[2] Combined ilmenite wastewater is stored in surface impoundments prior to NPDES discharge. Disposal practices under the listing would involve storage of liquid wastes in tanks prior to treatment and NPDES discharge. Disposal of solid wastes would involve settling in tanks prior to disposal to a Subtitle C landfill. Table 3-8 summarizes the baseline practices and the changes that would be necessitated by listing the wastes for both scenarios.

Table 3-8. Summary of Baseline and Listing Compliance Waste Management Practices for a Typical Titanium Dioxide Facility—Chloride-Ilmenite Process

Baseline practice	Compliance management practice (treatment and disposal)
Ilmenite-Combined Wastewater	(Scenarios 2 only)
Treat in impoundment	Construct tank system for listed portion of waste
Discharge to NPDES outfall	Neutralize and clarify wastewaters in tank system; dewater sludge
	Discharge treated wastewaters to NPDES outfall
Ilmenite Nonexempt Nonwastewater	(Scenarios 1 & 2)
Loading as nonhazardous waste	Construct tank system for listed portion of waste, loading as hazardous waste from tank system
Transportation as nonhazardous waste	Transportation as hazardous waste
Off-site disposal in Subtitle D landfill	Off-site disposal and stabilization in Subtitle C landfill
	Administrative costs

3.2.3 *Typical Facility for Sodium Chlorate*

Data on production capacity are available for all firms in the sodium chlorate sector, but the majority of information on wastes is unavailable or confidential. The typical plant capacity for the sodium chlorate industry was derived by taking the numeric average for all plants in this industry.

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[2] EPA notes that one titanium dioxide chloride-ilmenite facility recycles its chloride solid/wastewater treatment solid mixture and has used it for landfill capping and as a soil substitute. EPA believes that a large amount of this material may be exempt under 40 CFR §261.4(b)(7) from the proposed listing for K178 chloride-ilmenite nonexempt nonwastewaters. For this reason, EPA believes that a large amount of this recycled material will continue to be used post-rule. The facility may achieve this through process changes. As stated above for purposes of this analysis, EPA has estimated volumes of nonexempt nonwastewaters from publicly available information for facility capacity, and published ratios of chloride solids to titanium tetrachloride production. See the *Titanium Dioxide Listing Background Document for the Inorganic Chemical Listing Determination* (August 2000) for non-CBI volume information.

The wastes considered for listing (Scenario 2 only) are process sludge without chromium and spent filters without chromium. All existing facilities producing sodium chlorate also produce both of these wastes, so the typical facility as modeled produces quantities of both process sludge and spent filters. The amount of process sludge produced by the typical plant was found by averaging available non-CBI data from three facilities. The amount of spent filter wastes produced by the typical plant was taken from non-CBI data available for one facility. In all cases, average values from non-CBI plant data were used to calculate the values for the typical plant. These amounts were then scaled to the typical plant capacity and used in the analysis.

Table 3-9 shows the capacity and waste amount numbers for the typical facility producing sodium chlorate and generating wastes that could be affected by Scenario 2 of the proposed listing.

Table 3-9. Sodium Chlorate: Typical Facility (plant capacity: 83,638 Mt/yr) (five facilities)

Type of waste generated	Process sludge without chromium	Spent filters without chromium
Amount of waste generated (Mt/yr)	108	0.5

Current baseline practices for handling and managing process sludge without chromium involves disposal to either municipal landfill, industrial landfill, or landfarm. Spent filters without chromium are managed by three of the four firms affected via disposal in a municipal landfill. The fourth firm already manages this waste as hazardous in a Subtitle C landfill. Compliance with the Scenario 2 listing of these wastes would involve storing, handling, and disposing of both of these byproducts as hazardous waste. Disposal would be to a Subtitle C landfill. Table 3-10 summarizes the current baseline practices and compliance procedures necessitated by the listing. These changes would only be necessitated under Scenario 2 of the proposed listing.

Table 3-10. Summary of Baseline and Listing Compliance Waste Management Practices (Scenario 2 only) for a Typical Sodium Chlorate Facility

Baseline practice	Compliance management practice (treatment and disposal)
Loading as nonhazardous waste	Loading as hazardous waste
Transportation as nonhazardous waste	Transportation as hazardous waste
Off-site disposal in Subtitle D landfill	Off-site disposal in Subtitle C landfill
	Administrative costs

3.2.4 Typical Facility for Sodium Phosphate

Data on plant capacity and production for firms in the sodium phosphate industry are not available. Data on wastes are available and were used in creating the cost model.

Table 3-11 shows the waste types and amounts for the typical plant producing sodium phosphate. Since no data are available to suggest capacity or production, the Agency was unable to estimate model facility sales of sodium phosphate.

Table 3-11. Sodium Phosphate: Typical Facilities (four facilities)

Type of waste produced	Filter press cake	Dust collector bags
Amount of waste produced (Mt/yr)	27	0.53

Current baseline practices for the management of filter press cake involve storage in bins on-site prior to off-site disposal in an industrial Subtitle D landfill. Filter press cake is also recycled back to the reactor. Dust collector filter bags are typically stored in containers on-site prior to off-site disposal to Subtitle D industrial landfills. Compliance with a Scenario 2 listing of these wastes as hazardous would require on-site containment, transportation, and disposal as hazardous waste to a Subtitle C landfill. Table 3-12 summarizes the current baseline practices and compliance procedures necessitated by the listing. These changes would only be necessitated under Scenario 2 of the proposed listing.

Table 3-12. Summary of Baseline and Listing Compliance Waste Management Practices (Scenario 2 only) for a Typical Sodium Phosphate Facility

Baseline practice	Compliance management practice
Loading as nonhazardous waste	Loading as hazardous waste
Transportation as nonhazardous waste	Transportation as hazardous waste
	Off-site stabilization
Off-site disposal in Subtitle D landfill	Off-site disposal in Subtitle C landfill
	Permit modification

3.2.5 Typical Facility for Inorganic Hydrogen Cyanide

Data for production and wastes are available for facilities producing inorganic hydrogen cyanide. The typical facility capacity for the inorganic hydrogen cyanide industry was derived by taking the numeric average of all the plants that are within the scope of the ruling. The wastes considered for listing for this process are hydrogen cyanide combined wastewaters and ammonia recycle filtration residuals (Scenario 2 only). Since waste disposal practices vary within the ten companies that produce inorganic hydrogen cyanide, three different typical facilities were developed to reflect the waste management and disposal methods used by plants in the industry.

3.2.5.1 Hydrogen Cyanide: Typical Facility 1

The first typical plant manages hydrogen cyanide wastewaters in an impoundment and disposes of filtration residuals to a Subtitle D landfill. The production capacity and waste amounts for this typical plant were estimated by averaging quantities at two facilities shown in the Table 3-13.

Table 3-13. Inorganic Hydrogen Cyanide: Typical Facility 1 (production capacity: 95,000 Mt/yr) (two facilities)

Type of waste generated	Ammonium filtration recycle residuals landfilled	Hydrogen cyanide wastewater
Amount of waste generated (Mt/yr)	30	333,000

Current baseline practices for disposal of wastes at the typical facility involve holding the wastewaters in a surface impoundment and sending the ammonia filtration recycle residuals to either an industrial landfill or a municipal landfill.

Under Scenario 2 of the proposed listing, management and disposal practices would have to be upgraded to reflect the hazardous nature of the wastes. Compliance waste management practices would involve tank storage of the wastewaters and disposing of filtration residuals to a Subtitle C landfill via hazardous waste hauler. Table 3-14 summarizes the baseline practices and the changes that would be necessitated by listing the wastes.

Table 3-14. Summary of Baseline and Listing Compliance Waste Management Practices (Scenario 2 only) for Typical Hydrogen Cyanide Facilities Generating Hydrogen Cyanide Wastewaters and Ammonia Recycle Filtration Residuals

Baseline practice	Compliance management practice (managment and disposal)
Hydrogen Cyanide Wastewaters	Construct a tank and clarifier system for listed portion of wastewaters
Treat wastewaters in impoundment	Clarify and neutralize wastewaters in tank system
Ammonia Recycle Filtration Residuals	Loading of solids as hazardous waste
Loading as nonhazardous waste	Transportation of solids as hazardous waste
Transportation as nonhazardous waste	Off-site disposal of solids in Subtitle C landfill
Disposal in Subtitle D landfill	Administrative costs

3.2.5.2 Hydrogen Cyanide: Typical Facility 2

The second typical facility stores and treats its hydrogen cyanide wastewaters in a tank prior to filtering and deepwell injection. This facility incinerates its filtration residuals, disposing of the ash in a Subtitle D landfill. The capacity and waste amounts for this typical facility are based on data for plants incinerating their wastes at baseline and were scaled to the typical facility capacity. Table 3-15 shows the production capacity and waste amounts for the second typical inorganic hydrogen cyanide facility.

Table 3-15. Inorganic Hydrogen Cyanide: Typical Facility 2 (production capacity: 164,000 Mt/yr) (two facilities)

Type of waste generated	Incineration ash from ammonia recycle filtration residuals
Amount of waste generated	234.5 Mt/yr

Current baseline practices for disposal of wastes are modeled based on on-site incineration of the ammonia recycle filtration residuals in a hazardous waste incinerator and off-site disposal of the filters at a Subtitle D landfill. The listing of this waste in Scenario 2 would require permit modification and disposal of the incinerator ash in a Subtitle C landfill. For this typical facility, it is assumed for economic impact purposes that typical facility 2 currently treats its wastes as nonhazardous at least in some steps of its waste management practices. Table 3-16 summarizes baseline practices and changes that would be required as a result of listing this waste. These changes would only be necessitated under Scenario 2 of the proposed listing.

Table 3-16. Summary of Baseline and Listing Compliance Waste Management Practices for HCN Facilities Incinerating Ammonia Filtration Recycle Residuals

Baseline practice	Compliance management practice (treatment and disposal)
Loading incinerator ash solids as nonhazardous waste	Loading of solids as hazardous waste
Transportation as nonhazardous waste	Transportation of solids as hazardous waste
Disposal in Subtitle D landfill	Off-site disposal of solids in Subtitle C landfill
	Administrative costs

3.2.5.3 Hydrogen Cyanide: Typical Facility 3

The third typical facility manages its hydrogen cyanide wastewaters in surface impoundments but generates no filtration residuals. Table 3-17 shows the production capacity and waste amounts for the third typical inorganic hydrogen cyanide facility.

Table 3-17. Inorganic Hydrogen Cyanide: Typical Facility 3 (production capacity: 35,000 Mt/yr) (one facility)

Type of waste generated	Hydrogen cyanide combined wastewaters only
Amount of waste generated (Mt/yr)	90,000

Current baseline practices for disposal of wastes at the third typical inorganic hydrogen cyanide facility include on-site storage of the wastewaters in a surface impoundment. The wastes are treated and then discharged to an NPDES outfall. Under Scenario 2 of the proposed listing, facilities currently managing their hydrogen cyanide wastewaters in this manner would have to construct a tank system for storage and treatment of the waste prior to release to the NPDES outfall. Table 3-18 summarizes baseline practices and changes that would be required as a result of listing this waste. These changes would only be necessitated under Scenario 2 of the proposed listing.

Table 3-18. Summary of Baseline and Listing Compliance Waste Management Practices for Hydrogen Cyanide Facilities Creating only Hydrogen Cyanide Wastewaters

Baseline practice	Compliance management practice (treatment and disposal)
Treat wastewaters in surface impoundment Discharge to NPDES outfall	Construct a tank and clarifier system for listed portion of wastewaters Clarify and neutralize wastewaters in tank system Discharge to NPDES outfall Administrative costs

3.3 Limitations of the Typical Plant Approach

By choosing to analyze the economic impacts of the proposed listing based on the waste generation, production capacity, costs, and economic impacts of typical facilities in each sector, EPA gave up the opportunity to develop precise cost and economic impact estimates for individual facilities. The estimates developed are reasonable and defensible "averages" for facilities in each sector generating each waste type. Where possible, EPA constructed the typical plant scenarios using baseline waste management practices that maximize the incremental costs of complying with the listing. Thus, the costs of compliance are, if anything, overestimated for the typical plant.

The typical facilities described above were developed based exclusively on non-CBI data In some cases, publicly available and nonconnfidential data were limited. In the case of privately owned companies, obtaining all of the desired company data was difficult. The RCRA 3007 survey and other sources did not provide all of the information that would have been ideal for producing precise estimates of waste generated. Despite these limitations, EPA believes that the analysis is reasonable and accurate, if somewhat less precise that it might have been if all available data were used.

3.4 Characteristics and Limitations of the Economic Impact Analysis Method

EPA measured the economic impact of the regulation by comparing the estimated costs of complying with the regulation to typical facilities' and companies' baseline revenues and, where data are available to estimate them, baseline profits. The typical facilities' revenues are estimated by multiplying the facilities' estimated production times the market price for the commodity. If the estimated costs of compliance are a significant share of the plant's revenues from producing the commodity, it is possible that the product line may become unprofitable and production may be stopped. EPA does not have sufficient data about production costs to estimate the baseline profitability of the individual product lines, so this analysis is only approximate.

The Agency also compared the estimated costs of compliance with typical revenues and, where available, profits for the companies owning the regulated facilities. These measures assess whether the companies owning the facilities are expected to have the financial resources to purchase the capital equipment and undertake the annual costs associated with compliance. If the costs of compliance represent a substantial share of baseline revenues or profits, it is possible that the companies will become less profitable as a result of complying with the regulation.

In both of these analyses, the costs of compliance, product line revenues, company revenues, and company profits were analyzed without accounting for market responses to the costs of the regulation. In reality, EPA expects firms facing regulatory costs to reduce the quantity of the regulated product they offer at a given price, thus reducing the market supply of the commodity. Depending on market conditions, this may result in an increase in the market price and a decrease in the production of the commodity. Facilities that produce the product but are not in-scope of the regulation (and thus incur no costs of compliance) may experience higher revenues, market shares, and profits, while facilities that are directly affected by the regulation may experience higher costs and lower market shares and profits. EPA's analysis abstracts from these responses and distributional impacts. By assuming that the facilities continue to produce the same quantities of the products and that market prices are unchanged, EPA's estimated impacts could be considered worst-case estimates of impacts on company profits for companies owning directly affected facilities. However, EPA notes that even though this assumption presents a worst-case scenario for the inorganic chemical producers themselves, in reality a decline in production and an increase in the price of the commodity would result in a loss of consumer surplus in the economy. The Agency believes that this loss and the decrease in supply would be relatively small because of the modest level of costs in relation to the value of the chemicals being supplied. EPA has presented qualitative information in Chapter 2 about the ability of inorganic chemical producers to pass costs through to consumers. The actual ability of inorganic chemical producers to pass costs through depends on the elasticities of supply and demand of the commodities themselves. And while quantitative elasticities are more informative than qualitative discussion, EPA does not have the data necessary to estimate this information.

Also, as mentioned in Chapter 2, under Executive Order 12866, economic analyses of Agency rulemakings are to address both the costs and benefits of regulation and alternative approaches. Because of data limitations, the Agency has been unable to quantify all benefits associated with this regulatory proposal and alternatives. The reader is referred to the background document *Risk Assessment for Listing Determination of Inorganic Chemical Manufacturing Wastes*[3] for a description of individual risks posed by wastes proposed for listing under this proposal.

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[3] U.S. Environmental Protection Agency. August 2000. *Risk Assessment for Listing Determination of Inorganic Chemical Manufacturing Wastes.*

CHAPTER 4

COSTS AND ECONOMIC IMPACTS OF THE PROPOSED LISTING

After sampling and analyzing the wastes generated by these inorganic chemical producers, the Agency has examined two regulatory scenarios for the proposed listing. The first, Scenario 1, consists of wastes that EPA has proposed to list as hazardous wastes. Scenario 1 lists specified wastes from the antimony oxide sector and titanium dioxide sector. Scenario 2 includes not only wastes that EPA has proposed to list but also any waste that has exceeded risk screens (or other screening criteria) and had quantitative risk assessment completed. These include all of the specified wastes listed in Scenario 1, and specified wastes generated in the production of sodium chlorate and sodium phosphate and inorganic hydrogen cyanide production, and additional specified wastes generated in the production of titanium dioxide. The individual wastes are listed in Table 2-13 below. EPA has selected Scenario 1 over Scenario 2 because the wastes specified in Scenario 1 either present individual risks that warrant hazardous waste listing or warrant additional controls than those provided under RCRA due to their hazardous characteristics. This chapter describes the cost analysis for each scenario of the proposed listing for each of those sectors separately and in detail. It also describes the estimated economic impacts of the proposed listing for both Scenarios 1 and 2 for each of the affected industry sectors and for typical affected firms within those sectors. Finally, it sums up all of the estimated costs for each of the scenarios of the proposed listing to estimate the national cost of implementing either scenario of this rulemaking.

The examination of the affected industry sectors is divided into four parts. The first part gives a brief review of current baseline conditions in each industry sector, including waste management practices and the changes that will be necessitated by the proposed listing. This has already been discussed thoroughly in Chapter 2. The second part reviews the information developed on the baseline financial condition of the typical facility in Chapter 3 and describes the typical company owning these typical facilities. The third section uses this information to analyze the costs of the proposed listing under Scenarios 1 and 2. The fourth part uses information on industry structure and firm-level sales and profits from Chapter 2, along with the cost analysis information developed in the third part of Chapter 4, to examine the costs of the proposed listing in the context of the affected companies' baseline financial condition. This part also estimates the economic impacts of the proposed listing under each regulatory scenario. Because two scenarios for the proposed rulemaking are being considered, the analysis of each industry sector compares the waste management and financial impacts of the two scenarios. Finally, the last part of this chapter sums costs across all of the affected firms in all of the affected sectors to show the national costs of this proposed rulemaking.

4.1 Antimony Oxide

The antimony oxide industry generates wastes that are candidates for listing. This section reviews the antimony oxide industry, provides a cost analysis for both of the proposed listing scenarios, and assesses the economic impacts of the proposed listing.

4.1.1 Review of Baseline and Compliance Waste Management Practices

This section reviews the baseline and post-rule compliance waste management practices incorporated into the cost and economic impact analysis in Sections 4.1.2 and 4.1.3. In the antimony oxide sector, baghouse filters and low-antimony slag are the only two wastes that the Agency has chosen to list, based on its risk assessment screening. These two wastes are considered for listing in both Scenario 1 and Scenario 2, but not all of the affected firms produce both wastes, as noted in Chapter 3. The baseline assumes that all affected companies are handling their waste according to current regulations. Both wastes are nonhazardous at baseline, and affected facilities dispose of the wastes by sending them to an industrial Subtitle D landfill without treatment, incinerating them, or recycling them.

Listing the wastes as hazardous means that they will now be considered hazardous “from the cradle to the grave” and must be disposed of, even after treatment, in a hazardous waste (Subtitle C) landfill. Similarly, all hazardous wastes and residuals from the production process must be transported to the landfill under a hazardous waste manifest by a licensed hazardous waste hauler, which is more expensive than industrial waste transportation. As noted above, both wastes would be conditionally exempt from listing as hazardous waste if they are recycled. Potentially affected generators thus have two scenarios in responding to the listing: recycle the wastes or manage them as listed hazardous wastes.

In modeling the two typical antimony oxide facilities for the cost and economic impact analysis, it was assumed that the plants manage their waste as nonhazardous and transport it via common carrier for disposal at an off-site Subtitle D landfill. Plants that currently recycle their wastes and continue to do so are conditionally exempt from the listing.

Three of the facilities producing antimony oxide are expected to be affected by this regulation because they both generate at least one of the wastes and do not currently recycle them. If any or all of these three plants chose to recycle their wastes post-rule, then they will also be exempt from the ruling.

4.1.2 Characterization of Antimony Oxide Facilities

To analyze the economic impacts of the proposed regulation, EPA used a typical facility approach. This was described in detail in Chapter 3.

Two typical facilities were developed to analyze the expected impacts on the industry: one that generates baghouse filters and one that generates low-antimony slag. For each typical plant two scenarios for compliance with the proposed rule were developed: one that models treatment and disposal of wastes and one that models recycling of wastes. Furthermore, two typical companies were modeled for each compliance scenario. The first represents the type of company that owns a typical facility generating baghouse filters. The second represents the type of company that owns a typical facility generating low-antimony slag.

Table 4-1 describes the companies associated with the typical plants. The companies represent the average baseline financial conditions for those companies that own a baghouse filter generating plant or a low-antimony slag generating plant. As Table 4-1 shows, the average company owning a plant that generates baghouse filters does not meet the SBA definition of small for this industry. However, the owner of the facility generating low-antimony slag does meet the SBA criterion, which is a business having fewer than 1,000 employees. Data come from Table 2-2 in Chapter 2.

Table 4-1. Antimony Oxide Typical Company Characteristics

	Number of affected companies	Sales ($\$10^6$)	Profits ($\$10^6$)	Employees
Baghouse filter generating company	2	$3,830	$224	4,628
Low-antimony slag generating company	1	$4.7	$0.304	31

4.1.3 Cost Analysis

The Agency used two typical plants to estimate incremental costs associated with listing solid wastes from antimony oxide production: one associated with each of the wastes proposed to be listed as hazardous. Each of these wastes is proposed to be listed under both Scenario 1 and Scenario 2. Costs were estimated for each compliance method for each waste type.

The listed wastes are used filter bags and low-antimony slag. This analysis made the following assumptions:

1. Waste volumes are 4 Mt/y for filter bags and 20 Mt/y for low-antimony slag.
2. For compliance by treatment and disposal, wastes are accumulated for 90 days then loaded and transported to an off-site treatment and disposal facility.
3. For compliance by recycling, wastes are shipped once a year to the recycling facility (a smelter).
4. For compliance by treatment and disposal, stabilization of post-rule wastes to universal treatment standards (UTS) standards is required.
5. Costs for stabilization and disposal are based on the quantity of waste generated.

Table 4-2 lists the unit cost for each of the management practices given in Table 3-2. Footnotes to the table provide the source for each cost. All antimony oxide wastes to be listed are solids. The cost estimates are made using the unit costs in Table 4-2 for aggregated solids

Table 4-2. Baseline and Compliance Management Unit Costs ($1999)

Management practice	Unit cost
Loading as nonhazardous waste	$61.80/load[a]
Loading as hazardous waste	$103.00/load[b]
Transportation as nonhazardous waste	$46.04/Mt[c]
Transportation to recovery facility	$44.00/Mt[d]
Transportation as hazardous waste	$239.38/Mt[e]
Off-site stabilization	$93.11/Mt[f]
Off-site disposal in Subtitle D landfill	$53.20/Mt,[g] $300 minimum charge per load[h]
Smelter charges for antimony waste	$122.38/Mt[i]
Value of recovered antimony	$63.49/Mt[j]
Off-site disposal in Subtitle C landfill	$238.36/Mt,[k] $2,319 minimum charge per load including stabilization[l]
RCRA recordkeeping	$51.07 for environmental technician, $21.45 for clerk[m]
Incremental administrative costs	$1,137 initial cost[n]

[a] U.S. Environmental Protection Agency, Office of Solid Waste. "Regulatory Impact Analysis of the Final Rule for 180-Day Accumulation Time for F006 Wastewater Treatment Sludges." Prepared by DPRA, Inc. St. Paul. January 14, 2000. p. 22. Estimated by deleting 1 hour from administration time listed in first footnote on page 22 and using an annual generation rate of 30 t/y. Converted to metric tons and updated to 1999.

[b] U.S. Environmental Protection Agency, Office of Solid Waste. "Regulatory Impact Analysis of the Final Rule for 180-Day Accumulation Time for F006 Wastewater Treatment Sludges." Prepared by DPRA, Inc. St. Paul. January 14, 2000. p. 21. Estimated from Table 4-3. 30 t/y annual generation rate. Converted to metric tons and updated to 1999.

[c] U.S. Environmental Protection Agency, Office of Solid Waste. "Background Documents for the Cost and Economic Impact Analysis of Listing Four Petroleum Refining Wastes as Hazardous under RCRA Subtitle C." Prepared by DPRA Incorporated, January 10, 1998. p. 3-61, trucks with drums. Updated to 1999.

[d] Derived from Form 3007 for the antimony oxide industry. Assumes transport distance of 1,250 miles.

[e] U.S. Environmental Protection Agency, Office of Solid Waste. "Background Documents for the Cost and Economic Impact Analysis of Listing Four Petroleum Refining Wastes as Hazardous under RCRA Subtitle C." Prepared by DPRA Incorporated, January 10, 1998. p. 3-61, trucks with drums. Updated to 1999.

[f] U.S. Environmental Protection Agency, Office of Solid Waste. "Regulatory Impact Analysis of the Final Rule for 180-Day Accumulation Time for F006 Wastewater Treatment Sludges." Prepared by DPRA, Inc. St. Paul. January 14, 2000. p. 18. Extracted from *Landfill Costs*. Minimum cost per load of $2,267. Converted to metric tons and updated to 1999.

[g] U.S. Environmental Protection Agency, Office of Solid Waste. "Background Documents for the Cost and Economic Impact Analysis of Listing Four Petroleum Refining Wastes as Hazardous under RCRA Subtitle C." Prepared by DPRA Incorporated, January 10, 1998. p. 3-41, Off-site Municipal Subtitle D Landfill. Updated to 1999.

(continued)

Table 4-2. Baseline and Compliance Management Unit Costs ($1999) (continued)

[h] U.S. Environmental Protection Agency, Office of Solid Waste. "Regulatory Impact Analysis of the Final Rule for 180-Day Accumulation Time for F006 Wastewater Treatment Sludges." Prepared by DPRA, Inc. St. Paul. January 14, 2000. p. 18. Taken from *Landfill Costs*. Estimated as the ratio of Subtitle D landfill unit cost to Subtitle C landfill unit cost times the minimum charge for Subtitle C landfills. Converted to metric tons and updated to 1999.

[i] Derived from average price charged to accept waste for metals recovery. US EPA. Office of Water, Office of Science and Technology. Waste Treatment Industry Questionnaire, 1991.

[j] Derived from USGS Mineral Industry Surveys, Anitmony in the Third Quarter 1999. Assumes 15 percent of dust on filter bags or in slag is recoverable at 30 percent of the market price for antimony. Market price for antimony taken as $0.64/lb.

[k] U.S. Environmental Protection Agency, Office of Solid Waste. "Background Documents for The Cost and Economic Impact Analysis of Listing Four Petroleum Refining Wastes as Hazardous under RCRA Subtitle C." Prepared by DPRA Incorporated, January 10, 1998. p. 3-41, Off-site Subtitle C Landfill. Updated to 1999.

[l] U.S. Environmental Protection Agency, Office of Solid Waste. "Regulatory Impact Analysis of the Final Rule for 180-Day Accumulation Time for F006 Wastewater Treatment Sludges." Prepared by DPRA, Inc. St. Paul. January 14, 2000. p. 18. Taken from *Landfill Costs*. Converted to metric tons and updated to 1999.

[m] U.S. Environmental Protection Agency, Office of Regulatory Enforcement. "Estimating Costs for the Economic Benefits of RCRA Noncompliance." December 1997 Update, Appendix B. Assumes 5 hours environmental coordinator and 3 hours clerical time annually. Updated to 1999.

[n] Supporting Statement for EPA Information Collection Request Number [ ], "Reporting and Recordkeeping Requirements for the Proposed Rule on Listing Hazardous Wastes from Inorganic Chemical Production." August 2000.

accumulated annually or over a 90-day period, depending on the compliance management practice chosen. A sample calculation is given in Appendix A for each compliance method. Table 4-3 presents the total costs of the listing for the antimony oxide sector. This total cost is the same for both Scenario 1 and Scenario 2.

4.1.4 Economic Impact Analysis

This section examines the costs of the proposed regulation in the context of the affected companies' baseline financial conditions. Using the typical facility information, EPA estimates that neither of the average companies will be severely affected by this regulation, even under the high-cost assumptions that are embodied in the Subtitle C landfill waste disposal scenario of the cost model.

4.1.4.1 Overview of Economic Impacts on Antimony Oxide Markets

When the proposed waste listing goes into effect, the cost of producing antimony oxide will increase for the affected facilities. Because only three of the five domestic producers are affected by this listing, the affected producers will be unable to pass the costs they incur along to their customers. Thus, producers will fully absorb the costs of responding to the rulemaking. This will reduce their profits. However, the conditional nature of the listing enables the companies to select the cost-minimizing response. In this case, the cost-minimizing response for

Table 4-3. Total Incremental Costs of Compliance for Listing Wastes from Antimony Oxide

Model facility type	Number of affected facilities	Total quantity of wastes treated (Mt/y)	Total capital cost ($)	Total annual costs ($/y)
Stabilization and Subtitle C Disposal Compliance Scenario				
Typical facility generating baghouse filters	2	8	$2,273	$22,620
Typical facility generating low-antimony slag	1	20	$1,137	$14,240
Total		28	$4,500	$36,860
Recycling Compliance Scenario				
Typical facility generating baghouse filters	2	8	$0	$2,736
Typical facility generating low-antimony slag	1	20	$0	$2,294
Total		28	$0	$5,030

all companies affected is to recycle their wastes. EPA estimates that the costs to any of the affected firms will increase only slightly.

4.1.4.2 Estimated Economic Impacts on Affected Facilities and Firms

As described in the previous section, the market supply of antimony oxide is unlikely to be affected as a result of the costs attributed to the rulemaking. Because the costs associated with this rulemaking are relatively small compared to the baseline cost of antimony oxide production, and especially small compared to baseline company costs and revenues, the decrease in supply is expected to be quite small.

The impacts of the regulation on affected companies were measured by comparing the costs of compliance to the typical company's baseline revenues. The impacts of the regulation were estimated assuming that the companies are unable to change the price of antimony oxide, so that they are absorbing all of the compliance costs for either Subtitle C landfill disposal or recycling. Tables 4-4 and 4-5 show that the costs associated with compliance using either waste management scenario comprise a small share of total sales for the typical company.

Table 4-4. Economic Impacts on a Typical Company Generating Baghouse Filters Antimony Oxide Sector: Scenarios 1 and 2

	Treat and dispose of as hazardous waste	Recycle
Number of facilities affected	2	2
Total annualized cost of the listing	$11,310	$1,368
Sales ($\$10^6$)	$3,830	$3,830
Cost to sales ratio	0.0003%	0.00004%
Profits ($\$10^6$)	$448	$448
Cost to profits ratio	0.003%	0.0003%

Table 4-5. Economic Impacts on a Typical Company Generating Low-Antimony Slag Antimony Oxide Sector: Scenarios 1 and 2

	Treat and dispose of as hazardous waste	Recycle
Number of facilities affected	1	1
Total annualized cost of the listing	$14,240	$2,294
Sales ($\$10^6$)	$4.7	$4.7
Cost to sales ratio	0.303%	0.048%
Profits ($\$10^6$)	$0.304	$0.304
Cost to profits ratio	4.68%	0.755%

Furthermore, the costs only represent a large percentage of profits for the company generating low-antimony slag and choosing the high cost disposal scenario. In this case, the company should simply make the cost-minimizing decision to recycle its waste.

4.1.4.3 National Costs

The estimated incremental annual costs to the antimony oxide sector of the inorganic chemicals industry as a result of this listing were calculated by multiplying the total annual costs of each of the two typical facilities by the number of affected facilities. The results are shown in Table 4-6.

Table 4-6. Total Annualized Costs of the Proposed Listing: Antimony Oxide

	Scenario 1		Scenario 2	
	Total capital costs	**Total annualized costs**	**Total capital costs**	**Total annualized costs**
Disposal as hazardous waste	$3,410	$36,860	$3,410	$36,860
Recycle	$0	$5,030	$0	$5,030

The analysis shows that costs and economic impacts for typical plants and typical firms in the antimony oxide industry will be minimal as a result of this listing. The recycling scenario is less expensive by an order of magnitude, so it is assumed that all firms affected by the ruling will choose this scenario to comply with the proposed listing. The total annualized costs for the recycling scenario are carried forward to Section 4.6 of this chapter, where they are summed with the costs and economic impacts on other affected industry sectors to arrive at the total costs and impacts of the proposed listing.

4.2 Titanium Dioxide

This section reviews the titanium dioxide industry, provides cost analysis for both of the proposed listing scenarios, and assesses the economic impacts of the proposed listing.

4.2.1 Review of Baseline and Compliance Waste Management Practices

This section reviews the baseline and post-rule compliance waste management practices that are incorporated into the cost and economic analysis in Sections 4.2.2 and 4.2.3. After completing its risk assessment screening, EPA identified seven waste by-products resulting from the titanium dioxide manufacturing process as potential candidates for listing. Four wastes are from the chloride/sulfate process. These are sulfate process digestion sludge, secondary gypsum, combined chloride/sulfate wastewater treatment solids and combined chloride/sulfate wastewaters. Another waste is generated by the nonilmenite chloride process. It is comingled chloride-only wastewater. The final two wastes are produced in the chloride-ilmenite process: combined ilmenite wastewaters and nonwastewaters not otherwise exempt from the chloride-ilmenite process (hereafter chloride ilmenite nonexempt nonwastewaters. The wastes are considered nonhazardous at baseline, and affected facilities currently dispose of the wastes in Subtitle D landfills or treat the wastes in impoundments.

One of these wastes, chloride-ilmenite nonexempt nonwastewaters (solids), is considered for listing under Scenario 1. All of the wastes are considered for listing under Scenario 2. Because there are three distinct processes for producing titanium dioxide, not all of the affected facilities produce all of the wastes. Table 2-13 lists which facilities produce which waste.

In modeling the three typical titanium dioxide facilities for the cost and economic impact analysis, EPA assumed that the three typical plants generally manage the waste as nonhazardous. Any transportation of waste would be via common carrier, and off-site disposal would be in a

Subtitle D landfill. Any waste managed on-site would be stored in piles or treated in an impoundment.

Nine of the facilities producing titanium dioxide are expected to be affected by this regulation because they generate at least one of the wastes considered for listing. Because of the complexity of the proposed listings for the titanium dioxide sector, the reader should refer back to Table 2-13 to gain a clearer understanding of which facilities produce which wastes. The titanium dioxide sector is further complicated by having different wastes listed for each of the two listing scenarios that the Agency has proposed. Table 2-13 also shows which wastes and which facilities are affected under each scenario.

4.2.2 Characterization of Titanium Dioxide Facilities

To analyze the impacts of the proposed regulation, EPA employed a typical facility approach. This was described in detail in Chapter 3. Three typical plants were developed to analyze the expected impacts on the industry. One plant represents the typical chloride-ilmenite plant. A second plant represents the typical chloride/sulfate facility, and the third plant represents the typical chloride-only facility. It should be noted that the typical chloride-ilmenite facility produces approximately twice the output of the typical chloride/sulfate or chloride-only facilities, with correspondingly higher titanium dioxide revenues. Table 4-7 shows the characteristics of each typical facility.

Table 4-7. Titanium Dioxide Typical Facility Characteristics

Type of facility	Titanium dioxide capacity (Mt/yr)	Titanium dioxide production (Mt/yr)	Estimated revenues from titanium dioxide, ($0.93/lb)
Chloride-ilmenite	243,333	231,166	$473,955,300
Chloride/sulfate	127,500	121,125	$248,339,900
Chloride-only	122,500	116,375	$238,601,100

Three typical companies were also developed, one to represent the parent company owning each typical facility. Table 4-8 describes the typical company associated with each of the typical facilities for that particular industry segment. The financial conditions of the typical company are representative of the average baseline financial conditions for all of those companies that own a facility in that segment of the industry and are affected by the proposed listing. Each typical company was developed based on average sales, profits, and employment data for the affected companies in that industry segment. Information in Table 4-8 is drawn directly from Table 2-4 and the data represent reported figures for 1999.

Consistent with the facility comparison, the company owning an ilmenite facility is much larger than its chloride/sulfate or chloride-only counterparts. None of the companies are small businesses, according to the SBA size definitions for this SIC code.

Table 4-8. Titanium Dioxide Average Company Characteristics

Type of facility owned by the company	Number of affected companies	Sales ($$10^6$)[a]	Profits ($$10^6$)[a]	Employees [a]
Chloride-ilmenite	1	$26,918	$7,690	94,000
Chloride/sulfate	2	$2,003	$158	7,571
Chloride-only	3	$1,810	$160	5,056

[a] Data for sales, profits, and employees was taken from online sources accessed June 2000, <www.hoovers.com>.

4.2.3 Cost Analysis

The Agency used three typical plants to estimate incremental costs associated with listing solid and liquid wastes from titanium dioxide production. These typical plants are based on the three processes used in the production of titanium dioxide and are discussed in Chapter 3.

Incremental costs for the listing of a waste were calculated based on the amount of a particular waste generated by a typical plant multiplied by the extra costs associated with treating and disposing of the waste as hazardous post-rule. Management practices for the three typical plants at baseline and post-regulation are shown in Tables 3-4, 3-6, and 3-8. Amounts of waste generated by the three typical plants are shown in Tables 3-3, 3-5, and 3-7. Waste stream quantities for each typical plant were obtained from Form 3007 information (non-CBI) supplied by the titanium dioxide industry. For the average plants, the quantities were estimated from the ratio of the typical plant capacity to an actual plant's capacity, multiplied by the actual plant's waste stream quantity.

Although secondary gypsum may be listed under Scenario 2, the costs of disposal for this waste are not considered in the cost analysis for two reasons. First, the one firm owning a facility that produces secondary gypsum has claimed all of its waste stream information to be CBI, so there is no quantitative way to accurately estimate a secondary gypsum quantity for the typical facility without violating this firm's CBI. Second, the Agency believes that this firm may choose to produce some other mineral salt with its waste acid post-rule and thus would not incur costs due to the ruling.

The following assumptions were used for estimating costs (input quantities are based on typical plants):

1. Ilmenite input for the ilmenite plant is 383,333 Mt/yr, based on 60 percent titanium dioxide in the ore.[1]

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[1] The Kerala Minerals and Metals Limited. Mineral Products - Typical Compositions. <www.kmml.com/mineral-pro.htm>. Accessed April 2000.

2. Ilmenite-combined wasterwater volumes are 347,739 Mt/yr.
3 Ilmenite nonexempt nonwastewaters that are not Bevill-exempt are 2,200 Mt/yr.[2]
4. Sulfate digestion sludge is 29,467 Mt/yr.
5. Chloride/sulfate and chloride-only, mixed wastewater treatment solids are 26,297 Mt/yr.
6. Chloride/sulfate/chloride-only wastewaters are 10,176,891 Mt/yr for chloride/sulfate processes and 589,934 Mt/yr for chloride-only processes.
7. For compliance with Subtitle C solids disposal, wastes are accumulated for 90 days and then loaded and transported to an offsite disposal facility.
8. Compliance for wastewaters and treatment solids includes constructing tanks for the portion of the wastestream to be listed.
9. Costs for disposal are based on the quantity of waste generated.
10. Post-rule management requires administrative costs that include permit revisions, recordkeeping, and hazardous waste manifest preparation.

Table 4-9 lists the unit cost or cost function for each of the management practices given in Tables 3-4, 3-6, and 3-8. Footnotes to Table 4-9 give the source for each cost or cost function.

Costs were estimated using the unit costs or functions in Table 4-9 for aggregated solids accumulated over a 90-day period. To estimate the total national costs of listing wastes from titanium dioxide production, EPA multiplied the costs for the average facility in each industry segment by the number of facilities in each segment. Table 4-10 shows the estimated incremental costs of Scenario 1 of the proposed listing. Table 4-11 shows the estimated incremental costs of Scenario 2 of the proposed listing.

Under the proposed listing in Scenario 1, chloride-ilmenite facilities are estimated to incur costs of approximately $0.97 million each for the disposal of their wastewater treatment solids.

Under Scenario 2 of the proposed listing, chloride/sulfate facilities are estimated to incur costs of approximately $20.4 million each for the disposal of their wastes. Under this same scenario, chloride-only facilities are estimated to incur costs of $161,263 each. Chloride-ilmenite facilities are estimated to incur costs of approximately $2.18 million each under Scenario 2 of the proposed listing. The total costs of compliance with Scenario 2 of this proposed listing is estimated to be $47.937 million.

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[2] This estimated quantity is based on average titanium dioxide production of 205,833 Mt/year with intermediate $TiCl_4$ production of 489,883 Mt/yr. Assuming the rate of chloride solids to $TiCl_4$ production of 0.04, and only 10 percent of the stream not exempt under the Bevill amendment gives an estimated 2,200 Mt/yr. A sensitivity analysis, assuming 6,600 Mt/yr of wastewater treatment solids, is presented in Appendix B.

Table 4-9. Baseline and Compliance Management Unit Costs ($1999)

Management practice	Unit cost or cost function
Loading as nonhazardous waste	$61.80/load[a]
Loading as hazardous waste	$103.00/load[b]
Transportation as nonhazardous waste	$79/Mt[c]
Transportation as hazardous waste	$239.38/mt[d]
Offsite disposal in Subtitle D landfill	$53.20/Mt,[e] $300 minimum charge per load[f]
Offsite disposal in Subtitle C landfill	$238.36/Mt,[g] $1,484 minimum charge per load[h]
Tank clarification, volume less than 370,000 Mt	
Capital cost[i]	$\text{Cost}(\$) = 36{,}131 + 151.95\ Q^{0.5}$
Annual cost[j]	$\text{Cost}(\$) = -206{,}719 + 36{,}594 \ln Q$
Tank clarification, volume more than 370,000 Mt	
Capital cost[k]	$\text{Cost}(\$) = \exp(11.552 + 0.409\ln(Q) + 0.020(\ln(Q))^2)$
Annual cost[l]	$\text{Cost}(\$) = \exp(10.294 + 0.362\ln(Q) + 0.019(\ln(Q))^2)$
Clarifier sludge dewatering	
Capital cost[m]	$\text{Cost}(\$) = 95{,}354 + 664.48\ Q^{0.5}$
Annual cost[n]	$\text{Cost}(\$) = 12{,}219 + 286.86\ Q^{0.5}$
Administrative costs	$1,137[o]

[a] U.S. Environmental Protection Agency, Office of Solid Waste. “Regulatory Impact Analysis of the Final Rule for 180-Day Accumulation Time for F006 Wastewater Treatment Sludges.” Prepared by DPRA, Inc. St. Paul. January 14, 2000. p. 22. Estimated by deleting 1 hour from administration time listed in first footnote on page 22 and using an annual generation rate of 30 t/y. Converted to metric tons and updated to 1999.

[b] U.S. Environmental Protection Agency, Office of Solid Waste. “Regulatory Impact Analysis of the Final Rule for 180-Day Accumulation Time for F006 Wastewater Treatment Sludges.” Prepared by DPRA, Inc. St. Paul. January 14, 2000. p. 21. Estimated from Table 4-3. 30 t/y annual generation rate. Converted to metric tons and updated to 1999.

[c] Average value taken from Forms 3007 for antimony oxide production.

[d] U.S. Environmental Protection Agency, Office of Solid Waste. “Background Documents for the Cost and Economic Impact Analysis of Listing Four Petroleum Refining Wastes as Hazardous under RCRA Subtitle C.” Prepared by DPRA Incorporated, January 10, 1998. p. 3-6, trucks with drums. Updated to 1999.

[e] U.S. Environmental Protection Agency, Office of Solid Waste. “Background Documents for the Cost and Economic Impact Analysis of Listing Four Petroleum Refining Wastes as Hazardous under RCRA Subtitle C.” Prepared by DPRA Incorporated, January 10, 1998. p. 3-41, Offsite Municipal Subtitle D Landfill. Updated to 1999.

[f] U.S. Environmental Protection Agency, Office of Solid Waste. “Regulatory Impact Analysis of the Final Rule for 180-Day Accumulation Time for F006 Wastewater Treatment Sludges.” Prepared by DPRA, Inc. St. Paul. January 14, 2000. p. 18. Taken from *Landfill Costs*. Estimated as the ratio of Subtitle D landfill unit cost to Subtitle C landfill unit cost times the minimum charge for Subtitle C landfills. Converted to metric tons and updated to 1999.

[g] U.S. Environmental Protection Agency, Office of Solid Waste. “Background Documents for the Cost and Economic Impact Analysis of Listing Four Petroleum Refining Wastes as Hazardous under RCRA Subtitle C.” Prepared by DPRA Incorporated, January 10, 1998. p. 3-41, Offsite Subtitle C Landfill. Updated to 1999.

(continued)

Table 4-9. Baseline and Compliance Management Unit Costs ($1999) (continued)

[h] U.S. Environmental Protection Agency, Office of Solid Waste. "Regulatory Impact Analysis of the Final Rule for 180-Day Accumulation Time for F006 Wastewater Treatment Sludges." Prepared by DPRA, Inc. St. Paul. January 14, 2000. p. 18. Taken from *Landfill Costs*. Converted to metric tons and updated to 1999.

[i] Supporting Statement for EPA Information Collection Request Number [ ], "Reporting and Recordkeeping Requirements for the Proposed Rule on Listing Hazardous Wastes from Inorganic Chemical Production." August 2000.

[j] Ibid.

[k] U.S. Environmental Protection Agency. Detailed Costing Document for the Centralized Waste Treatment Industry. EPA 821/R-98-016. Dcember 1998. P. 2-60.

[l] Ibid, p. 2-63.

[m] U.S. Environmental Protection Agency, Office of Solid Waste, Regulatory Impact Analysis: Application of Phase IV Land Disposal Restrictions to Newly Identified Mineral Processing Wastes. Appendix F, p. F-6.

[n] Ibid.

Table 4-10. Total Incremental Costs of Compliance for Listing Wastes: Titanium Dioxide—Scenario 1

Industry segment	Number of affected facilities	Average total annual cost per facility ($$10^6$)	Total cost ($$10^6$)
Chloride-ilmenite	3	$0.97	$2.9

Table 4-11. Total Incremental Costs of Compliance for Listing Wastes: Titanium Dioxide—Scenario 2

Industry segment	Number of affected facilities	Average total annual cost per facility ($$10^6$)	Total cost ($$10^6$)
Chloride-ilmenite	3	$2.183	$6.550
Chloride/sulfate	2	$20.372	$40.744
Chloride-only	4	$0.161	$0.645
Total	9	NA	$47.937

4.2.4 Economic Impact Analysis

This section examines the costs of the proposed regulation in the context of the average companies' baseline financial conditions. Using the average facility and firm information, EPA estimates that some of the companies may experience significant impacts.

4.2.4.1 Estimated Economic Impacts on Affected Facilities and Firms

EPA measured the impacts of the regulation on companies' titanium dioxide operations by comparing the costs of compliance to the company's baseline sales of titanium dioxide. Impacts on the companies owning titanium dioxide facilities were measured by comparing compliance costs to total revenues and total profits for average facilities and companies in each titanium dioxide industry segment. The estimated impacts of the regulation were calculated keeping the price and quantity sold of titanium dioxide unchanged so that companies absorb all of the compliance costs and experience no increase in revenues. To the extent that this is an unrealistic model of producer behavior, this analysis overestimates impacts on firms.

Table 4-12 shows the total annualized costs for the three types of titanium dioxide facilities. Compliance costs comprise less than 1 percent of the revenues earned by titanium dioxide facilities from the sale of titanium dioxide, except for facilities using the sulfate process. For these facilities, costs of complying with Scenario 2 exceed 8 percent of baseline titanium dioxide sales.

Table 4-12. Estimated Economic Impacts of the Listing on Typical Titanium Dioxide Facilities

Type of facility	Total quantity of wastes treated, Mt/yr	Total annualized costs ($$10^6$/yr)	Estimated titanium dioxide sales ($$10^6$/yr)	Costs as a share of titanium dioxide sales
Chloride-ilmenite Scenario 1	349,939	$0.966	$473.955	0.20%
Chloride-ilmenite Scenario 2	349,939	$2.183	$473.955	0.46%
Chloride/sulfate Scenario 2	10,232,364	$20.372	$248.34	8.2%
Chloride-only Scenario 2	657,656	$0.161	$238.601	0.07%

Table 4-13 shows estimated impacts of the rulemaking on companies owning titanium dioxide facilities. Table 4-13 shows that the total annual cost represents a small share of total sales and profits for most of the average companies. The cost as a share of sales and profits represents less than 0.1 percent for all of the model companies, except for chloride/sulfate companies. Thus, although EPA does not expect the other companies to experience a significant adverse economic impact as a result of the regulation, the chloride/sulfate companies may be adversely affected.

Clearly, complying with the rulemaking will impose higher costs on companies using the sulfate process. The quantity of waste generated by the average such facility is estimated to be at

Table 4-13. Impacts on Typical Companies Owning Titanium Dioxide Facilities

Type of facility	Total quantity of wastes treated (Mt/yr)	Company Total annualized costs ($\$10^6$/yr)	Company sales ($\$10^6$/yr)	Costs as a share of sales (%)	Company profits ($\$10^6$/yr)	Costs as a share of profits (%)
Chloride-ilmenite: Scenario 1	349,739	$2.898	$26,918	0.011%	$7,690	0.038%
Chloride-ilmenite: Scenario 2	349,739	$6.550	$26,918	0.024%	$7,690	0.085%
Chloride/sulfate: Scenario 2[a]	10,232,364	$20.372	$2,003	1.02%	$158.3	12.87%
Chloride-only: Scenario 2[a]	657,656	$0.161	$1,810	0.008%	$159.8	0.10%

[a] Impacts are measured as if companies owning chloride/sulfate and chloride-only facilities are entirely separate. In fact, one company owns facilities of both types. The impacts on the average company in each sector may understate the impacts on this company.

least an order of magnitude higher than the quantity generated by average facilities using either of the chloride processes. The costs incurred by firms using the sulfate process to manage their wastes post-regulation are also significantly higher. The sulfate process accounts for less than 10 percent of the titanium dioxide production capacity nationwide. The costs incurred by plants using the chloride processes are estimated to be much lower, both absolutely and per metric ton of titanium dioxide produced. Thus, we expect that the firms using the chloride processes may increase their prices only slightly. This, in turn, is expected to limit the ability of the firms using the sulfate process to increase the price of their product to recover their compliance costs. The average firm using the sulfate process also has operations using the chloride process. It is conceivable that they will find that the cost of converting their sulfate titanium dioxide production capacity to the chloride process would be lower than the cost of managing the wastes generated by the sulfate process as hazardous waste.

As noted above, one facility producing titanium dioxide using the chloride-sulfate process generates secondary gypsum as a residual. The Agency is considering listing secondary gypsum under Scenario 2 of the proposed listing. Unfortunately, the Agency does not have data permitting it to quantitatively estimate the costs and economic impacts of listing secondary gypsum. If the facility chooses to continue generating secondary gypsum and comply with the listing, it would incur the costs of storing, treating, and disposing of the waste in compliance with Subtitle D of RCRA. The Agency believes, however, that the facility's cost-minimizing response would probably be to change its production process to produce a different salt from its waste acid. If this strategy were used, the facility would not generate any secondary gypsum and thus would not be subject to the rulemaking, at least for that waste.

Overall, EPA expects the rulemaking to have only a moderate financial impact on the companies owning titanium dioxide production facilities. Because the companies owning these facilities are all relatively large, it is estimated that they have the resources to comply with the rulemaking without incurring adverse financial impacts. Even for the companies using the sulfate process, EPA estimates that the costs of complying with Scenario 2 are 1.02 percent of the baseline company sales for the average company. The issue is not whether the companies have the resources to comply, but rather what their best compliance strategy would be. Companies using the sulfate process may choose to evaluate a pollution prevention compliance strategy, in which they re-fit their plants to use the chloride process. If this plant modification enables them to reduce the quantity of waste they must manage as hazardous, it may be their cost-minimizing approach to compliance with the rulemaking.

4.2.4.2 National Costs

The estimated national costs of implementing this rulemaking are given in Table 4-14. The totals were arrived at by multiplying the costs of compliance for each scenario for each typical facility by the number of affected facilities.

Table 4-14. National Costs of the Proposed Listing: Titanium Dioxide

	Scenario 1		**Scenario 2**	
	Capital costs	**Total annualized costs**	**Capital costs**	**Total annualized costs**
National costs ($\$10^6$)	$4,500	$2.898	$34.4	$47.9

The total annualized costs for both scenarios of the proposed listing are carried forward to Section 4.6 of this chapter, where they are summed with the costs and economic impacts on other affected industry sectors to arrive at the total costs and impacts of the proposed listing.

4.3 Sodium Chlorate

This section reviews the sodium chlorate industry, provides a cost analysis for both of the proposed listing scenarios, and assesses the economic impacts of the proposed listing.

4.3.1 Review of Baseline and Compliance Waste Management Practices

This section reviews the baseline and post-rule compliance waste management practices that will be incorporated into the cost and economic impact analysis in Sections 4.3.2 and 4.3.3. In the sodium chlorate sector, process sludge without chromium and spent filters without chromium are the only two wastes that the Agency has chosen to list, based on its risk assessment screening. These two wastes are considered for listing under Scenario 2 only. Not all of the affected firms produce both wastes, as was shown in Chapter 3. The baseline assumes that all affected companies are handling their waste according to current regulations. Both wastes are nonhazardous at baseline, and affected facilities dispose of the wastes by sending them to an industrial Subtitle D landfill without treatment.

Listing the wastes as hazardous means that they will now be considered hazardous "from the cradle to the grave" and must be disposed of, even after treatment, in a hazardous waste (Subtitle C) landfill. Similarly, all hazardous wastes and residuals from the production process must be transported to the landfill under a hazardous waste manifest by a licensed hazardous waste hauler, which is more expensive than industrial waste transportation.

In modeling the typical sodium chlorate facility for the cost and economic impact analysis, it was assumed that the plants manage their waste as nonhazardous and transport it via common carrier for disposal at an offsite Subtitle D landfill.

4.3.2 Characterization of Sodium Chlorate Facilities

To analyze the economic impacts of the proposed regulation, EPA used a typical facility approach described in Chapter 3. One typical facility was developed to analyze the expected impacts on the industry. This typical plant produces both process sludge without chromium and spent filters without chromium. In reality, only two of the five plants affected by the proposed listing produce spent filters without chromium, but the amount of this waste produced by the typical plant is very small relative to the total amount of waste produced. So to simplify the analysis, this difference was overlooked. Although it will overstate the waste treatment costs slightly, the Agency does not believe that this simplification will create a significant misestimation in its determination of the costs or economic impacts of the proposed listing. Table 4-15 describes the capacity, production, and revenues associated with the typical facility.

Table 4-15. Sodium Chlorate Typical Facility Characteristics

	Capacity (Mt/yr)	Production (Mt/yr)	Estimated revenues ($$10^6$)
Typical facility	83,636	77,781[a]	$35

[a] Production is based on the capacity utilization rate of the in-scope facilities for which data was available and is equal to approximately 93 percent.

This cost and economic analysis was conducted assuming that only the wastes listed above generated by the production of sodium chlorate are candidates for listing by the Agency as hazardous wastes. As a result, only five of the ten sodium chlorate-producing facilities are expected to be affected by this regulation; the remaining five facilities do not generate either of these wastes. Table 2-13 lists the facilities affected by the listing. Table 3-10 lists the typical baseline and post-rule compliance waste management practices for a typical sodium chlorate facility. Table 4-16 describes the typical company associated with the typical plant. This typical company represents the average baseline financial conditions for those companies that produce either of the wastes considered for listing. As Table 4-16 shows, the typical company that produces process sludge without chromium and spent filters without chromium does not meet the SBA definition of small for this industry.

Table 4-16. Sodium Chlorate Typical Company Characteristics

Wastes generated	Number of affected companies	Sales (\$$10^6$)	Profits (\$$10^6$)	Employees
Process sludge without chromium and spent filters without chromium	4	\$8,583	\$119.5	26,138

4.3.3 Cost Analysis

The average plant is used for estimating incremental costs associated with listing solid wastes from sodium chlorate production. Management practices for the plant at baseline and post-regulation are shown in Table 3-10.

The listed wastes are process sludge without chromium and filter wastes without chromium. This analysis made the following assumptions for cost estimation:

1. Waste volumes are 108 Mt/y of process sludges and 0.5 Mt/y of filter wastes.
2. For compliance by Subtitle C disposal, wastes are accumulated for 90 days then loaded and transported to an off-site disposal facility.
3. Costs for disposal are based on the quantity of waste generated.
4. Post-rule management requires administrative costs that include permit revisions, recordkeeping, and hazardous waste manifest preparation.

Table 4-17 lists the unit cost or cost function for each of the management practices given in Table 3-10. Footnotes to Table 4-17 give the source for each cost or cost function. All sodium chlorate wastes to be listed are solids. The cost estimates were made using the unit costs or functions in Table 4-17 for aggregated solids accumulated annually or over a 90-day period, depending on the compliance management practice chosen. Table 4-18 presents the total incremental costs of the listing for the sodium chlorate sector. This total cost is \$0 for Scenario 1, because sodium chlorate wastes are proposed for listing only under Scenario 2.

Table 4-17. Baseline and Compliance Management Unit Costs ($1999)

Management practice	Unit cost of cost function
Loading as non-hazardous waste	$61.80/load[a]
Loading as hazardous waste	$103.00/load[b]
Transportation as non-hazardous waste	$79/Mt[c]
Transportation as hazardous waste	$239.38/mt[d]
Offsite disposal in Subtitle D landfill	$53.20/Mt,[e] $300 minimum charge per load[f]
Offsite disposal in Subtitle C landfill	$238.36/Mt,[g] $1,484 minimum charge per load[h]
Administrative costs	$1,137[i]

[a] U.S. Environmental Protection Agency, Office of Solid Waste. “Regulatory Impact Analysis of the Final Rule for 180-Day Accumulation Time for F006 Wasterwater Treatment Sludges.” Prepared by DPRA, Inc. St. Paul. January 14, 2000. p. 22. Estimated by deleting 1 hour from administration time listed in first footnote and using an annual generation rate of 30 t/y. Converted to metric tons and updated to 1999.

[b] U.S. Environmental Protection Agency, Office of Solid Waste. “Regulatory Impact Analysis of the Final Rule for 180-Day Accumulation Time for F006 Wasterwater Treatment Sludges.” Prepared by DPRA, Inc. St. Paul. January 14, 2000. p. 21. Estimated from Table 4-3. 30 t/y annual generation rate. Converted to metric tons and updated to 1999.

[c] Average value taken from Forms 3007 for sodium chlorate production.

[d] U.S. Environmental Protection Agency, Office of Solid Waste. “Background Documents for The Cost and Economic Impact Analysis of Listing Four Petroleum Refining Wastes as Hazardous under RCRA Subtitle C.” Prepared by DPRA Incorporated, January 10, 1998. p. 3-6, trucks with drums. Updated to 1999.

[E] U.S. Environmental Protection Agency, Office of Solid Waste. “Background Documents for The Cost and Economic Impact Analysis of Listing Four Petroleum Refining Wastes as Hazardous under RCRA Subtitle C.” Prepared by DPRA Incorporated, January 10, 1998. p. 3-41, Offsite Municipal Subtitle D Landfill. Updated to 1999.

[f] U.S. Environmental Protection Agency, Office of Solid Waste. “Regulatory Impact Analysis of the Final Rule for 180-Day Accumulation Time for F006 Wastewater Treatment Sludges.” Prepared by DPRA, Inc. St. Paul. January 14, 2000. p. 18. Taken from *Landfill Costs*. Estimated as the ratio of Subtitle D landfill unit cost to Subtitle C landfill unit cost times the minimum charge for Subtitle C landfills. Converted to metric tons and updated to 1999.

[g] U.S. Environmental Protection Agency, Office of Solid Waste. “Background Documents for The Cost and Economic Impact Analysis of Listing Four Petroleum Refining Wastes as Hazardous under RCRA Subtitle C.” Prepared by DPRA Incorporated, January 10, 1998. p. 3-41, Offsite Subtitle C Landfill. Updated to 1999.

[h] U.S. Environmental Protection Agency, Office of Solid Waste. “Regulatory Impact Analysis of the Final Rule for 180-Day Accumulation Time for F006 Wastewater Treatment Sludges.” Prepared by DPRA, Inc. St. Paul. January 14, 2000. p. 18. Taken from *Landfill Costs*. Converted to metric tons and updated to 1999.

[i] Supporting Statement for EPA Information Collection Request Number [ ], “Reporting and Recordkeeping Requirements for the Proposed Rule on Listing Hazardous Wastes from Inorganic Chemical Production.” August 2000.

Table 4-18. Total Incremental Costs of Listing Wastes for Sodium Chlorate: Scenario 2 Only

	Number of affected facilities	Total annualized costs
Typical facility	4	$44,700

4.3.4 *Economic Impact Analysis*

In this section, we examine the costs of the proposed regulations in the context of the average company's baseline financial conditions. Using the average facility information, none of the companies are expected to be severely impacted by the regulations.

4.3.4.1 Estimated Economic Impacts on Affected Facilities and Firms

As described in the previous section, the costs associated with this rulemaking are relatively small compared to the baseline cost of sodium chlorate production.

This study measured the impacts of the regulation on affected companies by comparing the costs of compliance to the company's baseline revenues. The estimated impacts of the regulation are based on unchanged process and quantities of sodium chlorate, so that companies absorb all of the compliance costs of disposing to a Subtitle C landfill. To the extent that this model is unrealistic, impacts on affected facilities and companies are overestimated. Table 4-19 shows that the total annual cost of $44,700 associated with compliance comprises less than 1 percent of the revenues earned by the typical sodium chlorate facility for sales of sodium chlorate.

Table 4-19. Estimated Economic Impacts of the Listing on an Typical Sodium Chlorate Facility

Facility	Total annualized costs	Estimated sodium chlorate sales ($$10^6$)	Costs as a share of sodium chlorate sales
Sodium chlorate facility	$44,700	$35.0	0.13%

Table 4-20 shows that the total annualized cost represents an extremely small share of total sales and profits for the typical company. Thus, we do not expect the regulation to have a significant adverse economic impact on affected sodium chlorate facilities and companies.

Table 4-20. Estimated Economic Impacts of the Listing on an Typical Company Owning a Sodium Chlorate Facility

Facility	Total annualized costs	Company sales ($$10^6$)	Costs as a share of sales	Company profits ($$10^6$)	Costs as a share of profits
Sodium chlorate company	$44,700	$8,583	0.0005%	$119.5	0.037%

4.3.4.3 *National Costs*

The estimated incremental annualized costs to the sodium chlorate sector of the inorganic chemicals industry as a result of this listing were calculated by multiplying the total annualized cost of the typical facility by the number of affected facilities. The results are shown in Table 4-21.

Table 4-21. Total Annualized National Costs of the Proposed Listing: Sodium Chlorate

Scenario 1	Scenario 2	
	Total capital costs	Total annualized costs
$0	$0	$223,400

The analysis shows that costs and economic impacts for typical plants and typical firms in the sodium chlorate industry will be minimal as a result of this listing. No costs would be incurred in the sodium chloride industry under Scenario 1, and the total annualized costs represent only a very small share of facility and company revenues. The total annualized costs are carried forward to Section 4.6 of this chapter, where they are summed with the costs and economic impacts on other affected industry sectors to arrive at the total costs and impacts of the proposed listing.

4.4 Sodium Phosphates

This section reviews the sodium phosphates industry, provides a cost analysis for both of the proposed listing scenarios, and assesses the economic impacts of the proposed listing.

4.4.1 Review of Baseline and Compliance Waste Management Practices

This section reviews the baseline and post-rule compliance waste management practices that will be incorporated into the cost and economic impact analysis in Sections 4.4.2 and 4.4.3. In the sodium phosphates sector, filter press cake and dust collector filter bags are the only two wastes that the Agency has chosen to list, based on its risk assessment screening. These two wastes are considered for listing under Scenario 2 only. Not all of the affected firms produce both wastes, as shown in Chapter 3. The baseline assumes that all affected companies are handling their wastes according to current regulations. Both wastes are nonhazardous at baseline, and affected facilities dispose of the wastes by sending them to an industrial Subtitle D landfill without treatment.

4.4.2 Characterization of Sodium Phosphates Facilities

To analyze the economic impacts of the proposed regulations, EPA used a typical facility approach described in Chapter 3. One typical facility was developed to analyze the expected impacts on the industry. This typical facility produces filter press cake and dust collector filter bags. Production and capacity information for facilities in the sodium phosphates industry is not available or is CBI, so this information is omitted from consideration in modeling the typical facility.

This cost and economic analysis was conducted assuming that only dust collection filter bag residuals and filter press cake residuals generated by the production of sodium phosphates are candidates for listing by the Agency as hazardous wastes. As a result, this regulation is expected to affect all four of the facilities that produce sodium phosphates. Table 2-13 lists the facilities affected by the listing. Table 3-12 lists the typical baseline and post-rule compliance waste management practices for the typical sodium phosphates facility producing either waste. Tables 4-22 describes the typical company associated with the typical facility. The typical company represents the average baseline financial conditions for those companies that produce the waste associated with the typical facility. As Tables 4-22 shows, the typical company that produces filter press cake and dust collector filter bags does not meet the SBA definition of small for this industry.

Table 4-22. Sodium Phosphates Typical Company Characteristics

Waste generated	Number of affected companies	Sales ($\$10^6$)	Profits ($\$10^6$)	Employees
Filter press cake and dust collector filter bags	2	$4,203	$218	17,050

Listing the wastes as hazardous means that they will now be considered hazardous “from the cradle to the grave” and must be disposed of, even after treatment, in a hazardous waste (Subtitle C) landfill. Similarly, all wastes and residuals from the production process must be transported to the landfill under a hazardous waste manifest by a licensed hazardous waste hauler—more expensive than industrial waste transportation. The following section summarizes the estimated costs of the listing under these assumptions.

4.4.3 Cost Analysis

A single model was used to estimate the incremental costs associated with listing solid wastes from sodium phosphate production. Management practices for the model at baseline and post-rule compliance are shown in Table 3-12.

The listed wastes are used filter bags and filter cake. This study made the following assumptions for cost modeling:

1. Waste volumes are 27 Mt/y for filter cake and 0.53 Mt/y for filter bags.
2. Wastes are accumulated for 90 days then loaded and transported to an off-site disposal or treatment and disposal facility.
3. Stabilization of post-rule wastes to UTS standards is required.
4. Costs for stabilization and disposal are based on the quantity of waste generated.

Table 4-23 lists the unit cost or cost function for each of the management practices given in Table 3-12. Footnotes to the table give the source for each cost or cost function. All sodium phosphate wastes to be listed are solids. The cost model estimates costs using the unit costs or functions in Table 4-23 for aggregated solids accumulated over a 90-day period.

4.4.4 Economic Impact Analysis

In this section, we examine the costs of the proposed regulation in the context of the typical company's baseline financial conditions. Using typical facility information, neither of the companies are expected to be severely impacted by the regulation.

4.4.4.1 Overview of Economic Impacts on Markets for Sodium Phosphate

When the proposed waste listing goes into effect, the cost of producing sodium phosphates will increase. Because of the small number of producers, the Agency believes that the producers have some price-setting power. This power may be somewhat offset by possible substitutes. In sum, the producers may be able to raise prices and pass off a significant portion of the cost of regulation on to consumers. The slight increase in price may lead to a small decrease in the quantity demanded but should not cause any significant impacts on the sodium phosphates market.

4.4.4.2 Estimated Economic Impacts on Affected Facilities and Firms

As described in the previous section, the market supply of sodium phosphates will decrease slightly as a result of the costs attributed to the rulemaking. Because the costs associated with this rulemaking are relatively small compared to the baseline cost of sodium phosphate production, and especially small compared to baseline company costs and revenues, the decrease in supply is expected to be fairly small. To estimate the economic impacts of the proposed listing decision on affected companies, the Agency first estimated costs of compliance for each affected facility, based on the current disposal method. Total annualized compliance cost for the model facility is $15,600. Table 4-24 shows the facility-level costs. However, to

Table 4-23. Baseline and Compliance Management Unit Costs ($1999)

Management practice	Unit cost of cost function
Loading as non-hazardous waste	$61.80/load[a]
Loading as hazardous waste	$103.00/load[b]
Transportation as non-hazardous waste	$15.35/Mt[c]
Transportation as hazardous waste	$239.38/mt[d]
Offsite stabilization	$93.11/Mt[e]
Offsite disposal in Subtitle D landfill	$53.20/Mt,[f] $300 minimum charge per load[g]
Offsite disposal in Subtitle C landfill	$238.36/Mt,[h] $2,319 minimum charge per load including stabilization[i]
State permit modification (small quantity generator)	$50 initial cost[j]

[a] U.S. Environmental Protection Agency, Office of Solid Waste. "Regulatory Impact Analysis of the Final Rule for 180-Day Accumulation Time for F006 Wasterwater Treatment Sludges." Prepared by DPRA, Inc. St. Paul. January 14, 2000. p. 22. Estimated by deleting 1 hour from administration time listed in first footnote and using an annual generation rate of 30 t/y. Converted to metric tons and updated to 1999.

[b] U.S. Environmental Protection Agency, Office of Solid Waste. "Regulatory Impact Analysis of the Final Rule for 180-Day Accumulation Time for F006 Wasterwater Treatment Sludges." Prepared by DPRA, Inc. St. Paul. January 14, 2000. p. 21. Estimated from Table 4-3. 30 t/y annual generation rate. Converted to metric tons and updated to 1999.

[c] U.S. Environmental Protection Agency, Office of Solid Waste. "Background Documents for The Cost and Economic Impact Analysis of Listing Four Petroleum Refining Wastes as Hazardous under RCRA Subtitle C." Prepared by DPRA Incorporated, January 10, 1998. p. 3-6, trucks with drums. Updated to 1999.

[d] U.S. Environmental Protection Agency, Office of Solid Waste. "Background Documents for The Cost and Economic Impact Analysis of Listing Four Petroleum Refining Wastes as Hazardous under RCRA Subtitle C." Prepared by DPRA Incorporated, January 10, 1998. p. 3-6, trucks with drums. Updated to 1999.

[e] U.S. Environmental Protection Agency, Office of Solid Waste. "Regulatory Impact Analysis of the Final Rule for 180-Day Accumulation Time for F006 Wastewater Treatment Sludges." Prepared by DPRA, Inc. St. Paul. January 14, 2000. p. 18. Extracted from *Landfill Costs*. Minimum cost per load of $2,267. Converted to metric tons and updated to 1999.

[f] U.S. Environmental Protection Agency, Office of Solid Waste. "Background Documents for The Cost and Economic Impact Analysis of Listing Four Petroleum Refining Wastes as Hazardous under RCRA Subtitle C." Prepared by DPRA Incorporated, January 10, 1998. p. 3-41, Offsite Municipal Subtitle D Landfill. Updated to 1999.

[g] U.S. Environmental Protection Agency, Office of Solid Waste. "Regulatory Impact Analysis of the Final Rule for 180-Day Accumulation Time for F006 Wastewater Treatment Sludges." Prepared by DPRA, Inc. St. Paul. January 14, 2000. p. 18. Taken from *Landfill Costs*. Estimated as the ratio of Subtitle D landfill unit cost to Subtitle C landfill unit cost times the minimum charge for Subtitle C landfills. Converted to metric tons and updated to 1999.

[h] U.S. Environmental Protection Agency, Office of Solid Waste. "Background Documents for The Cost and Economic Impact Analysis of Listing Four Petroleum Refining Wastes as Hazardous under RCRA Subtitle C." Prepared by DPRA Incorporated, January 10, 1998. p. 3-41, Offsite Subtitle C Landfill. Updated to 1999.

[i] U.S. Environmental Protection Agency, Office of Solid Waste. "Regulatory Impact Analysis of the Final Rule for 180-Day Accumulation Time for F006 Wastewater Treatment Sludges." Prepared by DPRA, Inc. St. Paul. January 14, 2000. p. 18. Taken from *Landfill Costs*. Converted to metric tons and updated to 1999.

[j] U.S. Environmental Protection Agency, Office of Regulatory Enforcement. "Estimating Costs for the Economic Benefits of RCRA Noncompliance." December 1997 Update. p. B-2. Assumes 5 hours environmental coordinator and 3 hours clerical time annually. Updated to 1999.

Table 4-24. Facility-Level Impacts

Facility	Production (Mt)	Compliance cost	Costs/Mt of waste
Sodium phosphates facility	CBI	$15,600	$567

safeguard CBI, the costs cannot be compared to sodium phosphate revenues for a more complete picture.

This analysis measured the impacts of the regulation on affected companies by comparing the costs of compliance to the company's baseline revenues. The impacts of the regulation are estimated as if the companies are unable to change the price of sodium phosphates so that they are absorbing all of the compliance costs[3]. In fact, this approach probably overstates impacts on companies producing sodium phosphates and understates impacts on their customers. Table 4-25 shows that the costs associated with compliance comprise a small share of total sales for the model company as described in Section 4.4.4.1. Since each typical company owns two sodium phosphate facilities, the annual costs of the typical company are double those faced by the typical facility.

Table 4-25. Typical Costs of Regulation as a Share of Company Sales and Profits

Company	Total annualized costs	Company sales ($\$10^6$)	Costs as a share of sales	Company profits ($\$10^6$)	Costs as a share of profits
Sodium phosphates company	$31,200	$4,203	0.0007%	$218	0.014%

Compliance costs as a share of company revenues are less that 0.001 percent for the model company. Thus, it does not appear that the proposed rulemaking will result in significant economic impacts on the affected companies.

4.4.4.3 National Costs

The estimated incremental annualized costs to the sodium phosphates sector of the inorganic chemicals industry as a result of this listing were calculated by multiplying the total

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[3] The total annual cost for each company is estimated to be $31,200. Thus, the total annual cost of the regulation is estimated to be $62,400.

annualized costs of the typical facility by the number of affected facilities. The results are shown in table 4-26.

Table 4-26. National Costs of the Proposed Listing: Sodium Phosphates Industry

Scenario 1	Scenario 2	
	Total capital costs	**Total annualized costs**
$0	$4,500	$62,400

The analysis shows that costs and economic impacts for typical plants and typical firms in the sodium phosphates industry will be minimal as a result of this listing. The sector is unaffected under Scenario 1 and incurs costs that are a very small share of revenues and profits under Scenario 2. The total annualized costs are carried forward to Section 4.6 of this chapter, where they are summed with the costs and economic impacts on other affected industry sectors to arrive at the total costs and impacts of the proposed listing.

4.5 Inorganic Hydrogen Cyanide (HCN)

This section reviews the inorganic hydrogen cyanide industry, provides a cost analysis for both of the proposed listing scenarios, and assesses the economic impacts of the proposed listing.

4.5.1 Review of Baseline and Compliance Waste Management Practices

This section reviews the baseline and post-rule compliance waste management practices that will be incorporated into the cost and economic impact analysis in Sections 4.5.2 and 4.5.3. After completing its risk assessment screening, EPA identified two waste by-products resulting from the inorganic hydrogen cyanide manufacturing process as potential candidates for listing. These wastes are hydrogen cyanide combined wastewaters and ammonia recycle filtration residuals. These wastes are considered nonhazardous at baseline.

Both hydrogen cyanide wastewaters and ammonium recycle filtration residuals are considered for listing under Scenario 2. Not all of the affected facilities produce all of the wastes. Table 2-13 shows which facilities produce which waste.

The baseline assumes that all affected companies are handling their hazardous waste according to RCRA regulations. Both wastes are nonhazardous at baseline. Facilities that will be affected by the Scenario 1 listing currently store their wastewaters in surface impoundments prior to NPDES or POTW discharge. Facilities that will be affected by the listing of ammonium recycle filtration residuals currently dispose of this waste by landfilling off-site in a Subtitle D landfill, landfilling on-site in a Subtitle C landfill or incinerating in a hazardous waste incinerator on-site and then landfilling the ash off-site in a Subtitle C landfill.

In modeling the average HCN facility for the cost and economic impact analysis for the two scenarios, it was assumed that the plant manages the solid wastes as nonhazardous and transports these filtration residuals via common carrier for disposal in a Subtitle D landfill. It is assumed that the wastewaters are treated in an on-site surface impoundment prior to discharge.

Five of the facilities producing inorganic hydrogen cyanide are expected to be affected by the proposed regulation because they produce at least one of the wastes considered for listing.

4.5.2 Characterization of Inorganic Hydrogen Cyanide Facilities

To analyze the impacts of the proposed regulation, EPA employed a typical facility approach. This was described in detail in Chapter 3.

Three types of facilities are expected to be affected by the listing and so three typical facilities were created for the analysis. The first typical facility produces only HCN wastewaters and generates no ammonium recycle filtration residuals. The second typical facility produces HCN wastewaters, generates ammonium filtration recycle residuals, and then disposes of these residuals to a Subtitle D landfill. The third typical facility produces no HCN wastewaters, incinerates its ammonium filtration recycle residuals and disposes of the ash in a Subtitle C landfill. Section 4.5.3 lists the characteristics of these typical facilities in greater detail. Table 4-27 shows the characteristics of each typical facility.

Table 4-27. Inorganic Hydrogen Cyanide Typical Facility Characteristics

Type of wastes generated	Capacity (Mt)	Production (Mt)	Estimated revenues from HCN ($$10^6$) ($0.60/lb)
HCN wastewater only	35,000	23,000	$30
HCN wastewater, ammonium filtration recycle residuals—landfilled	95,000	62,000	$82
Ammonium filtration recycle residuals—incinerated	164,000	107,000	$142

Three typical companies were also developed, one to represent the parent company owning each typical facility. Table 4-28 describes the typical company associated with each of the typical plants for that particular industry segment. The financial conditions of the typical company are representative of the average baseline financial conditions for all of those companies that own a facility in that segment of the industry and are affected by the proposed

Table 4-28. Inorganic Hydrogen Cyanide Typical Company Characteristics

Potentially affected wastes	Sales ($\$10^6$)	Profits ($\$10^6$)	Employees
HCN wastewater only	$13,267	$279	45,355
HCN wastewater, ammonium filtration recycle residuals—landfilled	$16,128	$3,969.5	57,750
Ammonium filtration recycle residuals—incineration	$26,918	$7,690	94,000

listing. Each typical company was developed based on average sales, profits, and employment data for the affected companies in that industry segment.

Information in Table 4-28 is drawn directly from Table 2-12 and the data represent reported figures for 1999. The typical company owning a facility that incinerates its ammonium filtration recycle residuals is considerably larger than the other two companies. None of the companies are small businesses, according to the SBA size definitions for this SIC code.

4.5.3 Cost Analysis

The Agency used three typical facilities to estimate the incremental costs associated with listing solid and liquid wastes from inorganic hydrogen cyanide production. These three typical facilities are based on the three processes used in the production of hydrogen cyanide and were discussed thoroughly in Chapter 3.

Three models are used for estimating incremental costs associated with listing wastes from inorganic hydrogen cyanide production. One model represents facilities that currently produce only wastewaters and send them to a surface impoundment for treatment prior to discharge. The second model represents facilities that produce wastewaters and send them to a surface impoundment prior to discharge. The facility represented by the second model also produces ammonium filtration residuals along with the filter materials (resin, fabric or carbon), which they dispose of at a Subtitle D landfill. The third model represents facilities that produce ammonium filtration residuals and spent filters, incinerating them and disposing of the ash at a Subtitle C landfill. Tables 3-14, 3-16, and 3-18 summarize the baseline and listing compliance waste management practices for inorganic hydrogen cyanide facilities.

In those facilities that produce solid wastes, the listed wastes consist of filters or spent carbon from ammonia recycling. This study made the following assumptions:

1. No stabilization of wastes or incinerator ash is required.

2. For the facilities that have characteristic (D) wastes, no incremental transportation costs are charged.
3. For facilities that incinerate their wastes, the reduction in mass of material entering the incinerator is 92 percent (i.e., the quantity of ash from incinerator equals 8 percent of the entering waste).
4. Transportation costs for unlisted wastes are taken from a background document for mineral wastes processing[4] ($25/Mt for an undisclosed distance); for listed waste, from the average of costs found on a subset of Forms 3007 submitted by facilities in the inorganic chemicals industry ($202.90/Mt, 100 miles transportation assumed).
5. For each new listed waste, a facility is assumed to incur incremental administrative costs associated with ongoing compliance with new rules.
6. Cost for disposal in a Subtitle C landfill is $126.86/Mt[5]. Cost for disposal in a Subtitle D landfill is $35.81/Mt[6]. Both costs are derived from the background documents for mineral wastes processing, but are adjusted for inflation.
7. Facilities that currently use incineration incur no new incineration costs.
8. Facilities that currently use impoundments for wastewater treatment will build a new tank and clarifier system for compliance.

4.5.3.1 Cost Models

The models are devised to categorize information from Form 3007 into solids or liquids, and RCRA coded or not RCRA coded. Each model's waste stream quantities are entered by individual stream, then categorized. The stream quantities are then summed by category and costs are estimated for each category. The category costs are summed to arrive at a total cost for each model. The cost equation for facilities disposing of their wastes in Subtitle C landfills is given in Eq. (4.1) where Q = Annual quantity of waste treated in Mt/y.

$$Annual\ cost\ (\$) = (202.90 + 124) \times Q \tag{4.1}$$

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[4] U.S. Environmental Protection Agency, Office of Solid Waste, Regulatory Impact Analysis: Application of Phase IV Land Disposal Restrictions to Newly Identified Mineral Processing Wastes. Appendix F, p. F-18. April 30, 1998.

[5] U.S. Environmental Protection Agency, Office of Solid Waste, Regulatory Impact Analysis: Mineral Processing Waste Treatment and Disposal Costs, Low-cost Analysis. Appendix E, pp. E-2, E-3. April 30, 1998.

[6] Supra Note 4.

For disposal in Subtitle D landfills the cost is estimated from Eq. (4.2) if the waste is transported as a hazardous waste or from Eq. (4.3) if the waste is transported as a nonhazardous waste.

$$\textit{Annual cost}\ (\$) = (202.90 + 35.81) \times Q \tag{4.2}$$

$$\textit{Annual cost}\ (\$) = (25 + 35.81) \times Q \tag{4.3}$$

Transporting hazardous waste and nonhazardous waste costs \$202.90/Mt and \$25/Mt, respectively. Landfilling waste in Subtitle C facilities or in Subtitle D facilities costs \$124/Mt and \$35.81/Mt, respectively. These costs are further multiplied by an escalation factor of 1.023 where needed to bring the costs to 1999 values.

$$\textit{Annual cost}\ (\$) = (202.90 + 124) \times Q \times 0.08 \tag{4.4}$$

$$\textit{Annual cost}\ (\$) = (25 + 35.81) \times Q \times 0.08 \tag{4.5}$$

$$\textit{Annual cost}\ (\$) = (202.90 + 35.81) \times Q \times 0.08 \tag{4.6}$$

For facilities that incinerate their wastes, costs are estimated from Eq. (4.4) for Subtitle C ash disposal or from Eq. (4.5) (hazardous waste transport) or Eq. (4.6) (nonhazardous waste transport) for Subtitle D ash disposal.

In each equation, Q is the total annual waste (subject to listing) that is generated by a facility. In Eq.(4.4) through (4.6), the factor 0.08 represents the reduction in waste volume obtained by incineration.

No estimates of capital cost are required in the modeling for cyanide manufacturing solid wastes. In each case wastes or ash residues are transported to an off-site location for disposal or for incineration and disposal. For facilities with liquid wastes, capital and annual costs for the purchase and operation of a clarifier system are estimated from Eqs. (4.7) and (4.8), respectively.

$$\textit{Capital cost}\ (\$) = \exp(11.552 + 0.409 \times \ln(Q) + 0.02 \times \ln(Q)^2) \tag{4.7}$$

$$\textit{Annual cost}\ (\$) = \exp(10.294 + 0.362 \times \ln(Q) + 0.019 \times \ln(Q)^2) \tag{4.8}$$

Table 4-29 presents the estimated costs of complying with the rulemaking for the typical facilities under Scenario 2. Plants currently managing their ammonia recycle filters and filtrations solids through incineration and landfilling are expected to have to install no additional capital equipment; thus, they incur only the annual costs of transporting and landfilling their incinerator ash according to Subtitle C regulatory requirements. Facilities currently disposing of their solid residuals from ammonia recycling at a Subtitle D landfill, and managing wastewaters in surface impoundments, are expected to incur the highest incremental costs of compliance, including both capital investments to install tanks and annual costs to manage, transport, and dispose of their wastes according to Subtitle C regulatory requirements. Finally, facilities generating no solid residuals but managing wastewaters in surface impoundments incur intermediate levels of costs, including both capital equipment costs and annual costs.

Table 4-29. Total Incremental Costs of Compliance for Listing Wastes: Scenario 2

Potentially affected wastes	Number of facilities affected	Total annualized cost per facility ($\$10^3$/year)	Total annualized compliance cost ($\$10^3$/year)
Ammonium filtration recycle residuals landfilled, and HCN wastewater	2	$34.400	$68.800
Ammonium filtration recycle residuals— incineration	2	$2.900	$5.800
HCN wastewater only	1	$18.300	$18.300
Total	5	NA	$92.800

4.5.4 Economic Impact Analysis

This section examines the costs of the proposed regulation in the context of the affected companies' baseline financial conditions. Using the average facility and firm characteristics, none of the companies are expected to be severely impacted by the regulation.

4.5.6.1 Overview of Economic Impacts on Markets for Inorganic Hydrogen Cyanide

If Scenario 2 of the proposed waste listing goes into effect the cost of producing inorganic hydrogen cyanide would increase for the affected plants, somewhat reducing the supply of inorganic hydrogen cyanide. The supply of organic hydrogen cyanide would be unaffected. As a result, the total supply of hydrogen cyanide would decrease. The decrease in quantity would likely result in some increase in the price of hydrogen cyanide, although because organic producers of hydrogen cyanide are unaffected by the regulation, the extent to which the market price will increase would be small. In the short run, organic producers would earn more profit because the market price of their commodity increases but their costs are unchanged. They might choose to increase their production as a result, increasing their market share at the expense of the inorganic producers.

4.5.6.2 Estimated Economic Impacts on Affected Facilities and Firms

To estimate the economic impacts of the proposed listing decision on affected companies, EPA first estimated costs of compliance using a model facility approach based on the average characteristics of plants using each current disposal method.

For facilities currently incinerating their waste, EPA used the incineration model plant and scaled the costs to the affected facilities' volume of incineration ash generated. For facilities currently disposing of their waste in a Subtitle D landfill, EPA estimated costs of compliance using the landfill model plant and scaled the costs to the affected facilities' volume of waste generated. Finally, for the HCN wastewaters, EPA estimated costs based on moving from surface impoundment to tanks and treatment.

Under Scenario 2, the total annual cost for the average plant that incinerates ammonium recycle filtration residuals is $2,900. The cost for facilities that generate wastewater and landfill their ammonia recycle filters at baseline is $34,400. The cost for the facility that only generates wastewater is $18,300. Total annual cost for the industry is $92,800.

The impacts of the regulation on a specific facility can be measured by comparing the costs of the regulation to HCN revenues for that facility. Table 4-30 shows that at most, costs represent 0.06 percent of estimated model facility sales of HCN.

EPA measured the impacts of the regulation on affected companies by comparing the costs of compliance to the company's baseline revenues. The estimated impacts of the regulation are based on the assumption that the companies are unable to change the price of hydrogen cyanide so that they are absorbing all of the compliance costs. Table 4-31 shows that the costs associated with compliance comprise a small share of total sales for all of the model companies.

Compliance costs as a share of company revenues are appreciably less than 0.001 percent for all companies. Compliance costs as a share of company profits are less than 0.01 percent. Thus, it does not appear that Scenario 2 of the proposed rulemaking will result in significant economic impacts on affected HCN companies.

Table 4-30. Average Facility-Level Impacts

Potentially affected wastes	HCN sales (\$$10^6$)	Annual HCN production (10^3 Mt)	Annualized compliance cost (\$$10^3$/year)	Costs per Mt of HCN produced	Costs as a share of estimated HCN revenues
Ammonium filtration recycle residuals landfilled, and HCN wastewater	$82.0	61.9	$34.4	$0.55	0.042%
Ammonium filtration recycle residuals—incineration	$141.5	106.1	$2.9	$0.03	0.002%
HCN wastewater only	$30.4	23.4	$18.3	$0.79	0.06%

Table 4-31. Company-Level Costs of Regulation as a Share of Company Sales

Facility	Number of affected companies	Total annual cost (\$$10^3$/year)	Company sales (\$$10^6$/year)	Costs as a share of sales (%)	Company profits (\$$10^6$/year)	Costs as a share of profits (%)
Ammonium filtration recycle residuals landfilled, and HCN wastewater	2	$34.4	$16,129	0.00021%	$3,969	0.0009%
Ammonium filtration recycle residuals—incineration	1	$2.9	$26,918	0.00001%	$7,690	0.00004%
Hcn wastewater only	1	$18.3	$13,267	0.00014%	$279	0.0066%

Table 4-32 summarizes the national costs for the inorganic hydrogen cyanide sector. The total annualized costs for the recycling scenario are carried forward to Section 4.6 of this chapter, where they are summed with the costs and economic impacts on other affected industry sectors to arrive at the total costs and impacts of the proposed listing.

Table 4-32. National Costs of the Proposed Listing: Inorganic Hydrogen Cyanide ($$10^3$)

	Scenario 2	
	Total capital costs	**Total annualized costs**
Total annualized costs	$168.572	$92.830

4.6 Total Annualized National Costs

Table 4-33 summarizes the total national annualized costs for each of the affected sectors of the inorganic chemicals industry for each of the listing scenarios chosen by the Agency.

Table 4-33. National Costs of the Proposed Listing Under Regulatory Scenarios 1 and 2

	Scenario 1		Scenario 2	
Sector	**Total capital costs**	**Total annualized costs**	**Total capital costs**	**Total annualized costs**
Antimony oxide	0	5,030	0	5,030
Titanium dioxide	3,400	2,898,000	34,440,000	47,937,000
Sodium chlorate	0	0	5,680	223,000
Sodium phosphate	0	0	4,550	62,500
Hydrogen cyanide	0	0	168,572	92,800
	3,400	2,903,000	34,619,700	48,320,000

As shown in Table 4-33, the total annualized national costs for Scenario 1 of the proposed listing come to $2.9 million. The total annualized national costs for Scenario 2 of the proposed listing come to $48 million. The majority of the cost of Scenario 1 is incurred by firms producing titanium dioxide via the chloride-ilmenite process. The majority of the cost of Scenario 2 is borne by two firms producing titanium dioxide via the sulfate process. While substantial, even the costs of Scenario 2 represent only a small share (less than 1 percent) of company revenues for most of the typical companies affected by the proposed listing.

CHAPTER 5

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APPENDIX A

EXAMPLE CALCULATIONS

A.1 Cost Estimation

Costs of compliance for inorganic waste handling are estimated with a spreadsheet program. The program is constructed to aggregate wastes in four categories: liquids, solids wastes currently handled as RCRA wastes, and wastes currently handled as non-RCRA wastes. Not all categories are necessarily used for wastes in a specific industry.

The spreadsheet is arranged to show one waste type per row, with columns A through S for waste identification, characteristics, and quantities; columns AB through AG for collection of wastes by type and status; columns AH through AM for collection of estimated capital and annual costs by type of waste; and columns AN through BY for costing of individual waste management operations. For any single model plant, one row is used for describing each waste stream. Below the rows for waste streams are three rows that aggregate RCRA, non-RCRA, and total wastes (either quantities or costs); and a fourth row that is used to estimate unit waste management costs by dividing the cost of management by the quantity managed. Unit costs are estimated for liquids, solids/sludges, and total waste managed. Costing is done with the assumption that all wastes are managed in aggregate quantities of RCRA liquids, non-RCRA liquids, RCRA solids/sludges, and non-RCRA solids/sludges.

Steps may differ from one industry to another because of information found in Forms 3007 specific to an industry or costing procedures used in other EPA work and considered appropriate for inorganics industries.

The costing equations used for each step are given in the individual sections of the economic analysis. An example spreadsheet (for titanium dioxide) is shown in Table A-1, where costs for three model plants are estimated. A description of columns in the spreadsheet follows. Capital costs are in dollars; annual and operation and maintenance (O&M) costs are given in dollars per year. Note that not all columns are used. For titanium dioxide manufacture, no wastes considered for listing are treated as RCRA wastes at baseline.

Table A-1. Costing Spreadsheet for Titanium Dioxide Manufacture

	A	B	C	S	AB	AC	AD	AE	AF	AG	AH
1	**Company**	**RIN**	**Common Name**								
2				Waste Generated	Waste Type	RCRA Managed?	Quantity of RCRA Liquids, Mt/y	Quantity of Non-RCRA Liquids, Mt/y	Quantity of RCRA solids, Mt/y	Quantity of Non-RCRA Solids, Mt/y	Capital Cost for Liquids, $
3											
4											
5											
6	Model - ilmenite	10	Ferric chloride	22000	Liquid	False		0			
7	Model - ilmenite	11	Combined wastewaters	347739	Liquid	False		347,739			
8	Model - ilmenite	8	Ww treat sludge	2200	Solid	False				2,200	
9	Total	Total RCRA					0		0		0
10		Total non-RCRA						347,739		2,200	9,229,548
11		Total									9,229,548
12		Unit cost								349,939	
13											
14											
15	Model - Cl/Su	10	Sulfate digestion sludge	29,467	Solid	False				29,466.67	
16	Model - Cl/Su	10	Mixed wastewater treat solids	26,297	Solid	False				26,296.88	
17	Model - Cl/Su	11	Chloride/sulfate wastewaters	10,176,891	Liquid	False		10,176,891			
18	Model - Cl/Su	12	Secondary gypsum	95,625							
19	Total	Total RCRA					0		0		0
20		Total non-RCRA						10,176,891		55,764	2,589,548
21		Total									2,589,548
22		Unit cost								10,232,654	
23											
24											
25											
26	Model - Cl	8	Chloride only wastewaters	589,934	Liquid	False		589,934			
27	Total	Total RCRA					0		0		0
28		Total non-RCRA						589,934		0	390,413
29		Total									390,413
30		Unit cost								589,934	

(continued)

Table A-1. Costing Spreadsheet for Titanium Dioxide Manufacture (continued)

	A	B	C	AJ	AK	AL	AM	AN	AO	AR	AS
1	**Company**	**RIN**	**Common Name**								
2				Total capital cost, $	Annual cost for liquids, $/y	Annual cost for solids/sludges, $/y	Total annual cost, $/y	On-site neut., capital	On-site neut. O&M	Closure, capital	On-site dewater, capital
3											
4											
5											
6	Model - ilmenite	10	Ferric chloride								
7	Model - ilmenite	11	Combined wastewaters								
8	Model - ilmenite	8	Ww treat sludge								
9	Total	Total RCRA		750	0	0	750	0	0	0	0
10		Total non-RCRA		9,230,298	1,216,906	769,759		9,204,266	266,199	0	252,819
11		Total		9,231,048	1,216,906	769,759	1,988,165				
12		Unit cost			3.50	350	5.68				
13											
14											
15	Model - Cl/Su	10	Sulfate digestion sludge								
16	Model - Cl/Su	10	Mixed wastewater treat solids								
17	Model - Cl/Su	11	Chloride/sulfate wastewaters								
18	Model - Cl/Su	12	Secondary gypsum								
19	Total	Total RCRA		750	0	0	750	0	0	0	0
20		Total non-RCRA		2,590,298	1,102,036	19,268,699		261,110,077	7,385,745	210,236	2,108,582
21		Total		2,591,048	1,102,036	19,268,699	20,372,235				
22		Unit cost			0.108	346	1.99				
23											
24											
25											
26	Model - Cl	8	Chloride only wastewaters								
27	Total	Total RCRA		750	0	0	750	0	0	0	0
28		Total non-RCRA		391,163	159,763	0		15,136,034	428,137	12,187	299,785
29		Total		391,913	159,763	0	161,263				
30		Unit cost			0.271	#DIV/0!	0.27				

(continued)

Table A-1. Costing Spreadsheet for Titanium Dioxide Manufacture (continued)

	A	B		C	AT	BF	BG	BH	BM	BP	BX	BY
1	**Company**	**RIN**		**Common Name**								
2					On-site dewater, O&M	Loading and transport (incremental), $/y	Cost index	Incremental admin costs (Permit change, etc.)	Offsite disposal of sludges and solids (Sub. D)	Offsite disposal of liquid waste sludges (Sub. C)	clarifier capital cost, $	Clarifier annual cost, %/y
3												
4								1500				
5												
6	Model - ilmenite		10	Ferric chloride								
7	Model - ilmenite		11	Combined wastewaters								
8	Model - ilmenite		8	Ww treat sludge								
9	Total	Total RCRA			0	0	1.023		0	0		
10		Total non-RCRA			79,529	353,001			119,743	536,501		
11		Total										
12		Unit cost										
13												
14												
15	Model - Cl/Su		10	Sulfate digestion sludge								
16	Model - Cl/Su		10	Mixed wastewater treat solids								
17	Model - Cl/Su		11	Chloride/sulfate wastewaters			1.023	1500				
18	Model - Cl/Su		12	Secondary gypsum								
19	Total	Total RCRA			0	0	1.023		0	0		
20		Total non-RCRA			788,106	8,943,522			2,966,620	13,291,798	270,731	69,503
21		Total										
22		Unit cost										
23												
24												
25												
26	Model - Cl		8	Chloride only wastewaters								
27	Total	Total RCRA			0	0	1.023		0	0		
28		Total non-RCRA			99,805	0			0	0	78,442	23,107
29		Total										
30		Unit cost										

Column A: Model plant type.

Column B: Waste stream identification number for rows with waste streams. Total waste quantity identifiers for RCRA and non-RCRA wastes and for unit costs.

Column C: Common name for each waste stream.

Column D: Waste stream type code (used to identify the waste as liquid or solid).

Column E: Waste stream RCRA code, if the waste is managed as a RCRA waste at baseline.

Column S: Waste stream quantity for the model plant, Mt/y.

Column AB: Waste type, liquid or solid.

Column AC: Waste management as a RCRA waste, true or false.

Column AD: Sum of liquid wastes managed at baseline as RCRA wastes for the model plant, Mt/y.

Column AE: Sum of liquid wastes managed at baseline as non-RCRA wastes for the model plant, Mt/y.

Column AF: Sum of solid wastes managed at baseline as RCRA wastes for the model plant, Mt/y.

Column AG: Sum of solid wastes managed at baseline as non-RCRA wastes for the model plant, Mt/y.

Column AH: Estimated capital costs for managing the sum of all liquid wastes for the model plant. Estimated as the sum of columns AN + AR + 0.1 × AS for non-RCRA liquids.

Column AJ: Estimated total capital costs for managing the sum of all wastes from the model plant. Estimated as the sum of column AH for non-RCRA wastes.

Column AK: Estimated annual costs for managing the sum of all liquid wastes for the model plant. Estimated as the sum of columns AH × 0.09439 + AO + AT for non-RCRA liquids, where 0.09439 is a capital recovery factor (CRF) to provide an annualized cost for the capital cost estimated in column AH. The CRF = $i(1+i)^n/([1+i]^n - 1)$, where i = interest rate (7 percent) and n = time for which the capital is borrowed (20 years).

Column AL: Estimated annual costs for managing the sum of all waste solids or sludges for the model plant. Estimated as the sum of columns BF + BP – BM for non-RCRA solids/sludges.

Column AM: Estimated total annual costs for managing the sum of all wastes from the model plant. Estimated as the sum of columns AK + AL + BH for non-RCRA wastes.

Column AN: Estimated capital costs for on-site neutralization of non-RCRA liquids. For column AE < 350 Mt/y, column AN = 111.35 × column AE. For column AE > 370,000 Mt/y, column AN = $(36{,}131 + 15{,}195 + 370{,}000^{0.5}) \times$ column AE/370,000. For 350 < column AE < 370,000 Mt/y, column AN = $36{,}131 + 15{,}195 + 370{,}000^{0.5}$. Column AN is also multiplied by a factor from column BG to update costs to 1999.

Column AO: Estimated O&M costs for on-site neutralization of non-RCRA liquids. For column AE < 350 Mt/y, column AN = 21.85 × column AE. For column AE > 370,000 Mt/y, column AN = (-206,719 + 36,594 × ln(370,000) × column AE/370,000. For 350 < column AE < 370,000 Mt/y, column AN = (-206,719 + 36,594 × ln(AE). Column AO is also multiplied by a factor from column BG to update costs to 1999.

Column AR: Estimated closure cost for hazardous waste treatment operations. For column AE < 37,910 Mt/y, column AR = 0.17 × column AE. For column AE > 370,000 Mt/y, column AR = (6,361 + 0.003 × 370,000) × column AE/370,000. For 37,910 < column AE < 370,000 Mt/y, column AR = 6,361 + 0.003 × column AE. Column AR is also multiplied by a factor from column BG to update costs to 1999.

Column AS: Estimated capital costs for on-site dewatering of solids from treatment of non-RCRA liquids (solids assumed to be equivalent to 15 percent of the liquid waste). For column AE < 0.15 × 350 Mt/y, column AS = 307.96 × column AE. For column AE > 0.15 × 370,000 Mt/y, column AS = $95{,}354 + 664.48 \times 370{,}000^{0.5}) \times (0.15 \times 370{,}000/\text{column AE})$. For (0.15 × 350) < 0.15 × column AE < (0.15 × 370,000), column AS = $95{,}354 + 664.48 \times (0.15 \times \text{AE})^{0.5}$. Column AS is also multiplied by a factor from column BG to update costs to 1999.

Column AT: Estimated O&M costs for on-site dewatering of solids from treatment of non-RCRA liquids (solids assumed to be equivalent to 15 percent of the liquid waste). For column AE < 0.15 × 350 Mt/y, column AT = 50.24 × column AE. For column AE > 0.15 × 370,000 Mt/y, column AT = $12{,}219 + 286.86 \times 370{,}000^{0.5}) \times (0.15 \times 370{,}000/\text{column AE})$. For (0.15 × 350) < 0.15 × column AE < (0.15 × 370,000), column AT = $12{,}219 + 286.86 \times (0.15 \times \text{AE})^{0.5}$. Column AT is also multiplied by a factor from column BG to update costs to 1999.

Column BF:	Estimated incremental annual loading and transport costs for non-RCRA solids. Estimated from the difference in loading and shipping costs between listed and non-listed wastes. Wastes are accumulated for 90 days, then loaded and shipped i.e., loading costs are incurred four times per year. Column BF = $(239.38-79) \times$ column AG + $(103-61.8) \times 4$.
Column BG:	Value of Chemical Engineering Cost Index ratio; used for escalating costs to 1999.
Column BH:	Estimated incremental annual administrative costs attributable to listing.
Column BM:	Estimated annual costs for offsite disposal of waste solids and sludges in a Subtitle D landfill. Estimated from the unit charge for offsite disposal and escalated to 1999. Column BM = $53.2 \times$ column AG $\times$ column BG.
Column BP:	Estimated annual costs for offsite disposal of sludges from waste liquids in a Subtitle C landfill. Estimated from the unit charge for offsite disposal and escalated to 1999. Column BM = $238.36 \times$ column AG $\times$ column BG.
Column BX:	Estimated capital cost for a clarifier for non-RCRA liquids. Column BX = $\exp(11.552+0.409 \times \ln(\text{column F}) + 0.02 \times \ln(\text{column F})^2) \times$ column BG. Where column F provides a conversion from Mt/y to millions of gal/day; the units of the costing equation. One Mt/y is approximately equal to 7.81×10^{-7} million gal/day.
Column BY:	Estimated annual cost for a clarifier for non-RCRA liquids. Column BY = $\exp(10.294 + 0.362 \times \ln(\text{column F}) + 0.019 \times \ln(\text{column F})^2) \times$ column BG. Where column F provides a conversion from Mt/y to millions of gal/day; the units of the costing equation. One Mt/y is approximately equal to 7.81×10^{-7} million gal/day.

A.2 Cost Presentation

After estimating costs for individual model plants, the costs are transferred to a second spreadsheet for presentation and application to the total number of model plants that represent the U.S. population of existing plants that would be affected by the proposed listing. Table A-2 shows this second spreadsheet. Columns are given for liquid, solids/sludges, and total capital cost; liquid, solids/sludges, and total annual cost; and liquid, solids/sludges, and total unit costs. In some cases, notes are given below the cost presentations.

One model plant row is given for each U.S. plant represented by the model. For example, three ilmenite plants are shown in Table A-2, one with a ferric chloride recovery process that may allow for sale of the ferric chloride as a byproduct.

Table A-2. Costing Presentation Spreadsheet for Titanium Dioxide

Incremental treatment and disposal costs for TiO$_2$ facilites changing to listed wastes										
Ilmenite										
Facility	Capital cost for liquids, $	Capital cost for solids/ sludges, $	Total capital cost, $	Annual cost for liquids, $/y	Annual cost for solids/sludges, $/y	Total annual cost, $/y	Unit cost for liquids, $/Mt	Unit cost for solids, $/Mt	Overall unit cost, $/Mt	Total quantity of wastes treated, Mt/y
Model	9,229,548	0	9,231,048	1,216,906	769,759	1,988,165	3.50	349.89	5.68	349,939
Model	9,229,548	0	9,231,048	1,216,906	769,759	1,988,165	3.50	349.89	5.68	349,939
Model	9,229,548	0	9,231,048	1,216,906	769,759	1,988,165	3.50	349.89	5.68	349,939
Total	27,688,644	0	27,693,144	3,650,717	2,309,277	5,964,494				1,049,816
Aggregate incremental annual unit cost, $/Mt y						1,988,165				
Note. Total annual costs are increased by $14.77 million for each facility losing sales of ferric chloride. Cost is based on sales price of $253/Mt–61.80/Mt loading cost.										
Chloride sulfate										
Facility	Capital cost for liquids, $	Capital cost for solids/ sludges, $	Total capital cost, $	Annual cost for liquids, $/y	Annual cost for solids/sludges, $/y	Total annual cost, $/y	Unit cost for liquids, $/Mt	Unit cost for solids, $/Mt	Overall unit cost, $/Mt	Total quantity of wastes treated, Mt/y
Model	2,589,548	0	2,591,048	1,102,036	19,268,699	20,372,235	0.108	346	1.99	10,232,654
Model	2,589,548	0	2,591,048	1,102,036	19,268,699	20,372,235	0.108	346	1.99	10,232,654
Total	5,179,097	0	5,182,097	2,204,073	38,537,398	40,744,471				20,465,308
Aggregate incremental annual unit cost, $/Mt y										
Chloride only										
Facility	Capital cost for liquids, $	Capital cost for solids/sludges, $	Total capital cost, $	Annual cost for liquids, $/y	Annual cost for solids/sludges, $/y	Total annual cost, $/y	Unit cost for liquids, $/Mt	Unit cost for solids, $/Mt	Overall unit cost, $/Mt	Total quantity of wastes treated, Mt/y
Model	390,413	0	391,913	159,763	0	161,263	0.253938	#DIV/0!	0.256219	657,656
Model	390,413	0	391,913	159,763	0	161,263	0.253938	#DIV/0!	0.256219	657,656
Model	390,413	0	391,913	159,763	0	161,263	0.253938	#DIV/0!	0.256219	657,656
Model	390,413	0	391,913	159,763	0	161,263	0.253938	#DIV/0!	0.256219	657,656
Total	1,561,654	0	1,567,654	639,052	0	645,052				2,630,624
Aggregate incremental annual unit cost, $/Mt y										
Totals for chloride sulfate and chloride-only facilities										
	6,740,751	0	6,749,751	2,843,125	38,537,398	41,389,523				23,095,932
Aggretate incremental annual unit cost for chloride sulfate and chloride-only facilities							1.79			
Totals for all facilities										
	34,429,395	0	34,442,895	6,493,842	40,846,675	47,354,017				24,145,748
Aggretate incremental annual unit cost for chloride sulfate and chloride-only facilities							1.96			

APPENDIX B

SENSITIVITY ANALYSIS FOR THE TITANIUM DIOXIDE SECTOR

This appendix analyzes the estimated costs and economic impacts associated with management of wastewater treatment solids from production of titanium dioxide using the chloride-ilmenite process, based on revised data on the cost of incineration. In the July 2000 Economic Analysis for Listing of Inorganic Chemicals, Notice of Proposed Rulemaking, we presented a cost and economic impact analysis assuming the wastewater treatment solids, to comply with the proposed listing, were disposed without treatment in a Subtitle C landfill. We examined two possible volumes generated by the model facility, 2,200 Mt per year and 6,600 Mt per year.[1] Because the characteristics of the wastewater treatment solids are uncertain, in a memorandum dated July 13, 2000, we modeled not only alternative volumes, but also alternative management: solidifcation prior to landfilling in a Subtitle C landfill, and incineration with ash disposed in a Subtitle C landfill. This appendix revises those results using more recent data on the cost of incineration[2]. The 1999 data on incineration cost are more current and more consistent with other costs used in the analysis. The results from the landfilling-without-solidification scenario are also included for comparison purposes.

B.1 Introduction

Facilities producing titanium dioxide using the chloride-ilmenite process generate wastewater which, after treatment, produces wastewater treatment solids. The Agency is considering listing the wastewater treatment solids as hazardous wastes under both Scenarios 1 and 2. Under Scenario 2, EPA is also considering listing as hazardous waste the chloride-ilmenite wastewater itself. There are three facilities that produce titanium dioxide using the chloride-ilmenite process, all owned by a single company: Du Pont.

B.1.1 Baseline Characterization of Facilities and Companies

In modeling the costs and economic impacts of the proposed listing, EPA has employed a model facility approach, analyzing the costs and impacts to model entities that represent typical facilities and owner-companies in each market segment. For the chloride-ilmenite segment of the titanium dioxide sector, the typical facility has a capacity of 243,333 Mt per year, and is estimated to operate at the industry-wide capacity utilization rate of 95 percent, producing an

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[1] These volumes of wastewater treatment solids reflect alternative assumptions of chloride solids being 0.04 or 0.12 of $TiCl_4$ volume, respectively.

[2] Environmental Technology Council. August 1999. Hazardous Waste Resource Center. July 1999 Incinerator and Landfill Cost Data. <http;//www.etc.org/costsurvey2.cfm>. As obtained August 2000.

estimated 231,167 Mt of titanium dioxide per year. The typical plant generates 347,739 Mt of wastewater, and as noted above, either 2,200 Mt or 6,600 Mt of wastewater treatment solids, depending on the assumption made about the ratio of chloride solids to $TiCl_4$ in the chloride-ilmenite process. The owner company represents DuPont, with sales of $26,918 million per year, and profits of $7,690 million per year.

At baseline, the typical waste disposal practices are as follows: the chloride ilmenite wastewater treatment solids are settled in impoundments and then disposed of in off-site Subtitle D landfills. Combined ilmenite wastewater is stored in surface impoundments prior to NPDES discharge. Under the listing (Scenario 2 only), the typical facility will store the liquid wastes in tanks prior to treatment and NPDES discharge. Disposal of solid wastes (under either Scenario 1 or Scenario 2) would entail either:

- settling in tanks prior to off-site disposal in a Subtitle C landfill,
- settling in tanks prior to off-site stabilization and disposal in a Subtitle C landfill, or
- settling in tanks prior to off-site incineration, with the ash disposed in a Subtitle C landfill.

Section B.2 describes the data and assumptions used in estimating the costs for the stabilization and incineration treatment scenarios.

B.2 Costs

Costs for additional waste treatment steps of stabilization or incineration are estimated by adding cost functions for the steps and subtracting cost functions for steps being replaced. For stabilization and the difference between disposal in a Subtitle C landfill minus disposal in a Subtitle D landfill, costs are as shown in Table B-1 (unchanged since the July appendix). Each unit cost is multiplied by the quantity of waste being treated. From the sum of offsite stabilization and offsite disposal in a Subtitle C landfill, the cost of disposal in a Subtitle D landfill is subtracted to arrive at the incremental cost of waste treatment and disposal for the listed waste. Because the waste is assumed to be accumulated for 90 days, then shipped for treatment and disposal, the annual waste quantity is divided be 4 to include four shipments to the waste treatment site. Incremental loading and shipping costs are obtained by subtracting cost of non-hazardous from costs of hazardous waste.

For example, if the quantity of waste to be treated and disposed of is 6,600 Mt/y, the estimated incremental annual cost after listing is

$$\text{Loading-transport (\$)} = 6{,}600 \times (239.38 - 79.00) + (103.00 - 61.80) \times 4$$

$$= \$1{,}058{,}673$$

$$\text{Stabilization-disposal (\$)} = 6{,}600/4 \times (93.11 + 238.36 - 53.20) \times 4$$

$$= \$1{,}836{,}582$$

Table B-1. Baseline and Compliance Management Unit Costs ($1999)

Management practice	Unit cost of cost function
Loading as nonhazardous waste	$61.80/load[a]
Loading as hazardous waste	$103.00/load[b]
Transportation as nonhazardous waste	$79.00/Mt[c]
Transportation as hazardous waste	$239.38/mt[d]
Off-site stabilization	$93.11/Mt[e]
Off-site disposal in Subtitle D landfill	$53.20/Mt,[f] $300 minimum charge per load[g]
Off-site disposal in Subtitle C landfill	$238.36/Mt,[h] $2,319 minimum charge per load including stabilization[i]

[a] U.S. Environmental Protection Agency, Office of Solid Waste. "Regulatory Impact Analysis of the Final Rule for 180-Day Accumulation Time for F006 Wastewater Treatment Sludges." Prepared by DPRA, Inc. St. Paul. January 14, 2000. p. 22. Estimated by deleting 1 hour from administration time listed in first footnote and using an annual generation rate of 30 t/y. Converted to metric tons and updated to 1999.

[b] U.S. Environmental Protection Agency, Office of Solid Waste. "Regulatory Impact Analysis of the Final Rule for 180-Day Accumulation Time for F006 Wastewater Treatment Sludges." Prepared by DPRA, Inc. St. Paul. January 14, 2000. p. 21. Estimated from Table 4-3. 30 t/y annual generation rate. Converted to metric tons and updated to 1999.

[c] U.S. Environmental Protection Agency, Office of Solid Waste. "Background Documents for The Cost and Economic Impact Analysis of Listing Four Petroleum Refining Wastes as Hazardous under RCRA Subtitle C." Prepared by DPRA Incorporated, January 10, 1998. p. 3-6, trucks with drums. Updated to 1999.

[d] U.S. Environmental Protection Agency, Office of Solid Waste. "Background Documents for The Cost and Economic Impact Analysis of Listing Four Petroleum Refining Wastes as Hazardous under RCRA Subtitle C." Prepared by DPRA Incorporated, January 10, 1998. p. 3-6, trucks with drums. Updated to 1999.

[e] U.S. Environmental Protection Agency, Office of Solid Waste. "Regulatory Impact Analysis of the Final Rule for 180-Day Accumulation Time for F006 Wastewater Treatment Sludges." Prepared by DPRA, Inc. St. Paul. January 14, 2000. p. 18. Extracted from *Landfill Costs*. Minimum cost per load of $2,267. Converted to metric tons and updated to 1999.

[f] U.S. Environmental Protection Agency, Office of Solid Waste. "Background Documents for The Cost and Economic Impact Analysis of Listing Four Petroleum Refining Wastes as Hazardous under RCRA Subtitle C." Prepared by DPRA Incorporated, January 10, 1998. p. 3-41, Offsite Municipal Subtitle D Landfill. Updated to 1999.

[g] U.S. Environmental Protection Agency, Office of Solid Waste. "Regulatory Impact Analysis of the Final Rule for 180-Day Accumulation Time for F006 Wastewater Treatment Sludges." Prepared by DPRA, Inc. St. Paul. January 14, 2000. p. 18. Taken from *Landfill Costs*. Estimated as the ratio of Subtitle D landfill unit cost to Subtitle C landfill unit cost times the minimum charge for Subtitle C landfills. Converted to metric tons and updated to 1999.

[h] U.S. Environmental Protection Agency, Office of Solid Waste. "Background Documents for The Cost and Economic Impact Analysis of Listing Four Petroleum Refining Wastes as Hazardous under RCRA Subtitle C." Prepared by DPRA Incorporated, January 10, 1998. p. 3-41, Offsite Subtitle C Landfill. Updated to 1999.

[i] U.S. Environmental Protection Agency, Office of Solid Waste. "Regulatory Impact Analysis of the Final Rule for 180-Day Accumulation Time for F006 Wastewater Treatment Sludges." Prepared by DPRA, Inc. St. Paul. January 14, 2000. p. 18. Taken from *Landfill Costs*. Converted to metric tons and updated to 1999.

Total cost for treatment and disposal is the sum of the above two numbers, or $2,895,255. To this quantity is added a further $1,500 for incremental administrative costs.

Costs for offsite incineration of wastewater treatment solids are estimated with a unit cost of $727.51/Mt[3] plus ash disposal costs of $152.43 per ton of ash. The incineration process is assumed to produce 7 percent ash. As for stabilization, incremental transport costs are added to the treatment and disposal costs. For example, using 6,600 Mt/y of waste, annual costs of treatment and disposal are

$$\text{Incineration-ash disposal (\$)} = 6{,}600 \times 727.51 + (6{,}600*0.07)*152.43$$

$$= \$4{,}872{,}989$$

Adding loading and transport costs as estimated above ($1,058,673) gives a total of $5,930,688. To this amount, a further $1,500 is added for incremental administrative costs.

Implementing these models, we estimate the costs of complying with the proposed listing, for each volume scenario and management approach. These costs are shown in Table B-2.

Table B-2. Estimated Costs of the Proposed Listing on Typical Chloride-Ilmenite Titanium Dioxide Facilities

Chloride solids scenario	Total quantity of waste treated, Mt/y	Total annualized cost (10^6 $/yr)
Low Volume Scenario		
Scenario 1, Landfill	2,200	0.771
Scenario 1, Stabilization and Landfill		0.967
Scenario 1, Incineration and Landfill Ash		1.979
Scenario 2, Landfill Solids	349,939	1.988
Scenario 2, Stabilize and Landfill Solids		2.184
Scenario 2, Incinerate Solids and Landfill Ash		3.195
High Volume Scenario		
Scenario 1, Landfill	6,600	2.310
Scenario 1, Stabilization and Landfill		2.897
Scenario 1, Incineration and Landfill Ash		5.932
Scenario 2, Landfill Solids	354,339	3.527
Scenario 2, Stabilize and Landfill Solids		4.114
Scenario 2, Incinerate Solids and Landfill Ash		7.149

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[3] See Note 2 above.

B.3 Estimated Economic Impacts of the Proposed Listing

To estimate the impacts of compliance on the facilities producing titanium dioxide using the chloride ilmenite process, we compare the estimated costs of compliance with the facility's estimated sales of titanium dioxide. If the facility's costs of compliance represent a substantial share of its titanium dioxide sales, it may find that the product line becomes unprofitable post-rule. The estimated facility impacts are shown in Table B-3. Even for the most costly scenario, under which the facility incurs costs for treating both wastewater and wastewater treatment solids in compliance with Scenario 2 of the listing, and treatment of solids includes incineration followed by disposing the ash in a Subtitle C landfill, the costs represent only 1.5 percent of the typical facility's estimated titanium dioxide sales. Unless the titanium dioxide product line has a much lower profit margin than the company as a whole (28.6 percent), these costs are not likely to make it unprofitable.

Table B-3. Estimated Economic Impacts of the Proposed Listing on Typical Chloride-Ilmenite Titanium Dioxide Facilities

Chloride solids scenario	Total annualized cost (10^6 \$/yr)	Estimated TiO_2 sales (10^6 \$/y)	Cost/sales
Low Volume Scenario			
Scenario 1: 2,200 Mt/yr			
Scenario 2: 349,939 Mt/yr			
Scenario 1, Landfill	0.771	473.955	0.163%
Scenario 1, Stabilization and Landfill	0.967	473.955	0.204%
Scenario 1, Incineration and Landfill Ash	1.979	473.955	0.417%
Scenario 2, Landfill Solids	1.988	473.955	0.419%
Scenario 2, Stabilize and Landfill Solids	2.184	473.955	0.461%
Scenario 2, Incinerate Solids and Landfill Ash	3.195	473.955	0.674%
High Volume Scenario			
Scenario 1: 6,600 Mt/yr			
Scenario 2: 354,339 Mt/yr			
Scenario 1, Landfill	2.310	473.955	0.487%
Scenario 1, Stabilization and Landfill	2.897	473.955	0.611%
Scenario 1, Incineration and Landfill Ash	5.932	473.955	1.252%
Scenario 2, Landfill solids	3.527	473.955	0.744%
Scenario 2, Stabilize and Landfill solids	4.114	473.955	0.868%
Scenario 2, Incinerate Solids and Landfill Ash	7.149	473.955	1.508%

To assess the impacts of the proposed rulemaking on the company owning the typical facility, we compare the estimated costs of complying with the proposed listing to the company's sales and profits, assuming the company owns three facilities like the typical facility. Table B-4 shows this comparison.

Table B-4. Estimated Economic Impacts of the Proposed Listing on Typical Companies owning Chloride-Ilmenite Titanium Dioxide Facilities

Chloride Solids Scenario	Total annualized costs (10^{6} \$/yr)	Company sales (10^{6} \$yr)	Cost/sales (10^{6} \$yr)	Company profits (10^{6} \$yr)	Cost/profits (10^{6} \$yr)
Low Volume Scenario					
Scenario 1, Landfill	2.314	26,918	0.003%	7,690	0.010%
Scenario 1, Stabilization and Landfill	2.900	26,918	0.011%	7,690	0.038%
Scenario 1, Incineration and Landfill Ash	5.936	26,918	0.022%	7,690	0.077%
Scenario 2, Landfill Solids	5.964	26,918	0.007%	7,690	0.026%
Scenario 2, Stabilize and Landfill Solids	6.551	26,918	0.024%	7,690	0.085%
Scenario 2, Incinerate Solids and Landfill Ash	9.586	26,918	0.036%	7,690	0.125%
High Volume Scenario					
Scenario 1, Landfill	6.931	26,918	0.009%	7,690	0.030%
Scenario 1, Stabilization and Landfill	8.691	26,918	0.032%	7,690	0.113%
Scenario 1, Incineration and Landfill Ash	17.797	26,918	0..066%	7,690	0.231%
Scenario 2, Landfill Solids	10.582	26,918	0.013%	7,690	0.046%
Scenario 2, Stabilize and Landfill Solids	12.342	26,918	0.046%	7,690	0.160%
Scenario 2, Incinerate Solids and Landfill Ash	21.447	26,918	0.080%	7,690	0.279%

B.4 Conclusions

The estimated costs of complying with the proposed listing vary considerably, depending on the volume of wastewater treatment solids assumed to be generated, the Regulatory Scenario assumed to be selected by the Agency for proposal, and the treatment required to comply. Revising the analysis to incorporate more recent data on the cost of offsite incineration reduces EPA's estimate of the cost of the incineration options by approximately half, although the incineration options are still higher cost than the landfill options.

At the facility level, costs range from \$771,000 per year for the low volume scenario under Regulatory Scenario 1, where the solids are disposed offsite in a Subtitle C landfill with no stabilization, to more than $7 million per year for the high volume scenario under Regulatory Scenario 2, where the facility is assumed to send the waste offsite for incineration, followed by Subtitle C landfilling of the ash. Even at the highest, the costs of compliance represent only 1.5 percent of the typical facility's estimated sales of titanium dioxide, and are thus unlikely to significantly change the profitability of the product line.

The typical company owning three typical facilities incurs costs that range from $2.3 million to $21.4 million, depending on the volume, regulatory Scenario, and treatment and disposal method. At most, the costs represent less than 0.1 percent of the company's sales and only 0.3 percent of its profits. Even under the highest-cost assumptions, therefore, the company is expected to have sufficient financial resources to be able to comply with the proposed listing without experiencing significant financial impacts.

Thus, while the costs vary substantially depending on the scenario and Regulatory Scenario, because the typical chloride-ilmenite facilities and the company that owns them are both very large, having large revenues both from titanium dioxide sales and overall, the typical facility and company are expected to incur relatively insignificant impacts under all scenarios and Regulatory Scenarios.

APPENDIX C

FEDERALISM ANALYSIS (E.O. 13132) FOR LISTING OF INORGANIC CHEMICALS, NOTICE OF PROPOSED RULEMAKING: SUBSTANTIAL DIRECT EFFECTS

Under Section 6 of Executive Order 13132 (August 4, 1999)[1] on Federalism, agencies are required to consult with State and local officials when developing regulatory policies that have federalism implications. Policies that have federalism implications are defined in Section 1 of the Executive Order as including regulations that have "substantial direct effects" on the States. The purpose of this analysis is to determine whether this notice of proposed rulemaking has substantial direct effects on States affected by the proposal. Because the purpose of the Executive Order 13132 is to "further the policies of the Unfunded Mandates Reform Act" (UMRA)[2], EPA has applied the $100 million threshold specified in §202 of UMRA to quantify "substantial direct effects" for purposes of determining whether this proposed rulemaking has federalism implications. For the reasons stated below, the proposed rulemaking for listing of wastes from inorganic chemical production does not have substantial direct effects or federalism implications associated with this rationale on State or local governments.

C.1 Analysis

State and local governments who either implement or who are subject to the provisions of this proposed rulemaking could incur four types of potential costs: 1) administrative costs (reading and understanding the regulation, processing notifications and other reporting requirements, record management, other), 2) state program authorization revision costs (amending their state authorizations to include newly listed wastes), 3) enforcement costs (inspection, settlement, litigation costs), and 4) direct compliance costs (e.g., a municipally owned landfill required to manage it's leachate as hazardous waste). Taking all of these costs together, if the total expenditure in any one year resulting from this proposed rule does not exceed $100 million, then the rule would not have "substantial direct effects" on State and local government and therefore not have federalism implications for this reason (other rationales for federalism implications are addressed in the preamble to this rulemaking).

There are 7 States having jurisdiction over wastes proposed for listing in this rulemaking with 9 potentially affected facilities. These States and facilities include New Jersey (Amspec), Louisiana (Degussa), Tennessee (Dupont Memphis, Dupont New Johnsonville), Montana (U.S. Antimony), Mississippi (Dupont Delisle), Texas (Rohm and Haas, Laurel Industries), Delaware (Dupont Edgemoor).

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[1] 64 FR 43255 (Tuesday, August 10, 1999)

[2] E.O. 13132, Introduction

Regarding administrative costs, all the potentially affected facilities are previously regulated under RCRA. Therefore, affected States would not incur additional facility reports from this proposal (including 3010 notification, Biennial Reporting System reports, etc). There may be some administrative cost from reading and familiarization with the rule. This cost is likely to be nominal, less than $5,000.[3]

Regarding state authorization, all of the States affected by this proposal are authorized for the base RCRA program. This means that in order for these States to be authorized for the new hazardous waste listings, the would need to revise their program. State program authorization revision applications are estimated to cost approximately $6,500 per respondent (State).[4] Thus, the total state authorization cost associated with this rulemaking would be approximately. $45,500 ($6,500 per revision application × 7 states).

Because there are only 9 facilities affected by this proposal, this represents the upper bound number of inspections, settlements and enforcement actions potentially incurred by State and local government. EPA has used a model inspection, settlement, and litigation approach for this analysis. Because not all inspections costs may be fully enumerated, the Agency has adjusted the estimate upward by 15 percent to account for any unenumerated costs. EPA has estimated the upper bound enforcement cost incurred by State and local governments from this rulemaking to be less than $550,000.

Inspection costs are modeled with 1 state inspector having an annual case load of 4 cases at 520 hours per case (0.25 FTE × 2,080 hours = 520 hours). Using an loaded labor rate of $47.52[5] for State inspectors, this amounts to roughly $25,000 labor cost per inspection per year. Sampling costs from the inspection are expected to average $15,000.[6] Unenumerated costs are estimated at 15 percent of labor and sampling cost resulting in $6,000 ($40,000 labor plus sampling × 0.15). The average State inspection cost associated with this rulemaking is $46,000 per inspection.

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[3] For example, in estimating respondent burden for Information Collection Requests, the time and cost of reading regulations regulations has been between 0.1 and 8 hours and between $25 and $680 per respondent. Supporting Statement for EPA Information Collection Request Number 1189.05 Identification Listing and Rulemaking Petitions, 1/16/98, Supporting Statement for EPA Information Collection Request Number 0820.06, Hazardous Waste Generator Standards, 7/15/97. Thus, upperbound rule familiarization costs for this rulemaking would be approximately $5000 total (7 States × $700 per State).

[4] Supporting Statement for EPA Information Collection Request Number 969 Final Authorization For Hazardous Waste Management Programs, December 1998. Exhibit 3.

[5] Ibid., p.18.

[6] Assumes an average of 10 samples per inspection at a cost of $1500 per sample TLCP analysis for a range of metal analytes. TCLP cost for metal analytes, best professional judgement, Oliver Fordham, Inorganic Chemical Program, U.S.E.P.A. Office of Solid Waste, June 16, 2000.

If the inspection results in either an administrative or judicial action being filed, then either settlement costs or litigation costs would need to be added to the inspection costs to determine the aggregate enforcement cost. Based on conversations with EPA enforcement personnel, an average Agency RCRA enforcement attorney has a caseload of 2 to 3 cases per year that take up 50 percent of his time.[7] This translates to a maximum of 0.25 FTE per case (2 cases times 50 percent). EPA enforcement personnel indicated that the actual time spent on a case would depend upon how long it took the case to settle. Cases that might settle quickly would take 3 to 4 months. Longer cases could take over one year. Thus, the range of hours per year that an attorney might devote to a case could vary from 200 to 800[8] hours (assuming a higher percentage of time in the event of a trial). Using an average loaded labor rates for State attorneys of $62.85 per hour[9], the total labor cost settling or litigating a case could range from $12,500 for a quick 4 month settlement to $50,000 per case per year. Because cases are more likely to settle than to go to trial, this analysis assumes a value of $15,000 per case filed. In the event of a trial, expert witness costs are estimated at $10,000 per case.

With a total of 9 facilities potentially affected by this proposal, even if all facilities were inspected and cases were filed (an unlikely event) , the total expenditure of States for these enforcement activities would not exceed $550,000 (9 facilities × $61,000 per inspection/case)

There are no State or local government entities that would incur direct compliance cost as a result of this proposal. Therefore, as broken out in Table C-1, the estimated expenditure for State and local governments in any one year from this rulemaking would be less than $600,000 per year.

Table C-1. Summary of Upperbound State and Local Expenditures Associated with the Inorganics Proposed Listing of Hazardous Waste

Cost estimate	$$10^3$
Administrative	<5
State Authorization	45
Enforcement	550
Direct Compliance	0
Total	**600**

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[7] Personal Communication between Paul A. Borst, EPA Office of Solid Waste and Lewis Maldonado, EPA Region 9, Office of Regional Counsel, June 19, 2000.

[8] This analysis assumes one attorney FTE equal to approximately 2500 hours per year. 2500 per year × 0.25 FTE = 625 hours per year. A case that settles in 4 months is assumed to take approximately 200 hours. A case that exceeds one year, 600 to 800 (if a higher percentage of time is involved).

[9] Supporting Statement for EPA Information Collection Request Number 969 Final Authorization For Hazardous Waste Management Programs, December 1998. p. 18.

APPENDIX D

ESTIMATED TOTAL ANNUALIZED COSTS BY WASTE FOR TYPICAL FACILITIES

Table D-1. Estimated Total Annualized Costs by Waste for Typical Facilities

	Scenario 1 Costs			Scenario 2 Costs		
Sector	**Quantity of waste (Mt/yr)**	**Total annualized cost, treatment ($/yr)**	**Total annualized cost, recycling scenario**	**Quantity of waste (Mt/yr)**	**Total annualized cost, treatment ($/yr)**	**Total annualized cost, recycling scenario**
Antimony Oxide						
Dust collector filter bags	4	11,310	1,368	4	11,310	1,368
Low-antimony slag	20	14,240	2,294	20	14,240	2,294
Total	24	25,550	3,662	24	25,550	3,662
Titanium Dioxide						
Chloride-ilmenite wastewaters				347,739	1,217,500	
Chloride-ilmenite Wastewater treatment solids	2,200	966,400		2,200	965,800	
Total, chloride-ilmenite facility		966,400			2,183,300	
Sulfate digestion sludge				29,467	10,183,000	
Mixed wastewater treatment solids				26,297	9,088,000	
Chloride/sulfate wastewaters				10,176,891	1,102,000	
Total, chloride-sulfate facility					20,373,000	
Chloride-only wastewaters				589,934	160,900	
Total, chloride-only facility					160,900	
Sodium Chlorate						
Process waste solids				108	44,500	
Filter waste				0.5	200	
Total				108.5	44,700	
Sodium Phosphates						
Dust collector filter bags				0.53	300	
Filter press cake				27	15,300	
Total				27.5	15,600	
Hydrogen Cyanide						
Ammonia recycle solids (landfilled at baseline)				29.5	8,600	
Wastewater at facilities that LF ammonia recycle residuals at baseline				333,000	25,800	
Total for facilities that LF solids at baseline					34,400	
Ammonia recycle carbon				4	49	
Ammonia recycle filter cartridges				230.5	2,840	
Total					2,890	
Wastewater at facilities that have only wastewater				90,000	18,300	