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Environmental Assessment of Proposed Effluent Limitations Guidelines and Standards for Industrial Waste Combustors

ENVIRONMENTAL ASSESSMENT OF PROPOSED EFFLUENT GUIDELINES FOR INDUSTRIAL WASTE COMBUSTORS

Volume I

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EXECUTIVE SUMMARY

This environmental assessment quantifies the water quality-related benefits associated with achievement of the proposed BAT (Best Available Technology) and PSES (Pretreatment Standards for Existing Sources) controls for commercial industrial waste combustors (IWCs). Based on site-specific analyses of current conditions and changes in discharges associated with the proposal, the U.S. Environmental Protection Agency (EPA) estimated instream pollutant concentrations for 17 priority and nonconventional pollutants from direct and indirect discharges using stream dilution modeling. The potential impacts and benefits to aquatic life are projected by comparing the modeled instream pollutant concentrations to published EPA aquatic life criteria guidance or to toxic effect levels. Potential adverse human health effects and benefits are projected by: (1) comparing estimated instream concentrations to health-based water quality toxic effect levels or criteria; and (2) estimating the potential reduction of carcinogenic risk and noncarcinogenic hazard (systemic) from consuming contaminated fish or drinking water. Upper-bound individual cancer risks, population risks, and systemic hazards are estimated using modeled instream pollutant concentrations and standard EPA assumptions. Modeled pollutant concentrations in fish and drinking water are used to estimate cancer risk and systemic hazards among the general population, sport anglers and their families, and subsistence anglers and their families. EPA used the findings from the analyses of reduced occurrence of instream pollutant concentrations in excess of both aquatic life and human health criteria or toxic effect levels to assess improvements in recreational fishing habitats that are impacted by IWC wastewater discharges (ecological benefits). These improvements in aquatic habitats are then expected to improve the quality and value of recreational fishing opportunities.

Potential inhibition of operations at publicly owned treatment works (POTW) and sewage sludge contamination (here defined as a sludge concentration in excess of that permitting land application or surface disposal of sewage sludge) are also evaluated based on current and proposed pretreatment levels. Inhibition of POTW operations is estimated by comparing modeled POTW influent concentrations to available inhibition levels. Contamination of sewage sludge is estimated by comparing projected pollutant concentrations in sewage sludge to available EPA regulatory standards for land application and surface disposal of sewage sludge. Economic productivity benefits are estimated on the basis of the incremental quantity of sludge that, as a result of reduced pollutant discharges to POTWs, meets criteria for the generally less expensive disposal method, namely land application and surface disposal.

In addition, the potential fate and toxicity of pollutants of concern associated with IWC wastewater are evaluated based on known characteristics of each chemical. Recent literature and studies are also reviewed, and State environmental agencies are contacted for evidence of documented environmental impacts on aquatic life, human health, POTW operations, and on the quality of receiving water.

These analyses are performed for discharges of the 11 commercial industrial waste combustors (8 direct dischargers and 3 indirect dischargers) identified as within the scope of this regulation. This report provides the results of these analyses, organized by the type of discharge (direct and indirect).

Comparison of Instream Concentrations with Ambient Water Quality Criteria (AWQC)/Impacts at POTWs

The water quality modeling results for 8 direct IWC facilities discharging 17 pollutants (metals) to 8 receiving streams indicate that at **current** discharge levels, instream concentrations of 3 pollutants are projected to exceed **acute aquatic life criteria** or toxic effect levels in 1 of the 8 receiving streams (12 percent). Instream concentrations of 8 pollutants are projected to exceed **chronic aquatic life criteria** or toxic effect levels in 50 percent (4 of the total 8) of the receiving streams. The **proposed BAT** regulatory option will reduce **acute aquatic life** excursions from 3 pollutants to 2 pollutants. The regulatory option will also reduce the **chronic aquatic life** excursions from 8 pollutants to 7 pollutants in the 4 receiving streams. Additionally, at **current** discharge levels, instream concentrations of 2 pollutants (using a target risk of 10^{-6} (1E-6) for carcinogens) are projected to exceed **human health criteria** or toxic effect levels (developed for consumption of water and organisms) in 50 percent (4 of the total 8) receiving streams. The instream concentration of 1 pollutant (using a target risk of 10^{-6} (1E-6) for carcinogens) is projected to exceed the **human health criteria** or toxic effect levels (developed for organisms consumption only) in 25 percent (2 of the total 8) receiving streams. The **proposed BAT** regulatory option will eliminate **human health criteria** or toxic effect level (developed for consumption of water and organisms) excursions by 1 pollutant, but 4 receiving streams are still impacted. **Human health criteria** or toxic effect level (developed for organisms consumption only) excursions are eliminated in 1 of the 2 impacted receiving streams at the **proposed BAT** regulatory option. Under the **proposed BAT** regulatory option, pollutant loadings are reduced 29 percent.

Modeling results for 3 indirect IWC facilities that discharge 17 pollutants (metals) to 3 POTWs located on 3 receiving streams indicate that at **current** discharge levels no instream pollutant concentrations are expected to exceed **acute aquatic life criteria** or toxic effect levels. The instream concentration of 1 pollutant is projected to exceed **chronic aquatic life criteria** or toxic effect levels in 33 percent (1 of the total 3) receiving streams. The **proposed pretreatment** regulatory option will eliminate this **chronic aquatic life** excursion. Additionally, at **current** discharge levels, the instream concentration of 1 pollutant is projected to exceed both **human health criteria** or toxic effect levels (developed for consumption of water and organisms) and **human health criteria** or toxic effect levels (developed for organisms consumption only) in 1 receiving stream. Projected excursions are eliminated by the **proposed pretreatment** regulatory option. Pollutant loadings are reduced 97 percent.

In addition, POTW inhibition problems and sludge contamination problems are projected only at **current** discharge levels. Inhibition problems are projected to occur at 33 percent (1 of the 3) of the POTWs from the discharge of 1 pollutant. The **proposed pretreatment** regulatory option eliminates any inhibition problem. Sludge contamination is projected to occur at 67 percent

(2 of the 3) of the POTWs due to the discharge of 3 pollutants. The <u>proposed pretreatment</u> regulatory option will also eliminate sludge contamination problems.

<u>Human Health Risks and Benefits</u>

The excess annual cancer cases at <u>current</u> discharge levels and, therefore, at <u>proposed BAT</u> and <u>proposed pretreatment</u> discharge levels are projected to be far less than 0.5 for all populations evaluated from the ingestion of contaminated fish and drinking water for both direct and indirect IWC wastewater discharges. A monetary value of this benefit to society is, therefore, not projected. Systemic toxicant effects are projected from fish consumption for both direct and indirect discharges. For direct discharges, systemic effects are projected to result from the discharge of 3 pollutants to 3 receiving streams at <u>current</u> discharge levels. An estimated population of 705 subsistence anglers and their families are projected to be affected. At the <u>proposed BAT</u> regulatory option, systemic toxicity is limited to 1 pollutant in 1 receiving stream with 373 subsistence anglers and their families remaining exposed; a 47 percent reduction. For indirect discharges, systemic toxicant effects are projected at <u>current</u> discharge levels due to the discharge of 2 pollutants to 1 receiving stream. An estimated population of 249 subsistence anglers and their families are projected to be affected. No systemic toxicant effects are projected at <u>proposed pretreatment</u> discharge levels. Monetary values for the reduction of systemic toxic effects cannot currently be estimated.

<u>Ecological Benefits</u>

Potential ecological benefits of the proposed regulation, based on improvements in recreational fishing habitats, are projected for only indirect IWC wastewater discharges, because the proposed regulation is not projected to completely eliminate instream concentrations in excess of aquatic life and human health ambient water quality criteria (AWQC) in any stream receiving wastewater discharge from direct discharge IWC facilities. For indirect discharges, concentrations in excess of AWQC are projected to be eliminated at 1 receiving stream as a result of the proposed pretreatment regulatory option. The monetary value of improved recreational fishing opportunity is estimated by first calculating the baseline value of the receiving stream using a value per person day of recreational fishing, and the number of person-days fished on the receiving stream. The value of improving water quality in this fishery, based on the increase in value to anglers of achieving contaminant-free fishing, is then calculated. The resulting estimate of the increase in value of recreational fishing to anglers on the improved receiving stream is $78,600 to $281,000 (1992 dollars).

The estimated benefit of improved recreational fishery opportunities is only a limited measure of the value to society of the improvements in aquatic habitats expected to result from the proposed regulation. Additional benefits, which could not be quantified in this assessment, include increased assimilation capacity of the receiving stream, protection of terrestrial wildlife and birds that consume aquatic organisms, maintenance of an aesthetically pleasing environment, and improvements to other recreational activities such as swimming, water skiing, boating, and wildlife observation. Such activities contribute to the support of local and State economies.

Economic Productivity Benefits

Potential economic productivity benefits, based on reduced sewage sludge contamination and sewage sludge disposal costs, are projected at 1 POTW that will meet land application pollutant concentration limits as a result of the proposed regulation. Savings in disposal cost are estimated at $7,400 (1992 dollars). In addition, 2 POTWs (1 additional) are expected to accrue a modest benefit through reduced record-keeping requirements and exemption from certain sewage sludge management practices. A monetary value for these modest benefits cannot currently be estimated.

Pollutant Fate and Toxicity

EPA identified 21 pollutants of concern (10 priority pollutants, 4 conventional/classical pollutant parameters, and 7 nonconventional pollutants) in wastestreams from IWC facilities. Seventeen (17) of these pollutants (all metals) are evaluated to assess their potential fate and toxicity based on known characteristics of each chemical.

Most of the 17 pollutants have at least one known toxic effect. Based on available physical-chemical properties and aquatic life and human health toxicity data for these pollutants, 10 exhibit moderate to high toxicity to aquatic life; 3 are classified as known or probable human carcinogens; 13 are human systemic toxicants; 13 have drinking water values; and 10 are designated by EPA as priority pollutants. In terms of projected partitioning, 4 have a moderate to high potential to bioaccumulate in aquatic biota, potentially accumulating in the food chain and causing increased risk to higher trophic level organisms and to exposed human populations via consumption of fish and shellfish. All of the modeled pollutants are metals, which in general are not applicable to evaluation based on volatility and adsorption to solids. It is assumed that all of the metals have a high potential to sorb to solids.

The impacts of the 4 conventional/classical pollutants are not evaluated when modeling the effect of the proposed regulation on receiving stream water quality and POTW operations or when evaluating the potential fate and toxicity of discharged pollutants. These pollutants are total suspended solids (TSS), chemical oxygen demand (COD), total dissolved solids (TDS), and total organic carbon (TOC). The discharge of these pollutants can have adverse effects on human health and the environment. For example, habitat degradation can result from increased suspended particulate matter that reduces light penetration, and thus primary productivity, or from accumulation of sludge particles that alter benthic spawning grounds and feeding habitats. High COD levels can deplete oxygen concentrations, which can result in mortality or other adverse effects on fish. High TOC levels may interfere with water quality by causing taste and odor problems and mortality in fish.

Documented Environmental Impacts

This assessment also summarizes documented environmental impacts on aquatic life, human health, POTW operations, and receiving stream water quality. The summaries are based on a review of published literature abstracts, State 304(l) Short Lists, State Fishing Advisories, and contact with State environmental agencies. Two (2) direct discharging IWC facilities and 2 POTWs receiving the discharge from 2 IWC facilities are identified by States as being point sources causing water quality problems and are included on their 304(l) Short List. State contacts indicate that of the two direct facilities, one is no longer in operation and the other is currently in compliance with its permit limits and is no longer a source of impairment. Both of the POTWs listed are also currently in compliance for the listed pollutants. In addition, two IWC facilities are located on waterbodies with State-issued fish consumption advisories. However, the advisories are based on dioxins, which are not proposed for regulation for the IWC industry.

1. INTRODUCTION

The purpose of this report is to present an assessment of the water quality benefits of controlling the discharge of wastewater from commercial industrial waste combustors (IWCs) to surface waters and publicly-owned treatment works (POTWs). Potential aquatic life and human health impacts of direct discharges on receiving stream water quality and of indirect discharges on POTWs and their receiving streams are projected at current, proposed BAT (Best Available Technology), and proposed PSES (Pretreatment Standards for Existing Sources) levels by quantifying pollutant releases and by using stream modeling techniques. The potential benefits to human health are evaluated by: (1) comparing estimated instream concentrations to health-based water quality toxic effect levels or U.S. Environmental Protection Agency (EPA) published water quality criteria; and (2) estimating the potential reduction of carcinogenic risk and noncarcinogenic hazard (systemic) from consuming contaminated fish or drinking water. Reduction in carcinogenic risks is monetized, if applicable, using estimated willingness-to-pay values for avoiding premature mortality. Potential ecological benefits are projected by estimating improvements in recreational fishing habitats and, in turn, by projecting, if applicable, a monetary value for enhanced recreational fishing opportunities. Economic productivity benefits are estimated based on reduced POTW sewage sludge contamination (thereby increasing the number of allowable sludge uses or disposal options). In addition, the potential fate and toxicity of pollutants of concern associated with IWC wastewater are evaluated based on known characteristics of each chemical. Recent literature and studies are also reviewed for evidence of documented environmental impacts (e.g., case studies) on aquatic life, human health, and POTW operations and for impacts on the quality of receiving water.

While this report does not evaluate impacts associated with reduced releases of one conventional pollutant (total suspended solids [TSS]) and three classical pollutant parameters (chemical oxygen demand [COD], total dissolved solids [TDS], and total organic carbon [TOC]), the discharge of these pollutants can have adverse effects on human health and the environment. For example, habitat degradation can result from increased suspended particulate matter that reduces light penetration and primary productivity, or from accumulation of sludge particles that alter benthic spawning grounds and feeding habitats. High COD levels can deplete oxygen levels, which can result in mortality or other adverse effects in fish. High TOC levels may interfere with water quality by causing taste and odor problems and mortality in fish.

The following sections of this report describe: (1) the methodology used in the evaluation of projected water quality impacts and projected impacts on POTW operations for direct and indirect discharging facilities (including potential human health risks and benefits, ecological benefits, and economic productivity benefits) in the evaluation of the potential fate and toxicity of pollutants of concern, and in the evaluation of documented environmental impacts; (2) data sources used to evaluate water quality impacts such as plant-specific data, information used to evaluate POTW operations, water quality criteria, and information used to evaluate human health risks and benefits, ecological benefits, economic productivity benefits, pollutant fate and toxicity, and documented environmental impacts; (3) a summary of the results of this analysis; and (4) a complete list of references cited in this report. The various appendices presented in Volume II provide additional detail on the specific information addressed in the main report. These appendices are available in the administrative record.

2. METHODOLOGY

2.1 Projected Water Quality Impacts

The water quality impacts and associated risks/benefits of IWC discharges at various treatment levels are evaluated by: (1) comparing projected instream concentrations with ambient water quality criteria,[1] (2) estimating the human health risks and benefits associated with the consumption of fish and drinking water from waterbodies impacted by the IWC industry, (3) estimating the ecological benefits associated with improved recreational fishing habitats on impacted waterbodies, and (4) estimating the economic productivity benefits based on reduced sewage sludge contamination at POTWs receiving the wastewater of IWC facilities. The methodologies used in this evaluation are described in detail below.

2.1.1 Comparison of Instream Concentrations with Ambient Water Quality Criteria

Current and proposed pollutant releases are quantified and compared, and potential aquatic life and human health impacts resulting from current and proposed pollutant releases are evaluated using stream modeling techniques. Projected instream concentrations for each pollutant are compared to EPA water quality criteria or, for pollutants for which no water quality criteria have been developed, to toxic effect levels (i.e., lowest reported or estimated toxic concentration). Inhibition of POTW operation and sludge contamination are also evaluated. The following three sections (i.e., Section 2.1.1.1 through Section 2.1.1.3) describe the methodology and assumptions used for evaluating the impact of direct and indirect discharging facilities.

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[1]In performing this analysis, EPA used guidance documents published by EPA that recommend numeric human health and aquatic life water quality criteria for numerous pollutants. States often consult these guidance documents when adopting water quality criteria as part of their water-quality standards. However, because those State-adopted criteria may vary, EPA used the nationwide criteria guidance as the most representative values.

2.1.1.1 *Direct Discharging Facilities*

Using a stream dilution model that does not account for fate processes other than complete immediate mixing, projected instream concentrations are calculated at current and proposed BAT treatment levels for stream segments with direct discharging facilities. For stream segments with multiple IWC facilities, pollutant loadings are summed, if applicable, before concentrations are calculated. The dilution model used for estimating instream concentrations is as follows.

$$C_{is} = \frac{L/OD}{FF + SF} \times CF \qquad \text{(Eq. 1)}$$

where:

C_{is}	=	instream pollutant concentration (micrograms per liter [μg/L])
L	=	facility pollutant loading (pounds/year [lbs/year])
OD	=	facility operation (days/year)
FF	=	facility flow (million gallons/day [gal/day])
SF	=	receiving stream flow (million gal/day)
CF	=	conversion factors for units

The facility-specific data (i.e., pollutant loading, operating days, facility flow, and stream flow) used in Eq. 1 are derived from various sources as described in Section 3.1.1 of this report. One of three receiving stream flow conditions (1Q10 low flow, 7Q10 low flow, and harmonic mean flow) is used for the two treatment levels; use depends on the type of criterion or toxic effect level intended for comparison. The 1Q10 and 7Q10 flows are the lowest 1-day and the lowest consecutive 7-day average flow during any 10-year period, respectively, and are used to estimate potential acute and chronic aquatic life impacts, respectively, as recommended in the *Technical Support Document for Water Quality-based Toxics Control* (U.S. EPA, 1991a). The harmonic mean flow is defined as the inverse mean of reciprocal daily arithmetic mean flow values and is used to estimate potential human health impacts. EPA recommends the long-term harmonic mean flow as the design flow for assessing potential human health impacts, because it provides a more conservative estimate than the arithmetic mean flow. 7Q10 flows are not appropriate for assessing potential human health impacts, because they have no consistent relationship with the long-term mean dilution.

For assessing impacts on aquatic life, the facility operating days are used to represent the exposure duration; the calculated instream concentration is thus the average concentration *on days the facility is discharging wastewater.* For assuming long-term human health impacts, the operating days (exposure duration) are set at 365 days; the calculated instream concentration is thus the average concentration *on all days of the year.* Although this calculation for human health impacts leads to a lower calculated concentration because of the additional dilution from days when the facility is not in operation, it is consistent with the conservative assumption that the target population is present to consume drinking water and contaminated fish every day for an entire lifetime.

Because stream flows are not available for hydrologically complex waters such as bays, estuaries, and oceans, site-specific critical dilution factors (CDFs) or estuarine dissolved concentration potentials (DCPs) are used to predict pollutant concentrations for facilities discharging to estuaries and bays, if applicable, as follows:

$$C_{es} = \left[\left(\frac{L/OD}{FF} \right) x\ CF \right] / \ CDF \qquad \text{(Eq. 2)}$$

where:

C_{es}	=	estuary pollutant concentration (μg/L)
L	=	facility pollutant loading (lbs/year)
OD	=	facility operation (days/year)
FF	=	facility flow (million gal/day)

CDF	=	critical dilution factor
CF	=	conversion factors for units

$$C_{es} = L \; x \; DCP \; x \; CF \qquad \text{(Eq. 3)}$$

where:

C_{es}	=	estuary pollutant concentration (μg/L)
L	=	facility pollutant loading (lbs/year)
DCP	=	dissolved concentration potential (milligrams per liter [mg/L])
CF	=	conversion factor for units

Site-specific critical dilution factors are obtained from a survey of States and Regions conducted by EPA's Office of Pollution Prevention and Toxics (OPPT) *Mixing Zone Dilution Factors for New Chemical Exposure Assessments*, Draft Report, (U.S. EPA, 1992a). Acute CDFs are used to evaluate acute aquatic life effects; whereas, chronic CDFs are used to evaluate chronic aquatic life or adverse human health effects. It is assumed that the drinking water intake and fishing location are at the edge of the chronic mixing zone.

The Strategic Assessment Branch of the National Oceanic and Atmospheric Administration's (NOAA) Ocean Assessments Division has developed DCPs based on freshwater inflow and salinity gradients to predict pollutant concentrations in each estuary in the National Estuarine Inventory (NEI) Data Atlas. These DCPs are applied to predict concentrations. They also do not consider pollutant fate and are designed strictly to simulate concentrations of nonreactive dissolved substances. In addition, the DCPs reflect the predicted estuary-wide response and may not be indicative of site-specific locations.

Water quality excursions are determined by dividing the projected instream (Eq. 1) or estuary (Eq. 2 and Eq. 3) pollutant concentrations by EPA ambient water quality criteria or toxic effect levels. A value greater than 1.0 indicates an excursion.

2.1.1.2 *Indirect Discharging Facilities*

Assessing the impacts of indirect discharging facilities is a two-stage process. First, water quality impacts are evaluated as described in Section (a) below. Next, impacts on POTWs are considered as described in Section (b) that follows.

(a) Water Quality Impacts

A stream dilution model is used to project receiving stream impacts resulting from releases by indirect discharging facilities as shown in Eq. 4. For stream segments with multiple IWC facilities, pollutant loadings are summed, if applicable, before concentrations are calculated. The facility-specific data used in Eq. 4 are derived from various sources as described in Section 3.1.1 of this report. Three receiving stream flow conditions (1Q10 low flow, 7Q10 low flow, and harmonic mean flow) are used for the current and proposed pretreatment options. Pollutant concentrations are predicted for POTWs located on bays and estuaries using site-specific CDFs or NOAA's DCP calculations (Eq. 5 and Eq. 6).

$$C_{is} = (L/OD)\ x\ \frac{(1-TMT)\ x\ CF}{PF + SF} \qquad \text{(Eq. 4)}$$

where:

C_{is}	=	instream pollutant concentration (μg/L)
L	=	facility pollutant loading (lbs/year)
OD	=	facility operation (days/year)
TMT	=	POTW treatment removal efficiency
PF	=	POTW flow (million gal/day)
SF	=	receiving stream flow (million gal/day)
CF	=	conversion factors for units

$$C_{es} = \left[\left(\frac{L/OD \ x \ (1-TMT)}{PF} \right) x \ CF \right] / \ CDF \qquad \text{(Eq. 5)}$$

where:

C_{es}	=	estuary pollutant concentration (μg/L)
L	=	facility pollutant loading (lbs/year)
OD	=	facility operation (days/year)
TMT	=	POTW treatment removal efficiency
PF	=	POTW flow (million gal/day)
CDF	=	critical dilution factor
CF	=	conversion factors for units

$$C_{es} = L \ x \ (1-TMT) \ x \ DCP \ x \ CF \qquad \text{(Eq. 6)}$$

where:

C_{es}	=	estuary pollutant concentration (μg/L)
L	=	facility pollutant loading (lbs/year)
TMT	=	POTW treatment removal efficiency
DCP	=	dissolved concentration potential (mg/L)
CF	=	conversion factors for units

Potential impacts on freshwater quality are determined by comparing projected instream pollutant concentrations (Eq. 4) at reported POTW flows and at 1Q10 low, 7Q10 low, and harmonic mean receiving stream flows with EPA water quality criteria or toxic effect levels for the protection of aquatic life and human health; projected estuary pollutant concentrations (Eq. 5 and Eq. 6), based on CDFs or DCPs, are compared to EPA water quality criteria or toxic effect levels to determine impacts. Water quality criteria excursions are determined by dividing the projected instream or estuary pollutant concentration by the EPA water quality criteria or toxic effect levels. (See Section 2.1.1.1 for discussion of streamflow conditions, application of CDFs or DCPs, assignment of exposure duration, and comparison with criteria or toxic effect levels.) A value greater than 1.0 indicates an excursion.

(b) Impacts on POTWs

Impacts on POTW operations are calculated in terms of inhibition of POTW processes (i.e., inhibition of microbial degradation) and contamination of POTW sludges, defined as a sewage sludge concentration that exceeds the levels at which sewage sludge may be land applied or surface disposed under 40 CFR Part 503. Inhibition of POTW operations is determined by dividing calculated POTW influent levels (Eq. 7) with chemical-specific inhibition threshold levels. Excursions are indicated by a value greater than 1.0.

$$C_{pi} = \frac{L/OD}{PF} \times CF \qquad \text{(Eq. 7)}$$

where:

C_{pi}	=	POTW influent concentration (μg/L)
L	=	facility pollutant loading (lbs/year)
OD	=	facility operation (days)
PF	=	POTW flow (million gal/day)
CF	=	conversion factors for units

Contamination of sludge (thereby limiting its use for land application, etc.) is evaluated by dividing projected pollutant concentrations in sludge (Eq. 8) by available EPA-developed criteria values for sludge. A value greater than 1.0 indicates an excursion.

$$C_{SP} = C_{pi} \times TMT \times PART \times SGF \qquad \text{(Eq. 8)}$$

where:

C_{sp}	=	sludge pollutant concentration (milligrams per kilogram [mg/kg])
C_{pi}	=	POTW influent concentration (μg/L)
TMT	=	POTW treatment removal efficiency
PART	=	chemical-specific sludge partition factor
SGF	=	sludge generation factor (5.96 parts per million [ppm])

Facility-specific data and information used to evaluate POTWs are derived from the sources described in Sections 3.1.1 and 3.1.2. For facilities that discharge to the same POTW, their individual loadings are summed, if applicable, before the POTW influent and sludge concentrations are calculated.

The partition factor is a measure of the tendency for the pollutant to partition in sludge when it is removed from wastewater. For predicting sludge generation, the model assumes that 1,400 pounds of sludge are generated for each million gallons of wastewater processed (Metcalf & Eddy, 1972). This results in a sludge generation factor of 5.96 mg/kg per μg/L (that is, for every 1 μg/L of pollutant removed from wastewater and partitioned to sludge, the concentration in sludge is 5.96 mg/kg dry weight).

2.1.1.3 ***Assumptions and Caveats***

The following major assumptions are used in this analysis:

- Background concentrations of each pollutant, both in the receiving stream and in the POTW influent, are equal to zero; therefore, only the impacts of discharging facilities are evaluated.
- Facilities are assumed to operate 365 days per year.
- An exposure duration of 365 days is used to determine the likelihood of actual excursions of human health criteria or toxic effect levels.
- Complete mixing of discharge flow and stream flow occurs across the stream at the discharge point. This mixing results in the calculation of an

"average stream" concentration, even though the actual concentration may vary across the width and depth of the stream.

- The process water at each facility and the water discharged to a POTW are obtained from a source other than the receiving stream.

- The pollutant load to the receiving stream is assumed to be continuous and is assumed to be representative of long-term facility operations. These assumptions may overestimate risks to human health and aquatic life, but may underestimate potential short-term effects.

- 1Q10 and 7Q10 receiving stream flow rates are used to estimate aquatic life impacts, and harmonic mean flow rates are used to estimate human health impacts. 1Q10 low flows are estimated using the results of a regression analysis conducted by Versar, Inc. for EPA's Office of Pollution Prevention and Toxics (OPPT) of 1Q10 and 7Q10 flows from representative U.S. rivers and streams taken from *Upgrade of Flow Statistics Used to Estimate Surface Water Chemical Concentrations for Aquatic and Human Exposure Assessment* (Versar, 1992). Harmonic mean flows are estimated from the mean and 7Q10 flows as recommended in the *Technical Support Document for Water-Quality-based Toxics Control* (U.S. EPA, 1991a). These flows may not be the same as those used by specific States to assess impacts.

- Pollutant fate processes, such as sediment adsorption, volatilization, and hydrolysis, are not considered. This may result in estimated instream concentrations that are environmentally conservative (higher).

- Pollutants without a specific POTW treatment removal efficiency provided by EPA or found in the literature are assigned a removal efficiency of zero; pollutants without a specific partition factor are assigned a value of zero.

- Sludge criteria levels are only available for seven pollutants--arsenic, cadmium, copper, lead, mercury, selenium, and zinc.

- Water quality criteria or toxic effect levels developed for freshwater organisms are used in the analysis of facilities discharging to estuaries or bays.

2.1.2 Estimation of Human Health Risks and Benefits

The potential benefits to human health are evaluated by estimating the risks (carcinogenic and noncarcinogenic hazard [systemic]) associated with reducing pollutant levels in fish tissue and drinking water from current to proposed treatment levels. Reduction in carcinogenic risks is monetized, if applicable, using estimated willingness-to-pay values for avoiding premature mortality. The following three sections (i.e., Section 2.1.2.1 through Section 2.1.2.3) describe the methodology and assumptions used to evaluate the human health risks and benefits from the consumption of fish tissue and drinking water derived from waterbodies impacted by direct and indirect discharging facilities.

2.1.2.1 *Fish Tissue*

To determine the potential benefits, in terms of reduced cancer cases, associated with reducing pollutant levels in fish tissue, lifetime average daily doses (LADDs) and individual risk levels are estimated for each pollutant discharged from a facility based on the instream pollutant concentrations calculated at current and proposed treatment levels in the site-specific stream dilution analysis. (See Section 2.1.1.) Estimates are presented for sport anglers, subsistence anglers, and the general population. LADDs are calculated as follows:

$$LADD = (C \times IR \times BCF \times F \times D) \,/\, (BW \times LT) \qquad \text{(Eq. 9)}$$

where:

LADD	=	potential lifetime average daily dose (milligrams per kilogram per day [mg/kg/day])
C	=	exposure concentration (mg/L)
IR	=	ingestion rate (See Section 2.1.2.3 - Assumptions)
BCF	=	bioconcentration factor, (liters per kilogram [L/kg] (whole body x 0.5)
F	=	frequency duration (365 days/year)

D	=	exposure duration (70 years)
BW	=	body weight (70 kg)
LT	=	lifetime (70 years x 365 days/year)

Individual risks are calculated as follows:

$$R = LADD \times SF \qquad \text{(Eq. 10)}$$

where:

R	=	individual risk level
LADD	=	potential lifetime average daily dose (mg/kg/day)
SF	=	potency slope factor $(mg/kg\text{-}day)^{-1}$

The estimated individual pollutant risk levels are then applied to the potentially exposed populations of sport anglers, subsistence anglers, and the general population to estimate the potential number of excess annual cancer cases occurring over the life of the population. The number of excess cancer cases is then summed on a pollutant, facility, and overall industry basis. The number of reduced cancer cases are assumed to be the difference between the estimated risks at current and proposed treatment levels.

A monetary value of benefits to society from avoided cancer cases is estimated if current wastewater discharges result in excess annual cancer cases greater than 0.5. The valuation of benefits is based on estimates of society's willingness-to-pay to avoid the risk of cancer-related premature mortality. Although it is not certain that all cancer cases will result in death, to develop a worst case estimate for this analysis, avoided cancer cases are valued on the basis of avoided *mortality*. To value mortality, a range of values recommended by an EPA, Office of Policy Analysis (OPA) review of studies quantifying individuals' willingness-to-pay to avoid risks to life is used (Fisher, Chestnut, and Violette, 1989; and Violette and Chestnut, 1986). The reviewed studies used hedonic wage and contingent valuation analyses in labor markets to estimate the amounts that individuals are willing to pay to avoid slight increases in risk of mortality or will need to be compensated to accept a slight increase in risk of mortality. The willingness-to-pay values estimated in these studies are associated with small changes in the probability of mortality. To estimate a willingness-to-pay for avoiding certain or high probability mortality events, they are extrapolated to the value for a 100 percent probability event.[2] The resulting estimates of the value of a "statistical life saved" are used to value regulatory effects that are expected to reduce the incidence of mortality.

From this review of willingness-to-pay studies, OPA recommends a range of \$1.6 to \$8.5 million (1986 dollars) for valuing an avoided event of premature mortality or a statistical life saved. A more recent survey of value of life studies by Viscusi (1992) also supports this range with the finding that value of life estimates are clustered in the range of \$3 to \$7 million (1990 dollars). For this analysis, the figures recommended in the OPA study are adjusted to 1992 using the relative change in the Employment Cost Index of Total Compensation for All Civilian Workers from 1986 to 1992 (29 percent). Basing the adjustment in the willingness-to-pay values on change in nominal Gross Domestic Product (GDP) instead of change in inflation, accounts for the expectation that willingness-to-pay to avoid risk is a normal economic good, and, accordingly, society's willingness-to-pay to avoid risk will increase as national income increases. Updating to 1992 yields a range of \$2.1 to \$11.0 million.

Potential reductions in risks due to reproductive, developmental, or other chronic and subchronic toxic effects are estimated by comparing the estimated lifetime average daily dose and the oral reference dose (RfD) for a given chemical pollutant as follows:

$$HQ = ORI/RfD \qquad \text{(Eq. 11)}$$

[2]These estimates, however, do not represent the willingness-to-pay to avoid the certainty of death.

where:

HQ	=	hazard quotient
ORI	=	oral intake (LADD x BW, mg/day)
RfD	=	reference dose (mg/day assuming a body weight of 70 kg)

A hazard index (i.e., sum of individual pollutant hazard quotients) is then calculated for each facility or receiving stream. A hazard index greater than 1.0 indicates that toxic effects may occur in exposed populations. The size of the subpopulations affected are summed and compared at the various treatment levels to assess benefits in terms of reduced systemic toxicity. While a monetary value of benefits to society associated with a reduction in the number of individuals exposed to pollutant levels likely to result in systemic health effects could not be estimated, any reduction in risk is expected to yield human health related benefits.

2.1.2.2 *Drinking Water*

Potential benefits associated with reducing pollutant levels in drinking water are determined in a similar manner. LADDs for drinking water consumption are calculated as follows:

$$LADD = (C \times IR \times F \times D) \, / \, (BW \times LT) \qquad \text{(Eq. 12)}$$

where:

LADD	=	potential lifetime average daily dose (mg/kg/day)
C	=	exposure concentration (mg/L)
IR	=	ingestion rate (2L/day)
F	=	frequency duration (365 days/year)
D	=	exposure duration (70 years)
BW	=	body weight (70 kg)
LT	=	lifetime (70 years x 365 days/year)

Estimated individual pollutant risk levels greater than 10^{-6} (1E-6) are applied to the population served downstream by any drinking water utilities within 50 miles from each discharge site to determine the number of excess annual cancer cases that may occur during the life of the population. Systemic toxicant effects are evaluated by estimating the sizes of populations exposed to pollutants from a given facility, the sum of whose individual hazard quotients yields a hazard index (HI) greater than 1.0. A monetary value of benefits to society from avoided cancer cases is estimated, if applicable, as described in Section 2.1.2.1.

2.1.2.3 *Assumptions and Caveats*

The following assumptions are used in the human health risks and benefits analyses:

- A linear relationship is assumed between pollutant loading reductions and benefits attributed to the cleanup of surface waters.

- Synergistic effects of multiple chemicals on aquatic ecosystems are not assessed; therefore, the total benefit of reducing toxics may be underestimated.

- The total number of persons who might consume recreationally caught fish and the number who rely upon fish on a subsistence basis in each State is estimated, in part, by assuming that these anglers regularly share their catch with family members. Therefore, the number of anglers in each State is multiplied by the average household size in each State. The remainder of the population of these States is assumed to be the "general population" consuming commercially caught fish.

- Five percent of the resident anglers in a given State are assumed to be subsistence anglers; the other 95 percent are assumed to be sport anglers.

- Commercially or recreationally valuable species are assumed to occur or to be taken in the vicinity of the discharges included in the evaluation.

- Ingestion rates of 6.5 grams per day for the general population, 30 grams per day (30 years) + 6.5 grams per day (40 years) for sport anglers, and 140 grams per day for subsistence anglers are used in the analysis of fish tissue (*Exposure Factors Handbook*, U.S. EPA, 1989a)

- All rivers or estuaries within a State are equally fished by any of that State's resident anglers, and the fish are consumed only by the population within that State.

- Populations potentially exposed to discharges to rivers or estuaries that border more than one State are estimated based only on populations within the State in which the facility is located.

- The size of the population potentially exposed to fish caught in an impacted water body in a given State is estimated based on the ratio of impacted river miles to total river miles in that State or impacted estuary square miles to total estuary square miles in that State. The number of miles potentially impacted by a facility's discharge is assumed to be 50 miles for rivers and the total surface area of the various estuarine zones for estuaries.

- Pollutant fate processes (e.g., sediment adsorption, volatilization, hydrolysis) are not considered in estimating the concentration in drinking water or fish; consequently, estimated concentrations are environmentally conservative (higher).

2.1.3 Estimation of Ecological Benefits

The potential ecological benefits of the proposed regulation are evaluated by estimating improvements in the recreational fishing habitats that are impacted by IWC wastewater discharges. Stream segments are first identified for which the proposed regulation is expected to eliminate all occurrences of pollutant concentrations in excess of both aquatic life and human health ambient water quality criteria (AWQC) or toxic effect levels. (See Section 2.1.1.) The elimination of pollutant concentrations in excess of AWQC is expected to result in significant improvements in aquatic habitats. These improvements in aquatic habitats are then expected to improve the quality and value of recreational fishing opportunities. The estimation of the monetary value to society of improved recreational fishing opportunities is based on the concept of a "contaminant-free fishery" as presented by Lyke (1993).

Research by Lyke (1993) shows that anglers may place a significantly higher value on a contaminant-free fishery than a fishery with some level of contamination. Specifically, Lyke estimates the consumer surplus[3] associated with Wisconsin's recreational Lake Michigan trout and salmon fishery, and the additional value of the fishery if it was completely free of contaminants affecting aquatic life and human health. Lyke's results are based on two analyses:

1. A multiple site, trip generation, travel cost model was used to estimate net benefits associated with the fishery under baseline (i.e., contaminated) conditions.

2. A contingent valuation model was used to estimate willingness-to-pay values for the fishery if it was free of contaminants.

Both analyses used data collected from licensed anglers before the 1990 season. The estimated incremental benefit values associated with freeing the fishery of contaminants range from 11.1 percent to 31.3 percent of the value of the fishery under current conditions.

To estimate the gain in value of stream segments identified as showing improvements in aquatic habitats as a result of the proposed regulation, the baseline recreational fishery value of the stream segments are estimated on the basis of estimated annual person-days of fishing per segment and estimated values per person-day of fishing. Annual person-days of fishing per segment are calculated using estimates of the affected (exposed) recreational fishing populations. (See Section 2.1.2.) The number of anglers are multiplied by estimates of the average number of fishing days per angler in each State to estimate the total number of fishing days for each segment. The baseline value for each fishery is then calculated by multiplying the estimated total number of fishing days by an estimate of the net benefit that anglers receive from a day of fishing where net benefit represents the total value of the fishing day exclusive of any fishing-related costs (license fee, travel costs, bait, etc.) incurred by the angler. In this analysis, a range of median

[3]Consumer surplus is generally recognized as the best measure from a theoretical basis for valuing the net economic welfare or benefit to consumers from consuming a particular good or service. An increase or decrease in consumer surplus for particular goods or services as the result of regulation is a primary measure of the gain or loss in consumer welfare resulting from the regulation.

net benefit values for warm water and cold water fishing days, $27.75 and $35.14, respectively, in 1992 dollars is used. Summing over all benefiting stream segments provides a total baseline recreational fishing value of incinerator stream segments that are expected to benefit by elimination of pollutant concentrations in excess of AWQC.

To estimate the increase in value resulting from elimination of pollutant concentrations in excess of AWQC, the baseline value for benefiting stream segments are multiplied by the incremental gain in value associated with achievement of the "contaminant-free" condition. As noted above, Lyke's estimate of the increase in value ranged from 11.1 percent to 31.3 percent. Multiplying by these values yields a range of expected increase in value for the IWC stream segments expected to benefit by elimination of pollutant concentrations in excess of AWQC.

2.1.3.1 *Assumptions and Caveats*

The following major assumptions are used in the ecological benefits analysis:

- Background concentrations of the IWC pollutants of concern in the receiving stream are not considered.

- The estimated benefit of improved recreational fishing opportunities is only a limited measure of the value to society of the improvements in aquatic habitats expected to result from the proposed regulation; increased assimilation capacity of the receiving stream, improvements in taste and odor, or improvements to other recreational activities, such as swimming and wildlife observation, are not addressed.

- Significant simplifications and uncertainties are included in the assessment. This may overestimate or underestimate the monetary value to society of improved recreational fishing opportunities. (See Sections 2.1.1.3 and 2.1.2.3.)

- Potential overlap in valuation of improved recreational fishing opportunities and avoided cancer cases from fish consumption may exist. This potential is considered to be minor in terms of numerical significance.

2.1.4 Estimation of Economic Productivity Benefits

Potential economic productivity benefits are estimated based on reduced sewage sludge contamination due to the proposed regulation. The treatment of wastewaters generated by IWC facilities produces a sludge that contains pollutants removed from the wastewaters. As required by law, POTWs must use environmentally sound practices in managing and disposing of this sludge. The proposed pretreatment levels are expected to generate sewage sludges with reduced pollutant concentrations. As a result, the POTWs may be able to use or dispose of the sewage sludges with reduced pollutant concentrations at lower costs.

To determine the potential benefits, in terms of reduced sewage sludge disposal costs, sewage sludge pollutant concentrations are calculated at current and proposed pretreatment levels. (See Section 2.1.1.2.) Pollutant concentrations are then compared to sewage sludge pollutant limits for surface disposal and land application (minimum ceiling limits and pollutant concentration limits). If, as a result of the proposed pretreatment, a POTW meets all pollutant limits for a sewage sludge use or disposal practice, that POTW is assumed to benefit from the increase in sewage sludge use or disposal options. The amount of the benefit deriving from changes in sewage sludge use or disposal practices depends on the sewage sludge use or disposal practices employed under current levels. This analysis assumes that POTWs choose the least expensive sewage sludge use or disposal practice for which their sewage sludge meets pollutant limits. POTWs with sewage sludge that qualifies for land application in the baseline are assumed to dispose of their sewage sludge by land application; likewise, POTWs with sewage sludge that meets surface disposal limits (but not land application ceiling or pollutant limits) are assumed to dispose of their sewage sludge at surface disposal sites.

The economic benefit for POTWs receiving wastewater from an incinerator facility is calculated by multiplying the cost differential between baseline and post-compliance sludge use or disposal practices by the quantity of sewage sludge that shifts into meeting land application (minimum ceiling limits and pollutant concentration limits) or surface disposal limits. Using these cost differentials, reductions in sewage sludge use or disposal costs are calculated for each POTW (Eq. 13):

$$SCR = PF \times S \times CD \times PD \times CF \qquad \text{(Eq. 13)}$$

where:

SCR	=	estimated POTW sewage sludge use or disposal cost reductions resulting from the proposed regulation (1992 dollars)
PF	=	POTW flow (million gal/year)
S	=	sewage sludge to wastewater ratio (1,400 lbs (dry weight) per million gallons of water)
CD	=	estimated cost differential between least costly composite baseline use or disposal method for which POTW qualifies and least costly use or disposal method for which POTW qualifies post-compliance ($1992/dry metric ton)
PD	=	percent of sewage sludge disposed
CF	=	conversion factor for units

2.1.4.1 *Assumptions and Caveats*

The following major assumptions are used in the economic productivity benefits analysis:

- 13.4 percent of the POTW sewage sludge generated in the United States is generated at POTWs that are located too far from agricultural land and surface disposal sites for these use or disposal practices to be economical. This percentage of sewage sludge is not associated with benefits from shifts to surface disposal or land application.

- Benefits expected from reduced record-keeping requirements and exemption from certain sewage sludge management practices are not estimated.

- No definitive source of cost-saving differential exists. Analysis may overestimate or underestimate the cost differentials.

- Sewage sludge use or disposal costs vary by POTW. Actual costs incurred by POTWs affected by the IWC regulation may differ from those estimates.
- Due to the unavailability of such data, baseline pollutant loadings from all industrial sources are not included in the analysis.

2.2 Pollutant Fate and Toxicity

Human and ecological exposure and risk from environmental releases of toxic chemicals depend largely on toxic potency, inter-media partitioning, and chemical persistence. These factors are dependant on chemical-specific properties relating to toxicological effects on living organisms, physical state, hydrophobicity/lipophilicity, and reactivity, as well as the mechanism and media of release and site-specific environmental conditions.

The methodology used in assessing the fate and toxicity of pollutants associated with IWC wastewaters is comprised of three steps: (1) identification of pollutants of concern; (2) compilation of physical-chemical and toxicity data; and (3) categorization assessment. These steps are described in detail below. A summary of the major assumptions and limitations associated with this methodology is also presented.

2.2.1 Pollutants of Concern Identification

From 1993 through 1995, EPA conducted three sampling episodes to determine the presence or absence of priority, conventional, and nonconventional pollutants at IWCs located nationwide. EPA visited 14 IWCs and collected grab samples of untreated IWC scrubber blowdown water from 12 of the 14 IWCs. EPA also collected samples of wastewater, including influent and effluent streams at 3 of the 14 IWCs. Most of these samples were analyzed for over 450 analytes to identify pollutants at these facilities. Using these data, EPA applied two criteria to identify pollutants of concern. These criteria required concentration levels of 10 times the minimum level, and concentrations at this level in at least three samples. EPA detected 21 pollutants (10 priority pollutants, 4 conventional/classical pollutant parameters, and 7 nonconventional pollutants) in waste streams that met the selection criteria. Seventeen (17) of these pollutants (all metals) are evaluated, including all of the priority and nonconventional pollutants, to assess their potential fate and toxicity based on known characteristics of each chemical.

2.2.2 Compilation of Physical-Chemical and Toxicity Data

The chemical specific data needed to conduct the fate and toxicity evaluation for this study include aquatic life criteria or toxic effect data for native aquatic species, human health reference doses (RfDs) and cancer potency slope factors (SFs), EPA maximum contaminant levels (MCLs) for drinking water protection, Henry's Law constants, soil/sediment adsorption coefficients (K_{oc}), and bioconcentration factors (BCFs) for native aquatic species.

Sources of the above data include EPA ambient water quality criteria documents and updates, EPA's ASsessment Tools for the Evaluation of Risk (ASTER) and the associated AQUatic Information REtrieval System (AQUIRE) and Environmental Research Laboratory-Duluth fathead minnow data base, EPA's Integrated Risk Information System (IRIS), EPA's 1993-1995 Health Effects Assessment Summary Tables (HEAST), EPA's 1991-1996 Superfund Chemical Data Matrix (SCDM), EPA's 1989 Toxic Chemical Release Inventory Screening Guide, Syracuse Research Corporation's CHEMFATE data base, EPA and other government reports, scientific literature, and other primary and secondary data sources. To ensure that the examination is as comprehensive as possible, alternative measures are taken to compile data for chemicals for which physical-chemical property and/or toxicity data are not presented in the sources listed above. To the extent possible, values are estimated for the chemicals using the quantitative structure-activity relationship (QSAR) model incorporated in ASTER, or for some physical-chemical properties, utilizing published linear regression correlation equations.

(a) Aquatic Life Data

Ambient criteria or toxic effect concentration levels for the protection of aquatic life are obtained primarily from EPA ambient water quality criteria documents and EPA's ASTER. For several pollutants, EPA has published ambient water quality criteria for the protection of freshwater aquatic life from acute effects. The acute value represents a maximum allowable 1-hour average concentration of a pollutant at any time that protects aquatic life from lethality. For pollutants for which no acute water quality criteria have been developed by EPA, an acute value from published aquatic toxicity test data or an estimated acute value from the ASTER QSAR model is used. In selecting values from the literature, measured concentrations from flow-through studies under typical pH and temperature conditions are preferred. In addition, the test organism must be a North American resident species of fish or invertebrate. The hierarchy used to select the appropriate acute value is listed below in descending order of priority.

- National acute freshwater quality criteria;
- Lowest reported acute test values (96-hour LC_{50} for fish and 48-hour EC_{50}/LC_{50} for daphnids);
- Lowest reported LC_{50} test value of shorter duration, adjusted to estimate a 96-hour exposure period;
- Lowest reported LC_{50} test value of longer duration, up to a maximum of 2 weeks exposure; and
- Estimated 96-hour LC_{50} from the ASTER QSAR model.

BCF data are available from numerous data sources, including EPA ambient water quality criteria documents and EPA's ASTER. Because measured BCF values are not available for several chemicals, methods are used to estimate this parameter based on the octanol/water partition coefficient or solubility of the chemical. Such methods are detailed in Lyman et al. (1982).

Multiple values are reviewed, and a representative value is selected according to the following guidelines:

- Resident U.S. fish species are preferred over invertebrates or estimated values.
- Edible tissue or whole fish values are preferred over nonedible or viscera values.
- Estimates derived from octanol/water partition coefficients are preferred over estimates based on solubility or other estimates, unless the estimate comes from EPA Criteria Documents.

The most conservative value (i.e., the highest BCF) is selected among comparable candidate values.

(b) Human Health Data

Human health toxicity data include chemical-specific RfD for noncarcinogenic effects and potency SF for carcinogenic effects. RfDs and SFs are obtained first from EPA's IRIS, and secondarily from EPA's HEAST. The RfD is an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious noncarcinogenic health effects over a lifetime (U.S. EPA, 1989b). A chemical with a low RfD is more toxic than a chemical with a high RfD. Noncarcinogenic effects include systemic effects (e.g., reproductive, immunological, neurological, circulatory, or respiratory toxicity), organ-specific toxicity, developmental toxicity, mutagenesis, and lethality. EPA recommends a threshold level assessment approach for these systemic and other effects, because several protective mechanisms must be overcome prior to the appearance of an adverse noncarcinogenic effect. In contrast, EPA assumes that cancer growth can be initiated from a single cellular event and, therefore, should not be subject to a threshold level assessment approach. The SF is an upper bound estimate of the probability of cancer per unit intake of a chemical over a lifetime (U.S. EPA, 1989b). A chemical with a large SF has greater potential to cause cancer than a chemical with a small SF.

Other chemical designations related to potential adverse human health effects include EPA assignment of a concentration limit for protection of drinking water, and EPA designation as a priority pollutant. EPA establishes drinking water criteria and standards, such as the MCL, under authority of the Safe Drinking Water Act (SDWA). Current MCLs are available from IRIS. EPA has designated 126 chemicals and compounds as priority pollutants under the authority of the Clean Water Act (CWA).

(c) Physical-Chemical Property Data

Two measures of physical-chemical properties are used to evaluate environmental fate: Henry's Law constant (HLC) and organic carbon-water partition coefficient (K_{oc}).

HLC is the ratio of vapor pressure to solubility and is indicative of the propensity of a chemical to volatilize from surface water (Lyman et al., 1982). The larger the HLC, the more likely the chemical will volatilize. Most HLCs are obtained from EPA's Office of Toxic Substances' (OTS) 1989 Toxic Chemical Release Inventory Screening Guide (U.S. EPA, 1989c), the Office of Solid Waste's (OSW) Superfund Chemical Data Matrix (U.S. EPA, 1994a), or the quantitative structure activity relationship (QSAR) system (U.S. EPA, 1993), maintained by EPA's Environmental Research Laboratory (ERL) in Duluth, Minnesota.

K_{oc} is indicative of the propensity of an organic compound to adsorb to soil or sediment particles and, therefore, partition to such media. The larger the K_{oc}, the more likely the chemical will adsorb to solid material. Most K_{oc}s are obtained from Syracuse Research Corporation's CHEMFATE data base and EPA's 1989 Toxic Chemical Release Inventory Screening Guide.

2.2.3 Categorization Assessment

The objective of this generalized evaluation of fate and toxicity potential is to place chemicals into groups with qualitative descriptors of potential environmental behavior and impact. These groups are based on categorization schemes derived for:

- Acute aquatic toxicity (high, moderate, or slightly toxic);
- Volatility from water (high, moderate, slight, or nonvolatile);
- Adsorption to soil/sediment (high, moderate, slight, or nonadsorptive); and
- Bioaccumulation potential (high, moderate, slight, or nonbioaccumulative).

Using appropriate key parameters, and where sufficient data exist, these categorization schemes identify the relative aquatic and human toxicity and bioaccumulation potential for each chemical associated with IWC wastewater. In addition, the potential to partition to various media (air, sediment/sludge, or water) and to persist in the environment is identified for each chemical. These schemes are intended for screening purposes only and do not take the place of detailed pollutant assessments analyzing all fate and transport mechanisms.

This evaluation also identifies chemicals which: (1) are known, probable, or possible human carcinogens; (2) are systemic human health toxicants; (3) have EPA human health drinking water standards; and (4) are designated as priority pollutants by EPA. The results of this analysis can provide a qualitative indication of potential risk posed by the release of these chemicals. Actual risk depends on the magnitude, frequency, and duration of pollutant loading; site-specific environmental conditions; proximity and number of human and ecological receptors; and relevant exposure pathways. The following discussion outlines the categorization schemes. Ranges of parameter values defining the categories are also presented.

(a) Acute Aquatic Toxicity

Key Parameter: Acute aquatic life criteria/LC_{50} or other benchmark (AT) (μg/L)

Using acute criteria or lowest reported acute test results (generally 96-hour and 48-hour durations for fish and invertebrates, respectively), chemicals are grouped according to their relative short-term effects on aquatic life.

Categorization Scheme:

$AT < 100$	Highly toxic
$1{,}000 \geq AT \geq 100$	Moderately toxic
$AT > 1{,}000$	Slightly toxic

This scheme, used as a rule-of-thumb guidance by EPA's OPPT for Premanufacture Notice (PMN) evaluations, is used to indicate chemicals that could potentially cause lethality to aquatic life downstream of discharges.

(b) Volatility from Water

Key Parameter: Henry's Law constant (HLC) (atm-m^3/mol)

$$HLC = \frac{\text{Vapor Pressure (atm)}}{\text{Solubility (mol/m}^3\text{)}} \qquad \text{(Eq. 14)}$$

HLC is the measured or calculated ratio between vapor pressure and solubility at ambient conditions. This parameter is used to indicate the potential for organic substances to partition to air in a two-phase (air and water) system. A chemical's potential to volatilize from surface water can be inferred from HLC.

Categorization Scheme:

HLC $> 10^{-3}$	Highly volatile
$10^{-3} \geq$ HLC $\geq 10^{-5}$	Moderately volatile
$10^{-5} >$ HLC $\geq 3 \times 10^{-7}$	Slightly volatile
HLC $< 3 \times 10^{-7}$	Essentially nonvolatile

This scheme, adopted from Lyman et al. (1982), gives an indication of chemical potential to volatilize from process wastewater and surface water, thereby reducing the threat to aquatic life and human health via contaminated fish consumption and drinking water, yet potentially causing risk to exposed populations via inhalation.

(c) Adsorption to Soil/Sediments

Key Parameter: Soil/sediment adsorption coefficient (K_{oc})

K_{oc} is a chemical-specific adsorption parameter for organic substances that is largely independent of the properties of soil or sediment and can be used as a relative indicator of adsorption to such media. K_{oc} is highly inversely correlated with solubility, well correlated with octanol-water partition coefficient, and fairly well correlated with BCF.

Categorization Scheme:

$K_{oc} > 10,000$	Highly adsorptive
$10,000 \geq K_{oc} \geq 1,000$	Moderately adsorptive
$1,000 > K_{oc} \geq 10$	Slightly adsorptive
$K_{oc} < 10$	Essentially nonadsorptive

This scheme is devised to evaluate substances that may partition to solids and potentially contaminate sediment underlying surface water or land receiving sewage sludge applications. Although a high K_{oc} value indicates that a chemical is more likely to partition to sediment, it also indicates that a chemical may be less bioavailable.

(d) Bioaccumulation Potential

Key Parameter: Bioconcentration Factor (BCF)

$$BCF = \frac{\text{Equilibrium chemical concentration in organism (wet weight)}}{\text{Mean chemical concentration in water}} \quad \text{(Eq. 15)}$$

BCF is a good indicator of potential to accumulate in aquatic biota through uptake across an external surface membrane.

Categorization Scheme:

$BCF > 500$	High potential
$500 \geq BCF \geq 50$	Moderate potential
$50 > BCF \geq 5$	Slight potential
$BCF < 5$	Nonbioaccumulative

This scheme is used to identify chemicals that may be present in fish or shellfish tissues at higher levels than in surrounding water. These chemicals may accumulate in the food chain and increase exposure to higher trophic level populations, including people consuming their sport catch or commercial seafood.

2.2.4 Assumptions and Limitations

The major assumptions and limitations associated with the data compilation and categorization schemes are summarized in the following two sections.

(a) Data Compilation

- If data are readily available from electronic data bases, other primary and secondary sources are not searched.
- Much of the data are estimated and, therefore, can have a high degree of associated uncertainty.
- For some chemicals, neither measured nor estimated data are available for key categorization parameters. In addition, chemicals identified for this study do not represent a complete set of wastewater constituents. As a result, this study does not completely assess IWC wastewater.

(b) Categorization Schemes

- Receiving waterbody characteristics, pollutant loading amounts, exposed populations, and potential exposure routes are not considered.
- Placement into groups is based on arbitrary order of magnitude data breaks for several categorization schemes. Combined with data uncertainty, this may lead to an overstatement or understatement of the characteristics of a chemical.
- Data derived from laboratory tests may not accurately reflect conditions in the field.

- Available aquatic toxicity and bioconcentration test data may not represent the most sensitive species.

2.3 Documented Environmental Impacts

State environmental agencies are contacted, and State 304(l) Short Lists, State Fishing Advisories, and published literature are reviewed for evidence of documented environmental impacts on aquatic life, human health, POTW operations, and the quality of receiving water due to discharges of pollutants from IWCs. Reported impacts are compiled and summarized by study site and facility.

3. DATA SOURCES

3.1 Water Quality Impacts

Readily available EPA and other agency data bases, models, and reports are used in the evaluation of water quality impacts. The following six sections describe the various data sources used in the analysis.

3.1.1 Facility-Specific Data

EPA's Engineering and Analysis Division (EAD) provided projected IWC facility effluent process flows, facility operating days, and pollutant loadings (Appendix A) in May 1997 (U.S. EPA, 1997). For each option, the long-term averages (LTAs) were calculated for each pollutant of concern based on sampling data. Facilities reported in the 1994 Waste Treatment Industry Phase II: Incinerator Questionnaire the annual quantity discharged to surface water and POTWs (U.S. EPA, 1994b). The annual quantity discharged (facility flow) was multiplied by the LTA for each pollutant and converted to the proper units to calculate the loading (in pounds per year) for each pollutant.

The locations of IWC facilities on receiving streams are identified using the U.S. Geological Survey (USGS) cataloging and stream segment (reach) numbers contained in EPA's Industrial Facilities Discharge (IFD) data base (U.S. EPA, 1994-1996a). Latitude/longitude coordinates, if available, are used to locate those facilities and POTWs that have not been assigned a reach number in IFD. The names, locations, and the flow data for the POTWs to which the indirect facilities discharge are obtained from the 1994 Waste Treatment Industry Phase II: Incinerator Questionnaire (U.S. EPA, 1994b), EPA's 1992 NEEDS Survey (U.S. EPA, 1992b), IFD, and EPA's Permit Compliance System (PCS) (U.S. EPA, 1993-1996). If these sources did not yield information for a facility, alternative measures are taken to obtain a complete set of receiving streams and POTWs.

The receiving stream flow data are obtained from either the W.E. Gates study data or from measured streamflow data, both of which are contained in EPA's GAGE file (U.S. EPA, 1994-1996b). The W.E. Gates study contains calculated average and low flow statistics based on the best available flow data and on drainage areas for reaches throughout the United States. The GAGE file also includes average and low flow statistics based on measured data from USGS gaging stations. "Dissolved Concentration Potentials (DCPs)" for estuaries and bays are obtained from the Strategic Assessment Branch of NOAA's Ocean Assessments Division (NOAA/U.S. EPA, 1989-1991) (Appendix B). Critical Dilution Factors are obtained from the *Mixing Zone Dilution Factors for New Chemical Exposure Assessments* (U.S. EPA, 1992a).

3.1.2 Information Used to Evaluate POTW Operations

POTW treatment efficiency removal rates are obtained from a study of 50 well-operated POTWs, referred to as the "50 POTW Study," September 1982 (U.S. EPA, 1982) (Appendix C). Due to the large number of pollutants applicable for this industry, additional data from the Risk Reduction Engineering Laboratory (RREL) data base (now renamed the National Risk Management Research Laboratory data base) were used to augment the POTW data base for the pollutants for which the 50 POTW Study did not cover (U.S. EPA, 1995a). When data are not available, the removal rate is based on the removal rate of a similar pollutant.

Inhibition values are obtained from *Guidance Manual for Preventing Interference at POTWs* (U.S. EPA, 1987) and from *CERCLA Site Discharges to POTWs: Guidance Manual* (U.S. EPA, 1990a). The most conservative values for activated sludge are used. For pollutants with no specific inhibition value, a value based on compound type (e.g., aromatics) is used (Appendix C).

Sewage sludge regulatory levels, if available for the pollutants of concern, are obtained from the Federal Register 40 CFR Part 503, Standards for the Use or Disposal of Sewage Sludge, Final Rule (October 25, 1995) (U.S. EPA, 1995b). Pollutant limits established for the final use or disposal of sewage sludge when the sewage sludge is applied to agricultural and non-agricultural land are used (Appendix C). Sludge partition factors are obtained from the *Report to Congress on the Discharge of Hazardous Wastes to Publicly-Owned Treatment Works (Domestic Sewage Study)* (U.S. EPA, 1986) (Appendix C).

3.1.3 Water Quality Criteria (WQC)

The ambient criteria (or toxic effect levels) for the protection of aquatic life and human health are obtained from a variety of sources including EPA criteria documents, EPA's ASTER, and EPA's IRIS (Appendix C). Ecological toxicity estimations are used when published values are not available. The hierarchies used to select the appropriate aquatic life and human health values are described in the following sections.

3.1.3.1 *Aquatic Life*

Water quality criteria for many pollutants are established by EPA for the protection of freshwater aquatic life (acute and chronic criteria). The acute value represents a maximum allowable 1-hour average concentration of a pollutant at any time and can be related to acute toxic effects on aquatic life. The chronic value represents the average allowable concentration of a toxic pollutant over a 4-day period at which a diverse genera of aquatic organisms and their uses should not be unacceptably affected, provided that these levels are not exceeded more than once every 3 years.

For pollutants for which no water quality criteria are developed, specific toxicity values (acute and chronic effect concentrations reported in published literature or estimated using various application techniques) are used. In selecting values from the literature, measured concentrations from flow-through studies under typical pH and temperature conditions are preferred. The test organism must be a North American resident species of fish or invertebrate. The hierarchies used to select the appropriate acute and chronic values are listed below in descending order of priority.

Acute Aquatic Life Values:

- National acute freshwater quality criteria;
- Lowest reported acute test values (96-hour LC_{50} for fish and 48-hour EC_{50}/LC_{50} for daphnids);
- Lowest reported LC_{50} test value of shorter duration, adjusted to estimate a 96-hour exposure period;
- Lowest reported LC_{50} test value of longer duration, up to a maximum of 2 weeks exposure; and
- Estimated 96-hour LC_{50} from the ASTER QSAR model.

Chronic Aquatic Life Values:

- National chronic freshwater quality criteria;
- Lowest reported maximum allowable toxic concentration (MATC), lowest observable effect concentration (LOEC), or no observable effect concentration (NOEC);
- Lowest reported chronic growth or reproductive toxicity test concentration; and
- Estimated chronic toxicity concentration from a measured acute chronic ratio for a less sensitive species, QSAR model, or default acute:chronic ratio of 10:1.

3.1.3.2 *Human Health*

Water quality criteria for the protection of human health are established in terms of a pollutant's toxic effects, including carcinogenic potential. These human health criteria values are developed for two exposure routes: (1) ingesting the pollutant via contaminated aquatic organisms only, and (2) ingesting the pollutant via both water and contaminated aquatic organisms as follows.

For Toxicity Protection (ingestion of organisms only)

$$HH_{oo} = \frac{RfD \ x \ CF}{IR_f \ x \ BCF} \qquad \text{(Eq. 16)}$$

where:

HH_{oo}	=	human health value (μg/L)
RfD	=	reference dose for a 70-kg individual (mg/day)
IR_f	=	fish ingestion rate (0.0065 kg/day)
BCF	=	bioconcentration factor (liters/kg)
CF	=	conversion factor for units (1,000 μg/mg)

For Carcinogenic Protection (ingestion of organisms only)

$$HH_{oo} = \frac{BW \ x \ RL \ x \ CF}{SF \ x \ IR_f \ x \ BCF} \qquad \text{(Eq. 17)}$$

where:

HH_{oo}	=	human health value (μg/L)
BW	=	body weight (70 kg)
RL	=	risk level (10^{-6})
SF	=	cancer slope factor $(mg/kg/day)^{-1}$
IR_f	=	fish ingestion rate (0.0065 kg/day)
BCF	=	bioconcentration factor (liters/kg)
CF	=	conversion factor for units (1,000 μg/mg)

For Toxicity Protection (ingestion of water and organisms)

$$HH_{wo} = \frac{RfD \ x \ CF}{IR_w + (IR_f \ x \ BCF)} \qquad \text{(Eq. 18)}$$

where:

HH_{wo}	=	human health value (μg/L)
RfD	=	reference dose for a 70-kg individual (mg/day)
IR_w	=	water ingestion rate (2 liters/day)
IR_f	=	fish ingestion rate (0.0065 kg/day)
BCF	=	bioconcentration factor (liters/kg)
CF	=	conversion factor for units (1000 μg/mg)

For Carcinogenic Protection (ingestion of water and organisms)

$$HH_{wo} = \frac{BW \ x \ RL \ x \ CF}{SF \ x \ (IR_w + (IR_f \ x \ BCF))} \qquad \text{(Eq. 19)}$$

where:

HH_{wo}	=	human health value (μg/L)
BW	=	body weight (70 kg)
RL	=	risk level (10^{-6})
SF	=	cancer slope factor $(mg/kg/day)^{-1}$
IR_w	=	water ingestion rate (2 liters/day)
IR_f	=	fish ingestion rate (0.0065 kg/day)
BCF	=	bioconcentration factor (liters/kg)
CF	=	conversion factor for units (1,000 μg/mg)

The values for ingesting water and organisms are derived by assuming an average daily ingestion of 2 liters of water, an average daily fish consumption rate of 6.5 grams of potentially contaminated fish products, and an average adult body weight of 70 kilograms (U.S. EPA, 1991a). Values protective of carcinogenicity are used to assess the potential effects on human health, if EPA has established a slope factor.

Protective concentration levels for carcinogens are developed in terms of non-threshold lifetime risk level. Criteria at a risk level of 10^{-6} (1E-6) are chosen for this analysis. This risk level indicates a probability of one additional case of cancer for every 1-million persons exposed. Toxic effects criteria for noncarcinogens include systemic effects (e.g., reproductive, immunological, neurological, circulatory, or respiratory toxicity), organ-specific toxicity, developmental toxicity, mutagenesis, and lethality.

The hierarchy used to select the most appropriate human health criteria values is listed below in descending order of priority:

- Calculated human health criteria values using EPA's IRIS RfDs or SFs used in conjunction with adjusted 3 percent lipid BCF values derived from *Ambient Water Quality Criteria Documents* (U.S. EPA, 1980); three percent is the mean lipid content of fish tissue reported in the study from which the average daily fish consumption rate of 6.5 g/day is derived;

- Calculated human health criteria values using current IRIS RfDs or SFs and representative BCF values for common North American species of fish or invertebrates or estimated BCF values;

- Calculated human health criteria values using RfDs or SFs from EPA's HEAST used in conjunction with adjusted 3 percent lipid BCF values derived from *Ambient Water Quality Criteria Documents* (U.S. EPA, 1980);

- Calculated human health criteria values using current RfDs or SFs from HEAST and representative BCF values for common North American species of fish or invertebrates or estimated BCF values;

- Criteria from the *Ambient Water Quality Criteria Documents* (U.S. EPA, 1980); and

- Calculated human health values using RfDs or SFs from data sources other than IRIS or HEAST.

This hierarchy is based on Section 2.4.6 of the *Technical Support Document for Water Quality-based Toxics Control* (U.S. EPA, 1991a), which recommends using the most current risk information from IRIS when estimating human health risks. In cases where chemicals have both RfDs and SFs from the same level of the hierarchy, human health values are calculated using the formulas for carcinogenicity, which always result in the more stringent value of the two given the risk levels employed.

3.1.4 Information Used to Evaluate Human Health Risks and Benefits

Fish ingestion rates for sport anglers, subsistence anglers, and the general population are obtained from the *Exposure Factors Handbook* (U.S. EPA, 1989a). State population data and average household size are obtained from the 1995 *Statistical Abstract of the United States* (U.S. Bureau of the Census, 1995). Data concerning the number of anglers in each State (i.e., resident fishermen) are obtained from the 1991 *National Survey of Fishing, Hunting, and Wildlife Associated Recreation* (U.S. FWS, 1991). The total number of river miles or estuary square miles within a State are obtained from the 1990 *National Water Quality Inventory - Report to Congress* (U.S. EPA, 1990b). Drinking water utilities located within 50 miles downstream from each discharge site are identified using EPA's PATHSCAN (U.S. EPA, 1996a). The population served by a drinking water utility is obtained from EPA's Drinking Water Supply Files (U.S. EPA, 1996b) or Federal Reporting Data System (U.S. EPA, 1996c). Willingness-to-pay values are obtained from OPA's review of a 1989 and a 1986 study *The Value of Reducing Risks of Death: A Note on New Evidence* (Fisher, Chestnut, and Violette, 1989) and *Valuing Risks: New Information on the Willingness to Pay for Changes in Fatal Risks* (Violette and Chestnut, 1986). Values are adjusted to 1992, based on the relative change in the Employment Cost Index of Total Compensation for all Civilian Workers. Information used in the evaluation is presented in Appendix D.

3.1.5 Information Used to Evaluate Ecological Benefits

The concept of a "contaminant-free fishery" and the estimate of an increase in the consumer surplus associated with a contaminant-free fishery are obtained from *Discrete Choice Models to Value Changes in Environmental Quality: A Great Lakes Case Study*, a thesis submitted at the University of Wisconsin-Madison by Audrey Lyke in 1993. Data concerning the number of resident anglers in each State and average number of fishing days per angler in each State are obtained from the 1991 *National Survey of Fishing, Hunting, and Wildlife Associated Recreation* (U.S. FWS, 1991) (Appendix D). Median net benefit values for warm water and cold water fishing days are obtained from *Nonmarket Values from Two Decades of Research on Recreational Demand* (Walsh et al., 1990). Values are adjusted to 1992, based on the change in the Consumer Price Index for all urban consumers, as published by the Bureau of Labor Statistics.

3.1.6 Information Used to Evaluate Economic Productivity Benefits

Sewage sludge pollutant limits for surface disposal and land application (ceiling limits and pollutant concentration limits) are obtained from the Federal Register 40 CFR Part 503, Standards for the Use or Disposal of Sewage Sludge, Final Rule (October 25, 1995) (U.S. EPA, 1995b). Cost savings from shifts in sludge use or disposal practices from composite baseline disposal practices are obtained from the *Regulatory Impact Analysis of Proposed Effluent Limitations Guidelines and Standards for the Metal Products and Machinery Industry (Phase I)* (U.S. EPA, 1995c). Savings are adjusted to 1992 using the Construction Cost Index published in the Engineering News Record. In this report, EPA consulted a wide variety of sources, including:

- 1988 National Sewage Sludge Survey;
- 1985 EPA *Handbook for Estimating Sludge Management Costs*;
- 1989 EPA *Regulatory Impact Analysis of the Proposed Regulations for Sewage Sludge Use and Disposal*;
- Interviews with POTW operators;
- Interviews with State government solid waste and waste pollution control experts;
- Review of trade and technical literature on sewage sludge use or disposal practices and costs; and
- Research organizations with expertise in waste management.

Information used in the evaluation is presented in Appendix D.

3.2 Pollutant Fate and Toxicity

The chemical-specific data needed to conduct the fate and toxicity evaluation are obtained from various sources as discussed in Section 2.2.2 of this report. Aquatic life and human health values are presented in Appendix C. Physical/chemical property data are also presented in Appendix C.

3.3 Documented Environmental Impacts

Data are obtained from State environmental agencies in Regions I, II, III, and IV. Data are also obtained from the 1990 State 304(l) Short Lists (U.S. EPA, 1991b) and the 1995 *National Listing of Fish and Wildlife Consumption Advisories* (U.S. EPA, 1995d). Literature abstracts are obtained through the computerized information system DIALOG (Knight-Ridder Information, 1996), which provides access to Enviroline, Pollution Abstracts, Aquatic Science Abstracts, and Water Resources Abstracts.

4. SUMMARY OF RESULTS

4.1 Projected Water Quality Impacts

4.1.1 Comparison of Instream Concentrations with Ambient Water Quality Criteria

The results of this analysis indicate the water quality benefits of controlling discharges from IWC facilities to surface waters and POTWs. The following two sections summarize potential aquatic life and human health impacts on receiving stream water quality and on POTW operations and their receiving streams for direct and indirect discharges. All tables referred to in these sections are presented at the end of Section 4. Appendices E, F, and G present the results of the stream modeling for each type of discharge, respectively.

4.1.1.1 *Direct Discharges*

The effects of direct wastewater discharges on receiving stream water quality are evaluated at **current** and **proposed BAT** treatment levels for 8 facilities discharging 17 pollutants (metals) to 8 receiving streams (8 rivers) (Table 1). At **current** discharge levels, these 8 facilities discharge 23,532 pounds-per-year of metals (Table 2). These loadings are reduced to 16,765 pounds-per-year at **proposed BAT** levels; a 29 percent reduction.

Modeled instream pollutant concentrations are projected to exceed **human health criteria** or toxic effect levels (developed for water and organisms consumption) in 50 percent (4 of the total 8) of the receiving streams at **current** and **proposed BAT** discharge levels (Table 3). A total of 2 pollutants at **current** and 1 pollutant at **proposed BAT** discharge levels are projected to exceed instream **human health criteria** or toxic effect levels using a target risk of 10^{-6} (1E-6) for carcinogens (Table 4).

Instream pollutant concentrations are projected to exceed **chronic aquatic life criteria** or toxic effect levels in 50 percent (4 of the total 8) of the receiving streams at **current** discharge levels (Table 3). A total of 8 pollutants at **current** are projected to exceed instream criteria or toxic effect levels (Table 4). **Proposed BAT** discharge levels reduce projected excursions to 7 pollutants in the 4 receiving streams (Tables 3 and 4).

Excursions of **human health criteria** or toxic effect levels (developed for organisms consumption only) and of **acute aquatic life criteria** or toxic effect levels are also presented in Table 3. A similar reduction in the number of pollutants exceeding criteria is noted.

4.1.1.2 *Indirect Discharges*

The effects of POTW wastewater discharges of 17 pollutants (metals) on receiving stream water quality are evaluated at **current** and **proposed pretreatment** discharge levels, for 3 facilities, which discharge to 3 POTWs located on 3 receiving streams (2 rivers and 1 estuary) (Table 1). Pollutant loadings for 3 facilities at **current** discharge levels are 48,574 pounds-per-year (Table 2). The loadings are reduced to 1,298 pounds-per-year after **pretreatment**; a reduction of 97 percent.

Instream pollutant concentrations are projected to exceed **human health criteria** or toxic effect levels (developed for water and organisms consumption) in 33 percent (1 of the total 3) of the receiving streams at **current** discharge levels (Table 5). A total of 1 pollutant at **current** is projected to exceed instream criteria or toxic effect levels using a target risk of 10^{-6} (1E-6) for the carcinogens (Table 6). No excursions of **human health criteria** or toxic effect levels are projected at **proposed pretreatment** discharge levels. A similar reduction in the number of pollutants and streams exceeding **human health criteria** or toxic effect levels (developed for organism consumption only) is noted (Table 5).

Instream pollutant concentrations of 1 pollutant are projected to exceed **chronic aquatic life criteria** or toxic effect levels at **current** discharge levels in 33 percent (1 of the total 3) of the receiving streams (Tables 5 and 6). No excursions of **chronic aquatic life criteria** or toxic effect levels are projected at **proposed pretreatment** discharge levels. No excursions of **acute aquatic life criteria** or toxic effect levels are projected at **current** or **proposed pretreatment** discharge levels (Table 5).

In addition, the potential impact of 3 facilities, which discharge to 3 POTWs, are evaluated in terms of inhibition of POTW operation and contamination of sludge. Inhibition problems and sludge contamination problems are projected at **current** discharge levels only (Table 7). Inhibition problems are projected to occur at 33 percent (1 of the 3) of the POTWs from 1 pollutant (Tables 7 and 8). Sludge contamination is projected to occur at 67 percent (2 of the 3) of the POTWs due to 3 pollutants (Tables 7 and 8).

4.1.2 Estimation of Human Health Risks and Benefits

The results of this analysis indicate the potential benefits to human health by estimating the risks (carcinogenic and systemic effects) associated with current and reduced pollutant levels in fish tissue and drinking water. The following two sections summarize potential human health impacts from the consumption of fish tissue and drinking water derived from waterbodies impacted by direct and indirect discharges. Risks are estimated for recreational (sport) and subsistence anglers and their families, as well as the general population. Appendices H and I present the results of the modeling for each type of discharge, respectively.

4.1.2.1 *Direct Discharges*

The effects of direct wastewater discharges on human health from the consumption of fish tissue and drinking water are evaluated at **current** and **proposed BAT** treatment levels for 8 facilities discharging 17 pollutants (metals) to 8 receiving streams (8 rivers) (Table 1).

(a) Fish Tissue

At current and proposed BAT discharge levels, 4 streams have total estimated individual pollutant cancer risks greater than 10^{-6} (1E-6) due to the discharge of 1 carcinogen from 4 facilities (Tables 9 and 10). Total estimated risks greater than 10^{-6} (1E-6) are projected for the general population, sport anglers, and subsistence anglers. At current discharge levels, total excess annual cancer cases are estimated to be 5.7E-3 (Table 9). Total excess annual cancer cases are reduced to 3.0E-3 at proposed BAT levels (Table 9). Because the number of excess annual cancer cases at current discharge levels is less than 0.5, a monetary value of benefits to society from avoided cancer cases is not estimated.

Systemic toxicant effects (hazard index greater than 1.0) are projected for only subsistence anglers in 3 receiving streams from 3 pollutants at current discharge levels (Table 11). An estimated population of 705 subsistence anglers and their families are projected to be affected. The proposed BAT discharge level will reduce the systemic toxicant effects to 1 receiving stream and 1 pollutant affecting an estimated population of 373 subsistence anglers and their families (Table 11). A monetary value of benefits to society could not be estimated.

(b) Drinking Water

At current and proposed BAT discharge levels, 4 streams have total estimated individual pollutant cancer risks greater than 10^{-6} (1E-6) due to the discharge of 1 carcinogen from 4 facilities (Table 12). Estimated risks range from 5.2E-6 to 3.0E-5 at current and from 1.8E-6 to 1.7E-5 at proposed BAT. However, no drinking water utility is located within 50 miles downstream of any of the discharge sites (i.e., total excess annual cancer cases are not projected). The hazard index exceeds 1.0 in one receiving stream at current discharge levels only (Table 11). However, systemic toxicant effects are not projected, because no drinking water utility is located within 50 miles downstream.

4.1.2.2 *Indirect Discharges*

The effects of POTW wastewater discharges on human health from the consumption of fish tissue and drinking water are evaluated at **current** and **proposed pretreatment** discharge levels for 3 facilities that discharge 17 pollutants (metals) to 3 POTWs on 3 receiving streams (2 rivers and 1 estuary) (Table 1).

(a) Fish Tissue

At **current** discharge levels, 1 stream, receiving the discharge from 1 facility, has a total estimated individual pollutant cancer risk greater than 10^{-6} (1E-6) from 1 carcinogen (Tables 13 and 14). Total estimated risks greater than 10^{-6} (1E-6) are projected for the **general population**, **sport anglers**, and **subsistence anglers**. Total excess annual cancer cases are estimated at 7.7E-3. At **proposed pretreatment** levels, no streams are projected to have a total estimated individual cancer risk greater than 10^{-6} (1E-6) (Table 13). Because the number of excess annual cancer cases at current discharge levels is less than 0.5, a monetary value of benefits to society from avoided cancer cases is not estimated.

Systemic toxicant effects (hazard index greater than 1.0) are projected at **current** discharge levels for subsistence anglers only due to the discharge of 2 pollutants to 1 receiving stream (Table 15). An estimated population of 249 subsistence anglers and their families are projected to be affected. No systemic toxicant effects are projected at **proposed pretreatment** levels (Table 15). A monetary value of benefits to society could not be estimated.

(b) Drinking Water

At **current** discharge levels, 1 stream has a total estimated individual pollutant cancer risk greater than 10^{-6} (1E-6) due to the discharge of 1 carcinogen from 1 facility (Table 16). The estimated risk is 1.4E-4. However, no drinking water utility is located within 50 miles downstream of the discharge site (i.e., total excess annul cancer cases are not projected). At **proposed pretreatment** levels, no streams are projected to have a total estimated individual cancer risk greater than 10^{-6} (1E-6) (Table 16). In addition, no systemic toxicant effects (hazard index greater than 1.0) are projected at **current** or **proposed pretreatment** levels (Table 15).

4.1.3 Estimation of Ecological Benefits

The results of this analysis indicate the potential ecological benefits of the proposed regulation by estimating improvements in the recreational fishing habitats that are impacted by direct and indirect IWC wastewater discharges. Such impacts include acute and chronic toxicity, sublethal effects on metabolic and reproductive functions, physical destruction of spawning and feeding habitats, and loss of prey organisms. These impacts will vary due to the diveristy of species with differing sensitivities to impacts. For example, lead exposure can cause spinal deformities in rainbow trout. Copper exposure can affect the growth activity of algae. In addition, copper and cadmium can be acutely toxic to aquatic life, including finfish. The following sections summarize the potential monetary benefits for direct and indirect discharges as well as additional benefits that are not monetized. Appendices H and I present the results of the analyses for each type of discharge, respectively.

4.1.3.1 *Direct Discharges*

The effects of direct wastewater discharges on aquatic habitats are evaluated at **current** and **proposed BAT** treatment levels for 8 facilities discharging 17 pollutants (metals) to 8 receiving streams (Tables 1 and 3). Because the proposed regulation is not estimated to completely eliminate instream concentrations in excess of AWQC, no benefits to recreational (sport) anglers, based on improved quality and improved value of fishing opportunities, are estimated.

4.1.3.2 *Indirect Discharges*

The effects of indirect wastewater discharges on aquatic habitats are evaluated at current and proposed pretreatment levels for 3 facilities that discharge 17 pollutants to 3 POTWs located on 3 receiving streams (Tables 1 and 5). Concentrations in excess of AWQC are projected to be eliminated at 1 receiving stream as a result of the proposed regulation. The monetary value of improved recreational fishing opportunity is estimated by first calculating the baseline value of the benefiting stream segment (Table 17). From the estimated total of 25,517 person-days fished on the stream segment, and the value per person-day of recreational fishing ($27.75 and $35.14, 1992 dollars), a baseline value of $708,000 to $897,000 is estimated for the 1 stream segment. The value of improving water quality in this fishery, based on the increase in value (11.1 percent to 31.3 percent) to anglers of achieving a contaminant-free fishing (Lyke, 1993), is then calculated. The resulting estimate of the increase in value of recreational fishing to anglers ranges from $78,600 to $281,000.

4.1.2.3 *Additional Ecological Benefits*

As noted in Section 2.1.3.1, the estimated benefit of improved recreational fishing opportunities is only a limited measure of the value to society of the improvements in aquatic habitats expected to result from the proposed regulation. Additional ecological benefits include protection of terrestrial wildlife and birds that consume aquatic organisms. The proposed regulation will also result in a reduction in the presence and discharge of toxic pollutants, thereby protecting those aquatic organisms currently under stress, providing the opportunity for the re-establishment of productive ecosystems in damaged waterways, and protection of resident endangered species. In addition, recreational activities, such as boating, water skiing, and swimming, will also be preserved along with the maintenance of an asthetically pleasing environment. Such activities contribute to the support of local and State economies.

4.1.4 Estimation of Economic Productivity Benefits

The results of this analysis indicate the potential productivity benefits of the proposed regulation based on reduced sewage sludge contamination at POTWs receiving the discharges from indirect IWC facilities. As a result of the proposed regulation, 1 POTW will meet land application pollutant concentration limits. Estimated disposal cost differentials are used to calculate cost-savings values (Table 18). Based on cost savings of $23/DMT, benefits are estimated at $7,400 annually (1992 dollars). In addition, 2 POTWs (1 additional) are expected to accrue a modest benefit through reduced record-keeping requirements and exemption from certain sewage sludge management practices. A monetary value for these modest benefits could not be estimated. Appendix I presents the results of the analysis.

4.2 Pollutant Fate and Toxicity

Human exposure, ecological exposure, and risk from environmental releases of toxic chemicals depend largely on toxic potency, inter-media partitioning, and chemical persistence. These factors are dependent on chemical-specific properties relating to toxicological effects on living organisms, physical state, hydrophobicity/lipophilicity, and reactivity, as well as the mechanism and media of release and site-specific environmental conditions. Based on available physical-chemical properties, and aquatic life and human health toxicity data for the 17 evaluated pollutants (metals), 10 exhibit moderate to high toxicity to aquatic life; 13 are human systemic toxicants; 3 are classified as known or probable human carcinogens; 13 have drinking water values (6 with enforceable health-based MCLs), 5 with secondary MCLs for asthetics or taste, and 2 with action levels for treatment); and 10 are designated by EPA as priority pollutants (Tables 19, 20, and 21). In terms of projected environmental partitioning among media, only 1 of the evaluated pollutants is moderately to highly volatile (potentially causing risk to exposed populations via inhalation); and 4 have a moderate to high potential to bioaccumulate in aquatic biota (potentially accumulating in the food chain and causing increased risk to higher trophic level organisms and to exposed human populations via fish and shellfish consumption). All of the pollutants are metals, which, in general, are not applicable to evaluation based on volatility and adsorption to solids. It is assumed that all of the metals have a high potential to sorb to solids.

4.3 Documented Environmental Impacts

Literature abstracts, State 304(l) Short Lists, and State fishing advisories are reviewed for documented impacts due to discharges from IWC facilities. Two (2) direct IWC facilities and 2 POTWs receiving wastewater from 2 IWC facilities are identified by States as being point sources causing water quality problems and are included on their 304(l) Short List (Tables 22 and 23). Section 304(l) of the Water Quality Act of 1987, which requires States to identify waterbodies impaired by the presence of toxic substances, to identify point-source discharges of these toxics, and to develop Individual Control Strategies (ICSs) for these discharges. The Short List is a list of waters for which a State does not expect applicable water quality standards (numeric or narrative) to be achieved after technology-based requirements are met due entirely or substantially to point source discharges of Section 307(a) toxics. State contacts indicate that of the two direct facilities, one is no longer in operation, and the other is currently in compliance with its permit limits and is no longer a source of impairment. Both POTWs listed are also currently in compliance for the listed pollutants. In addition, two IWC facilities are located on waterbodies with State-issued fish consumption advisories. However, the advisories are based on dioxins, which are not a pollutant of concern for the IWC industry.

Table 1. Evaluated Pollutants of Concern Discharged from 8 Direct and 3 Indirect IWC Facilities

CAS Number	Pollutant Name
7429905	Aluminum
7440360	Antimony
7440382	Arsenic*
7440428	Boron
7440439	Cadmium*
7440473	Chromium*
7440508	Copper*
7439896	Iron
7439921	Lead*
7439965	Manganese
7439976	Mercury*
7439987	Molybdenum
7782492	Selenium
7440224	Silver*
7440315	Tin
7440326	Titantium*
7440666	Zinc*

* Proposed for regulation

Source: Engineering and Analysis Division (EAD), May 1997.

Table 2. Summary of Pollutant Loadings for Direct and Indirect IWC Facilities

	Loadings (Pounds-per-Year)*		
	Direct Dischargers	Indirect Dischargers	Total
Current	23,532	48,574	72,106
Proposed BAT/Pretreatment	16,765	1,298	18,063
No. of Pollutants Evaluated	17	17	17**
No. of Facilities Evaluated	8	3	11

* Loadings are representative of metals evaluated; conventional and nonconventional pollutants, such as COD, TDS, TOC, and TSS, are not included.

** The same pollutant may be discharged from a number of direct and indirect facilities; therefore, the total does not equal the sum of pollutants.

Table 3. Summary of Projected Criteria Excursions for Direct IWC Dischargers
(National Basis)

	Acute Aquatic Life	Chronic Aquatic Life	Human Health Water and Orgs.	Human Health Orgs. Only	Total*
Current					
Stream (No.)	1	4	4	2	4
Pollutants (No.)	3 (1.1-6.6)	8 (1.1-40.8))	2 (1.9-35.8)	1 (1.4-4.4)	9
Total Excursions	**3**	**15**	**5**	**2**	
Proposed BAT					
Stream (No.)	1	4	4	1	4
Pollutants (No.)	2 (1.5-2.2)	7 (1.8-19.6)	1 (2.1-20.1)	1 (2.4)	8
Total Excursions	**2**	**14**	**4**	**1**	

NOTE: Number in parentheses represents magnitude of excursions.
Number of streams evaluated = 8 (8 rivers), number of facilities = 8, and number of pollutants = 17.

* Pollutants may exceed criteria on a number of streams; therefore, total does not equal sum of pollutants exceeding criteria.

Table 4. Summary of Pollutants Projected to Exceed Criteria for Direct IWC Dischargers (National Basis)

	Number of Excursions							
	Acute Aquatic Life		Chronic Aquatic Life		Human Health Water and Orgs.		Human Health Orgs. Only	
	Current	Proposed BAT	Current	Proposed BAT	Current	Proposed BAT	Current	Proposed BAT
Antimony	1 (4.5)	1 (1.5)	1 (11.9)	1 (3.9)	1 (1.9)	0	0	0
Arsenic	0	0	0	0	4 (6.1-35.8)	4 (2.1-20.1)	2 (1.4-4.4)	1 (2.4)
Boron	0	0	3 (3.9-18.7)	3 (3.9-18.7)	0	0	0	0
Cadmium	1 (6.6)	1 (2.2)	1 (20.8)	1 (6.8)	0	0	0	0
Copper	0	0	1 (1.1)	0	0	0	0	0
Lead	0	0	1 (4.5)	1 (4.5)	0	0	0	0
Mercury	0	0	4 (1.8-40.8)	4 (1.8-19.6)	0	0	0	0
Molybdenum	0	0	1 (3.0)	1 (3.0)	0	0	0	0
Silver	1 (1.1)	0	3 (5.3-32.0)	3 (3.6-14.2)	0	0	0	0

NOTE: Number of pollutants evaluated = 17.

Table 5. Summary of Projected Criteria Excursions for Indirect IWC Dischargers
(National Basis)

	Acute Aquatic Life	Chronic Aquatic Life	Human Health Water and Orgs.	Human Health Orgs. Only	Total*
<u>Current</u>					
Stream (No.)	0	1	1	1	1
Pollutants (No.)	0	1 (3.3)	1 (166)	1 (20.1)	2
Total Excursions	**0**	**1**	**1**	**1**	
<u>Proposed Pretreatment</u>					
Stream (No.)	0	0	0	0	0
Pollutants (No.)	0	0	0	0	0
Total Excursions	**0**	**0**	**0**	**0**	

NOTE: Number in parentheses represents magnitude of excursions.
Number of streams evaluated = 3 (2 rivers and 1 estuary), number of POTWs = 3, number of facilities = 3, and number of pollutants = 17.

* Pollutants may exceed criteria on a number of streams; therefore, total does not equal sum of pollutants exceeding criteria.

Table 6. Summary of Pollutants Projected to Exceed Criteria for Indirect IWC Dischargers
(National Basis)

	Number of Excursions							
	Acute Aquatic Life		Chronic Aquatic Life		Human Health Water and Orgs.		Human Health Orgs. Only	
	Current	Proposed Pretreatment	Current	Proposed Pretreatment	Current	Proposed Pretreatment	Current	Proposed Pretreatment
Arsenic	0	0	0	0	1 (166)	0	1 (20.1)	0
Mercury	0	0	1 (3.3)	0	0	0	0	0

NOTE: Number of pollutants evaluated = 17.

Table 7. Summary of Projected POTW Inhibition and Sludge Contamination Problems from Indirect IWC Dischargers (National Basis)

	Biological Inhibition	Sludge Contamination	Total
Current			
POTWs (No.)	1	2	2
Pollutants (No.)	1 (1.5)	3 (1.0 - 10.5)	3
Total Problems	**1**	**3**	
Proposed Pretreatment			
POTWs (No.)	0	0	0
Pollutants (No.)	0	0	0
Total Problems	**0**	**0**	

NOTE: Number of POTWs evaluated = 3, number of facilities = 3, and number of pollutants = 17.

Table 8. Summary of Pollutants from Indirect IWC Dischargers Projected to Cause POTW Inhibition and Sludge Contamination Problems (National Basis)

	Number of Excursions			
	Biological Inhibition		Sludge Contamination	
	Current	Proposed Pretreatment	Current	Proposed Pretreatment
Arsenic	0	0	1 (1.0)	0
Cadmium	0	0	1 (10.5)	0
Lead	1 (1.5)	0	1 (2.6)	0

NOTE: Number of Pollutants = 17

Table 9. Summary of Potential Human Health Impacts for Direct IWC Dischargers (Fish Tissue Consumption) (National Basis)

	Total Individual Cancer Risks > 10^{-6}	Total Excess Annual Cancer Cases
Current		
Stream (No.)/Facilities (No.)	4/4	NA/NA
Carcinogens (No.)	1	NA
General Population	2 (1.4E-6 to 4.4E-6)	3.5E-3
Sport Anglers	4 (1.9E-6 to 1.1E-5)	1.5E-3
Subsistence Anglers	4 (1.6E-5 to 9.4E-5)	6.9E-4
TOTAL		**5.7E-3**
Proposed BAT		
Stream (No.)/Facilities (No.)	4/4	NA/NA
Carcinogens (No.)	1	NA
General Population	1 (2.4E-6)	1.9E-3
Sport Anglers	2 (1.9E-6 to 6.2E-6)	7.2E-4
Subsistence Anglers	4 (5.4E-6 to 5.3E-5)	3.6E-4
TOTAL		**3.0E-3**

NOTE: Total number of streams evaluated = 8 (8 rivers), number of facilities = 8, and number of pollutants = 17. Table presents results for those streams/facilities for which the projected excess cancer risk for any pollutant exceeds 10^{-6} (1E-6).
NA = Not Applicable

Table 10. Summary of Pollutants Projected to Cause Human Health Impacts for Direct IWC Dischargers
(Fish Tissue Consumption)
(National Basis)

	Cancer Risks > 10^{-6}/ Excess Annual Cancer Cases General Population	Cancer Risks > 10^{-6}/ Excess Annual Cancer Cases Sport Fishermen	Cancer Risks > 10^{-6}/ Excess Annual Cancer Cases Subsistence Fishermen
Current:			
Stream No. 1 Arsenic	4.4E-6/3.3E-3	1.1E-5/1.1E-3	9.4E-5/5.0E-4
Stream No. 2 Arsenic	0/NA	2.0E-6/1.8E-4	1.7E-5/8.2E-5
Stream No. 3 Arsenic	0/NA	1.9E-6/8.6E-5	1.6E-5/3.8E-5
Stream No. 4 Arsenic	1.4E-6/1.6E-4	3.5E-6/1.6E-4	3.0E-5/7.1E-5
Proposed BAT:			
Stream No. 1 Arsenic	2.4E-6/1.9E-3	6.2E-6/6.3E-4	5.3E-5/2.8E-4
Stream No. 2 Arsenic	0/NA	0/NA	5.4E-6/2.7E-5
Stream No. 3 Arsenic	0/NA	1.9E-6/8.6E-5	1.6E-5/3.8E-5
Stream No. 4 Arsenic	0/NA	0/NA	5.9E-6/1.4E-5

NOTE: Total number of streams evaluated = 8 (8 rivers), number of facilities = 8, and total number of pollutants = 17. Table presents results for those streams/facilities for which the projected excess cancer risk for any pollutant exceeds 10^{-6} (1E-6).
NA = Not Applicable

Table 11. Summary of Potential Systemic Human Health Impacts for Direct IWC Dischargers
(Fish Tissue and Drinking Water Consumption)
(National Basis)

	Fish Tissue Hazard Indices > 1	Drinking Water Hazard Indices > 1
Current		
Stream (No.)/Facilities (No.)	3/3[a]	1/1[b]
Pollutants (No.)	3[c]	1[d]
General Population	0	1 (1.9)
Affected Population	NA	0
Sport Anglers	0	1 (1.9)
Affected Population	NA	0
Subsistence Anglers	3 (1.0 - 1.7)	1 (1.9)
Affected Population	705	0
Proposed BAT		
Stream (No.)/Facilities (No.)	1/1	0/0
Pollutants (No.)	1[f]	0
General Population	0	0
Affected Population	NA	NA
Sport Anglers	0	0
Affected Population	NA	NA
Subsistence Anglers	1 (1.7)	0
Affected Population	373	NA

NOTE: Total number of streams evaluated = 8 (8 rivers), number of facilities = 8, and number of pollutants = 17.
Table presents results for those streams/facilities for which the projected hazard index for any pollutant exceeds 1.0.

[a] For two streams, the hazard index did not exceed 1.0 for any one pollutant, but did exceed 1.0 in combination.
[b] No drinking water utilities located within 50 miles downstream.
[c] Arsenic, cadmium, and mercury.
[d] Antimony.
[f] Mercury.

Table 12. Summary of Potential Human Health Impacts for Direct IWC Dischargers (Drinking Water Consumption) (National Basis)

	Total Individual Cancer Risks > 10^{-6}	Total Excess Annual Cancer Cases
Current		
Stream (No.)	4	NA
Carcinogens (No.)*	1 (5.2E-6 to 3.0E-5)	NA
With Drinking Water Utility ≤ 50 miles	0	NA
Carcinogens (No.)	0	NA
TOTAL		NA
Proposed BAT		
Stream (No.)	4	NA
Carcinogens (No.)*	1 (1.8E-6 to 1.7E-5)	NA
With Drinking Water Utility ≤ 50 miles	0	NA
Carcinogens (No.)	0	NA
TOTAL		NA

NOTE: Total number of streams evaluated = 8 (8 rivers), number of facilities = 8, and number of pollutants = 17. Table presents results for those streams/facilities for which the projected excess cancer risk for any pollutant exceeds 10^{-6} (1E-6).

NA = Not Applicable

* Arsenic: EPA has published a drinking water criterion for arsenic, and it is assumed that drinking water treatment systems will reduce concentrations to below adverse effect thresholds.

Table 13. Summary of Potential Human Health Impacts for Indirect IWC Dischargers (Fish Tissue Consumption) (National Basis)

	Total Individual Cancer Risks > 10^{-6}	Total Excess Annual Cancer Cases
<u>Current</u>		
Stream (No.)/Facilities (No.)	1/1	NA/NA
Carcinogens (No.)	1	NA
General Population	1 (2.0E-5)	2.7E-3
Sport Anglers	1 (5.1E-5)	3.5E-3
Subsistence Anglers	1 (4.3E-4)	1.5E-3
TOTAL		7.7E-3
<u>Proposed Pretreatment</u>		
Stream (No.)/Facilities (No.)	0/0	NA/NA
Carcinogens (No.)	0	NA
General Population	0	NA
Sport Anglers	0	NA
Subsistence Anglers	0	NA
TOTAL		NA

NOTE: Total number of streams evaluated = 3 (2 rivers and 1 estuary), number of POTWs = 3, number of facilities = 3, and number of pollutants = 17. Table presents results for those streams/facilities for which the projected excess cancer risk for any pollutant exceeds 10^{-6} (1E-6).
NA = Not Applicable

Table 14. Summary of Pollutants Projected to Cause Human Health Impacts for Indirect IWC Dischargers
(Fish Tissue Consumption)
(National Basis)

	Cancer Risks $>10^{-6}$/ Excess Annual Cancer Cases General Population	Cancer Risks $>10^{-6}$/ Excess Annual Cancer Cases Sport Fishermen	Cancer Risks $>10^{-6}$/ Excess Annual Cancer Cases Subsistence Fishermen
Current:			
Stream No. 1 Arsenic	2.0E-5/2.7E-3	5.1E-5/3.5E-3	4.3E-4/1.5E-3

NOTE: Total number of streams evaluated = 3 (2 rivers and 1 estuary), number of POTWs = 3, number of facilities = 3, and total number of pollutants = 17. Table presents results for those streams/facilities for which the projected excess cancer risk for any pollutant exceeds 10^{-6} (1E-6).
NA = Not Applicable

Table 15. Summary of Potential Systemic Human Health Impacts for Indirect IWC Dischargers
(Fish Tissue and Drinking Water Consumption)
(National Basis)

	Fish Tissue Hazard Indices > 1	Drinking Water Hazard Indices > 1
Current		
Stream (No.)/Facilities (No.)	1/1	0/0
Pollutants (No.)	2[a]	0
General Population	0	0
Affected Population	NA	NA
Sport Anglers	0	0
Affected Population	NA	NA
Subsistence Anglers	1 (2.0)	0
Affected Population	249	NA
Proposed Pretreatment		
Stream (No.)/Facilities (No.)	0/0	0/0
Pollutants (No.)	0	0
General Population	0	0
Affected Population	NA	NA
Sport Anglers	0	0
Affected Population	NA	NA
Subsistence Anglers	0	0
Affected Population	NA	NA

NOTE: Total number of streams evaluated = 3 (2 rivers and 1 estuary), number of POTWs = 3, number of facilities = 3, and number of pollutants = 17. Table presents results for those streams/facilities for which the projected hazard index for any pollutant exceeds 1.0.
NA = Not Applicable.

[a] Arsenic and mercury; hazard index for arsenic does not exceed 1.0 but is a primary contributor.

Table 16. Summary of Potential Human Health Impacts for Indirect IWC Dischargers (Drinking Water Consumption) (National Basis)

	Total Individual Cancer Risks > 10^{-6}	Total Excess Annual Cancer Cases
Current		
Stream (No.)	1	NA
Carcinogens (No.)*	1 (1.4E-4)	NA
With Drinking Water Utility ≤ 50 miles	0	NA
Carcinogens (No.)	0	NA
TOTAL		NA
Proposed Pretreatment		
Stream (No.)	0	NA
Carcinogens (No.)*	0	NA
With Drinking Water Utility ≤ 50 miles	0	NA
Carcinogens (No.)	0	NA
TOTAL		NA

NOTE: Total number of streams evaluated = 3 (2 rivers and 1 estuary), number of POTWs = 3, number of facilities = 3, and number of pollutants = 17. Table presents results for those streams/facilities for which the projected excess cancer risk for any pollutant exceeds 10^{-6} (1E-6).
NA = Not Applicable
* Arsenic: EPA has published a drinking water criterion for arsenic, and it is assumed that drinking water treatment systems will reduce concentrations to below adverse effect thresholds.

Table 17. Summary of Ecological (Recreational) Benefits for Indirect IWC Dischargers (National Basis)

Number of Stream Segments with Concentrations Exceeding AWQC Eliminated	Total Fishing Days	Baseline Value of Fishery ($ 1992)	Increased Value of Fishery ($ 1992)
1	25,517	$708,000-$897,000	$78,600-$281,000

NOTE: Value per person day of recreational fishing = $27.75 (warm water) and $35.14 (cold water).

Increase value of contaminant-free fishing = 11.1 to 31.3 percent.

Table 18. Cost Savings from Shifts in Sludge Use or Disposal Practices from Composite Baseline Disposal Practices (1992$/DMT)

Assumed Baseline POTW Mix of Sewage Sludge Use or Disposal Practices	Post-Compliance POTW Sewage Sludge Use or Disposal Practice		
	Agricultural Application (86.6 percent of sewage sludge that meets land application pollutant limits)	Bagged Sewage Sludge (13.4 percent of sewage sludge that meets land application pollutant limits)	Surface Disposal* (Meet surface pollutant limits; do not meet land application pollutant limits)
Meet surface disposal pollutant limits; do not meet land application ceiling pollutant limits Assumed disposal mix: 47% dedicated site 28% monofills 25% surface impoundment	$0-$23	$0	N/A
Do not meet land application pollutant limits or surface disposal pollutant limits Assumed disposal mix: 32% incineration 68% co-disposal	$94-$202	$0-$32	$32-$202

* Surface disposal includes monofills, surface impoundments, and dedicated sites.

Source: U.S. Environmental Protection Agency, 1995b.

Table 19. Potential Fate and Toxicity of Pollutants of Concern

Chemical Name	CAS Number	Aquatic Toxicity Category	Volatility Category	Sediment Adsorption Category	Bioaccumulation Category	Carcinogenic Effect	Systemic Health Effect	Drinking Water Value	Priority Pollutant
Aluminum	7429905	Moderate	NA	NA	Moderate			SM	
Antimony	7440360	High	NA	NA	Insignificant		X	M	X
Arsenic	7440382	Moderate	NA	NA	Slight	X	X	M	X
Boron	7440428	Unknown	NA	NA	Unknown		X		
Cadmium	7440439	High	NA	NA	Moderate	X	X	M	X
Chromium	7440473	Slight	NA	NA	Slight		X	M	X
Copper	7440508	High	NA	NA	Moderate			TT	X
Iron	7439896	Unknown	NA	NA	Unknown			SM	
Lead	7439921	High	NA	NA	Slight	X	X	TT	X
Manganese	7439965	Unknown	NA	NA	Unknown		X	SM	
Mercury	7439976	High	High	High	High		X	M	X
Molybdenum	7439987	Unknown	NA	NA	Unknown		X		
Selenium	7782492	High	NA	NA	Insignificant		X	M	X
Silver	7440224	High	NA	NA	Insignificant		X	SM	X
Tin	7440315	Unknown	NA	NA	Unknown		X		
Titanium	7440326	Unknown	NA	NA	Unknown				
Zinc	7440666	Moderate	NA	NA	Slight		X	SM	X
Total Suspended Solids									
Total Organic Carbon									
Total Dissolved Solids									
Chemical Oxygen Demand									

Note: NA = Not applicable to these pollutants; all metals assumed to be "adsorptive" to sediment.
M = Maximum Contaminant Level established for health-based effect.
SM = Secondary Maximum Contaminant Level (SMCL) established for taste or aesthetic effect.
TT = Treatment technology action level established.

Table 20. Toxicants Exhibiting Systemic and Other Adverse Effects*

Toxicant	Reference Dose Target Organ and Effects
Antimony	Longevity, blood glucose, cholesterol
Arsenic	Hyperpigmentation, keratosis, and possible vascular complications
Boron	Testicular atrophy, spermatogenic arrest
Cadmium	Significant proteinuria
Chromium	No adverse effects observed**
Lead***	Cardiovascular and CNS effects
Manganese	CNS effects
Mercury	CNS effects
Molybdenum	Increased uric acid
Selenium	Clinical selenosis (hair or nail loss), liver dysfunction
Silver	Argyria (skin discoloration)
Tin	Kidney and liver lesions
Zinc	Anemia

* Chemicals with EPA verified or provisional human health-based reference doses, referred to as "systemic toxicants."

** Reference dose based on a no observed adverse effect level (NOAEL).

*** Pollutant has no reference dose; however, EPA criterion for systemic toxicity protection has been assigned.

Table 21. Human Carcinogens Evaluated, Weight-of-Evidence Classifications, and Target Organs

Carcinogen	Weight-of-Evidence Classification	Target Organs
Arsenic	A	Skin and lung
Cadmium	B1	Lung, tracheae, and bronchus
Lead	B2	Kidney, stomach, and lung

A Human Carcinogen
B1 Probable Human Carcinogen (limited human data)
B2 Probable Human Carcinogen (animal data only)

TABLE 22. IWCS INCLUDED ON STATE 304(l) SHORT LISTS

SIC Code	NPDES	Facility Name	City	Waterway	REACH Number	Listed Pollutants
3612	MA0003891*	General Electric-Pittsfield	Pittsfield	Housatonic River	01100005079	NOAEL >30%, Metals, PCBs
4953	NJ0005240**	Rollins Environmental Services	Bridgeport	Raccoon Creek	02040202004	Copper, Cadmium, Lead

* No longer in operation (State contact, December 1996).
** Currently in compliance and no longer a source of impairment (State contact - January 1997).

Source: Compiled from OW files dated April/May 1991.

TABLE 23. POTWS WHICH RECEIVE DISCHARGE FROM IWCS AND ARE INCLUDED ON STATE 304(l) SHORT LISTS

Facility Name	City	Receiving POTW	POTW NPDES	Waterbody	REACH Number	Listed Pollutants
Rhone-Poulenc Basic Chem. Co.	Hammond	Hammond STP*	IN0023060	Grand Calumet River	04040001010	Cyanide, Copper
INMETCO	Ellwood City	Ellwood City Boro*	PA0026832	Connoquenessing Creek	05030105001	Chloroform, Mercury, Cadmium, Nickel

* Currently in compliance for listed pollutants (State contact, December 1996).

Source: Compiled from OW files dated April/May 1991.

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