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The Anti-Chlorine Campaign in the Great Lakes: Should Chlorinated Compounds Be Guilty Until Proven Innocent?

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COMMENTS

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Since the initial production of elemental chlorine around the turn of the century, those who used and produced this chemical were aware of its extreme toxicity. In the 1960's, beginning with the publication of Rachel Carson's "Silent Spring," chlorinated compounds were increasingly implicated in a variety of environmental hazards. In the 1970's, recognizing the need to control chemicals before they were allowed to be produced, the U.S. Congress passed the Toxic Substances Control Act. And yet, chlorine and its compounds continue to maintain the same right of innocence that is granted to citizens under the United States Constitution, while society is exposed to the risks associated with its use. In the 1990's, the public has been made aware that the use of chlorine may alter the reproductive development of future generations. Has the time come to declare a verdict of "Guilty?"

INTRODUCTION

Recently, industry and government officials have been forced to consider an unprecedented environmentalist movement: the attempt to banish an entire element from industrial chemistry. The campaign seeks to phase out the use of chlorine, along with the entire class of chlorinated compounds. Growing support for phasing out, or "sunsetting,"[1] the entire class of chlorinated compounds is based on the recognition that: (1) there are too many chlorinated chemicals for a regulatory agency to study and regulate one by one; (2) these chemicals are produced in complex mixtures, not individually and, therefore, they should not be regulated in isolation from one another; (3) there is scientific proof that many chlorinated compounds are hazardous, making the entire class suspect; (4) there is increasing evidence that chlorinated organics[2] have adverse health effects on humans and wildlife; and (5) there are feasible alternatives for most chlorine-containing products and processes.[3] For these reasons, many environmentalists, citizen groups, communities, and scientists believe that we should simply

1. Sunsetting is a systematic regulatory method of banning the production and use of toxic chemicals, the processes that create toxic by-products, and the products that are toxic or contain toxic material. NATIONAL WILDLIFE FED'N AND CANADIAN INST. FOR ENVTL. L. AND POL'Y, A PRESCRIPTION FOR HEALTHY GREAT LAKES: REPORT OF THE PROGRAM FOR ZERO DISCHARGE 21 (1991) [hereinafter NATIONAL WILDLIFE FED'N].

2. Chlorinated organics, also called organochlorines or chlorinated hydrocarbons, are chemicals in which at least one atom of chlorine is directly bonded to carbon-containing organic matter. *See infra* notes 30-47 and accompanying text.

3. Ivan Amato, *The Crusade Against Chlorine,* 261 SCI. NEWS 152, 152 (1993); Bette Hileman, *Concerns Broaden Over Chlorine and Chlorinated Hydrocarbons,* CHEM. & ENG'G NEWS, Apr. 19, 1993, at 11, 11.

play it safe and ban the element as an industrial feedstock.[4] The essence of their argument is that, "[i]f no chlorine goes in, none comes out."[5]

Increasing public concern and recent political developments have compelled the chemical industry to take seriously the threat of a chlorine ban. Various countries have implemented or proposed regulations that either ban certain types of chlorinated organics or severely limit the use of chlorinated compounds in specific processes.[6] In addition to these specific regulations addressing individual chlorinated compounds, several domestic and international bodies advocate a broad phase-out of chlorinated compounds as a class.[7] In their Sixth Biennial Report, the International Joint Com-

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4. An industrial feedstock is any raw material that is supplied to an industrial machine or processing plant. An example of chlorine's role as an industrial feedstock would be the supply of elemental chlorine to a pulp and paper mill for use in bleaching paper products.

5. Amato, *supra* note 3, at 152 (quoting Joe Thornton).

6. Representatives Bill Richardson (D-N.M.) and Henry Waxman (D-Cal.) introduced a bill in August 1993 which requires pulp and paper companies to phase out chlorine-based bleaching methods within 5 years. H.R. 2898, 103d Cong., 1st Sess. (1993). In addition, the proposed bill requires the EPA to report on other organochlorines and make recommendations for their phase-out. *CMA Leader Says Group Ready to Revise TSCA; Anti-Chlorine Movement Could Prompt Action*, 17 Chem. Reg. Rep. (BNA) 1445 (Nov. 5, 1993) [hereinafter *Group Ready to Revise TSCA*]. If passed, this legislation would establish a precedent that chlorine could be banned for specific uses in the United States. Amato, *supra* note 3, at 153-54. Furthermore, European nations have committed themselves to the elimination of chlorine gas as a bleach in the pulp and paper industry. *Id.* at 152. The Canadian provinces of British Columbia, Quebec, and Ontario have established standards to reduce the amount of chlorine found in the effluent which is discharged from pulp and paper mills. Hileman, *supra* note 3, at 12. Ontario's proposed regulations, which seek to achieve zero discharge of organochlorines from pulp and paper mills, became law in November 1993. INTERNATIONAL JOINT COMM'N, SEVENTH BIENNIAL REPORT ON THE GREAT LAKES WATER QUALITY 12 (1994) [hereinafter SEVENTH BIENNIAL REPORT].

Many cities and towns in Europe have decided to eliminate the use of polyvinyl chloride (PVC), a chlorinated plastic, in their new public construction projects, and one German state has banned the purchase of PVC products by the government for any purpose, unless no substitutes can be found. Hileman, *supra* note 3, at 12. Use of atrazine (a chlorinated herbicide which is used heavily in the United States) is restricted in Germany, the Netherlands, several Nordic countries, and northern Italy. *Id.* The Montreal Protocol is an international agreement to phase out chlorofluorocarbons (CFCs). Amato, *supra* note 3, at 154.

7. In 1992, Norway commissioned researchers to conduct studies on the policy implications of a complete chlorine ban. Amato, *supra* note 3, at 152. The Paris Commission, in September 1992, recommended that nations reduce discharges of organochorines and develop programs to phase out their use completely. Hileman, *supra* note 3, at 11; *see also* SEVENTH BIENNIAL REPORT, *supra* note 6, at 13. In addition, 21 Mediterranean states who are parties to the Barcelona Convention voted in October 1993 to stop the discharge of organochlorines and phase out their use by the year 2005. *Group Ready to Revise TSCA*, *supra* note 6; *see also* SEVENTH BIENNIAL REPORT, *supra* note 6, at 13. Similar conclusions were reached at the International Whaling Commission's 45th Annual Meeting (May 1993) and the Fifth World Wilderness Congress, Tromso, Norway (Oct. 1993). *Id.*

mission (IJC)[8] recommended that the U.S. and Canadian governments "sunset the use of chlorine and chlorine-containing compounds as industrial feedstocks."[9] For environmentalists, the IJC recommendation was a significant step toward the goal of zero discharge of chlorinated compounds.[10] For the chlorine industry, however, the recommendation triggered a vigorous public relations campaign to promote the wonders of chlorine chemistry.[11]

Through examination of the anti-chlorine campaign in light of the IJC's recommendation, this Comment argues that regulatory action and legislative reform should address the health and environmental effects of chlorine use in the Great Lakes Basin,[12] so that chlorine and its compounds will no longer be considered innocent of causing harm until proven guilty. Part I discusses the properties and applications of chlorine, as well as chlorine's effect on health and the environment. Part II examines the Great Lakes Basin and how the use of chlorine influences this ecosystem. Part III provides an overview of the United States and Canadian pollution control efforts in the Great Lakes, including the establishment of the IJC and the enactment of the Great Lakes Water Quality Agreements. Part IV examines the principle arguments that support a chlorine ban under the Great Lakes Water Quality Agreements, namely, that (1) traditional regulation is ineffective; (2) the weight of evidence supports the elimination of chlorine; and (3) the elimination of chlorine is both technologically and economically feasible. Part V discusses the policy decisions involved in a chlorine phase-out. Finally, Part VI offers preventative regulation and

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8. The IJC is a treaty organization established by the United States and Canada through the Boundary Waters Treaty of 1909 in order to ensure the sound management of the shared waters in the Great Lakes region. *See infra* notes 86-91 and accompanying text.

9. INTERNATIONAL JOINT COMM'N, SIXTH BIENNIAL REPORT ON THE GREAT LAKES WATER QUALITY 30 (1992) [hereinafter SIXTH BIENNIAL REPORT]. *See infra* note 118 and accompanying text. In addition, the Commission confirmed and emphasized this recommendation in its subsequent Seventh Biennial Report. SEVENTH BIENNIAL REPORT, *supra* note 6, at 9, 46.

10. Zero discharge is described as:

> [H]alting all inputs from all human sources and pathways to prevent any opportunity for persistent toxic substances to enter the environment as a result of human activity. To prevent such releases completely, their manufacture, use, transport and disposal must stop; they simply must not be available. Thus, zero discharge does not mean less than detectable. It also does not mean the use of controls based on best available technology, best management practices, or similar means of treatment that continue to allow the release of some residual chemicals.

SIXTH BIENNIAL REPORT, *supra* note 9, at 16-17.

11. *See infra* note 119 and accompanying text.

12. Although the use of chlorine in the Great Lakes Basin will need to be addressed by both the United States and Canadian governments, due to the breadth of the issue, the scope of this Comment will be limited to the United States.

reformed legislation as a means to address the problems associated with chlorine.

I. The Environmental Impact of Chlorine and Chlorinated Compounds

A. *Chlorine: Its Properties and Applications*

The chemical element chlorine (Cl)[13] exists in many naturally occurring compounds, often in the form of stable chloride ions (Cl_2) that pose no threat to the environment.[14] However, chlorine gas (Cl_2),[15] the pure elemental form of chlorine, does not exist freely in nature.[16] It is created by flashing electricity through brine, a saltwater solution, which splits the sodium chloride molecule (NaCl) and forms chlorine gas and sodium hydroxide (NaOH).[17]

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13. Chlorine's atomic number is 17, and its atomic weight is 35.453. It is a member of the halogen family, which is made up of five elements: fluorine, chlorine, bromine, iodine and astatine. Joe Downey et al., *Chlorine*, *in* 3 McGraw-Hill Encyclopedia of Science & Technology 568, 568-69 (7th ed. 1992) [hereinafter McGraw-Hill Encyclopedia]; Ralph J. Cicerone, *Halogen Elements*, *in* 8 McGraw-Hill Encyclopedia, *supra*, at 298, 298. Chlorine is the most abundant member of the halogen family. Saul L. Neidleman & John Geigert, Biohalogenation: Principles, Basic Roles and Applications 13 (1986).

The halogen elements, with the exception of astatine, are closely related and they generally participate in similar types of chemical reactions. Cicerone, *supra*, at 299. Therefore, the other halogens may present similar environmental problems.

14. Chloride ions exist predominantly as sodium chloride (NaCl), more commonly known as sea salt or table salt, and other metallic chlorides in the earth's crust. Downey et al., *supra* note 13, at 569, 572; *see also* Joe Thornton, The Product is the Poison: The Case for a Chlorine Phase-out 7 (1991) [hereinafter Thornton, The Product is the Poison]. Other natural sources of chlorinated compounds include volcanic eruptions (hydrochloric acid), forest and grass fires (organic chlorine compounds), and the biosynthesis of many living organisms, including humans. George Werezak, *A Report On Chlorine to the Virtual Elimination Task Force*, *in* 2 A Strategy For Virtual Elimination of Persistent Toxic Substances 33, 33 (1993). About 0.045% of the earth's crust and almost 2% of seawater is comprised of chlorine. Downey et al., *supra* note 13, at 568, 572; *cf.* Werezak, *supra*, at 33 (stating that stable chlorine compounds make up approximately 0.03% of the earth's crust, 2.0% of the water in the oceans, and 0.17% of the human body's total weight).

15. Elemental chlorine was discovered accidently over 200 years ago by the Swedish chemist Carl Wilhelm Scheele. Wyandotte Chemicals Corporation, Chlorine 12 (1956) [hereinafter Chlorine]. Chlorine is a clear, amber fluid that vaporizes quickly to a highly toxic greenish-yellow gas. Downey et al., *supra* note 13, at 568, 571-72; Werezak, *supra* note 14, at 33. In 1810, Sir Humphry Davy proved this gas was an element and named it chlorine after the Greek word for "greenish-yellow". Chlorine, *supra*, at 12.

16. Chlorine, *supra* note 15, at 12; *see also* Thornton, The Product is the Poison, *supra* note 14, at 7. Chlorine is seldom found in this elemental state because the reactivity of chlorine enables it to combine readily with other elements. Cicerone, *supra* note 13, at 298; Werezak, *supra* note 14, at 33.

17. Chlorine, *supra* note 15, at 13; Downey et al., *supra* note 13, at 572-73. Sodium hydroxide is also known as alkali or caustic soda. Up until the early 1900s, industry used the electrolytic preparation of chlorine and caustic soda primarily for the pure caustic it pro-

This chlorine gas is extremely unstable and therefore highly reactive, combining readily with other inorganic and organic (carbon-based) matter when it makes contact.[18]

Because of its particular chemical and physical properties, chlorine has become important in thousands of commercial applications. In fact, it is estimated that chlorine is involved in more than half of all industrial chemistry.[19] The fundamental reason for chlorine's widespread use is its high electron affinity, which enables chlorine to react readily with electron-rich atoms like carbon.[20] This high reactivity allows chlorine to take part in many different chemical reactions and processes.

Despite the extensive use of chlorine, "[m]ost people do not realize how much chlorine chemistry contributes to their lives."[21] Society uses chlorine in three distinct ways. First, elemental chlorine can be used directly.[22] Many consumers are aware of chlorine's direct consumption as a laundry bleach and a disinfectant for pub-

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duced, considering chlorine an unfortunate by-product. Once ways to stabilize, transport and handle chlorine safely were discovered, the demand for chlorine as a chemical intermediate increased. CHLORINE, *supra* note 15, at 13. Industry first began producing chlorine around the turn of the century, but it was not until World War II that large scale production occurred. Today, about 40 million tons of chlorine are produced per year. JOE THORNTON, CHLORINE, HUMAN HEALTH AND THE ENVIRONMENT: THE BREAST CANCER WARNING 14 (1993) [hereinafter THORNTON, THE BREAST CANCER WARNING].

It has been stated that "[d]uring the twentieth century, the amount of chlorine used [is] considered a measure of industrial growth." Downey et al., *supra* note 13, at 574. In 1956, a book published by a chemical manufacturer stated: "Thus, we see that chlorine, once tolerated as the ugly stepsister of the alkalies, has begun to play a decisive role in future plans of the chemical industry and those it serves. Truly, chlorine may well be known as the 'Cinderella Chemical.'" CHLORINE, *supra* note 15, at 13.

18. Downey et al., *supra* note 13, at 568; Werezak, *supra* note 14, at 33. The chemical behavior of chloride ions (Cl-) is different from that of elemental chlorine (Cl_2). Chloride ions do not react with the carbon atoms that are the "basic building blocks of 'organic' matter." THORNTON, THE PRODUCT IS THE POISON, *supra* note 14, at 7.

19. Werezak, *supra* note 14, at 34.

20. CHLORINE, *supra* note 15, at 18. Some atoms, such as chlorine, have an affinity for electrons and can acquire one or more to form negative ions. The measure of an element's electron affinity is the energy required to bring an electron from an infinite distance away up to a gaseous atom to form an ion. The higher the electron affinity, the more stable the newly formed ion is. JOHN C. KOTZ & KEITH F. PURCELL, CHEMISTRY & CHEMICAL REACTIVITY 279-81 (1987). A direct relationship exists between a high electron affinity and a high electronegativity (ability of an atom in a molecule to attract electrons to itself). *Id.* at 316. Chlorine is the third-most electronegative element in the periodic table; thus, its high reactivity. *Id.* at 316-17.

21. THE CHLORINE INST., INC., CHLORINE CHEMISTRY PLAYS A VITAL ROLE IN THE U.S. ECONOMY 2 (1993) (summarizing *Assessment of the Economic Benefits of Chlor-Alkali Chemicals to the United States and Canadian Economies* (1993), prepared by Charles River Assocs. (Boston, Mass.)).

22. Werezak, *supra* note 14, at 34.

lic water supplies and swimming pools. In addition, the bleaching cycle in pulp and paper mills and the treatment of wastewater effluent utilize the direct application of chlorine.[23] Second, many consumer products, such as plastics,[24] solvents,[25] and pesticides,[26] incorporate chlorine to attain certain desirable characteristics.[27] Third, chlorine is used as a facilitator, or catalyst,[28] where it is not part of the final consumer product. For example, the production of many pharmaceuticals is aided by chlorine.[29]

When chlorine attaches itself to organic compounds, the carbon-based materials that comprise the tissues of living organisms, new substances called organochlorines are formed.[30] As a result of

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23. *Id.*

24. The largest single use of chlorine is the manufacture of polyvinyl chloride (PVC or vinyl). *Id.* PVC is a versatile plastic used to produce many everyday consumer goods. Examples include: luggage; raincoats; furniture; packaging; automobile seat covers, floor mats, and dashboards; and building and construction materials, such as pipes, siding, gutters, window and door frames, flooring, and electrical wire insulation. *Id.*

25. Chlorinated solvents are used in dry cleaning processes, as well as processes which clean metal and other materials during their conversion to common consumer goods such as automobiles, electronics, and photographic film. *Id.*

26. Many crop protection chemicals, such as herbicides, fungicides, and insecticides, contain chlorine and are utilized to increase yields and reduce losses caused by pests. *Id.*

27. *Id.* These characteristics include durability, weight reduction, fire retardance, and water insolubility. *Id.*; *see infra* notes 33-38 and accompanying text.

28. A facilitator/catalyst is a chemical that can increase the rate of a reaction while not being consumed in the reaction.

29. Werezak, *supra* note 14, at 34. Nearly 85% of all pharmaceuticals are based on chlorine chemistry, even though less than 1% of all the chlorine produced is used in pharmaceutical manufacturing. Only 20% of the pharmaceuticals dependent on chlorine actually contain chlorine as an active ingredient. *Id.*

In addition, chlorine-based catalysts are used to produce polyethylene and polypropylene resins, which are used to make carpeting, rope, film, packaging, appliances, and automobiles. Chlorine is used to manufacture other plastics which do not contain chlorine, such as polycarbonate and fluoropolymer, which are used to make compact discs and bulletproof glass. The manufacture of all silicone products depends on chlorine chemistry, as well as the manufacture of propylene oxide, which is used in food additives and polyurethanes. *Id.* at 35.

30. THORNTON, THE PRODUCT IS THE POISON, *supra* note 14, at 7; *see also* James A. Moore, *Halogenated Hydrocarbon, in* 8 MCGRAW-HILL ENCYCLOPEDIA, *supra* note 13, at 300, 300-04 (discussing various organohalides, including some organochlorines). Fungi, algae and certain plants produce several organochlorines naturally. However, these naturally occurring organochorines are usually produced in small amounts, and they are found adjacent to or in the cells that produce them. THORNTON, THE BREAST CANCER WARNING, *supra* note 17, at 14 (citing Gordon Gribble, *Naturally Occurring Organohalogen Compounds: A Survey*, 55 J. NAT. PRODUCTS 1353-95 (1992)); Thomas Muir et al., *Case Study: Application of a Virtual Elimination Strategy to an Industrial Feedstock Chemical—Chlorine, in* 2 A STRATEGY FOR VIRTUAL ELIMINATION OF PERSISTENT TOXIC SUBSTANCES 47, 51 (1993) (citing A.A. Horton & Steven Fairhurst, *Lipid Peroxidation and Mechanisms in Toxicity, in* 18 CRITICAL REVIEWS IN TOXICOLOGY 27-28 (1987); Timothy P. Ryan & Steven D. Aust, *The Role of Iron in Oxygen-Mediated Toxicities, in* 22 CRITICAL REVIEWS IN TOXICOLOGY 119-41 (1992)).

chlorine's multiple applications, "most . . . elemental chlorine is eventually incorporated into organochlorines,"[31] either intentionally or unintentionally. Over 11,000 different organochlorines are produced for use by industries, but many more are created as unintended by-products of processes that involve chlorine.[32]

Most chlorinated organics are very stable, and therefore, are useful for products that require durability. The addition of a chlorine atom to a hydrocarbon forms an "impenetrable screen" which protects the molecule from physical, biological, and chemical breakdown.[33] As a result, a persistent compound is created.[34] The

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Several naturally occurring organochlorines are produced for their toxicity, serving as chemical defenses, antibiotics, and natural pesticides. NEIDLEMAN & GEIGERT, *supra* note 13, at 121-27; *see also* JAAKKO PAASIVIRTA, CHEMICAL ECOTOXICOLOGY 127 (1991) (stating that "[s]ome natural . . . chlorine compounds are potent biocides"); Muir et al., *supra*, at 51 (citing Gribble, *supra*, at 1353-95). Prior to the existence of anthropogenic chlorinated organics, the combined activities of plants, animals, and microbes maintained the amount of organohalides on the earth, because biosynthesis and biodegradation were in equilibrium. NEIDLEMAN & GEIGERT, *supra* note 13, at 156. However, "because of man's activity, a host of haologentated compounds . . . have been thrust into the natural ecosystem." *Id.; see also* THORNTON, THE PRODUCT IS THE POISON, *supra* note 14, at 7 (stating that the production of natural organochorines is "delicately regulated by metabolic and ecological balances").

Chloromethane (methylchloride), the simplest organochlorine, is the only organochlorine which occurs naturally in large amounts. Fungi and marine microorganisms produce between four and five million tons per year. THORNTON, THE PRODUCT IS THE POISON, *supra* note 14, at 7 (citing SYRACUSE RESEARCH CORP., TOXICOLOGICAL PROFILE FOR CHLOROMETHANE (1989)); Muir et al., *supra*, at 51 (citing James E. Lovelock & Lynn Margulis, *Atmospheric Homeostais By and For the Biosphere: The Gaia Hypothesis, in* 26 TELLUS 2-9 (1974)). In 1986, the U.S. alone produced almost 13 million tons of organochlorines. *Id.* (citing U.S. GOV'T PRINTING OFFICE, SYNTHETIC ORGANIC CHEMICALS: UNITED STATES PRODUCTION AND USE (1986)); *see also* NEIDLEMAN & GEIGERT, *supra* note 13, at 156-58; PAASIVIRTA, *supra*, at 127 (pointing out that "all known significant environmental toxicants among organohalogen compounds are anthropogenic"); Cicerone, *supra* note 13, at 299 ("While there is at least one atmospherically significant naturally occurring organohalogen, methyl chloride (CH_3Cl), much of the atmospheric burden is anthropogenic.").

No organochlorines are known to be found naturally in the tissues of mammals, terrestrial vertebrates, or humans. NEIDLEMAN & GEIGERT, *supra*, note 13, at 34; THORNTON, THE BREAST CANCER WARNING, *supra* note 17, at 14 (citing SCIENCE ADVISORY BD., REPORT TO THE INTERNATIONAL JOINT COMMISSION (1989)); THORNTON, THE PRODUCT IS THE POISON, *supra* note 14, at 7 (citing Jack Vallentyne, Testimony and Submission Before the Alberta-Pacific Environmental Impact Assessment Review Board (Dec. 1, 1989)).

31. THORNTON, THE PRODUCT IS THE POISON, *supra* note 14, at 8.

32. Jim Stiak, *The Trouble With Chlorine*, BUZZWORM, Nov.-Dec. 1992, at 22, 22; *see also* NEIDLEMAN & GEIGERT, *supra* note 13, at 156. In the U.S., about 70% of the chlorine produced is used to manufacture organochlorine products. The other 30% is used directly in its elemental form in processes which tend to form organochlorines as by-products. THORNTON, THE PRODUCT IS THE POISON, *supra* note 14, at 8.

33. Timothy Eder, *Chlorine & the IJC's Virtual Elimination Task Force*, GREAT LAKES UNITED, Fall 1993, at 3; Muir et al., *supra* note 30, at 50.

34. Eder, *supra* note 33, at 3; Muir et al., *supra* note 30, at 50. The compound becomes persistent because the chlorine-carbon bond is very strong, requiring large amounts of en-

more chlorine atoms attached to a hydrocarbon, the more protection there is against breakdown.[35] Chlorinated organics also tend to be fire resistant, which makes them useful as flame retardants and extinguishers.[36] In addition, many chlorinated organics are much more soluble in fats than in water.[37] Due to this high "lipophilicity" (fat solubility) and water insolubility, these substances make excellent solvents and degreasers.[38]

B. *Environmental and Health Effects of Chlorine*

The very characteristics that make chlorine and chlorinated organics useful in so many products and applications also make them dangerous to the environment. Many chlorine-based processes produce undesirable, unintended, and unknown organochlorine by-products due to chlorine's tendency to react and combine with other compounds.[39] Chlorine's high electron affinity stabilizes toxic organochlorines, creating persistent toxic substances that do not readily break down in the environment.[40] Chlo-

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ergy to break it. THORNTON, THE PRODUCT IS THE POISON, *supra* note 14, at 8. However, these compounds are not necessarily *permanent*, as "[m]any naturally occurring microorganisms have been isolated that degrade halogenated compounds to some degree." NEIDLEMAN & GEIGERT, *supra* note 13, at 158. For example, mixed cultures of microbes have been found to successfully degrade PCBs. *Id.* at 158-59.

35. Eder, *supra* note 33, at 3; Muir et al., *supra* note 30, at 50.

36. Eder, *supra* note 33, at 3; Muir et al., *supra* note 30, at 50.

37. Robert E. Menzer & Judd O. Nelson, *Water and Soil Pollutants*, *in* CASARETT & DOULL'S TOXICOLOGY: THE BASIC SCIENCE OF POISONS 825, 831 (Curtis D. Klaassen et al. eds., 3d ed. 1986) [hereinafter CASARETT & DOULL].

38. Eder, *supra* note 33, at 3; Muir et al., *supra* note 30, at 50.

39. Eder, *supra* note 33, at 3; Muir et al., *supra* note 30, at 50.

40. Eder, *supra* note 33, at 3; Muir et al., *supra* note 30, at 50; *see also* Amato, *supra* note 3, at 152. Under the 1978 Great Lakes Water Quality Agreement, a persistent toxic substance is defined as "[a]ny toxic substance with a half-life in water of greater than eight weeks." Great Lakes Water Quality Agreement, Nov. 22, 1978, U.S.-Can., annex 12(1)(a), 30 U.S.T. 1383 [hereinafter 1978 Great Lakes Water Quality Agreement]; *see infra* part III.C. "Toxic substance" is defined as one "which can cause death, disease, behavioural abnormalities, cancer, genetic mutations, physiological or reproductive malfunctions or physical deformities in any organism or its offspring, or which can become poisonous after concentration in the food chain, or in combination with other substances." *Id.* art. I(v). "Half-life" is defined as "the time required for the concentration of a substance to diminish to one-half of its original value in a lake or water body." *Id.* at annex 12(1)(b). The terms "toxic substance" and "persistent toxic substance" are not interchangeable. While a persistent toxic substance always exhibits the characteristics of a toxic substance, the reverse is not the case. 1 VIRTUAL ELIMINATION TASK FORCE, A STRATEGY FOR VIRTUAL ELIMINATION OF PERSISTENT TOXIC SUBSTANCES 9 (1993) [hereinafter VETF, A STRATEGY].

Classifying a chemical as a "toxic" or "persistent toxic" will determine whether it is subject to release controls or virtual elimination, respectively. *Synthesis Of Our Knowledge And Recommendations On Action For Policy, Education, And Research*, *in* HUMAN HEALTH RISKS FROM CHEMICAL EXPOSURE: THE GREAT LAKES ECOSYSTEM 229, 240 (R. Warren Flint &

rine's high lipophilicity allows chlorinated organics to be stored in oily locations, like the fatty tissues found in fish and mammals.[41] When combined with these compounds' persistence, high lipophilicity enables organochlorines to accumulate in the food-chain, where they build up in increasing concentrations.[42] This is known as bioaccumulation.[43] Examples of organochlorines that are known to be harmful to the environment include chlorofluorocarbons (CFCs),[44] dioxins,[45] DDT,[46] and PCBs.[47]

John Vena eds., 1991).

41. Amato, *supra* note 3, at 153. Because organochlorines are more soluble in fat than in water, they tend to migrate from a water body into the fatty tissues of fish, instead of remaining dissolved in the ambient water body. THORNTON, THE PRODUCT IS THE POISON, *supra* note 14, at 10. For example, TCDD (2,3,7,8-tetrachlorodibenzo-p-dioxin, or dioxin) has been found in fish tissues at concentrations up to 159,000 times greater than the concentrations found in the water where the fish swim. *Id.*

42. Amato, *supra* note 3, at 153; Eder, *supra* note 33, at 3; Muir et al., *supra* note 30, at 50. Organochlorines can reach toxic levels in the foodchain even if organochlorines in the ambient environment have not reached toxic levels. PAASIVIRTA, *supra* note 30, at 36; *see also* Menzer & Nelson, *supra* note 37, at 831 (stating that "high lipid solubility combined with chemical and biological stability can lead to biologic magnification of pesticide residues"); Sheldon D. Murphy, *Toxic Effects of Pesticides, in* CASARETT & DOULL, *supra* note 37, at 519, 521-22.

43. Menzer & Nelson, *supra* note 37, at 832. Those species which are at the top of the food chain, which include humans, are the ones who have the greatest exposure to bioaccumulative organochlorines. *Id.*; *see also* THORNTON, THE PRODUCT IS THE POISON, *supra* note 14, at 10.

44. Chlorofluorocarbons are used in refrigerants, air conditioning, industrial solvents, aerosols, fire-fighting chemicals, and lubricants. *Ozone Depletion: Safe CFC Alternatives Await Production; U.S. Firms Ignoring Them, Greenpeace Says*, 16 Chem. Reg. Rep. (BNA) 2319 (Feb. 26, 1993) [hereinafter *Ozone Depletion*]; *see also* Amato, *supra* note 3, at 152-53. They are extremely stable and are believed to be ozone-depleting. Gary Taubes, *Stratospheric Chlorine: Blaming It On Nature*, 260 SCI. NEWS 1582, 1582 (1993); *see also* Amato, *supra* note 3, at 153. The phase-out of CFCs is mandated under the Montreal Protocol on Substances That Deplete the Ozone Layer. Hileman, *supra* note 3, at 11. Production of CFCs in the U.S. will be banned as of January 1, 1996. *Ozone Depletion*, *supra*.

45. "Dioxin" is the popular name given to the family of chlorinated aromatic hydrocarbons, also known as polychlorinated dibenzo-*para*-dioxins. Arnold Schecter, *Dioxin, in* 5 MCGRAW-HILL ENCYCLOPEDIA, *supra* note 13, at 312, 312. Dioxins are unintended by-products created when chlorine and organic matter are subjected to intense heat. *Toxic Substances: Epidemiological Data on Dioxin Risk Seen as Consistent with Animal Studies*, 24 Env't Rep. (BNA) 890 (Sept. 17, 1993). For example, they are emitted as a result of the incineration of chlorine-containing wastes such as PVC, the bleaching of wood pulp for paper production, metal smelting, and herbicide production. *Id.* Dioxins are known to bioaccumulate as they move up the food chain, and to cause adverse health effects on humans (they are carcinogenic and they influence cellular DNA). Kate Charlesworth, *Chlorine and Its Pals*, NEW SCIENTIST, June 12, 1993, at 46, 46.

46. DDT (dichloro diphenyl trichloroethane), a chlorine-based insecticide, was banned in 1972 for domestic use in the United States. However, DDT is still manufactured in the U.S. for export to developing countries. BARRY COMMONER, MAKING PEACE WITH THE PLANET 29 (1990). DDT bioaccumulates in the fat cells of living organisms. Murphy, *supra* note 42,

Growing evidence that the accumulation of organochlorines in the environment is associated with adverse health effects on humans and wildlife has resulted in widespread public health concerns.[48] Historically, research has concentrated on the suspected carcinogenicity of these chlorinated compounds.[49] Some researchers believe that the rising rate of breast cancer in industrialized countries may be caused by chlorinated organics.[50] Several cancers

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at 543. Furthermore, DDT is persistent; degradation by biologic systems to non-toxic forms occurs very slowly. *Id.* at 521; *see also* PAASIVIRTA, *supra* note 30, at 36.

Adverse effects on wildlife include acute toxicity, chronic toxicity, reproductive failure, and behavioral changes. Menzer & Nelson, *supra* note 37, at 832. Human exposure to DDT is widespread: "[o]nly one in a hundred U.S. citizens do not carry DDT in their bodies. This includes children who were not even born . . . when the chemical was banned for use in this country." CHEMICAL CONTAMINATION AND ITS VICTIMS: MEDICAL REMEDIES, LEGAL REDRESS, AND PUBLIC POLICY 3 (David W. Schnare & Martin T. Katzman, eds., 1989) [hereinafter CHEMICAL CONTAMINATION].

47. PCBs (polychlorinated biphenyls) were used particularly in electrical equipment (60%), closed power and heat transfer systems (15%), and other miscellaneous uses (25%). PAASIVIRTA, *supra* note 30, at 130; *see also* VETF, A STRATEGY, *supra* note 40, at 33. They were used because of their stability, low flammability and good heat conductivity. *See* Charlesworth, *supra* note 45, at 46; Menzer & Nelson, *supra* note 37, at 840; *see also* Glenn Kuntz, *Polychlorinated Biphenyls, in* 14 MCGRAW-HILL ENCYCLOPEDIA, *supra* note 13, at 138, 138.

In 1979, under the Toxic Substances Control Act of 1976 (TSCA), their use and manufacture was banned in the United States, but massive amounts are still around in products and in the environment. VETF, A STRATEGY, *supra* note 40, at 33-34, 43. PCBs bioaccumulate and are extremely persistent. PAASIVIRTA, *supra* note 30, at 130; Menzer & Nelson, *supra* note 37, at 840; VETF, A STRATEGY, *supra* note 40, at 34. In addition, the incomplete incineration of materials containing PCBs results in the emission of dioxins (they are only destroyed at temperatures above 1200 degrees Celsius). Charlesworth, *supra* note 45, at 46. Adverse effects on wildlife include tumor promotion, estrogenic activity, and immunosuppression. Menzer & Nelson, *supra* note 37, at 840. Furthermore, PCBs are believed to be human carcinogens. Kuntz, *supra*, at 138; *Organochlorine Endocrine Disruptors, in* CHEMICALLY INDUCED ALTERATIONS IN SEXUAL AND FUNCTIONAL DEVELOPMENT: THE WILDLIFE/HUMAN CONNECTION 365, 383-84 (Theo Colborn & Coralie Clement eds., 1992) [hereinafter CHEMICALLY INDUCED ALTERATIONS].

48. Tracey Woodruff et al., *Organochlorine Exposure Estimation in the Study of Cancer Etiology*, 65 ENVTL. RES. 132, 132 (1994); SIXTH BIENNIAL REPORT, *supra* note 9, at 29; SEVENTH BIENNIAL REPORT, *supra* note 6, at 13; *see also* THORNTON, THE BREAST CANCER WARNING, *supra* note 17, at 15; Hileman, *supra* note 3, at 11.

49. *Organochlorine Endocrine Disruptors, in* CHEMICALLY INDUCED ALTERATIONS, *supra* note 47, at 375; Woodruff et al., *supra* note 48, at 133; *see also* Hileman, *supra* note 3, at 15.

50. Mary S. Wolff et al., *Blood Levels of Organochlorine Residues and Risk of Breast Cancer*, 85 J. NAT'L CANCER INST. 648, 648 (1993). The study found that higher blood levels of DDE, a breakdown product of DDT, were present in women with breast cancer. *Id.; see also* THORNTON, THE BREAST CANCER WARNING, *supra* note 17, at 38-43. When exposure to organochlorines declined sharply in Israel between 1976 and 1986 due to a phase-out of organochlorine pesticides, breast cancer mortality rates went down by 8%. *Id.* at 41-42. In other industrialized nations where exposures did not decrease, breast cancer rates rose. *Id.* at 42; Woodruff et al., *supra* note 48, at 132; *see also* Hileman, *supra* note 3, at 16.

are rising at faster rates among farmers, suggesting a direct relationship between exposure to chlorinated pesticides and an increase in cancer rates.[51] In addition, a strong link has been found between chlorinated drinking water and an increased risk of human bladder and rectal cancer.[52]

Evidence that chlorinated organics may be contributing to these increasing incidences of cancer is accompanied by relatively new research indicating that adverse effects on the reproductive system of both humans and wildlife may have broader societal impacts.[53] In 1991, researchers observed alterations in the sexual and functional development of wildlife fetuses that are exposed to a low level of certain organochlorines in the environment.[54] Chlorinated compounds have adverse effects on exposed fetuses due to their ability to mimic female sex hormones.[55] These chemicals, which disrupt the endocrine system, usually have completely different effects on an adult than they do on an embryo.[56] Many of

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51. Hileman, *supra* note 3, at 15-16. The National Cancer Institute speculates that pesticides may cause lymphoma, leukemia, brain cancer, and non-Hodgkin's lymphoma. *Id.* at 16. Studies show a strong link between non-Hodgkin's lymphoma and 2,4-dichlorophenoxy acetic acid (2,4-D), a chlorinated organic herbicide. *Id.* Dogs whose owners use 2,4-D on their lawns have higher cancer rates than dogs who are not exposed to it. *Id.*

52. Robert D. Morris et al., *Chorination, Chlorination By-products, and Cancer: A Meta-analysis*, 82 AM. J. PUB. HEALTH 955, 961-62 (1992). The study indicates that it is the by-products of chlorine's reaction with water contaminants, not the chlorine itself, which are actually carcinogenic. *Id.*; *see also* Kenneth P. Cantor, *Water Chlorination, Mutagenicity, and Cancer Epidemiology*, 84 AM. J. PUB. HEALTH 1211, 1212 (1994) (stating that although "[q]uantitative estimates of cancer risk owing to water chlorination by-products are highly uncertain . . . the available information supports the concern over an elevated carcinogenic risk"); Bette Hileman, *Cancer Risk Found From Water Chlorination*, CHEM. & ENG'G NEWS, July 13, 1992, at 7, 8; Janet Raloff, *Chlorination Products Linked to Cancer*, 143 SCI. NEWS 343, 343 (1993). *But see* Cantor, *supra*, at 1212 (suggesting that the meta-analysis which attemped to increase precision by combining studies was premature).

53. Robert L. Dixon, *Toxic Responses of the Reproductive System*, *in* CASARETT & DOULL, *supra* note 37, at 432, 432; *see* Hileman, *supra* note 3, at 14.

54. *Organochlorine Endocrine Disruptors*, *in* CHEMICALLY INDUCED ALTERATIONS, *supra* note 47, at 375; *see also* Hileman, *supra* note 3, at 14. The scientists concluded that:

> Many wildlife populations are already affected by these compounds. The impacts include thyroid dysfunction in birds and fish; decreased fertility in birds, fish, shellfish, and mammals; decreased hatching success in birds, fish, and turtles; gross birth deformities in birds, fish, and turtles; metabolic abnormalities in birds, fish, and mammals; behavioral abnormalities in birds; demasculinization and feminization of male fish, birds, and mammals; defeminization and masculinization of female fish and birds; and compromised immune systems in birds and mammals.

Organochlorine Endocrine Disruptors, *in* CHEMICALLY INDUCED ALTERATIONS, *supra* note 47, at 2.

55. Hileman, *supra* note 3, at 15.

56. *Organochlorine Endocrine Disruptors*, *in* CHEMICALLY INDUCED ALTERATIONS, *supra* note 47, at 2, 366; *see also* Hileman, *supra* note 3, at 14. While exposure to large doses may have little effect on an adult, very low dose exposure during fetal development can be very

these effects do not become apparent until the offspring reaches maturity.[57] Although it is not universally accepted that analogies can be drawn between adverse effects on wildlife and human populations, "[i]t is apparent that awareness of environmental toxicological impacts in Great Lakes Basin wildlife [has] useful predictive value."[58] This rationale is supported by human epidemiological studies.[59] For example, one study found that children prenatally exposed to PCBs have had mild, yet persistent, behavioral problems and higher activity levels.[60]

This growing body of evidence, that chlorinated organics have the potential to cause widespread harm to the human population and its future generations, has culminated in a widespread move-

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damaging. The timing of exposure is the critical factor. *Organochlorine Endocrine Disruptors, in* CHEMICALLY INDUCED ALTERATIONS, *supra* note 47, at 2, 366, 375.

DES (diethylstilbestrol), a drug taken by women to prevent miscarriage, is one example of an endocrine disrupter that is known to have adverse health effects on the offspring of humans. It is suspected that other synthetic chemicals, such as organochlorines, that interfere with the natural hormones would have similar effects. CHEMICALLY INDUCED ALTERATIONS, *supra* note 47, at 2.

57. *Organochlorine Endocrine Disruptors, in* CHEMICALLY INDUCED ALTERATIONS, *supra* note 47, at 388; *see also* Hileman, *supra* note 3, at 14. For example, a high percentage of women whose mothers were exposed to DES during pregnancy developed vaginal cancer or abnormalties upon reaching adulthood. Jeanne M. Manson, *Teratogens, in* CASARETT & DOULL, *supra* note 37, at 195, 198-99; COMMONER, *supra* note 46, at 65.

58. *Environmental and Wildlife Toxicology of Exposure to Toxic Chemicals, in* HUMAN HEALTH RISKS, *supra* note 40, at 61, 63. Evidence that toxics can cause adverse effects in fish and wildlife should be considered because biological similarities at the cellular level occur in all vertebrates. *Id.* at 61-62; *see also Synthesis of our Knowledge, in* HUMAN HEALTH RISKS, *supra* note 40, at 231. Because the basic processes of fetal development are uniform in all mammals, including humans, the "chemicals that have adverse effects on reproductive developments in [wildlife] should be considered potential human reproductive toxicants as well." Hileman, *supra* note 3, at 14.

59. Epidemiology is "the study of the distribution and the determinants of diseases, injuries, or abnormal physiological states in human populations." *Epidemiology of Exposure to Toxic Chemicals, in* HUMAN HEALTH RISKS, *supra* note 40, at 93, 93. Since the occurrence of diseases and their determinants differ among subgroups of human populations, the variance can be used to elucidate causal factors. *Id.* Epidemiological studies are the only studies that can establish causal associations between exposures and disease in humans. *Id.* at 93-94.

60. Yung-Cheng J. Chen et al., *A 6-year Follow-up of Behavior and Activity Disorders in the Taiwan Yu-cheng Children,* 84 AM. J. PUB. HEALTH 415, 417 (1994); *see also* International Joint Comm'n, Seventh Biennial Report On the Great Lakes Water Quality: Supplemental Information 1 (1994) (unpublished release on file with author) (stating that "[m]ale children born to mothers exposed to PCB-contaminated cooking oil in Taiwan . . . were found to have significantly shorter penises than children in a matched control group" and that "exposed children consistently scored lower on cognitive ability tests"); *Organochlorine Endocrine Disruptors, in* CHEMICALLY INDUCED ALTERATIONS, *supra* note 47, at 385 (discussing Michigan study in which children born to mothers exposed to PCBs had behavioral, cognitive, and motor problems at birth, as well as up to several years old).

ment to phase out the use of chlorine in the Great Lakes Basin, an ecosystem whose "health" has come to be questioned.[61]

II. The Great Lakes Basin[62]

> There are two ironies about the Great Lakes: first, that the people who have become most dependent upon them have misused them the most; and second, that despite our abuse of them the lakes remain as wondrous as they must have seemed to Melville and indeed to Etienne Brule, the first European to see them, when he stood on the shores of Georgian Bay in 1610.[63]

The Great Lakes form the world's largest body of fresh water, holding nearly twenty percent of the fresh water found on Earth.[64] In addition, these "sweet water seas," as early explorers described them,[65] contain between ninety and ninety-five percent of the United States' fresh surface water.[66] More than forty million people live in the basin,[67] and more than twenty-three million depend on the lakes for drinking water.[68] This region is the home of many industrialized and urbanized centers, with one-fifth of American and one-half of Canadian industry located on the Great Lakes.[69]

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61. James B. Whitaker, *Launching the Great Lakes Initiative*, WATER ENV'T & TECH., June 1993, at 41, 41; *see generally* CHARLES STEWART MOTT FOUND., THE GREAT LAKES: A STEWARDSHIP LEFT UNTENDED (1988) [hereinafter A STEWARDSHIP LEFT UNTENDED].

62. The Great Lakes Basin's waters include the five lakes (Lake Erie, Lake Michigan, Lake Ontario, Lake Superior, and Lake Huron) and four major connecting channels (Detroit River, St. Clair River, St. Mary's River, and Niagara River), with most of the outflow eventually entering the Gulf of St. Lawrence. Proposed Water Quality Guidance for the Great Lakes System, 58 Fed. Reg. 20,802 (1993) (to be codified at 40 C.F.R. pts. 122, 123, 131, and 132) (proposed Apr. 16, 1993) [hereinafter Proposed Water Quality Guidance]; NATIONAL RESEARCH COUNCIL OF THE U.S. AND THE ROYAL SOC'Y OF CAN., THE GREAT LAKES WATER QUALITY AGREEMENT: AN EVOLVING INSTRUMENT FOR ECOSYSTEM MANAGEMENT 2 (1985) [hereinafter NATIONAL RESEARCH COUNCIL].

63. THE ENDURING GREAT LAKES at x (John Rousmaniere ed., 1979).

64. A STEWARDSHIP LEFT UNTENDED, *supra* note 61, at 8; Carl A. Esterhay, *Restoring the Water Quality of the Great Lakes: The Joint Commitment of Canada and the United States*, 4 CAN.-U.S. L.J. 208, 209 (1981); Whitaker, *supra* note 61, at 41.

65. David Moberg, *Sunset For Chlorine?*, E MAG., Aug. 1993, at 26, 26 [hereinafter Moberg, *Sunset For Chlorine?*]; *see* Phil Busse, *The Great Lakes: Sweet Seas or Inland Sewers?*, SIERRA, Mar.-Apr. 1993, at 78, 79.

66. Proposed Water Quality Guidance, *supra* note 62, at I(A)(1); A STEWARDSHIP LEFT UNTENDED, *supra* note 61, at 8; Whitaker, *supra* note 61, at 41.

67. Proposed Water Quality Guidance, *supra* note 62, at I(A)(1); A STEWARDSHIP LEFT UNTENDED, *supra* note 61, at 8.

68. Proposed Water Quality Guidance, *supra* note 62, at I(A)(1); Esterhay, *supra* note 64, at 209 n.11; Whitaker, *supra* note 61, at 41.

69. A STEWARDSHIP LEFT UNTENDED, *supra* note 61, at 9; Esterhay, *supra* note 64, at 209; *see* R. Warren Flint, *Background on Toxic Chemicals in the Great Lakes*, *in* HUMAN

The lakes within this basin have a uniquely long water retention time,[70] which is a relative indication of the time required to flush out contaminants.[71] This long retention period allows persistent toxic substances to build up continuously without being flushed out of the Great Lakes. Therefore, these compounds influence the lakes more significantly than they would influence a riverine system, which flushes contaminants more readily.[72] As a result, toxic contamination threatens the Great Lakes environment and the health of the aquatic life, wildlife and humans that depend on the lakes.[73]

Each year, more than twenty billion pounds of toxics are released into the Great Lakes.[74] Of the 362 chemicals confirmed to be present in the water, sediment and/or biota of the Great Lakes Basin ecosystem in 1986, approximately half of these substances were anthropogenic, chlorinated organic substances.[75] In addition, many unidentified chlorinated organics are entering the ecosystem.[76] In 1985, the IJC's Great Lakes Water Quality Board identified eleven critical pollutants that bioaccumulate in living organisms, are persistent, cause adverse health effects on humans and the environment, and have been extensively, but unsuccessfully, regulated.[77] Of these eleven clearly threatening contaminants, eight

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HEALTH RISKS, *supra* note 40, at 1, 1.

70. NATIONAL RESEARCH COUNCIL, *supra* note 62, at 2; *see* Proposed Water Quality Guidance, *supra* note 62, at I(A)(2). Water retention time, or water renewal time, is the average time it takes for a molecule of water to exit the water system. *Id.*

71. NATIONAL RESEARCH COUNCIL, *supra* note 62, at 2. In fact, two of the lakes, Michigan and Superior, have a water retention time of 100 years or more. *Id.* The two lower lakes, Erie and Ontario, have a retention period that is much shorter. However, because their intake comes primarily from the upper lakes, the lower lakes will experience contamination if the upper lakes are contaminated. *Id.*

72. Proposed Water Quality Guidance, *supra* note 62, at I(A)(2); *see* Robert J. Sugarman, *Controlling Toxics on the Great Lakes: United States-Canadian Toxic Problems Control Program,* 12 SYRACUSE J. INT'L L. & COM. 299, 304-05 (1985).

73. Proposed Water Quality Guidance, *supra* note 62, at I(A)(4)(b). The Great Lakes "are extremely vulnerable to persistent pollutants that accumulate in the tissues of fish and wildlife. As a result, the ecosystem's wildlife have reproductive defects and tumors. Human health is threatened through consumption of fish and shellfish [from the basin]." Janice Long, *Ecosystem Approach to Cleaning Up Great Lakes Basin Proposed,* CHEM. & ENG'G NEWS, Apr. 12, 1993, at 22, 22 (quoting Carol M. Browner, EPA Administrator).

74. Busse, *supra* note 65, at 78-79.

75. SIXTH BIENNIAL REPORT, *supra* note 9, at 28-29.

76. *Id.* at 29.

77. GREAT LAKES WATER QUALITY BD., 1985 REPORT ON GREAT LAKES WATER QUALITY 17-18 (1985) [hereinafter GLWQB 1985 REPORT]. The Board concluded that these 11 pollutants are "known to be persistent and highly toxic, and known to be present in the Great Lakes ecosystem at levels of concern." THORNTON, THE PRODUCT IS THE POISON, *supra* note 14, at 21. These chemicals were given priority for regulations to reduce contaminant levels. *Id.*

were organochlorines.[78]

Humans living in and using the Great Lakes Basin are involuntarily exposed to many of these chemicals.[79] Exposure may occur through drinking water taken from the lakes, air inhalation, consumption of food originating in the basin, or contact through recreational use.[80] Currently, more than 164 fish advisories are in effect, warning people of the risks associated with eating fish from the Great Lakes.[81]

These unique qualities of the Great Lakes system, along with the history of environmental degradation within the basin,[82] have

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78. GLWQB 1985 REPORT, *supra* note 77, at 18. These eight organochlorines are total polychlorinated biphenyls (PCBs), DDT and metabolites, Dieldrin, 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD or dioxin), Hexachloro-benzene, Toxaphene, Mirex, and 2,3,7,8-tetrachlorodibenzofuran (2,3,7,8-TCDF). *Id.*

79. In 1985, a study by the United States National Research Council and the Royal Society of Canada found "substantial evidence that the human population living in the Great Lakes Basin is exposed to and accumulates appreciably more toxic chemical burden than people in other large regions of North America for which data are available." Flint, *supra* note 69, at 9.

80. NATIONAL RESEARCH COUNCIL, *supra* note 62, at 55. Seventy-five percent of the shoreline is unsafe for swimming or fishing. Busse, *supra* note 65, at 78-79; *see also Epidemiology of Exposure to Toxic Chemicals, in* HUMAN HEALTH RISKS, *supra* note 40, at 94 (stating that the "most significant human exposure to chemicals in the Great Lakes Basin ecosystem is likely to be through the ingestion of sport fish caught from the Great Lakes").

81. Proposed Water Quality Guidance, *supra* note 62, at II(G)(11); *see* Long, *supra* note 73, at 22; Whitaker, *supra* note 61, at 41.

PCB contamination in the Great Lakes fish may cause 38,000 cancer cases annually. Bette Hileman, *Cleanup of Great Lakes Toxic Sediments Urged*, CHEM. & ENG'G NEWS, June 28, 1993, at 8, 8. In addition, 14 animal species that depend on fish "are suffering severe health problems." Hileman, *supra* note 3, at 15. "After falling from a peak in 1972, DDT levels have begun to rise again in Great Lakes fish—most likely as a result of long-range atmospheric transport of the chemical." *Id.* at 13.

82. The vast tracts of timber located in the basin, which aided in the early settlement of the Great Lakes, were rapidly depleted. Beginning around 1820, large scale commercial fishing expanded rapidly. Overfishing, along with pollution, destruction of habitat, and the introduction of exotic species, has led to an overall decline in the value of the Great Lakes Fishery. Proposed Water Quality Guidance, *supra* note 62, at I(A)(3).

Agricultural practices, such as stripping the land, altered the flow of waterways and changed flood plains. In addition, the introduction of synthetic fertilizers, nutrient-rich organic pollutants (human wastes), and phosphate detergents caused widespread eutrophication. *Id.*

Industrialization followed, accompanied by rapid urbanization, which added to the overall degradation of the waters. Virtually untreated wastes were dumped into the lakes, resulting in fatal epidemics of waterborne diseases. *Id*; *see also* Esterhay, *supra* note 64, at 209 ("This deterioration and pollution was not merely a product of modern technology, but also the result of historical and constant abuse of the Great Lakes without proper, concerted management."); Moberg, *Sunset for Chlorine?*, *supra* note 65, at 27 ("The Great Lakes [have] served as an industrial toilet, but most people assumed they were large enough to handle the flush."); *see generally* WILLIAM ASHWORTH, THE LATE, GREAT LAKES: AN ENVIRONMENTAL HISTORY (1986).

brought the war on chlorine increasing support from the citizens and communities who call the Great Lakes their home.[83]

III. United States-Canadian Pollution Control Efforts

The anti-chlorine campaign is prevalent in the Great Lakes Basin for many reasons: (1) the basin's unique physical and aesthetic characteristics; (2) the large populations living within the basin; (3) the high concentration of industry located in the basin; and (4) the rapid environmental degradation of the basin's unstable ecosystem. Perhaps more importantly, unique international agreements support the campaign's goal: the elimination of persistent chlorinated organics from the Great Lakes ecosystem.

A. *The Boundary Waters Treaty and the Establishment of the International Joint Commission*

The Boundary Waters Treaty of 1909 between Canada and the United States—the impetus for various international agreements—is significant in two ways.[84] First, the Treaty imposed an important legal obligation on the two countries to control water pollution.[85] Second, the Treaty established the International Joint Commission[86] (IJC), which has become the "environmental watchdog" for the U.S. and Canada.[87] Each government has the author-

83. A group of scientific and technical experts has unanimously concluded that "[p]ersistent toxic chemicals . . . , due to their nature (ability to cross the placenta, to bioaccumulate, to occur as mixtures, possessing long half-lives and toxic properties), pose threats to the health of people who live in the Great Lakes Basin." *Synthesis of Our Knowledge*, *in* Human Health Risks, *supra* note 40, at 231.

84. Treaty Relating to Boundary Waters Between the United States and Canada, Jan. 11, 1909, U.S.-Gr. Brit., 36 Stat. 2448 [hereinafter Boundary Waters Treaty]. Because pollution was not a major concern at this time, the primary purpose of the Boundary Waters Treaty was to resolve disputes of water utilization and navigation between the two countries. "This treaty was the most important instrument ever concluded between the United States and Canada in terms of the Great Lakes system." Esterhay, *supra* note 64, at 211.

85. Article IV of the Treaty prohibited water contamination, stating: "[i]t is further agreed that the waters herein defined as boundary waters and water flowing across the boundary shall not be polluted on either side to the injury of health or property on the other." Boundary Waters Treaty, *supra* note 84, art. IV.

This obligation has led to complex bilateral pollution agreements, in particular the 1972 and 1978 Great Lakes Water Quality Agreements. Esterhay, *supra* note 64, at 211-12; Edith Brown Weiss, *New Directions for the Great Lakes Water Quality Agreement: A Commentary*, 65 Chi.-Kent L. Rev. 375, 375 (1989); *see infra* notes 92-101 and accompanying text.

86. Boundary Waters Treaty, *supra* note 84, art. VII.

87. Esterhay, *supra* note 64, at 213; Hileman, *supra* note 3, at 11. The IJC is a six-person binational commission, with three members appointed by the President of the United States and three members appointed by the Governor General in Council of Canada. Esterhay, *supra* note 64, at 213. These Commissioners do not represent the separate inter-

ity to refer specific problems to the IJC for investigation.[88] When this referral occurs, the Commission must develop a report of conclusions and recommendations for the two federal governments, which can either adopt or reject the Commission's recommendations.[89] The IJC functions in an advisory manner only, since the Treaty provided no enforcement mechanisms.[90] However, the U.S. and Canada "have increasingly invoked the reference procedure, and have allowed the IJC to become more active in policy matters."[91]

B. *The Great Lakes Water Quality Agreement of 1972*

The IJC plays a vital role in curtailing pollution in the Great Lakes by investigating problems and suggesting potential solutions.[92] In fact, it was the IJC's 1970 report on water pollution in

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ests of their countries, but act as a single body to advise the two governments *jointly* on matters of common interest. John R. Vallentyne, The Rationale for Sunsetting Industrially Produced Chlorine 2-3 (unpublished manuscript on file with author). The IJC was given absolute jurisdiction over cases involving uses, obstructions, or diversions of boundary waters. Boundary Waters Treaty, *supra* note 84, art. III, IV; *see* Esterhay, *supra* note 64, at 213; Jennifer Woodward, Note, *International Pollution Control: The United States and Canada—The International Joint Commission*, 9 N.Y.L. SCH. J. INT'L & COMP. L. 325, 328 (1988).

88. Boundary Waters Treaty, *supra* note 84, art. IX. When a reference is received, the IJC appoints a Board to conduct studies. After these studies are published, the IJC will hold public hearings in which interested parties may participate. Esterhay, *supra* note 64, at 214.

89. Esterhay, *supra* note 64, at 214.

90. Joel A. Gallob, *Birth of the North American Transboundary Environmental Plaintiff: Transboundary Pollution and the 1979 Draft Treaty for Equal Access and Remedy*, 15 HARV. ENVTL. L. REV. 85, 113-14 (1991). The IJC's "recommendations on pollution matters are not binding, in contrast to its power over water diversions." *Id.* at 113; *see also* Esterhay, *supra* note 64, at 215; Woodward, *supra* note 87, at 328. The IJC's authority to investigate and make recommendations on water pollution control in the Great Lakes is derived from Article IX in conjunction with Article IV's prohibition on pollution of the boundary waters. Woodward, *supra* note 87, at 328.

91. Esterhay, *supra* note 64, at 215.

92. Woodward, *supra* note 87, at 338; *see also* Esterhay, *supra* note 64, at 215 ("[T]he reference procedure under Article IX of the Boundary Waters Treaty has evolved into the major mechanism of regulating the . . . Great Lakes System.").

The U.S. and Canada requested that the IJC investigate water pollution in the Great Lakes in 1912. In 1919, the IJC reported that water quality problems were very serious and could only be resolved by further pollution controls. Each nation subsequently implemented water pollution control programs. Proposed Water Quality Guidance, *supra* note 62, at I(B)(1)(a).

In 1946, both governments authorized the IJC to investigate pollution in the connecting channels. Their report, issued in 1950, concluded that the boundary waters were being polluted in violation of Article IV of the Treaty by continuing discharge of domestic sewage and industrial waste. Esterhay, *supra* note 64, at 217; Woodward, *supra* note 87, at 330-31. The IJC recommended specific water quality objectives and asked the governments to allow the lower Great Lakes[93] that led to the Great Lakes Water Quality Agreement of 1972.[94] This agreement reaffirmed the countries' obligations under the 1909 Treaty to refrain from polluting the Great Lakes.[95] In addition, the agreement expanded the powers and re-

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the IJC to "establish and maintain continuing supervision over boundary waters pollution through boards of control." Woodward, *supra* note 87, at 331 (quoting INTERNATIONAL JOINT COMM'N, REPORT OF THE INTERNATIONAL JOINT COMMISSION, UNITED STATES AND CANADA, ON THE POLLUTION OF BOUNDARY WATERS 9-10 (1950)). These recommendations were adopted by the U.S. and Canadian governments. *Id.*; Esterhay, *supra* note 64, at 218; *see also* Proposed Water Quality Guidance, *supra* note 62, at I(B)(1)(a).

93. INTERNATIONAL JOINT COMM'N, FINAL REPORT ON POLLUTION IN LAKE ERIE, LAKE ONTARIO AND THE INTERNATIONAL SECTION OF THE ST. LAWRENCE RIVER (1970) [hereinafter IJC, 1970 FINAL REPORT]. The final report stated that the present contamination of the Lower Great Lakes "constituted a health hazard to the people and property off both shores, and that water quality deterioration would continue in the absence of quick, responsive action." Esterhay, *supra* note 64, at 219. It identified excessive phosphorous loadings as the principal cause of eutrophication and proposed basin-wide efforts to reduce these loadings. Proposed Water Quality Guidance, *supra* note 62, at I(B)(1)(b). In addition, the report set forth water quality objectives and recommended that the nations recognize them as minimum standards for water quality in their pollution control programs. Esterhay, *supra* note 64, at 219; Woodward, *supra* note 87, at 334.

94. Great Lakes Water Quality Agreement, April 15, 1972, U.S.-Can., 23 U.S.T. 301 [hereinafter 1972 Great Lakes Water Quality Agreement]. Under this Agreement, both governments established the common water quality objectives which the IJC recommended in its 1970 report. Esterhay, *supra* note 64, at 220.

95. Esterhay, *supra* note 64, at 220 (stating that the Agreement was an "unprecedented manifestation of joint cooperation in the area of international environmental matters").

At this time, the primary concern was with eutrophication and limiting the amount of phosphorous discharged into the lakes. Proposed Water Quality Guidance, *supra* note 62, at I(B)(1)(b). Eutrophication is a biological process resulting from an increase of nutrients in a body of water. Eutrophic lakes are rich in dissolved plant nutrients and have heavy growth in aquatic vegetation. Due to the decomposition of this organic matter, the waters become deficient in oxygen. Increased population, industrialization, agricultural practices, and the use of phosphorous-based detergents introduced large amounts of man-made nutrients, increasing the rate of eutrophication in the Great Lakes. IJC, 1970 FINAL REPORT, *supra* note 93, at 35-36; *see* Woodward, *supra* note 87, at 333 n.64.

The 1972 Agreement set up programs to regulate this pollution. Esterhay, *supra* note 64, at 221. As a result of the clean-up programs under the 1972 Agreement, the eutrophication of the Great Lakes was reduced and, between 1972 and 1978, dramatic improvement in the condition of the Great Lakes was apparent. Proposed Water Quality Guidance, *supra* note 62, at I(B)(1)(b); Sugarman, *supra* note 72, at 300 n.80. It was not until the 1978 Agreement that an increasing emphasis was placed on controlling toxic pollutants in the Great Lakes ecosystem.

However, certain chlorinated organics, such as PCBs, had already been determined to be causing adverse effects in the Great Lakes. "[B]y 1967, PCB's had become an environmental contaminant present in Lake Michigan sediments, water and fish posing a threat to the health of man and to the stability of the entire ecosystem." Sugarman, *supra* note 72, at 300. The adverse effects of PCBs were addressed through the Toxic Substances Control Act of 1976, in which Congress directed the EPA to establish regulations for controlling the disposal, marking, manufacture, processing, distribution, and use of PCBs. 15 U.S.C. §§ 2601-2629 (1976).

sponsibilities of the IJC with respect to Great Lakes water quality.[96] However, the ability to implement pollution controls still remained with the United States and Canadian governments.[97]

C. *The Great Lakes Water Quality Agreement of 1978*

By 1978, toxic contamination of the Great Lakes was a major concern.[98] The 1978 Great Lakes Water Quality Agreement[99] modified the 1972 Agreement. In addition to introducing an ecosystem approach to pollution in the Great Lakes,[100] the 1978 Agreement emphasized control of toxic pollutants.[101] This Agreement ambitiously required that "[t]he discharge of toxic substances in toxic amounts be prohibited and the discharge of any or all persistent toxic substances be virtually eliminated."[102] Its purpose was to "restore and maintain the chemical, physical and biological integrity of the waters of the Great Lakes Basin Ecosystem."[103] These goals were consistent with the 1909 Boundary Waters Treaty, which stated that the boundary waters should not be polluted to the injury of either country.[104]

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96. Esterhay, *supra* note 64, at 221.

97. *Id.* at 221-22; Woodward, *supra* note 87, at 337.

98. Proposed Water Quality Guidance, *supra* note 62, at I(B)(1)(b).

99. 1978 Great Lakes Water Quality Agreement, *supra* note 40.

100. Proposed Water Quality Guidance, *supra* note 62, at I(B)(1)(c); Esterhay, *supra* note 64, at 226. This ecosystem approach is founded on a "man-in-a-system concept" as opposed to a "system external-to-man" concept. It recognizes that the contamination of the Great Lakes is a result of human activities on the land. It focuses on the conditions within the total framework of the interacting ecosystem and institutes a preventative approach, rather than a curative approach. *Id.*

101. Proposed Water Quality Guidance, *supra* note 62, at I(B)(1)(c); Sugarman, *supra* note 72, at 300; Woodward, *supra* note 87, at 337-38. In addition, the 1978 Agreement required the IJC to report to the United States and Canadian governments biennially and established two permanent advisory boards. 1978 Great Lakes Water Quality Agreement, *supra* note 40, arts. VII(3), VII(6), VIII, 30 U.S.T. 1383, 1394-95. These boards are the Great Lakes Water Quality Board and the Great Lakes Science Advisory Board. *Id.* art. VII(6), VIII, 30 U.S.T. at 1394; *see* Woodward, *supra* note 87, at 338.

102. 1978 Great Lakes Water Quality Agreement, *supra* note 40, art. II, 30 U.S.T. at 187; *see also* Sugarman, *supra* note 72, at 300; Whitaker, *supra* note 61, at 41. In addition, the 1978 Agreement set up concentration limits for specific organochlorines which were known to be persistent toxic substances. These included aldrin/dieldrin, chlordane, DDT, endrin, heptachlor, lindane, methoxychlor, mirex, toxaphene, and PCBs. 1978 Great Lakes Water Quality Agreement, *supra* note 40, annex 1, 30 U.S.T. at 1415.

103. 1978 Great Lakes Water Quality Agreement, *supra* note 40, art. II, 30 U.S.T. at 1387; *see* Proposed Water Quality Guidance, *supra* note 62, at I(B)(1)(c).

104. *See supra* note 85 and accompanying text.

D. *Foundation for the Anti-Chlorine Campaign*

The Water Quality Agreements of 1972 and 1978, and their subsequent amendments,[105] have provided a framework for the anti-chlorine movement in two ways. First, the Agreements established the IJC, which has acted as a "clearing-house" for information and alerted the governments and the *public* to pollution issues.[106] The IJC's ability to monitor, investigate and collect data, together with the requirement that it develop reports and hold public hearings, have made it a leader in both communicating the urgency of pollution prevention and providing a forum to discuss these issues.[107] Second, under the Agreements, the federal government undertook the obligation to virtually eliminate persistent toxic substances.[108] Attempts to address this obligation have been made through legislation directed specifically at the Great Lakes.[109]

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105. In the 1987 Amendments to the Great Lakes Water Quality Agreements, the United States and Canada renewed their commitment to virtually eliminate persistent toxic substances. Proposed Water Quality Guidance, *supra* note 62, at I(B)(1)(d).

106. Woodward, *supra* note 87, at 344.

107. *Id.*; *see also* NATIONAL RESEARCH COUNCIL, *supra* note 62, at 205 n.24 ("The surveillance and monitoring process required by the Agreement appears to have fostered an early warning system for Great Lakes problems. Further, the Agreement process appears to offer a forum for interaction between scientists and managers that may facilitate development of management programs.").

108. 1978 Great Lakes Water Quality Agreement, *supra* note 40, art. II; 30 U.S.T. at 1387; *see* Vallentyne, *supra* note 87, at 3. It can be argued that:

> In calling for zero discharge and virtual elimination of persistent toxic substances, the Governments of the United States and Canada accepted in principle that persistent toxic substances are harmful to human health. Had this not been the case, there would have been no reason to eliminate persistent toxic substances. The whole sense of the Agreement was thus not proof or disproof that persistent toxic substances are harmful to human health, it was to rid the Great Lakes Basin Ecosystem of toxic chemicals.

Id.

109. For example, the Great Lakes Critical Programs Act of 1990 (CPA), Pub.L. 101-596, 104 Stat. 3000 (1990) (codified as amended at 33 U.S.C. §§ 1251 note, 1268-70, 1270 note, 1324, 1416 (1994)), uniformly addresses the goals of the above agreements. The CPA seeks to "improve the effectiveness of EPA's existing programs in the Great Lakes by identifying key treaty agreements between the U.S. and Canada in the Great Lakes Water Quality Agreement, imposing statutory deadlines for the implementation of the key activities, and increasing federal resources for program operations in the Great Lakes System." Proposed Water Quality Guidance, *supra* note 62, at I(D)(2). In December 1992, the National Wildlife Federation sued the EPA for failing to publish a proposed water quality guidance. The EPA was ordered by the court to publish the proposed guidance by April 15, 1993. National Wildlife Fed'n v. EPA, No. 92-2338 (D.C.D.C. Dec. 16, 1992).

The Proposed Great Lakes Water Quality Guidance, developed under § 118(c)(2) of the Clean Water Act, as amended by § 101 of the CPA of 1990, is a joint effort of the EPA, the eight Great Lakes States, and the local Indian tribes to safeguard the water quality of the

However, in its Sixth Biennial Report, the IJC concluded that in order to comply successfully with the nation's obligation to virtually eliminate the input of persistent toxic substances, the current regulatory approach must be changed.[110] Recognizing that once they have been produced, it is not possible to remove persistent toxic substances from a source completely, or retrieve them once they have entered the environment, the IJC concluded that "end of the pipe"[111] controls will not achieve the goal of virtual elimination.[112] Therefore, "the focus must be on preventing the generation of [these] substances in the first place."[113] This conclusion led the IJC to recommend the phase-out of chlorine as an industrial feedstock[114] and promoted the anti-chlorine campaign in the Great Lakes Basin.[115]

IV. THE ANTI-CHLORINE CAMPAIGN

After this framework was in place, the Great Lakes, historically a catch basin for factory wastes, became the focus of an ambitious campaign to ban the industrial use of chlorine.[116] In addition to the forum and foundation that the Great Lakes Water Quality Agreements established, the focus on the Great Lakes Basin can be

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basin in a uniform manner. It establishes minimum water quality standards, antidegradation policies, and implementation procedures for water within the Great Lakes system. Proposed Water Quality Guidance, *supra* note 62. The guidance represents the most far-reaching water quality regulation ever proposed by the EPA. Whitaker, *supra* note 61, at 41.

In order to protect species at all levels of the food chain (aquatic life, wildlife, and human health), the EPA, for the first time, determined water quality criteria based on bioaccumulation factors, which account for direct uptake of a chemical from water, plus uptake from the food chain. Proposed Water Quality Guidance, *supra* note 62, at I(E)(4). Previously, criteria was determined by using bioconcentration factors, accounting only for direct uptake from waters. *Id.*; Long, *supra* note 73, at 22-23. As a result, the guidance proposed specific water quality criteria for 28 chemicals with a bioaccumulation factor greater than 1000. Fifteen of these are chlorinated organics. Long, *supra* note 73, at 23.

110. SIXTH BIENNIAL REPORT, *supra* note 9, at 24-25.

111. "End of the pipe" regulation, or command and control regulation, involves the management and control of pollution discharges after they have been produced. *See infra* notes 124-27 and accompanying text.

112. SIXTH BIENNIAL REPORT, *supra* note 9, at 24-25; *see* COMMONER, *supra* note 46, at 43-44 (discussing the inability of control mechanisms to eliminate pollutants).

113. SIXTH BIENNIAL REPORT, *supra* note 9, at 25.

114. *See infra* note 118 and accompanying text.

115. SIXTH BIENNIAL REPORT, *supra* note 9, at 28-30. Although recommendations made by the IJC do not have the force of law, they do carry "moral and political" weight, especially since the members were appointed by conservative governments. Moberg, *Sunset For Chlorine?*, *supra* note 65, at 30; *see also* Gallob, *supra* note 90, at 113. Furthermore, these IJC recommendations provide a focus for, and lend support to, lobbying efforts by environmental interest groups.

116. *See* Moberg, *Sunset for Chlorine?*, *supra* note 65, at 26.

attributed to a combination of many other factors,[117] including the active participation of many well-organized grassroots environmental groups and concerned citizen groups. The most significant factor, however, was the IJC's 1991 report recommending that (1) chlorinated compounds should be treated as a class, rather than individual chemicals, and (2) the governments should sunset their use as industrial feedstocks.[118] This report breathed life into the chlorine debate.[119]

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117. *See supra* notes 62-83 and accompanying text.

118. In its Sixth Biennial Report, the IJC stated that:

> Even though many of these substances have not been proven to be individually toxic, it is likely that many of these chemicals—because of their chemical characteristics—will be substances to be virtually eliminated and subject to zero discharge . . . . There is a growing body of evidence that these compounds are at best foreign to maintaining ecosystem integrity and quite probably persistent and toxic and harmful to health. They are produced in conjunction with proven persistent toxic substances. In practice, the mix and exact nature of the various compounds cannot be precisely predicted or controlled in production processes. Thus, it is prudent, sensible and indeed necessary to treat these substances as a class rather than a series of isolated, individual chemicals. Further, in many cases alternative production processes do exist . . . . We know that when chlorine is used as a feedstock in a manufacturing process, one cannot necessarily predict or control which chlorinated organics will result, and in what quantity . . . . *The Commission therefore recommends that: the Parties, in consultation with industry and other affected interests, develop timetables to sunset the use of chlorine and chlorine-containing compounds as industrial feedstocks and that the means of reducing or eliminating other uses be examined.*

SIXTH BIENNIAL REPORT, *supra* note 9, at 29-30.

119. In response to the IJC, the chlorine industry launched a vigorous longterm pro-chlorine campaign to convince the public that chlorine does not threaten the Great Lakes and to persuade the IJC to reverse its stand on the chlorine phase-out. Industry's underlying premise is that "chlorine is woven into the fabric of society" and that denying chlorine's benefits to society would be socially and economically irresponsible. THE CHLORINE INST., INC., CHLORINE'S FUTURE (1993) [hereinafter CHLORINE'S FUTURE]. The industry argues that "[t]he current campaign to ban chlorine and chlorine feedstocks is based largely on emotion and stems from an expressed goal by certain environmentalists to shrink the petrochemical industry." The Chlorine Inst., Inc., *Listen to the Eco in Economy and Ecosystem* (on file with author). The industry believes that the IJC's recommendation was not based on credible, or "sound," science; did not evaluate the social, economic and environmental consequences; and did not involve a cooperative and open dialogue among all impacted stakeholders. Brad Lienhart, *Recommendation Offers No Proven Benefit at Great Cost to Citizens*, THE ADVISOR, Sept.-Oct. 1993, at 8, 8.

As a result of the 1991 recommendation, the chlorine issue was the main theme of the Seventh Biennial Meeting of the IJC, which was held in October 1993 in Windsor, Ontario. More than 220 industry representatives gathered at the meeting. Historically, industry has paid little attention to the IJC, with no more than 30 industry leaders attending the agency's meetings. Since the IJC's recommendation, Dow Chemical Co., the world's largest chlorine manufacturer, has created a separate division to handle chlorine affairs, and the chemical industry has created a trade association devoted to the issue. David Poulson, *Industry Fights Great Lakes Pollution Rules*, PLAIN DEALER, Oct. 23, 1993, at 4A.

Those in favor of banning chlorine argue that the current regulatory practices are inadequate to protect the Great Lakes Basin from persistent and toxic chlorinated organics. It is their position that chlorine should be guilty until proven innocent,[120] given the increasing weight of evidence[121] that the environmental build-up of chlorinated organics in the Great Lakes constitutes a serious threat to the health of humans, wildlife, and the entire ecosystem.[122]

A. *Ineffectiveness of Traditional Regulation*

The traditional command and control approach[123] is insufficient to virtually eliminate the thousands of organochlorines produced, used, and discharged into the workplace, communities, and environment. Traditional environmental regulations use a chemical-by-chemical, proof of harm approach, and are reactive rather than preventative.[124] Under this approach, individual chemicals and products can be produced or discharged into the environment until a conclusive link between the substance and a harm is established.[125] Even if a cause-effect relationship is found, the traditional regulatory system usually focuses on managing and control-

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120. Under a "guilty until proven innocent" regulatory approach, if there is evidence to believe that a class of chemicals, along with its products and processes, is harmful (i.e., they result in persistent toxic substances), then the burden of proof shifts to the industry to prove that a specific process or product within that class is both "safe" during its entire lifecycle and necessary before the industry is allowed to produce or use it. SEVENTH BIENNIAL REPORT, *supra* note 6, at 9; Joe Thornton, *Presumed Guilty: Phasing Out Organochlorines as a Class*, CHLORINE FREE, Fall 1993, at 2 [hereinafter Thornton, *Presumed Guilty*].

121. *See infra* notes 145-57 and accompanying text.

122. Muir et al., *supra* note 30, at 61; *see supra* notes 39-61 and accompanying text. Most of the 40 million tons of chlorine produced each year is eventually converted to chlorinated organics, either intentionally or as unintentional by-products. *See supra* notes 30-32 and accompanying text. The rate at which organochlorines are produced by industry is much greater than the slow rate at which organochlorines can be converted back into inorganic chlorines, such as salt. Thus, "[t]he total burden of organochlorines in the environment . . . grows each year." THORNTON, THE PRODUCT IS THE POISON, *supra* note 14, at 2.

123. Command and control statutes, or release controls, address the release of a pollutant after its production. *Public Health Law, Policy and Education Regarding Exposure to Toxic Chemicals*, *in* HUMAN HEALTH RISKS, *supra* note 40, at 181, 183. Examples include the Clean Air Act, 42 U.S.C.A. §§ 7401-7641 (West 1983 & Supp. 1992) and the Clean Water Act, 33 U.S.C.A. §§ 1251-1387 (West 1986 & Supp. 1992). *Id.*

124. VETF, A STRATEGY, *supra* note 40, at 13; PAUL MULDOON & MARCIA VALIANTE, ZERO DISCHARGE: A STRATEGY FOR THE REGULATION OF TOXIC SUBSTANCES IN THE GREAT LAKES ECOSYSTEM 22 (1988). These differ from production controls that "regulate the actual production of a commodity or product before the negative effect is produced." *Public Health Law*, *in* HUMAN HEALTH RISKS, *supra* note 40, at 183. Examples include bans, limits on production, and packaging legislation. *Id.*

125. SIXTH BIENNIAL REPORT, *supra* note 9, at 3; VETF, A STRATEGY, *supra* note 40, at 13; MULDOON & VALIANTE, *supra* note 124, at 22.

ling discharges of toxic pollutants.[126] Normally, a command and control approach first finds a "safe" level for pollutant discharges and then regulates accordingly.[127]

Advocates of a chlorine phase-out state many reasons why the chlorine industry and its products cannot be evaluated and regulated using the traditional command and control approach. The primary reason is that simply too many organochlorines exist to regulate one-by-one.[128] There are approximately 11,000 known chlorinated organics currently in commerce.[129] However, researchers have found that "toxicity information is available to support hazard assessments for less than 2 percent of the chemicals in commerce."[130] It would take generations to collect data and evaluate each of these known chemicals.[131] Meanwhile, persistent toxic chlorinated organics would remain uncontrolled and continue to build up in the Great Lakes ecosystem.[132] Furthermore, many organochlorines formed as by-products of chlorine-based processes could not be assessed individually because they are not yet identified.[133] Finally, it is impractical to insist on cause-effect linkages

126. SIXTH BIENNIAL REPORT, *supra* note 9, at 3; VETF, A STRATEGY, *supra* note 40, at 13.

127. MULDOON & VALIANTE, *supra* note 124, at 23. The existing laws and regulations were designed to address "conventional" pollutants, not persistent toxic pollutants, and therefore were based on the assumption that these pollutants would degrade, transform, or leave the ecosystem over time. This assumption allows for the conclusion that an ecosystem has a certain *assimilative capacity* for pollutants. For this reason, these regulations are based on the premise that it is feasible to find a "safe" level of discharge and still maintain the integrity of the ecosystem. *Id.*; VETF, A STRATEGY, *supra* note 40, at 14.

128. Thornton, *Presumed Guilty*, *supra* note 120, at 2.

129. THORNTON, THE PRODUCT IS THE POISON, *supra* note 14, at 13 (citing M. BRAUNGART, HALOGENATED HYDROCARBONS: PRINCIPLE THOUGHTS AND DATA ABOUT A POSSIBLE BAN AND SUBSTITUTION (1987)).

130. *Id.* at 21 (citing NATIONAL RESEARCH COUNCIL, TOXICITY TESTING: STRATEGIES TO DETERMINE NEEDS AND PRIORITIES (1984)).

131. Muir et al., *supra* note 30, at 50. For a discussion of the size and complexity of the "administrative machinery" one must use to establish and enforce standards for each pollutant, see COMMONER, *supra* note 46, at 57-59.

132. MULDOON & VALIANTE, *supra* note 124, at 22. The continuing discharge of organochlorines into the Great Lakes, while proof of harm is established, poses a significant threat to this ecosystem. The persistence of these compounds coupled with the long water retention time of the lakes allows organochlorines to remain in the system long after their discharge has been stopped. *Id.*; *see also* Moberg, *Sunset For Chlorine?*, *supra* note 65, at 31 (claiming that "[e]ven if chlorine disappeared from industry tomorrow, the residual effects would linger in the environment and in the bodies of people and wildlife for many decades to come"). Therefore, "[i]f we wait for proof of harm on a chemical-by-chemical basis, we will not act in time to prevent further unacceptable damage to the health of the ecosystem, its wildlife, and its human residents." Muir et al., *supra* note 30, at 50.

133. Thornton, *Presumed Guilty*, *supra* note 120, at 2. For example, "[n]inety-seven percent of the total amount of organochlorines from a [pulp and paper] bleach plant has not

between specific chlorinated organic chemicals and reported adverse health effects because the causation may involve multiple chemical interactions and the effects may not manifest themselves for many years.[134]

Even if chemical-by-chemical assessment were feasible, "managing" the release of chlorinated organics into the Great Lakes under the assumption that the ecosystem has an assimilative capacity[135] is inappropriate. Many of these chemicals are persistent and will accumulate in the environment. Therefore, a "safe" level of discharge does not exist because even minute, undetectable amounts may build up to toxic levels over time.[136]

Another reason that these organochlorines could not be regulated individually is because they generally are not *produced* individually.[137] Chlorine reacts readily and indiscriminately with carbon-based compounds; therefore, chlorine-based processes form organochlorine "soups" which cannot be controlled or predicted.[138] Upon release into the environment, these mixtures become even more complicated, since some compounds will partially degrade into more toxic or persistent ones.[139] Current regulations assume that chemicals exist in isolation. Therefore, these complex mixtures of organochlorines formed throughout the lifecycle of chlorine can not be controlled successfully.[140] Finally, if specific chlorinated organics were regulated one-by-one, the chlorine industry merely would shift the excess chlorine from production of caustic soda[141] into other products and processes and, therefore, nullify

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been identified as specific substances . . . . The obvious question is: *how many other subtle toxicants in bleach plant waste await discovery?*" THORNTON, THE PRODUCT IS THE POISON, *supra* note 14, at 23-24 (quoting N. BONSOR ET AL., MUNICIPAL INDUSTRIAL STRATEGY FOR ABATEMENT: KRAFT MILL EFFLUENTS IN ONTARIO (1988)) (emphasis in original).

134. Thornton, *Presumed Guilty*, *supra* note 120, at 2. Attempting to prove that a given organochlorine causes a specific effect is extremely difficult, if not impossible, because "[o]rganochlorines do not exert their effects in the environment on a chemical-by-chemical basis. [Instead, they] cause their effects in complex mixtures that add to or multiply the effects of individual compounds." Muir et al., *supra* note 30, at 50.

135. *See supra* note 127 and accompanying text.

136. MULDOON & VALIANTE, *supra* note 124, at 23; VETF, A STRATEGY, *supra* note 40, at 13.

137. Muir et al., *supra* note 30, at 50.

138. Thornton, *Presumed Guilty*, *supra* note 120, at 2. For example, "[h]undreds or thousands of organochlorines are present in the effluents from bleached pulp mills, in the emissions of incinerators burning chlorine-containing wastes, and in the discharges from waste-water treatment plants using chlorine as a disinfectant." *Id.* In addition, the manufacture of a single organochlorine, such as vinyl chloride, results in the formation of large quantities of wastes which contain a broad spectrum of chlorinated by-products. *Id.*

139. Muir et al., *supra* note 30, at 50.

140. *Id.*

141. *Id.* at 58. Originally, elemental chlorine was a nonuseful by-product of the chlor-

any net decrease in environmental build-up of organochlorines.[142]

Instead of regulating or managing one chemical at a time,[143] the focus must shift to the entire class of chlorinated compounds and the industrial processes which use or produce them. This new regulatory framework should focus on pollution prevention,[144] and decisions should be made based on the weight of evidence.

B. *Application of the Weight of Evidence Approach*

The weight of evidence approach does not require absolute proof of cause-effect linkages between a chemical and a harm in order to reach conclusions about the effect of a chemical on the environment.[145] Instead, this approach considers various studies

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alkali process which is used to produce caustic soda, or sodium hydroxide. *See supra* note 17 and accompanying text. This process is the root of chlorine chemistry, since the chlorine which results from the production of caustic soda is now the basic feedstock in the production of all other organochlorine products and by-products. Muir et al., *supra* note 30, at 58. In fact, a main stimulus to the early development of chlorine chemistry was the need to make use of the chlorine surplus from caustic soda production. Caustic soda is used in many diverse industrial activities, and demand continues to increase. *Id.*

142. Thornton, *Presumed Guilty*, *supra* note 120, at 2. Because chlorine is difficult to store, producers need a "sink" into which excess chlorine can be dumped in order to keep pace with the growing demand for caustic soda. Muir et al., *supra* note 30, at 58. It is argued that chlorine producers are counting on PVC growth to offset the decreased use of chlorine in other major sectors, such as the pulp and paper industry. In this way, PVC will become the "sink" for the excess chlorine. *Id.* In order to effectuate a phase-out of chlorine, caustic soda and chlorine production will need to be "decoupled." *Id.*

143. The problems associated with a chemical-by-chemical approach are apparent if one considers the historical ineffectiveness of the Toxic Substances Control Act of 1976 (TSCA). Despite TSCA's ability to ban or restrict the production, distribution, use, and disposal of a chemical, the EPA has issued regulations on only nine chemicals under the 18-year-old chemical control law. 98% of the chemicals in commerce have not been reviewed for safety. *GAO Says Congress Could Rewrite TSCA to Create 'Umbrella' Environmental Law*, Chem. Reg. Daily (BNA) (Oct. 27, 1994). In October 1994, the U.S. General Accounting Office issued a report which found that TSCA's regulatory control authority is rarely used and the EPA's existing chemical program has been slow to evaluate chemical risks. *Id.* For a more detailed discussion of TSCA, see *infra* part VI.B.

144. Pollution prevention is "any action which reduces or eliminates the creation of pollutants or wastes . . . at their sources. It can be achieved through: substitution/reduction in the use of raw material; product redesign; process changes; in-process recycling; improved maintenance and operating procedures." MINISTRY OF ENVIRONMENT AND ENERGY, RESTORING AND PROTECTING THE GREAT LAKES (1991); *see also* Richard Andrews & Alvis Turner, *Controlling Toxic Chemicals in the Environment*, *in* TOXIC CHEMICALS, HEALTH, AND THE ENVIRONMENT 5, 16-19 (Lester B. Lave & Arthur C. Upton eds., 1987). The pollution prevention framework is based on the idea of zero discharge, clean production, and a precautionary principle. *See* Thornton, *Presumed Guilty*, *supra* note 120, at 2.

145. Muir et al., *supra* note 30, at 50; *see* Vallentyne, *supra* note 87, at 4. Ethyl Corp. v. EPA, 541 F.2d 1 (D.C. Cir.) (en banc), *cert. denied*, 426 U.S. 941 (1976), which upheld an EPA rule banning lead from gasoline, is an example of a district court's rejection of an absolute proof requirement. Interpreting the EPA's mandate (to regulate emissions that

addressing the likely effect of a chemical on the environment.[146] Individual studies are considered cumulatively, not in isolation.[147] A causal relationship may be found if the quantity and consistency of interdisciplinary research are sufficient to indicate a probable linkage between a chemical, or class of chemicals, and an injury.[148] Therefore, "[a]bsence of evidence is not evidence of absence."[149]

The weight of evidence approach is the basis for a chlorine phase-out.[150] The cumulative weight of available evidence supports the conclusion that chlorine's use creates persistent toxic substances and therefore is harmful. This includes evidence that: (1) organochlorines dominate virtually every list of priority pollutants;[151] (2) organochlorines are often persistent and/or bioaccumulative;[152] (3) organochlorines are foreign and often toxic to complex organisms;[153] and (4) specific organochlorines have ad-

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"will endanger" public health) to be satisfied if the agency showed a significant risk of harm, not necessarily proof of actual harm, the court concluded: "Where a statute is precautionary in nature, the evidence difficult to come by, uncertain, or conflicting because it is on the frontiers of scientific knowledge . . . and the decision that of an expert administrator, we will not demand rigorous step-by-step proof of cause and effect." *Id.* at 28.

146. SEVENTH BIENNIAL REPORT, *supra* note 6, at 10. The IJC urged the adoption of a weight of evidence approach in its Sixth Biennial Report. SIXTH BIENNIAL REPORT, *supra* note 9, at 22.

147. SEVENTH BIENNIAL REPORT, *supra* note 6, at 10; *see The Injury, in* 2 A STRATEGY FOR VIRTUAL ELIMINATION OF PERSISTENT TOXIC SUBSTANCES 87, 90 (1993) [hereinafter *The Injury*] (indicating that the weight of evidence includes "comprehensive and authoritative reviews and case studies, syntheses, consensus statements, and workshop and symposia reports, wherein the evidence, positive and negative, the data, and the inherent uncertainties, are evaluated, weighed, articulated, and referenced").

148. SEVENTH BIENNIAL REPORT, *supra* note 6, at 10. Under the weight of evidence approach, conclusions are based on "common sense, logic and experience as well as formal science." *Id.*

149. *The Injury, supra* note 147, at 90. Historically, it has been difficult for regulators to address the problem of toxic pollution because decisions must be made within the limits of scientific knowledge. Therefore, "[b]ecause of insufficient knowledge in some areas, judgments regarding public health risks from environmental exposure to chemicals involves acceptance of an inherent level of uncertainty." Flint, *supra* note 69, at 10. *See also* Vallentyne, *supra* note 87, at 4. Dr. Vallentyne points out:

> The Science Advisory Board noted . . . that science does not primarily operate on the basis of proof; it operates by disproving null hypothesis, learning through error. The same scientist may state that there is no clear evidence that chemical X is harmful, yet disagree with a statement saying the chemical X is "safe." In other words, absence of evidence should not be construed as evidence of absence. The terms *scientific* and *wise* [are] not interchangeable.

Id.

150. *See supra* note 121 and accompanying text.

151. *See supra* notes 75-78 and accompanying text.

152. *See supra* notes 39-47 and accompanying text.

153. *See supra* note 30 and accompanying text.

verse impacts on human health, wildlife, and the environment.[154]

It is not argued that all organochlorines are *equally* toxic, persistent, or bioaccumulative. However, many organochlorines exhibit these qualities. Therefore, many of the compounds that have not been tested or identified will, more likely than not, turn out to be toxic, persistent, and/or bioaccumulative.[155] Sufficient evidence exists that chlorine-based products and processes create persistent toxic substances. Therefore, the entire class should be considered guilty of causing injury to the Great Lakes Basin, unless there is

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154. *See supra* part I.B.

155. SIXTH BIENNIAL REPORT, *supra* note 9, at 29; Muir et al., *supra* note 30, at 50-51.

According to the chlorine industry, there is no basis for a blanket condemnation of chlorinated compounds because "no scientific proof exists to support the claim by some that chlorine is at the root of environmental damage." CHLORINE'S FUTURE, *supra* note 119. The industry argues that a chlorine ban is supported merely by research on a few chlorinated organics, such as PCBs and DDT, which have already been phased out. *Id.*; Werezak, *supra* note 14, at 35. However, they argue, chlorine and organochlorines have different chemical and physical properties. These physiochemical properties govern the potential behavior and effects of a chemical in the environment, as well as determine the potential risks from the chemical's use and release. Some chlorine compounds do not share the same chemical characteristics of those proven to be harmful, negating the generalization that all chlorinated materials present similar risk of harm and, therefore, should be phased out. Lienhart, *supra* note 119, at 8. Banning a class of chemicals, without considering the individual properties of each compound within that class, is not based on credible science because "[h]istorical data should not be extrapolated to the whole class of existing organochlorines." Hileman, *supra* note 3, at 19.

The chlorine industry supports its argument with a 1993 study which concluded:

> Chlorinated chemicals span a wide range of molecular structures and biological activities and, as such, cannot be considered as a single group for the purposes of health risk assessment. With the exception of a few persistent bioaccumulative chlorinated organic chemicals in localized areas resulting from historical uses, there is no evidence that current concentrations of chlorine or chlorinated compounds are associated with these adverse effects on humans or the environment.

Chlorine Chemistry Council, *Interpretive Review of the Potential Adverse Effects of Chlorine and Chlorinated Chemicals* (on file with author) (summarizing the preliminary findings of CanTox, Inc., *Scientific Principles for Evaluating the Potential for Adverse Effects from Chlorinated Organic Chemicals in the Environment, in Regulatory Toxicology & Pharmacology* (forthcoming)); *see also Clinton Administration Seeking Restrictions On Chlorine Use*, CHEM. ENG'G PROGRESS, June 1994, at 12, 12; Michael Fumento, *Chemical Warfare*, REASON, June 1994, at 42, 42; *Chlorinophobia*, NAT'L REV., Aug. 15, 1994, at 19, 19.

However, as noted above, those seeking to ban chlorine do not base their argument on the proposition that all chlorinated compounds pose a similar risk. Rather, they argue that the weight of evidence indicates it is more likely than not that many organochlorines will be harmful. Simply because some chlorinated compounds are not harmful, does not mean we should be exposed to those that are. If a specific chlorinated compound is shown to be safe, the chlorine industry may produce it.

An analogy can be drawn to a person on a ship who has reason to believe that a bomb is hidden in the cargo and it is likely to go off soon, allowing no time to search each piece of cargo. It would make sense to pitch the cargo overboard (even though most of it was "innocent") to avoid a disaster.

proof of innocence.[156] In order to virtually eliminate persistent chlorinated organics, the use of chlorine as a feedstock should be phased out. The burden of proof should shift to the users of chlorine to show that a specific process or product within the class is necessary and does not result in a persistent toxic substance during its lifecycle.[157]

C. *Alternatives to Chlorine and the Economic Consequences*

Advocates of a chlorine ban point out that sunsetting the use of chlorine is both technologically and economically feasible. Currently, alternative products and production processes are available for the major uses of chlorine.[158] For example, some pulp and pa-

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156. Muir et al., *supra* note 30, at 51. This "guilty until proven innocent" approach is also referred to as "reverse onus." A reverse onus approach accepts the presumption that these compounds should be phased out, unless evidence is presented to demonstrate that individual compounds or processes do not produce persistent toxic substances. *Id.*

Industry argues that chemicals are innocent until scientifically proven guilty, and that any decision regarding a chlorine phase-out should be based on comprehensive risk assessment. CHEMICAL MFRS. ASS'N, BACKGROUND ON THE OCTOBER 21-24, 1993 MEETING OF THE INTERNATIONAL JOINT COMMISSION OF THE U.S. AND CANADA 1 (1993). Risk assessment is the quantitative measure of a substance's toxicity through scientific research. It also measures the degree to which exposure, of both humans and the environment, will occur. In order to determine the potential toxicity of a particular chemical, "researchers employ four basic methods, which include epidemiological study, long-term animal bioassay, short-term testing, and structure-activity relationship analysis." Andrew Hanan, *Pushing the Environmental Regulatory Focus a Step Back: Controlling the Introduction of New Chemicals Under the Toxic Substances Control Act*, 18 AM. J.L. & MED. 395, 406 (1992). A subjective policy stage, called risk management, follows completion of risk assessment. Determination of an acceptable level of risk is based on a cost-benefit analysis which compares the inherent risks of a substance with the potential benefits of its use. *Id.*; *see generally Risk and Exposure Assessment From Toxic Chemicals, in* HUMAN HEALTH RISKS, *supra* note 40, at 155.

Industry's insistence on "good" science and risk assessment, rather than social concerns, is flawed because "scientific knowledge is in part a social construct, with social factors impinging on every aspect of research, from problem selection to dissemination of research conclusions and the reactions that follow." *Social Science of Exposure to Toxic Chemicals, in* HUMAN HEALTH RISKS, *supra* note 40, at 141, 150. Widely accepted facts may lead to different interpretations and policies, depending on many social factors. *Id.*

Barry Commoner, discussing risk assessment and good science, states: "Immediately, the question becomes 'Acceptable as compared to what?' and the issue of how to set the standard becomes a battleground for contending economic, political, and moral interests. But these conflicts are elaborately clothed in statistics so that they can masquerade as 'science.'" COMMONER, *supra* note 46, at 62. *See infra* part V.

157. Muir et al., *supra* note 30, at 51. *See* R. Warren Flint & James Blascovich, *The Process, in* HUMAN HEALTH RISKS, *supra* note 40, at 13, 13-14 (arguing that "[i]t is both costly and inappropriate to place the burden of proof of harm from conceivably toxic chemicals on the general public, which is the exposed population").

158. SIXTH BIENNIAL REPORT, *supra* note 9, at 29. In fact, it is argued that there are readily available substitutes for 99% of chlorine-based products or processes. David Moberg, *Can You Live Without Chlorine?*, E MAG., Aug. 1993, at 30, 30 [hereinafter Moberg, *Can*

per mills produce chlorine-free paper using oxygen-based bleaching or other methods.[159] Manufacturers may use non-chemical cleaning agents, such as soaps or citrus-based solvents, instead of using chlorinated solvents.[160] Polyvinylchloride (PVC), a chlorinated plastic, constitutes the largest single use of chlorine.[161] However, most PVC products can be replaced with "traditional" materials.[162] Many farmers have achieved high yields and reduced expenses using organic farming methods instead of synthetic pesticides.[163] Alternative methods for disinfecting water supplies, such as ozone and ultraviolet treatment, reduce the amount of chlorine used in water treatment and delivery systems.[164] The availability of alternatives supports the argument for banning chlorine.[165]

The process by which a phase-out is implemented will determine the economic and social costs of sunsetting chlorine.[166] Industry's primary argument against a chlorine phase-out is that the ec-

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You Live Without Chlorine?]. The other 1% is the production of pharmaceuticals and the use of chlorine as a water system disinfectant. *Id.*

159. Thornton, *Presumed Guilty, supra* note 120, at 3. Paper can be bleached without chlorine, using oxygen, ozone or hydrogen peroxide. The world market for unbleached paper goods is growing, but so far only one U.S. mill has abandoned chlorine totally. European manufacturers, however, have progressed much further in non-chlorine methods. Moberg, *Can You Live Without Chlorine?, supra* note 158, at 30; *see supra* note 6.

160. Muir et al., *supra* note 30, at 63. The EPA has been evaluating the use of Eco-Clean, which is a dry cleaning alternative to chlorinated solvents that relies on skilled labor, soap and water. Moberg, *Can You Live Without Chlorine?, supra* note 158, at 31. The dry cleaning industry constitutes the major use of perchloroethylene, an organochlorine solvent. Muir et al., *supra* note 30, at 63.

161. Werezak, *supra* note 14, at 34.

162. Muir et al., *supra* note 30, at 60. Traditional materials include wood, metal, linoleum, non-chlorinated plastics, glass, and paper/cardboard. For example, PVC pipes (the largest single PVC use) can be substituted with pipes made of metal or chlorine-free plastics. *Id.* European efforts have led to the successful phase-out of PVC in a wide range of uses, including construction, commercial and medical packaging, automobiles, and furniture. *Id.*; *see supra* note 6.

163. Muir et al., *supra* note 30, at 63. "The U.S. National Academy of Sciences found that chemical-free agricultural methods can result in yields and productivity as high or higher than pesticide-intensive farming." *Id.* Some methods include improved crop rotation, choice, and mixing; maintenance and introduction of natural predators; and use of biological pesticides. *Id.*

164. *Id.* Although these alternatives are effective, where drinking water has a high content of organic matter and travels through long delivery systems, a residual is necessary to prevent regrowth of bacteria after initial treatment. Neither of these alternatives provides such a residual, so many treatment plants must continue to use chlorine as a residual. *Id.* Other alternatives, such as a photocatalytic process, are being studied. Catherine A. Simpson, *Water: New Processes May Replace Chlorine, Improve In Situ Remediation*, POLLUTION ENG'G, Aug. 1994, at 52, 52.

165. *See* Thornton, *Presumed Guilty, supra* note 120, at 3 (claiming that "[i]n the end, one of the best reasons to phase out chlorine is because we can").

166. *See infra* part VI.A.

onomic and social implications are far-reaching. A report written by the consulting group Charles River Associates[167] is the basis for this argument. Under the premise that the societal value of chlorine depends on the cost of suitable replacements for chlorine-based products,[168] the report assesses alternatives to chlorine uses and estimates that the cost of a total chlorine phase-out would be devastating.[169]

Those seeking to phase out chlorine criticize the report's economic conclusions on many grounds. In particular, the report assumes that the transition to a chlorine-free society would occur instantaneously.[170] However, advocates of a phase-out recommend that "priority sectors"[171] of chlorine chemistry be identified through the application of a "chlorine use tree."[172] After identify-

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167. CHARLES RIVER ASSOCS., INC., ASSESSMENT OF THE ECONOMIC BENEFITS OF CHLOR-ALKALI CHEMICALS TO THE UNITED STATES AND CANADIAN ECONOMIES—EXECUTIVE SUMMARY (1993). Charles River Associates (CRA) is a Boston-based consulting firm which provides businesses, governments, and legal clients with independent analysis that forms the basis of decision making. Founded in 1965, the firm has particularly extensive experience in chemicals and plastics, health care, energy, transportation, mineral and telecommunications. The Chlorine Institute contracted with CRA to undertake an independent analysis of the economic impact of chlorine chemistry. CRA investigated and evaluated chlorine from its initial production through ultimate consumption. *Id.*

168. *Id.* at 1. Therefore, any policy decision to ban chlorine should carefully consider the economic consequences of alternatives. The report argues that although a few processes allow easy substitution for chlorine, in most cases chlorine-free processes or materials involve significant performance losses or cost increases. In addition, alternatives may be less environmentally friendly than chlorine, or may present their own health risks. *Id.* Since the health and environmental risks of chlorine substitutes are not known, anyone suggesting replacement must demonstrate that the replacement serve the environment better than the chlorinated process or product. *Listen to the Eco in Economy and Ecosystem, supra* note 119.

169. CHARLES RIVER ASSOCS., *supra* note 167, at 4. The study points out that about 45% of all U.S. industries are direct consumers of chlorine and its coproducts, and 100% are indirect consumers. *Id.* at 6. The results of the study conclude that a total ban of chlorine would (1) cost consumers an additional $91 billion per year in the U.S. and $11 billion in Canada; (2) involve investments of nearly $67 billion, with a transition period of 10 to 20 years; (3) result in the loss of 1.4 million jobs in the U.S. and Canada, as well as $33 billion in wages; and (4) damage the U.S. and Canadian trade balances with the rest of the world. *Id.* at 2-4.

170. CITIZENS FOR ZERO DISCHARGE, CITIZENS' PRESENTATION TO THE INTERNATIONAL JOINT COMMISSION 1993 BIENNIAL MEETING 12-13 (1993) [hereinafter CITIZENS' PRESENTATION].

171. A priority sector would be a certain chlorinated product or process which is responsible for the largest discharge of persistent toxic substances and in which a sunset program could be most effectively implemented. Muir et al., *supra* note 30, at 51.

172. *Id.* at 52. A use tree provides a holistic view of chlorine-based substances and processes. *Id.* "[It] outlines the end uses and products of chemicals, and then traces those to identify the families of chemicals back to the base element, compound, or mixture," thereby clarifying the sources or origins of a persistent toxic substance. VETF, A STRATEGY, *supra*

ing priority sectors, the next step would be to establish practical timetables for sunsetting chlorine in those sectors.[173] The most important sectors would be paper bleaching, solvents, and chlorinated plastics such as PVC.[174] Alternatives for these sectors are currently available and affordable.[175] Since these three areas utilize more than half of the chlorine produced,[176] a phase-out addressing these areas first would eliminate the major sources of organochlorine pollution.

Another criticism of the report is that over one-half of its projected costs could be attributed to the immediate elimination of chlorine from a single industry: pharmaceuticals.[177] Since chlorine remains essential to the synthesis of many pharmaceutical drugs, these would be excepted from the phase-out until alternatives are found.[178] Furthermore, the pharmaceutical industry consumes only 1.2% of the total chlorine produced; it is not a priority sector for phase-out.[179] If the costs associated with an immediate ban of chlorine in the pharmaceutical industry were eliminated, the economic consequences of a phase-out would not be so drastic.[180]

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note 40, at 17.

The chlorine use tree begins with the trunk and its roots, which is the production of chlorine in chlor-alkali electrolysis. *See supra* note 17 and accompanying text. It then traces the various chlorinated processes and products, which form the limbs, branches, and twigs. Muir et al., *supra* note 30, at 52. Using this approach, it is possible to evaluate the full life cycle of chlorine and to identify those uses which result in persistent toxic substances. *Id.* The goal is to intervene, or "prune" the use tree, at the main branches (representing the bulk products or processes) which result in a substantial quantity of persistent toxic substances. *Id.*

Evaluation of the chlorine use tree indicates that "[t]he majority of chlorine production (80 to more than 90%) is used in just 8 to 10 easily discernible product groups or applications." *Id.* at 58.

173. CITIZENS' PRESENTATION, *supra* note 170, at 17-18. In October 1994, the Canadian government released its Chlorinated Substances Action Plan I. This 5-part action plan adopts the concept of establishing a chlorine use tree and seeks to eliminate the most harmful, toxic chlorinated substances. Sheila Copps, Canada's Environment Minister, commented that the Canadian government's approach "is to prune the chlorine use tree, it is not our intention to cut it down." *Government Sets Plan to Eliminate, Manage Harmful Chlorinated Substances*, Int'l. Envtl. Daily (BNA) (Oct. 27, 1994).

174. Muir et al., *supra* note 30, at 56.

175. Joe Thornton & Jay Palter, *Phasing Out Chlorine Looks Good Economically*, GREAT LAKES UNITED, Fall 1993, at 5 [hereinafter Thornton & Palter, *Phasing Out Chlorine Looks Good Economically*]; *see supra* notes 6, 159-62 and accompanying text.

176. CITIZENS' PRESENTATION, supra note 170, at 17; Hileman, *supra* note 3, at 13; Muir et al., *supra* note 30, at 59.

177. CITIZENS' PRESENTATION, *supra* note 170, at 13.

178. *Id.*

179. *Id.*; *see supra* note 29 and accompanying text.

180. Thornton & Palter, *Phasing Out Chlorine Looks Good Economically*, *supra* note 175, at 5 (claiming that the report actually lends support to the economic feasibility of a

Finally, critics of the report claim that it examined costs and burdens, but neglected to identify the potential for benefits and savings,[181] and ignored the future costs of failing to eliminate persistent chlorinated compounds that are toxic.[182]

Thus, a properly planned chlorine sunset, which determines priority sectors and considers socio-economic factors and available alternatives, could be accomplished. The feasibility of sunsetting chlorine, together with the weight of evidence that the use of chlorine creates harmful substances that traditional regulatory practices cannot effectively control, supports the phase-out of chlorine and its compounds.

V. Policy Decisions Regarding a Chlorine Ban

> It is often necessary to make a decision based on information which is sufficient for action but insufficient to satisfy the intellect.[183]

The Great Lakes Water Quality Agreements created a coherent framework within the Great Lakes Basin for debating the problems of persistent toxic substances such as chlorinated organics. Policymakers now are confronted with the challenge of developing a strategy for effective action.

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phase-out since 95% of chlorine can be eliminated for $20 billion annually, as opposed to the report's initial estimate of over $100 billion annually).

181. Citizens' Presentation, *supra* note 170, at 13. For example, the $20 billion it would cost annually to eliminate 95% of chlorine should be compared to the $90 billion that the U.S. industry spends on end-of-pipe controls per year. Thornton & Palter, *Phasing Out Chlorine Looks Good Economically, supra* note 175, at 5 (citing U.S. EPA Administrator William Reilly, in Bureau of National Affairs, *Environment Watch*, Oct. 15, 1990). *See Synthesis Of Our Knowledge, in* Human Health Risks, *supra* note 40, at 236 (arguing that "[e]conomically, and practically, it is far easier to regulate contaminants at the source of production, than to react after their release into the ecosystem").

182. Citizens' Presentation, supra note 170, at 13; Andrews & Alvis, *supra* note 144, at 26. When evaluating a strategy, "it is important to weigh all costs associated with the [strategy], not simply the direct costs of technology, and to make sure that the range of options considered does not ignore important opportunities." *Id.* In fact, pollution prevention "is not only the most effective control strategy but often the cheapest as well. Many products can be made as cheaply with less toxic components; and if one counts the reduction of health risks and associated liabilities, cost savings may be substantial." *Id.* For example, $75-$150 billion is spent in annual health care costs which are attributed to the harmful effects of persistent toxic substances. Thornton & Palter, *Phasing Out Chlorine Looks Good Economically, supra* note 175, at 5 (citing International Joint Comm'n, Virtual Elimination Task Force, Draft Final Report 3-7 (1993)).

183. Great Lakes Water Quality Bd., Int'l Joint Comm'n, Legislative and Regulatory Consideration for Virtual Elimination of Persistent Toxic Substances at vi (1993) (citing Immanuel Kant, *Critique of Pure Reason* (1786)) [hereinafter Great Lakes Water Quality Bd].

The challenge is to make "decisions in the face of uncertainty, given the implications of making a decision without a proven cause and effect."[184] The potential for chlorine to cause widespread harmful effects is apparent. However, scientific proof of harm is not readily available because it is difficult to establish a direct causal relationship between the harm and the toxic substance.[185] It will take much longer than our lifetime to thoroughly test all chlorinated compounds.[186] A chemical-by-chemical risk-assessment approach will merely maintain the status quo—the existing reactive regulatory system that has allowed contamination to develop in the first place. Rather, a preventative approach to harm is needed, not absolute proof of harm: "We should be willing to initiate preventative . . . action and to risk that the findings we accept as true may turn out to be untrue—rather than learn that we were not protective enough of human health and planet Earth . . . ."[187]

Policy decisions and solutions to environmental problems, such as the build-up of chlorinated organics in the Great Lakes Basin, are not as straightforward or objective as one would like them to be. The persistent toxic chlorinated compounds presently found in the environment were originally utilized to solve difficult problems. Many of them contributed enormously to the high standard of living to which our society has become accustomed.[188] As

184. *Id.* at 7; *see also Synthesis Of Our Knowledge, in* HUMAN HEALTH RISKS, *supra* note 40, at 243 (concluding that "[b]ecause of insufficient knowledge in some areas, judgments regarding public health risks from environmental exposure to chemicals involves acceptance of an inherent level of uncertainty").

185. "The idea of *cause* and *effect* is not often proven in health or related fields of environmental science. Further, despite best efforts, it may never be proven to the satisfaction of legal systems or from the perspective of a statistically significant requirement." *Synthesis Of Our Knowledge, in* HUMAN HEALTH RISKS, *supra* note 40, at 238. *See also* Robert L. Dixon, *Toxic Responses of the Reproductive System, in* CASARETT & DOULL, *supra* note 37, at 432, 467-68 (discussing the difficulty in establishing cause-effect relationships in the human population).

186. *See supra* notes 124-34 and accompanying text; *see also Synthesis Of Our Knowledge, in* HUMAN HEALTH RISKS, *supra* note 40, at 232 (concluding that "[i]t would not be wise to wait for science to measure the full extent of the threat to health before we act").

187. Glen A. Fox, *Epidemiological and Pathobiological Evidence of Contaminant-Induced Alterations in Sexual Development in Free-Living Wildlife, in* CHEMICALLY INDUCED ALTERATIONS IN SEXUAL AND FUNCTIONAL DEVELOPMENT: THE WILDLIFE/HUMAN CONNECTION, *supra* note 47, at 155, 155; *see also Synthesis Of Our Knowledge, in* HUMAN HEALTH RISKS, *supra* note 40, at 238 (arguing that "part of a new education emphasis must be to reverse the burden of proof; i.e., to show that substance 'X' does not have a toxic impact before it gets into the enviroment").

188. Wyandotte Chemicals concluded its book *Chlorine* with these words: "When the final chapter on scientific achievements of the 20th century is written, chlorine may be considered the genie of the centennium." CHLORINE, *supra* note 15, at 87. Compare this to a statement made in 1990 by the German Council of Experts for Environmental Issues:

the IJC stated in its Sixth Biennial Report, it is ironic that "persistent toxic substances seem to form the very essence of our modern existence, of our prosperity and lifestyles. Life without plastics, fuels, petrochemicals and durable white paper simply seems unrealistic."[189] In addition, much of our economic stability depends on the production, distribution, and use of these goods. Therefore, the underlying question is: Should we "limit [chlorine's] use—and thereby limit the economy—for the sake of the purity of our biosphere?"[190]

To answer this question, it is important to recognize that policy decisions involve moral as well as economic values.[191] Our society must realize that, due to the persistence of these chemicals, even if we were to ban their use now, many generations in the future would be affected by our current widespread use of chlorine: "What we are doing to the Great Lakes, we are doing to ourselves and to our children."[192] The abuse of natural resources may reap short-term benefits for present generations, but only by distributing the cost to future generations who have no input in these decisions. The potential for chlorine and its compounds to cause adverse effects on human health and the environment has been known for some time, and yet these substances still maintain the right of innocence until proven guilty. Their presumed innocence is not justified given their overwhelming potential for inflicting widespread injury.

Furthermore, it is necessary to make value judgments concerning what chemical benefits are so important to our society that sac-

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"[T]he dynamic growth of chlorine chemistry during the 50s and 60s represents a decisive mistake in twentieth century industrial development, which would not have occurred if our present knowledge as to environmental damage and health risks due to chlorine chemistry had then been available." Vallentyne, *supra* note 87, at 8-9.

189. SIXTH BIENNIAL REPORT, *supra* note 9, at 43-44. It has been noted that:

> [t]he toxic chemical issue strikes at the very core of our way of life. It has placed us at a point where we view, on the one hand, the vital importance of protecting the quality of our environment, yet, on the other hand, we wish to retain modern pleasures and conveniences, some of which may be associated with the environmental degradation about which we are all concerned.

Synthesis Of Our Knowledge, in HUMAN HEALTH RISKS, *supra* note 40, at 229.

190. THE ENDURING GREAT LAKES, *supra* note 63, at 74.

191. *See Synthesis Of Our Knowledge, in* HUMAN HEALTH RISKS, *supra* note 40, at 236 (arguing that "[w]e need to consider what is ethical rather than what is legal . . . [and] what is moral instead of what is permissible").

192. SIXTH BIENNIAL REPORT, *supra* note 9, at 7; *see* Flint, *supra* note 69, at 2 ("It is clear . . . that contaminants will persist in the lake environment for decades, even if all point sources were eliminated now."). For example, although mirex and PCBs are not produced or used anymore, these chlorinated organics are still being measured in sediments and fish in the Great Lakes. *Id.* at 3.

rificing the purity of our environment would be morally acceptable.[193] If use of chlorine provides no more than a luxury to our consuming society, sacrificing the environment would not be justified. However, if human health or some other essential need is at stake, a justification for the sacrifice may exist.[194] The use of chlorine should be limited particularly where non-essential items are involved.[195] As the chlorine industry continuously and dramatically points out, there are some areas, such as water chlorination and the manufacture of pharmaceuticals, in which the immediate elimination of chlorine would not be justified.[196] However, the need for more extensive research and development of alternatives in these areas does not mean that the phase-out of chlorine should not be pursued in other processes and products that are non-essential or replaceable. The long-term goal of a phase-out should be to channel economic growth away from industries that are hazardous to

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193. It is clear that "there exists a risk to health because there are no zero risks. Acceptability of the risk is a public decision rather than a scientific decision." *Synthesis Of Our Knowledge*, *in* HUMAN HEALTH RISKS, *supra* note 40, at 232.

194. *See* DAVID D. DONIGER, LAW AND POLICY OF TOXIC SUBSTANCES CONTROL 22 (1978) (stating "[t]hat some must die so that all can eat is one thing; that some must die so that all can have see-through food packaging is another").

195. Decisions as to what are "non-essentials" will not be as simple as the distinction between pharmaceuticals and the packaging used for the pharmaceuticals. *Id.* at 22 n.80b. However, simply because many of these value judgments will be difficult does not mean we should avoid making the clear-cut decisions.

It can be argued that the values of a society are malleable and influenced by those who have financial interests in promoting the materialistic, consuming behavior of the public. *Id.* However, society should not "stand mute when confronting the ultimate question of whether we want our children, and their children's children, to live in—and *enjoy*--a plastic world." *Id.* (quoting Laurence H. Tribe, *Ways Not to Think About Plastic Trees*, *in* WHEN VALUES CONFLICT 61, 70 (Laurence H. Tribe et al. eds., 1976) (emphasis in original)).

196. In addition to its widespread use in the manufacturing of many consumer products, the public health benefits of chlorine include the chlorination of water supplies, which has virtually eliminated the threat of waterborne diseases, and the manufacture of pharmaceuticals, including antibiotics. Earl V. Anderson, *Chlorine Producers Fight Back Against Call for Chemical's Phaseout*, CHEM. & ENG'G NEWS, May 10, 1993, at 12, 12; *Chlorine Industry Defends Treatment*, CHEMISTRY & INDUS., July 20, 1992, at 519, 519.

Ninety-eight percent of U.S. drinking water systems use chlorine and chlorine-based products to disinfect the water. Industry claims that 25,000 people in the world die every day from effects linked with drinking dirty water, and that since the inception of water chlorination, life expectancy has increased from 50 to 75 years. Worries over the adverse effects of chlorine prompted some South American countries not to chlorinate drinking water. This led to a recent cholera epidemic which killed over 5000 people. *Chlorine Industry Defends Treatment*, *supra*, at 519; *see supra* note 164 and accompanying text.

About 85% of all pharmaceuticals are manufactured using chlorine chemistry. The annual net cost of finding alternatives to chlorine in the pharmaceutical industry is almost eight times as much as the cost of finding substitutes for PVC products, despite the fact that PVC consumes 22 times more chlorine. Anderson, *supra*, at 12; *see supra* notes 177-80 and accompanying text.

health and towards safer ones. In this way, the economy need not be "limited," but shifted towards an economy that is socially and morally responsible for the environment.

The broadening campaign to phase out chlorine use should be seriously considered.[197] In fact, the chemical industry has begun to recognize that changes are coming.[198] The leader of Charles River Associates[199] warned the industry to anticipate a "sea change," urging them to move beyond the denial stage and prepare for new markets.[200]

Policymakers face challenges that must be approached collectively with businesses and industry actively involved and committed to the same goals. Any effective strategy must promote open dialogue, consultation, cooperation, and planning among all interested parties—environmentalists, citizens, governments, and industries.

VI. The Implementation of a Chlorine Ban

The IJC recommended a chlorine phase-out in the Great Lakes Basin to the U.S. and Canadian governments. However, the IJC has no authority under the Great Lakes Water Quality Agreements to implement a phase-out. Therefore, it is up to the federal administrative agencies and legislative bodies to either act upon, or ignore, this recommendation.[201]

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197. *See Group Ready to Revise TSCA*, *supra* note 6 (stating that the "staff attorney for U.S. Public Interest Research Group . . . agrees with people who have predicted the chlorine debate will probably become one of the fiercest environmental battles of the next decade"); Vallentyne, *supra* note 87, at 11 (concluding that "[r]egardless of what may be said on either side of the controversy, it is difficult to avoid the conclusion that when organizations as staid as the International Joint Commission and as provocative as Greenpeace agree on the need for a common action, there must be something to it").

198. *See* Raymond Ludwiszewski, *Heading Toward A Chlorine Ban*, WATER ENG'G & MGMT., June 1994, at 12, 12.

199. *See supra* note 167 and accompanying text.

200. Eder, *supra* note 33, at 5. Some large chemical companies have responded to anti-chlorine concerns by developing long-range strategic plans to cut back on use and production of chlorinated compounds.

201. Immediately preceding the IJC's Seventh Biennial Meeting in October 1993, both the U.S. and Canadian governments released reports which stated the federal governments did not support sunsetting chlorine and chlorine-containing compounds as industrial feedstocks. EPA, U.S. RESPONSE TO RECOMMENDATIONS IN THE SIXTH BIENNIAL REPORT OF THE INTERNATIONAL JOINT COMMISSION 9 (1993) (stating "[t]he United States does not support sunsetting all uses of chlorine and chlorine-containing compounds as industrial feedstocks"); CANADA, CANADA'S RESPONSE TO RECOMMENDATIONS IN THE SIXTH BIENNIAL REPORT OF THE INTERNATIONAL JOINT COMMISSION 6 (1993) (stating "the government of Canada is not prepared to support a comprehensive ban on the use of chlorine and chlorine-containing compounds as an industrial feedstock").

A. *Regulatory Action*

In the U.S., the Environmental Protection Agency (EPA) would be responsible for implementing a ban on chlorine throughout the Great Lakes Basin. The agency could promulgate a rule directed at the use of chlorine specifically in the Great Lakes Basin, or, since the chlorine debate is ultimately an issue of national impact, the agency could regulate chlorine on a national scale. Either approach would effectually satisfy the Water Quality Agreement's mandate to eliminate persistent toxic substances in the Great Lakes ecosystem.

The EPA should address the problems of chlorine chemistry by adopting a weight of evidence approach toward persistent toxic substances.[202] This approach supports the sunset of chlorine as an industrial feedstock since there is sufficient evidence to conclude that the class of chlorinated compounds[203] has adverse impacts on

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However, in February 1994, EPA Administrator Carol Browner released the Clinton administration's recommendations on Clean Water Act reauthorization, which included provisions to study the phase-out of the use of chlorine. EPA, PRESIDENT CLINTON'S PROPOSAL FOR THE CLEAN WATER ACT 22-24 (1994). The proposed provision states that the EPA "will develop a national strategy for substituting, reducing, or prohibiting the use of chlorine and chlorinated compounds." *Id.* at 22. In order to do so, the EPA shall convene a task force "to comprehensively assess the use, environmental and health impacts of chlorine and chlorinated compounds, and availability and relative efficacy and safety of substitutes for these substances as used in publicly owned treatment works and drinking water systems, and solvents, PVC and other plastics, and in pulp and paper manufacturing." *Id.* at 23. The administration would have two and half years to do so, at which time a final strategy would be released. *Id.*

The administration's commitment to have a final strategy developed within a limited time period suggests that the government has recognized the problems with chlorine use and will support a phase-out of chlorine.

In addition, in October 1994, the Canadian government responded to some of the IJC's concerns by releasing the Chlorinated Substances Action Plan I. Although rejecting a complete ban of all chlorine substitutes, it announced its intention to ban a small group of chlorinated substances that are highly toxic, persistent, and bioaccumulative. *Government Sets Plan to Eliminate, Manage Harmful Chlorinated Substances*, Int'l Envtl. Daily (BNA) (Oct. 27, 1994). *But see Canada Rejects IJC Call For Crackdown On Incinerators*, Int'l Envtl. Daily (BNA) (Oct. 26, 1994) (stating that the Canadian goverment does not support an IJC recommendation to phase out incinerators).

202. *See supra* notes 145-49 and accompanying text.

203. The regulation of a class of chemicals, as opposed to individual chemical substances, has already been adopted by Congress to some degree. For example, there are 209 different derivatives (isomers) of PCB—each with its own individual molecular structure. Kuntz, *supra* note 47, at 138. Some of these derivatives are extremely toxic, but most are relatively nontoxic. PAASIVIRTA, *supra* note 30, at 130; Woodruff, *supra* note 48, at 135. However, under § 2605(e) of TSCA, Congress mandated the phase-out of the entire "class" of PCBs. *See* 15 U.S.C. § 2605(e) (1988).

In addition, the phosphorus control program in the Great Lakes was a "class" control. Vallentyne, *supra* note 87, at 10. *See infra* note 213 and accompanying text.

human health and the environment. Under this premise, the EPA should develop an effective strategy for eliminating the existing uses of chlorine. This strategy should take socio-economic considerations into account with particular emphasis on the public health benefits of a given use of chlorine.

When implementing the phase-out of chlorine, the agency should focus first on those processes that use large amounts of chlorine, release large or potent quantities of organochlorines, or have the most viable alternatives to chlorine.[204] This focus can be accomplished effectively through the development of a chlorine use tree which would allow the societal use of chlorine to be viewed holistically.[205] After priorities have been identified, timetables for the eventual phase-out of chlorine in these areas would be developed. One way to enforce these timetables would be to give each priority process a "sunset permit" with an expiration date, after which the process would no longer be allowed.[206] Incentives or mandates to engage in research aimed at developing chlorine-free substitutes could be directed at those sectors for which alternatives are not presently available.[207]

Along with the sunset of existing chlorine uses, a screening—or "sunrise"—process should be developed. No new chlorine-based chemicals should be produced or used unless it has been demonstrated that the chemical is necessary to society and does not bioaccumulate or threaten the environment or the health of wildlife or people.[208] The burden of proving that these criteria have been met should be on the industry or manufacturer who wishes to use or produce the new chemical.[209] By following this strategy, the eventual phase-out of chlorine and chlorinated organics can be ac-

204. CITIZENS' PRESENTATION, *supra* note 170, at 17-18; *see supra* notes 171-76 and accompanying text. Chlorinated organics with a high bioaccumulative or toxic potential should be the highest priority.

205. *See supra* note 172.

206. Muir et al., *supra* note 30, at 51.

207. *Id.*

208. NATIONAL WILDLIFE FED'N, *supra* note 1, at 22.

209. Requiring testing and assessment of new chemicals before their introduction into commerce is not novel, as § 5 of TSCA requires assessment of the risk a new chemical poses before it can be distributed. *See infra* notes 217-21 and accompanying text. This provision under TSCA constitutes the first step of a preventative "sunrise" process. However, under § 5, the burden is initially on the Administrator to show there is a "reasonable basis" to find an "unreasonable risk" to the environment. 15 U.S.C. § 2604(f). Once this threshold determination is met, the burden then shifts to the producer to prove that its use will *not* pose an unreasonable risk. Under a sunrise process, this threshold determination that a chlorinated organic poses an unreasonable risk has already been met. Therefore, reverse onus would automatically apply, and it would be the manufacturer's burden to prove that the new compound is safe before it is released.

complished with maximum benefit and minimum cost to society.

B. *Legislative Authority to Ban Chlorine*

1. *Existing Legislation.* In order to evaluate the possibility of eliminating chlorine as an industrial feedstock in the Great Lakes Basin, it is necessary to consider whether, under the existing legal framework, the EPA has adequate authority to address all areas pertaining to the use, generation, release, and disposal of chlorine. In addition, it is necessary to consider whether the agency could *successfully* engage in the implementation of this authority.

The Toxic Substances Control Act (TSCA)[210] is the appropriate statute for the EPA to utilize when addressing the sunset of chlorine. TSCA, which Congress enacted in 1976, provides a statutory basis for the comprehensive identification and control of chemicals that pose an unreasonable risk to human health or the environment.[211] Determining that the control of toxic inputs would better protect human health and the environment, Congress attempted to adopt a preventative approach for the regulation of toxic substances.[212] Since TSCA is currently the only legislation that grants the EPA authority to investigate and control the use, generation, release, and disposal of new *and* existing substances on a multi-media basis, TSCA should address a chlorine phase-out. In addition, TSCA authorizes the EPA to regulate categories, or classes, of chemical substances.[213]

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210. 15 U.S.C.A. §§ 2601-2671 (West 1982 & Supp. 1992).

211. Cynthia Ruggerio, *Referral of Toxic Chemical Regulation Under the Toxic Substances Control Act: EPA's Administrative Dumping Ground*, 17 B.C. ENVTL. AFF. L. REV. 75, 76 (1989).

The regulation of toxic substances can be addressed under several other environmental statutes, including the Clean Air Act, 42 U.S.C.A. §§ 7401-7641 (West 1983 & Supp. 1992), the Clean Water Act, 33 U.S.C.A. §§ 1251-1387 (West 1986 & Supp. 1992), and the Comprehensive Environmental Response, Compensation and Liability Act, 42 U.S.C.A. §§ 9601-9675 (West 1983 & Supp. 1992). However, unlike TSCA, they do not provide for multimedia (air, land, and water) regulation of a toxic chemical through its entire lifecycle. Ruggerio, *supra*, at 76. These statutes are concerned primarily with controlling pollution discharges and cleaning up polluted resources. Therefore, they do not focus on prevention but on the end-products of an industrial process. Hanan, *supra* note 156, at 396; *see supra* part IV.A., which discusses the ineffectiveness of traditional command and control regulation.

212. Hanan, *supra* note 156, at 402 (stating that "[t]he purpose of TSCA is to identify potentially harmful substances before they are manufactured and placed in the market, thereby protecting the public from any 'unreasonable risk'," and "TSCA would essentially act as a filter by regulating and restricting the introduction of new chemicals into the marketplace").

213. 15 U.S.C. § 2625(c)(1). The Act defines "category of chemical substances . . . [as] a group of chemical substances the members of which are similar in molecular structure, in physical, chemical, or biological properties, in use, or in mode of entrance into the human

The Act has three major purposes: to (1) screen new chemicals to determine whether they pose a risk to human health and the environment;[214] (2) test chemicals that the EPA identifies as possible risks;[215] and (3) gather information on existing chemicals and empower the EPA to control those that pose a risk.[216]

Section 5 of TSCA[217] authorizes the agency to regulate the distribution of newly-manufactured chemicals into the marketplace and the environment, and allows for prior determination of a chemical's potential risks. Under this section, a company must inform the EPA of its intention to manufacture a new chemical before it is produced. The Administrator must then decide whether the chemical presents an "unreasonable risk of injury to health or the environment."[218] If the Administrator determines that an unreasonable risk exists, section 5 of the Act instructs the Administrator to modify introduction of the chemical into the environment through a limit or ban on the chemical's production and release.[219] Furthermore, section 5 authorizes the EPA to exempt a manufac-

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body or into the environment." *Id.* § 2625(c)(2)(A). The question of whether or not this definition can be applied to the entire class of chlorinated compounds is likely to be one of the most controversial issues involved in a phase-out of chlorine. *See supra* note 203.

214. 15 U.S.C. § 2604(a)(1). Under this provision, a premanufacture notification, or "PMN", must be submitted to the EPA at least 90 days prior to commercial manufacture or import of any chemical substance not on a list of chemicals in commerce that is compiled and maintained by the EPA (TSCA Inventory of Chemical Substances). *Id.*

215. *Id.* § 2603. This provision allows the Administrator to require that testing be conducted on any substance or mixture which poses a risk to health or the environment if there is an insufficiency of data to determine whether an unreasonable risk is present.

216. *Id.* § 2607. This provision requires that "[e]ach person . . . who manufactures or processes or proposes to manufacture or process a chemical substance . . . shall maintain such records, and shall submit to the Administrator such reports as the administrator may reasonably require," *Id.* § 2605, and provides that

> [i]f the Administrator finds that there is a reasonable basis to conclude that the manufacture, processing, distribution in commerce, use, or disposal of a chemical substance or mixture, or that any combination of such activity, presents or will present an unreasonable risk of injury to health or the environment, the Administrator shall by rule . . . protect adequately against such risk.

Id.

217. *Id.* § 2604(a), entitled "Manufacturing and Processing Notices."

218. TSCA § 5(f) provides in part:

> (1) If the Administrator finds that there is a reasonable basis to conclude that the manufacture, processing, distribution in commerce, use, or disposal of a chemical substance with respect to which notice is required by subsection (a) of this section, or that any combination of such activities, presents or will present an unreasonable risk of injury to health or the environment before a rule promulgated under [§ 6] can protect against such a risk, the Administrator shall . . . take the action authorized . . . to the extent necessary to protect against such risk.

Id. § 2604(f).

219. *Id.*

turer from a limit or ban upon proof that a chemical substance will not present an unreasonable risk to human health or the environment.[220] Therefore, upon a threshold determination that all new chlorinated compounds pose an "unreasonable risk," the agency could prohibit any new chlorine use in society. This would shift the burden of proof onto the manufacturer to prove that a new chlorinated compound or use will not expose society to an unreasonable risk.[221]

In order to regulate chemicals that already exist in commerce, section 6 of TSCA provides that if the Administrator finds there is a reasonable basis to conclude that the manufacture, processing, distribution in commerce, use, or disposal of a chemical substance or mixture presents or will present an unreasonable risk to human health or the environment, the Administrator shall prohibit or limit these activities.[222] Under this section, the EPA could implement a ban on the existing production, import, and use of chlorine in the U.S.

However, despite the potential for comprehensive regulation under section 6 of the Act, the EPA has failed to fully utilize the powers section 6 creates.[223] One factor that has rendered the Act ineffective for timely control of existing chemicals is that the EPA must formulate regulations that are the least burdensome necessary to achieve its objective to control the chemical.[224] Proposed regulatory controls of existing chemicals have been rejected on the grounds that the proposed regulation was not the least burdensome means of control available.[225] In addition, the EPA may be reluctant to implement controls under section 6 because such action must be supported by substantial evidence on the entire record in order to survive judicial review.[226] The Act has not been

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220. *Id.* § 2604(h)(4).

221. This would constitute a "sunrise" process. *See supra* notes 208-09 and accompanying text.

222. 15 U.S.C. § 2605.

223. *GAO Says Congress Could Rewrite TSCA to Create 'Umbrella' Environmental Law*, Chem. Reg. Daily (BNA) (Oct. 27, 1994); Joyce Merritt, *Standard of Review Under the Toxic Substances Control Act:* Corrosion Proof Fittings v. EPA, 8 J. NAT. RESOURCES & ENVTL. L. 167, 167 (1992). EPA's attempt to completely ban asbestos was not successful despite the availability of substantial proof that asbestos was harmful. *See infra* notes 228-37 and accompanying text.

224. 15 U.S.C. § 2605(a). *See* GREAT LAKES WATER QUALITY BD., *supra* note 183, at 8.

225. GREAT LAKES WATER QUALITY BD., *supra* note 224, at 8.

226. Hanan, *supra* note 156, at 411 (arguing that "[w]hen EPA imposes a final rule with respect to a particular chemical, it must be ready to defend its rule under the substantial evidence standard of review, and to devote significant amounts of time and money in doing so"); Ruggerio, *supra* note 211, at 87 n.56 (stating that "[m]embers of Congress and OTS officials agree that the requirement of substantial evidence on the entire rulemaking

usèd to ban any existing substances other than PCBs, the regulation of which Congress specifically mandated under section 6(e).[227]

The difficulties that the EPA would face in promulgating rules for the phase-out or ban of chlorine under TSCA are best illustrated by *Corrosion Proof Fittings v. EPA*.[228] The EPA used its authority under section 6 to promulgate a rule banning asbestos, a known dangerous substance.[229] However, the Fifth Circuit Court of Appeals rejected the EPA's final rule which prohibited the manufacture and sale of asbestos in almost all products.[230] Under the substantial evidence standard of review,[231] the court determined that the agency's asbestos rule was inadequate on four grounds. First, the EPA's conclusions were inadequate to support TSCA's "least-burdensome" requirement.[232] Although the agency did consider alternatives to a ban, such as labeling or controlled use, the court stated: "TSCA requires the EPA to consider, along with the effects of toxic substances on human health and the environment, 'the benefits of such substances[s] or mixture[s] for various uses and the availability of substitutes for such uses,' as well as 'the reasonably ascertainable economic consequences of the rule . . . .' "[233] The EPA did not calculate the risk levels for an intermediate level of regulation and, therefore, the record was insufficient to determine whether a complete ban was the "least-burdensome" means available. Second, the court found the agency's evaluation of alternative products to be insufficient, particularly with respect to those products that would be banned without replacements.[234] Third, the court criticized the EPA's cost-benefit

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record under §§ 6 and 7 has thwarted enforcement efforts under TSCA").

227. 15 U.S.C. § 2605(e)(2)(A) (stating "no person may manufacture, process, or distribute in commerce or use any polychlorinated biphenyl in any manner other than in a totally enclosed manner"); *see* INTERNATIONAL JOINT COMM'N, REPORT OF THE GREAT LAKES WATER QUALITY BOARD TO THE INTERNATIONAL JOINT COMMISSION 12-13 (1993).

228. 947 F.2d 1201 (5th Cir. 1991).

229. *Id.* at 1208; *see* Hanan, *supra* note 156, at 411. In considering exposure and health risk, the EPA noted that "asbestos is a human carcinogen and is one of the most hazardous substances to which humans are exposed in both occupational and non-occupational settings." *Id.* (quoting 54 Fed. Reg. 29,460, 29,468 (1989)).

230. *Corrosion Proof Fittings*, 947 F.2d at 1207.

231. The "substantial evidence" requirement under TSCA is more rigorous than the "arbitrary and capricious" standard that is usually applied to informal rulemaking, imposing a considerable burden on the agency and limiting its discretion in fact finding. Hanan, *supra* note 156, at 411.

232. *Corrosion Proof Fittings*, 947 F.2d at 1215. The court stated that because the EPA chose "the harshest remedy given to it under TSCA [a complete ban], the EPA assigned itself the toughest burden in satisfying TSCA's requirement that its alternative be the least burdensome of all those offered to it." *Id.* at 1216.

233. *Id.* (quoting 15 U.S.C. §§ 2605(c)(1)(C)-(D)).

234. Hanan, *supra* note 156, at 414. The court disagreed with the EPA's determination

analysis, especially the agency's consideration of "unquantifiable benefits."[235] Fourth, the court held that the EPA's determination of "unreasonable risk" was not supported,[236] since "the high costs of banning asbestos compared to the relatively small benefits derived did not constitute an unreasonable risk."[237]

The Fifth Circuit's opinion in *Corrosion Proof Fittings* has significantly narrowed the EPA's power to regulate toxic chemicals under TSCA.[238] The agency's first attempt to ban a compound under section 6 was not successful. The substantial evidence requirement led the court into a probing examination of the EPA's methodology, virtually eliminating the EPA's discretion in controlling toxic substances. Consequently, the Act has been unsuccessful in controlling existing chemicals, except for PCBs,[239] and has regulated an insignificant number of new chemicals.[240] Under the current provisions of TSCA, any EPA attempt to phase out the use of chlorine as an industrial feedstock is likely to be futile.[241]

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that the ban of asbestos "should not be delayed until the risk[s] of all replacement materials are fully quantified." *Corrosion Proof Fittings*, 947 F.2d at 1221.

235. *Corrosion Proof Fittings*, 947 F.2d at 1219. In its cost-benefit analysis, the EPA determined that some of the estimated costs of a ban would be offset by the elimination of costs associated with asbestos. These "unquantifiable benefits" included costs that would result from the increased risk of accumulation of asbestos in the environment, the resources that would be needed to treat the adverse health effects of asbestos, the removal and disposal costs, and litigation costs. *Id.*; *see also* Hanan, *supra* note 156, at 415.

236. *Corrosion Proof Fittings*, 947 F.2d at 1222-23.

237. Hanan, *supra* note 156, at 415 (citing *Corrosion Proof Fittings*, 947 F.2d at 1222-23).

238. *See* Merritt, *supra* note 223, at 167 (arguing that "[t]he decision in *Corrosion Proof Fittings* . . . turns the attempt by Congress to protect health and the environment, by allowing the EPA to ban dangerous substances under the TSCA, into a virtually useless tool").

239. *See supra* note 227 and accompanying text.

240. From 1979 to 1983, the EPA banned only thirteen new chemicals before their distribution. In this time period, the agency had received a total of 3,012 PMNs (premanufacture notices). Hanan, *supra* note 156, at 408-09 (arguing that the inability to effectively regulate new chemicals under TSCA is due to the overly strict standard of judicial review with respect to rules promulgated by the EPA, as well as the lack of information which exists for the majority of chemical substances).

Furthermore, it can be argued that the broadening campaign to ban chlorine is actually a product of the ineffectiveness of TSCA. If TSCA had been an effective tool for the regulation of chlorine uses, the present environmental build up of organochlorines would have been prevented. A Chemical Manufacturers Association official recently stated: "I think the reason we're talking about bans, and we are talking about things like toxic use reduction is because . . . TSCA . . . has not worked well." *Group Ready to Revise TSCA, supra* note 6.

241. The futility of using TSCA in its present form to effectuate a chlorine phase-out is best described by the following statements by Steve Shimberg, minority staff director and chief counsel of the Senate Environment and Public Works Committee: "TSCA is one of those lonely step-children of environmental statutes. There are not a lot of people out there who deal with it on a day-to-day basis, not a lot of people who believe it is very effective. I

2. *Congressional Reform.* Despite the historical inadequacies of TSCA in regulating toxic chemicals, this Act should address the risks associated with chlorine use. Absent any congressional action specifically directed to the phase-out of chlorine, TSCA is the only piece of federal legislation that provides for multi-media regulation of toxic substances, addresses both new and existing toxic substances, and authorizes prohibition of the use of toxic substances. These mechanisms lend themselves to the proactive, preventative regulation of persistent toxic substances. Therefore, in order to allow the EPA to address and eventually ban, the use, generation, release, and disposal of chlorine and its products, this Comment sets forth two suggestions for persistent toxic substance reform. First, Congress must clarify its concern with pollution prevention under TSCA. Second, TSCA should be revised to allow for an arbitrary and capricious standard of review when there is a reasonable basis to conclude that a chemical is a persistent toxic substance.

a. *Clarification of Policy.* It is clear that Congress' primary intent in passing TSCA was to create a framework for pollution prevention in order to better protect human health and the environment.[242] However, the goal of preventing injury to human health and the environment conflicts with the statute's additional policy concern with inhibiting technological innovation through restrictive regulation.[243] In determining what constitutes an "unreasonable risk," the EPA must engage in certain policy decisions. The Act enumerates what factors are to be considered in making these decisions,[244] but the conflicting goals of the Act provide little guidance to the agency on how much weight to accord each of these factors. Since the Act was enacted to provide the authority

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have had a number of my colleagues suggest that the only thing worth doing to TSCA is repealing it because it doesn't work." *Group Ready to Revise TSCA, supra* note 6. After the Fifth Circuit's decision to overturn the EPA's ban of asbestos under TSCA, "everyone [was led] to believe that if you can't even control asbestos with TSCA what can you do?" *Id.*

242. 15 U.S.C. § 2601(b) (stating that the primary purpose of the statute is "to assure that . . . innovation and commerce in . . . chemical substances and mixtures do not present an unreasonable risk of injury to health or the environment").

See S. REP. No. 698, 94th Cong., 2d Sess. (1976) ("The most effective and efficient time to prevent unreasonable risks . . . is prior to first manufacture. It is at this point that the costs of regulation in terms of human suffering, jobs lost, wasted capital expenditures, and other costs are lowest."); *see also supra* note 212 and accompanying text.

243. 15 U.S.C. § 2601(b)(3) (stating that "authority . . . should be exercised in such a manner as not to impede unduly or create unnecessary economic barriers to technological innovation").

244. *Id.* § 2605(c)(1). These factors include (1) the effects on health and the environment, and the magnitude of exposure; (2) the benefits and availability of substitutes; and (3) the economic consequences, after consideration of the effect on the national economy, small business, technological innovation, the environment, and public health. *Id.*

for pollution prevention, Congress should clarify that the social benefits of a persistent toxic substance, or potentially persistent toxic substance, must significantly outweigh its potential risk to human health and the environment in order for it to be produced.

b. *Standard of Review*. TSCA's requirement that the EPA support its decisions to promulgate regulations with substantial evidence in the rulemaking record and use the least burdensome means to achieve its objectives has significantly narrowed the discretion given to the EPA in controlling persistent toxic substances. It makes sense to require an agency to provide credible evidence in its rulemaking record to support a given decision. However, under this standard, EPA decisions to promulgate regulations are subjected to stringent factual review in the courts. This extensive review is not appropriate for determining "unreasonable risk," since a decision regarding the prevention of persistent toxic substances entering the environment "involves choices among different policies, legal interpretations and patterns of risk and uncertainty far more than choices determined by whether certain specific factual allegations are true or not."[245] Furthermore, such a judicial demand—that the EPA conduct a detailed cost-benefit analysis addressing all potential risk, all plausible regulatory alternatives, and the abundance of possible product substitutes in order to satisfy the least burdensome requirement—would "virtually negate[] meaningful chemical regulation."[246] Considering the number of potentially toxic chlorinated organics in commerce, and the requirements specified by *Corrosion Proof Fittings*, even if the EPA could

245. Legal Support Document for Proposed Procedures for Rulemaking Under Section 6 of the Toxic Substances Control Act, 42 Fed. Reg. 20,640 (1977), at 6. The legislative history of the act supports this conclusion:

> When, as here, regulatory action is intended to be taken to prevent the occurrence of harm in the future as well as protect against presently visible harm, such action often must be based not only [on] consideration of facts but also on consideration of scientific theories, projections of trends from currently available data, modeling using reasonable assumptions, and extrapolation from limited data. Further, regulatory action may be taken even though there are uncertainties as to the threshold levels of causation. . . . [A] judgment [to regulate] may be based upon items such as toxicological, physiological, epidemiological, biochemical or statistical research or studies or extrapolations therefrom . . . . It does not . . . require the factual certainty of a "finding of fact" of the sort associated with adjudication.

H.R. REP. No. 1341, 94th Cong., 2d Sess. 32 (1976).

Furthermore, in discussing the agency's decisions regarding unreasonable risk, the House Report states: "The Committee recognizes that, particularly with respect to such issues as the effects of substance or mixture on health or the environment, the Administrator's findings may necessarily deal with projections from imperfect data, experiments and simulations, educated predictions, differing assessments of possible risks, etc." *Id.* at 36.

246. Hanan, *supra* note 156, at 416.

provide evidence that would satisfy judicial review, the substantial time required to gather the necessary data and calculations would leave the public exposed to chlorinated compounds long after the EPA has determined that the risk is unreasonable. Therefore, meaningful regulation of organochlorines cannot be effectuated under the existing standard of review. TSCA should be revised so that when the EPA has a reasonable basis to conclude that a chemical is a persistent toxic substance, the agency should be accorded more rulemaking deference. A reviewing court should reject a regulation only upon a determination that the agency acted arbitrarily and capriciously. If the above reforms are enacted, TSCA's goal of pollution prevention can be achieved, and the EPA would stand on firmer ground when implementing a chlorine phase-out.

CONCLUSION

The knowledge of risks associated with chlorine and chlorinated compounds is not a recent development. However, the public's increasing awareness and refusal to be subjected to these risks is recent. Chlorine's unique properties have allowed industry to provide society with many useful and beneficial products. But it is these very same properties that have subjected human health and the environment to widespread injury. In the Great Lakes Basin, the adverse effects of organochlorines are far-reaching due to their continuing build-up in the environment. Under the Great Lakes Water Quality Agreements, the United States government undertook an obligation to virtually eliminate exposure to persistent toxic chemicals. In order to achieve this goal, decisions concerning the risks posed by chlorine must be based on the weight of evidence, which does support a determination that the entire class of chlorinated compounds is guilty of causing harm. Through proper regulation, the phase-out of chlorine would allow future generations to enjoy these "sweet water seas."