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Executive Director

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TO: VI Executive Board

RE: Economic Study

On April 8th, the CCC/Chlorine Institute held an industry briefing in Washington, D.C. to introduce the study by Charles River Associates on the economic benefits of the chlor-alkali industry.

Attached for your information and internal distribution as appropriate is the executive summary and PVC-specific sections of the report.

We ask that this information be used as "background" for the moment, pending recommendations from the Communications Committee (CCC/CI) as to the best means of utilization. This "game plan" should be ready within 30 days.

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Executive Summary

Every day, U.S. and Canadian consumers benefit from chlorine and chlorine-based products. When someone takes a drink of water, pours bleach into a washing machine, or buys cooking oil in a PVC container, he or she benefits from chlorine. Every time consumers use automobiles, buy produce in the supermarket, fill prescriptions in a drug store, or take pictures of their families, they are also benefiting from chlorine. Water purification, bleaches, plastics like PVC, crop protection chemicals, pharmaceuticals, and the manufacture of photographic film are only a few examples of how U.S. and Canadian consumers gain from processes and products that use chlorine.

Even though the use of chlorine chemistry results in substantial economic benefits in most sectors of our society, consumers may not realize how broadly this element touches their daily lives. Most people generally are only aware of chlorine's direct uses, but *direct consumption* is one of three distinct ways in which society uses chlorine and its coproducts. The element is also incorporated in other *consumer products*, providing them with specific, desirable characteristics, and it is used to *facilitate* the manufacture of hundreds of other products.

Chlorine has become important in these diverse applications because of its physical and chemical properties. There are some instances where other elements can replace chlorine with modest incremental cost or performance penalties, but in most instances the use of alternative processes or materials entails significant performance loss or cost increases. In some cases, the alternative processes or materials are less environmentally friendly or present health risks.

In spite of the broad range of uses and benefits from chlorine, there are certain groups that propose a total ban on chlorine production and use because some chlorine-containing compounds have been found to pose unacceptable health and environmental risks. These risks should not be taken lightly, and any situation where chlorine-dependent processes or chlorine-containing compounds create unacceptable health and environmental risks should be corrected. In April 1992 the International Joint Commission on Great Lakes Water Quality recommended that the United States and Canada consider phasing out the use of chlorine and chlorine-containing compounds as industrial feedstocks. But any public policy debate concerning the banning of all chlorine production and use should take into

Exhibit 1. 1990 Value of Chlorine Chemistry

To Consumers	Units	Economic Value		
		United States	Canada	Total
Economic benefits				
In direct uses	\$Billion/Year ⁽¹⁾	9.8	1.2	11.0
In products containing chlorine	\$Billion/Year	31.4	3.3	34.7
As a facilitator	\$Billion/Year	49.9	6.8	56.7
Total	\$Billion/Year	91.1	11.3	102.4
To Local Economies				
Economic contributors				
Value of sales	\$Billion/Year	71.4	8.5	79.9
Employment, direct	Workers	366,700	28,400	395,100
Employment, indirect	Workers	948,300	55,600	1,003,900
Employment, total	Workers	1,315,000	84,000	1,399,000
Wages, direct	\$Billion/Year	9.9	0.8	10.7
Wages, indirect	\$Billion/Year	21.4	1.5	22.9
Wages, total	\$Billion/Year	31.3	2.3	33.6
Gross domestic investment	\$Billion	56.8	4.4	61.2
Balance of trade	\$Billion/Year	+2.9	+0.1	+3.0

Note:

(1) All costs are in U.S. dollars.

SOURCE: Charles River Associates, 1993.

- The investment needed to build plants to make the substitutes would approach \$67 billion. The transition would take 10 to 20 years, and consumers would more than likely be forced to shoulder the cost over

1. At some cost, alternatives exist for *all* uses of chlorine and chlorine-derived compounds.
2. Although we know that technology is constantly changing, we can only estimate the costs of the existing or definable technological alternatives for chlorine. As a result, we based our evaluation of chlorine substitutes on:
 - Products or processes currently or previously used;
 - Information provided in the patent literature and other sources concerning chlorine substitutes; and
 - Modified versions of existing processes that are highly likely to be technically workable.
3. All chlorine substitute materials and processes would comply with *current* environment-, safety-, and health-related laws and regulations.

In cases where more than one chlorine substitute exists, we used our best business and engineering judgment to determine the most likely alternative. Typically, we selected the substitute that would cost the consumer the least.

All information for this report came from publicly available sources and from contacts with experts in both the public and private sectors. CRA used its best business and engineering judgment to determine costs and engineering losses that would be caused by substitution, and to design economic models of consumer behavior.

CRA's analysis focuses on the extent of chlorine chemistry's influence on industrial activities and consumers' daily lives. It provides specific information on the economic tradeoffs that would result from a total ban of chlorine production and use in the United States and Canada. These tradeoffs are significant given chlorine's diverse use and the intricate association of chlorine chemistry with many technologies.

References

- (1) "Chemical Profile — Caustic Potash," *Chemical Marketing Reporter*, October 1, 1990.
- (2) *Riegel's Handbook of Industrial Chemistry*, 9th Ed., J. Kent, ed., Van Nostrand Reinhold, 1992, Chap. 12.
- (3) *Kirk-Othmer Encyclopedia of Chemical Technology*, 2nd Ed., J. Wiley & Sons, 1963, Vol. 16.

Summary of Benefits

Consumer net benefits from direct chlorine consumption in water disinfection and pulp bleaching and from all uses of coproduced sodium and potassium hydroxides are estimated to be \$11.0 billion per year. The estimated capital requirements for the new processes required to produce or use substitute materials amounts to \$49.4 billion. The most likely substitute technologies that we have identified are both capital and energy intensive and pose their own environmental and health risks.

Chlorine-Containing Products

Polyvinyl Chloride Products

The making of polyvinyl chloride (PVC) products has been the largest single use for chlorine for many years. In 1990, about 26 percent of chlorine production was required for the manufacture of vinyl chloride monomer (VCM), the immediate precursor to PVC. An additional six percent of chlorine production was required for the manufacture of ethylene dichloride, the immediate precursor of VCM, which was either exported or converted to products other than PVC. PVC resins are produced by polymerizing VCM, and resins with different properties for a variety of end uses can be made by controlling the reaction conditions. The bulk resins are mixed with various additives that impart specific properties required for fabrication and use. Fabricators can tailor the properties of the resin-additive mixtures to optimize fabrication techniques and product performance properties,

Exhibit 3-5. Benefits of Chlorine in PVC Products (U.S. and Canada)

Product Forms	Estimated 1990 Consumption (000 tons)	Substitutes ⁽¹⁾	Estimated Investment Required (\$Million)	Estimated Incremental Cost of Substitutes (\$Million/Year)	Estimated Total Cost of Substitution (\$Million/Year)
Pipe and Fittings					
Pressure water	700	Ductile iron, copper, HDPE	273	1,587	1,642
Sewer/drains	375	Ductile iron, HDPE, RCP	114	590	613
Duct and conduit	285	Aluminum, steel	24	483	487
Drain/waste/vent	300	Ductile iron, ABS	158	774	806
Irrigation	100	HDPE, AL, ABS	36	106	114
Fittings and other	160	From above	55	322	333
Fabricated Products					
Flooring, textiles, and other calendered	515	Ceramics, carpet, nylon, paper, HDPE, PET	147	1,486	1,515
Siding and accessories	410	Aluminum	9	266	267
Wire and cable	230	LDPE, TPO	4	51	51
Windows and other extrusions	305	Aluminum	7	198	199
Adhesives	60	Polyurethanes	0	224	224
Films and sheet	210	LLDPE, HDPE, TPO	88	36	54
Plastic bottles	120	PET-G	0	39	39
Other	430	Miscellaneous plastics	59	535	547
TOTAL	4,200		974	6,697	6,891

(1) HDPE = high-density polyethylene; RCP = reinforced concrete pipe; ABS = acrylonitrile butadiene styrene; PET = polyethylene terephthalate; LDPE = low-density polyethylene; TPO = thermoplastic olefins; LLDPE = linear low-density polyethylene; PET-G = polyethylene terephthalate-G.

SOURCE: Charles River Associates, 1993.

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example, and PVC-based systems are not subject to leakage or to picking up infiltrated water that increases loads on water treatment plants. PVC products provide performance advantages in calendered products and coatings that are difficult to replace with other plastics. While uses in these product areas are highly fragmented, we believe that the most likely substitutes across all applications would be more costly per pound than PVC. Significant new investments would be required to produce and fabricate them into the PVC product forms they would substitute for, although we have assumed that all fabricators would remain in business by refurbishing their finishing lines at relatively low cost. If the properties of the substitute material preclude this, costs would be higher than shown, and some fabricators would be forced to shut down.

Producing substitute materials, particularly metals and concrete, is energy intensive and can create other environmental and safety problems. Producing ductile iron requires large amounts of coke (5). Regulations governing allowable emissions in Coke production are currently being implemented because these emissions pose their own risks. In addition, operating steel mills and copper and aluminum smelters also involves significant environmental impacts. (6,7) Substituting thermoplastic olefinic materials like low-density polyethylene for PVC in electrical uses would, at minimum, require revision of existing codes and would raise safety issues because these substitutes do not have PVC's fire resistance. Our estimates do not include the costs of making the changes in building codes and other regulations that would be required if PVC products were not available.

References

- (1) *Engineered Materials Handbook, Vol. 2 — Engineering Plastics*, ASM International, 1988, p. 209.
- (2) "Resins 1992: Supply Patterns are Changing," *Modern Plastics*, January 1992, p. 53.
- (3) "PVC and the Environment," N. Kansvog and J. Baldwin, Norsk Hydro a.s., Petrochemical Division, Oslo, Norway, 1992.
- (4) *A Cost/Benefit Study: In-Place Costs and Technical and Regulatory Constraints to Use of PVC-Based Pipe, Tube, and Conduit in Construction*, IFT Technical Services, Berkeley, CA, 1989.

Economic Contributions

Polyvinyl Chloride

Chlorine's largest single outlet is in the manufacture of polyvinyl chloride (PVC) resin. This versatile plastic product is used in numerous fabricated products, as shown in Exhibit 4-4 and the product tree in Appendix B. Most applications are for durable goods that have a very long period of service, in some cases upwards of 20 years or more. U.S. and Canadian consumption of PVC amounted to 4.2 million tons in 1990, making it one of the top-selling thermoplastic resins. CRA estimates that the value of sales of PVC products amounts to more than \$3.8 billion in 1990.

Exhibit 4-4. Typical Products Made from PVC

Household Items	Building and Construction	Automotive	Medical
Raincoats	Sewer and drain pipe	Upholstery	Blood bags
Handbags	Flooring	Floor mats	Tubing
Toys	Electrical conduits	Roof tops	Sheeting
Shower curtains	Weather stripping	Instrument panels	Packaging

SOURCE: Charles River Associates, 1993.

Chlorinated Solvents

Another large outlet for chlorine is in a group of products called chlorinated solvents. Over 910,000 tons of these products were consumed in the United States in 1988, but consumption was estimated to have dropped to about 720,000 tons in 1990. For purposes of this study, CRA collected data on sales and use of these products for each major application: for dry cleaning, for degreasing and special parts cleaning, for paint stripping and adhesives, and for use as a process solvent. Exhibit 4-5 summarizes these end uses. We estimate that the value of sales of 794,000 tons of chlorinated solvents in the United States and Canada amounted to \$690 million in 1990. Some chlorinated solvents have the potential to deplete stratospheric ozone and are being phased out under the Montreal Protocols. Others have no ozone-depleting potential but may have other health and safety

