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13. ABSTRACT ***(Maximum 200 Words)***

This project was sponsored by the Department of Defense SERDP and conducted by the U.S. Environmental Protection Agency National Risk Management Research Laboratory (NRMRL). In support of SERDP's objective to develop environmental solutions that improve mission readiness for federal activities, this report was developed to determine the optimum materials and equipment for applying chemical agent resistant coating (CARC) to vehicles at the Army Transportation Center at Fort Eustis, VA. A life cycle assessment (LCA) was conducted to identify the performance, cost, and environmental impacts of various combinations of CARC materials and equipment. The variables for this study were the primer, thinner, CARC topcoat, and spray application equipment. Combinations of the variables were grouped to develop five alternatives. The recommended alternative would change the existing primer and application equipment, but retain the existing thinner and topcoat. This alternative would maintain required performance characteristics, achieve cost objectives, and result in low environmental impacts in relation to the other alternatives.

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LIFE CYCLE ASSESSMENT FOR CHEMICAL AGENT RESISTANT COATING

By

Battelle Columbus
and
Lockheed-Martin Environmental

Contract No. 68-C4-0020

Project Officers

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Foreword

Today's rapidly developing and changing technologies and industrial products and practices frequently carry with them the increased generation of material that, if improperly dealt with, can threaten both public health and the environment. The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and carry out action leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. These laws direct the EPA to do research to define our environmental problems, measure the impacts, and search for solutions.

The National Risk Management Research Laboratory is responsible for planning, implementing, and managing research development, and demonstration programs. These provide an authoritative defensible engineering basis in support of the policies, programs and regulation of the EPA with respect to drinking water, wastewater, pesticides, toxic substances, solid and hazardous wastes, and Superfund -related activities. This publication is a product of that research and provides a vital communication link between researchers and users.

This report describes a life cycle assessment on the painting, depainting and repainting of military vehicles with chemical agent resistant coating (CARC). A life cycle design approach that follows EPA's guidance manual includes consideration in the areas of environmental, performance, and cost requirements for the products and processes evaluated. Four specific final products associated with the painting, depainting, and repainting of military vehicles were used in the life-cycle assessment.

E. Timothy Oppelt, Director
National Risk Management Research Laboratory

Abstract

This project was sponsored by the Department of Defense Strategic Environmental Research and Development Program (SERDP) and conducted by the U. S. Environmental Protection Agency National Risk Management Research Laboratory (NRMRL). In support of SERDP's objective to develop environmental solutions that improve mission readiness for federal activities, this report was developed to determine the optimum materials and equipment for applying chemical agent resistant coating (CARC) to vehicles at the Army Transportation Center at Fort Eustis, VA. A life cycle assessment (LCA) was conducted to identify the performance, cost, and environmental impacts of various combinations of CARC materials and equipment. The variables for this study were the primer, thinner, CARC topcoat, and spray application equipment. Combinations of the variables were grouped to develop five alternatives. The recommended alternative would change the existing primer and application equipment, but retain the existing thinner and topcoat. This alternative would maintain required performance characteristics, achieve cost objectives, and result in low environmental impacts in relation to the other alternatives.

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Acronyms

AG	alternative gun
AHP	Analytical Hierarchy Process
AP	acidification potential
BCF	bioconcentration factor
BG	baseline gun
BOD	biological oxygen demand
BTU	British Thermal Unit
CARC	chemical agent resistant coating
CAS	Chemical Abstract Service
CIS	Chemical Information Systems
CSD	Chemical Specialists & Development
DfE	design for the environment
DoD	Department of Defense
DOE	Department of Energy
EC	Expert Choice™
EPA	Environmental Protection Agency
FCI	fixed capital investment
FSC	Federal Stock Class
ft^2	square feet
gal	gallon
GWP	global warming potential
HAP	hazardous air pollutant
HSDB	Hazardous Substances Databank
HV	hazard value
HVLP	high-volume, low-pressure
IRIS	Integrated Risk Information System
kw	kilowatt
lbs	pounds
LC_{50}	lethal concentration, 50%
LCA	life cycle assessment
LCI	life cycle inventory
LCIA	life cycle impact assessment
LCImA	life cycle improvement assessment
LD_{50}	lethal dose, 50%
ln	natural log
MEDLARS	Medical Literature and Analysis Retrieval System
MEK	methyl ethyl ketone
MIL-SPEC	military specification
MSDSs	Material Safety Data Sheets
NIINs	National Item Identification Number
NO_x	nitrogen oxides
NRMRL	National Risk Management Research Laboratory
ODP	ozone depletion potential

P2	pollution prevention
Pb	lead
PE	purchased equipment
PES	Pacific Environmental Services
PM	particulate matter
POCP	photochemical oxidant creation potential
ppm	parts per million
PPOA	pollution prevention opportunity assessment
QSAR	quantitative structure-activity relationship
RD&D	Research, Design and Development
RTECS	Registry of Toxic Effects of Chemical Substances
SAR	structure-activity relationship
SERDP	Strategic Environmental Research and Developement Program
SETAC	Society of Environmental Toxicology and Chemistry
SO_x	sulfur oxides
SRI	Southern Research Institute
TE	transfer efficiency
TRI	toxic release inventory
VOC	volatile organic compound
WA	Work Assignment
WREAFS	Waste Reduction Evaluation At Federal Sites

1.0 Introduction

The research effort described in this report was conducted under cooperating programs of both the Department of Defense (DoD) and the Environmental Protection Agency (EPA). Among the shared objectives of the cooperators is demonstrating the effectiveness of analytical tools and environmental technques to reduce environmental impacts and costs of operations while maintaining performance standards. This project was sponsored by the DoD's Strategic Environmental Research and Development Program (SERDP) and conducted by the EPA's Life Cycle Assessment (LCA) Research Team at the National Risk Management Research Laboratory (NRMRL).

1.1 Strategic Environmental Research and Development Program

DoD EPA DOE SERDP
Strategic Environmental Research and Development Program

Improving Mission Readiness Through Environmental Research

SERDP was established in order to sponsor cooperative research, development, and demonstration activities for environmental risk reduction. Funded with DoD resources, SERDP is an interagency initiative between DoD, the Department of Energy (DOE), and EPA. SERDP seeks to develop environmental solutions that improve mission readiness for federal activities. In addition, it is expected that many techniques developed will have applications across the public and private sectors.

1.2 Life Cycle Assessment Research Program

Since 1990, NRMRL has been at the forefront of development of Life Cycle Assessment as a methodology for environmental assessment. In 1994, NRMRL established an LCA Team to organize individual efforts into a comprehensive research program. The LCA Team coordinates work in both the public and private sectors with cooperators ranging from members of industry and academia to federal facility operators and commands. The team has published project reports and guidance manuals, including "Life Cycle Assessment: Inventory Guidelines and Principles" and "Life Cycle Design Guidance Manual." The work described in this report is a part of an expanding program of research in LCA taking place under the direction of NRMRL in Cincinnati, Ohio.

1.3 DfE Life-Cycle Approach

A life-cycle design for the environment (DfE) approach that follows EPA's (1993a) guidance manual includes consideration of requirements in the following areas: environmental, performance, cost, cultural, and legal requirements. However, this report focuses on evaluation of the first three life-cycle design requirements. The life-cycle environmental evaluation and cost and performance information are based on data from the draft life cycle inventory (LCI) (Hendricks et al., 1995), pollution prevention opportunity assessment (PPOA) (Cavender et al., 1994), and supplementary information collected as part of the life cycle impact assessment (LCIA) and life cycle improvement assessment (LCImA).

The DfE approach is derived from a generalized process for product design, which begins with a needs analysis, defines product or process requirements, and identifies design solutions. When implemented as a DfE effort, the requirements assessment includes environmental elements specified as essential or desirable features. The design solutions then have a broader range of attributes than would be the case in a traditional analysis.

The procedures for interpreting LCI and LCIA results for the determination of improvement opportunities are not standardized. A multi-step process combining analysis of the baseline environmental data along with the possible engineering changes in the system was used to directionally identify promising options. The steps include:

- Definition of improvement objectives and constraints
- Translation of objectives into design/technology requirements
- Preliminary identification of options
- Determination of potential changes in system boundaries

These steps were conducted as part of the exercise to define the baseline and complete the inventory analysis and impact assessment. The alternatives assessment process, which constitutes the LCImA, then continues with the following elements:

- Identification of data needs for alternatives
- Generation of LCI/LCIA data for alternatives
- Generation of economic and performance data for alternatives, and
- Application of a decision support process for conducting tradeoffs analysis.

1.4 Life Cycle Assessment for CARC

NRMRL has developed projects to promote the integration of pollution prevention concepts into the design of systems. The purpose is to enhance performance, reduce logistics and maintenance requirements, reduce environmental and energy burdens and extend service life. Under this program, SERDP and NRMRL are focusing on painting and depainting operations for aircraft and military vehicles.

The U.S. Army's Transportation Center at Fort Eustis, Virginia provides educational and training services in military transport to Army personnel. Part of the mission at Fort Eustis is to paint, depaint and repaint military vehicles with a chemical agent resistant coating (CARC). The purpose of this project is to conduct an LCA for CARC operations at Fort Eustis which also considers cost and performance as described in EPA's life-cycle design manual (EPA 1993a).

A PPOA was conducted by Southern Research Institute (SRI) and PES at Fort Eustis to evaluate waste reduction opportunities associated with CARC painting and depainting operations (Cavender et al., 1994). The PPOA was part of the Waste Reduction Evaluations at Federal Sites (WREAFS) program and involved identification and evaluation of new technologies and techniques for reducing waste generation from CARC painting/depainting operations at Fort Eustis. The advantages and disadvantages of the base case and each P2 option are discussed. As in the case of most P2 studies, this PPOA only considered the use stage (depainting/painting) of the CARC life cycle. The PPOA was used to establish the potential options for the LCA.

A draft LCI was prepared by Pacific Environmental Services (PES) to provide a baseline of environmental and utility data that describes the production of components for the CARC painting/depainting system (i.e., topcoat, primer, thinner, and blast media), their raw materials, paint application and depainting, and disposal of spent CARC and blast media (Hendricks, et.al., 1995). The LCI baseline was revised to account for actual operations at Ft. Eustis and additional impact information was included to complete the LCA. The LCIA and LCImA were prepared according to EPA's LCA guidance document (EPA, 1993b) and the Society of Environmental Toxicology and Chemistry (SETAC 1991, 1993, and 1994) framework documents. This document contains a revised and summarized version of the LCI data along with the LCIA and LCImA results.

1.5 CARC System Improvement Potential

Within the established environmental criteria for the LCA, the baseline CARC system improvement potential appears to be greatest in the relative environmental impact contribution to global warming. However, this does not imply that CARC is a major contributor to this issue on an absolute basis. Somewhat less important are the regional scale impacts of photochemical smog and the aggregated indicators associated with toxicity potential. Alternative formulations emitting less of these constituents throughout the life cycle coupled with application practices that increase the efficiency of material usage (translating back up the life-cycle stages due to lower contributions per functional unit) are the most attractive.

However, the environmental aspects of CARC painting must be balanced with economic and performance aspects. It may be possible to conceive of a system where the coating is transferred with 100% efficiency through the use of no solvent at all (a powder coating for example). Although such a system may be a long-term R&D goal, its performance could not be guaranteed according to current military specifications (MIL-SPECS) and its cost may be prohibitive. Considering that operating labor and overheads represent more than half the baseline costs, alternatives that decrease the human input at the expense of modest increases in material or variable operating costs (material costs, electricity, and supplies represent about 25% of the total baseline costs) would be an overall improvement, especially if there were corresponding performance and environmental benefits.

The assessment of CARC alternatives is intended to identify and evaluate alternatives that are able to be implemented with a reasonable level of institutional, logistical, and operational challenges and within a short-term time frame. Therefore, it was decided that certain performance and cost constraints should be imposed as preliminary assessment thresholds. Identification of CARC systems that are improvement candidates on all three assessment dimensions (environmental, performance, cost) were constrained to those that currently provide acceptable performance (i.e. that are MIL-SPEC compliant), that are cost-competitive, and reduce environmental impacts. Systems considered to be attractive included various combinations of CARC topcoat, primer, and thinner, having different environmental properties than the baseline, as well as application methods and tools that potentially could increase materials use efficiency and decrease the time involved for painting operations. Equipment and technology to implement the improvements was also a consideration.

Application of the cost and performance thresholds resulted in a matrix of alternatives to be considered. The alternatives shown in Table 1-1 include permutations of alternative primer, thinner, and application technology (spray gun). Additional technology-related options appeared to be site-specific (e.g., spray booth configuration, filtration systems, and material storage, and were not considered separate alternatives). Similarly, the blast medium and technology (aluminum oxide) was considered both cost-effective and environmentally acceptable and was not subject to evaluation.

Table 1-1. **CARC Systems for Evaluation in LClmA**

CARC Systems Evaluated	CARC Topcoat[(a)]	Primer[(b)]	Thinner[(c)]	Topcoat Spray Gun[(d)]
1 (Baseline)	BC	BP	BT	BG
2	BC	AP	BT	BG
3	BC	BP	BT	AG
4	BC	AP	BT	AG
5	BC	BP	AT	BG
6	BC	AP	AT	BG

(a) BC = Baseline CARC Topcoat, MIL-C-53039A, Hentzen 08605GUZ-GD, 1-part urethane

(b) BP = Baseline Primer, MIL-P-53022, Niles 2-part epoxy, solvent thinned; AP = Alternative Primer, MIL-P-53030, Deft 2-part epoxy, water thinned

(c) BT = Baseline Thinner, MIL-T-81772B, CSD; AT = Alternative Thinner, Fed. Std. A-A-857B (used by Fort Eustis, but not evaluated by in LCI)

(d) BG = Baseline Gun, high volume, low pressure (HVLP) spray gun (thinning of topcoat required); AG = Alternative Gun, turbine HVLP spray gun with increased transfer efficiency relative to conventional HVLP gun.

2.0 Life Cycle Inventory

To fully account for all impacts of the CARC operation, a complete evaluation must be made of the raw materials used, energy required, water used, and the generation of atmospheric emissions, solid waste, waterborne waste, and hazardous waste. A baseline should incorporate inputs and outputs from every operation used, from processing the basic raw materials through all operations involved in taking the material from the earth and disposal of the residue material back to the earth. To be practical and useful, a baseline must reflect the reality of the process as it is currently practiced.

2.1 LCI Scope and Limitations

The initial phase of the life cycle inventory (LCI) consisted of studying available information on the CARC application and depainting processes and conducting an intensive, three-day site survey, literature search, and phone survey of major Army installations. Using the information obtained from the site survey, literature survey, and telephone contacts with the major U.S. Army facilities, a scoping document was prepared. The scoping document identified uses of CARC, the CARC product manufacturers, the primers and the thinners used in CARC systems, the blasting media used in the removal of CARC systems, and the types of CARC application and depainting techniques used.

The scoping document and input from EPA's NRMRL personnel were used to identify the specific products (the CARC, the primer, the thinner) to be addressed in the LCI. The specific application and depainting techniques to be investigated were also selected. The recommendations were based mainly on the products and techniques being used at Fort Eustis. A one-component topcoat is used as the final CARC layer to protect military vehicles from chemical warfare agents, primarily because it is more resistant to penetration by these chemical agents than alkyd paints. CARC paint does not absorb these substances, while alkyd paints absorb these toxic chemical agents and slowly release them. Also, CARC can last up to four times longer than alkyd paints. The only CARC topcoat used at Fort Eustis is MIL-C-53039A produced by Hentzen Coatings under the name 383 Green Zenthane.

Primers are applied to the surface of military equipment after depainting and surface preparation, in order to provide anticorrosive properties and adhesion of the topcoat. The CARC primer used at Fort Eustis and most other military installations is MIL-P-53022, a two-component epoxy primer. The brand used at Fort Eustis is produced by Niles Chemical Company and was chosen for the baseline LCI. The two-component epoxy primer is prepared for application by mixing four parts of Part A with one part of Part B. Once the primer is dry, a one-component CARC topcoat is applied. Both the primer and topcoat are applied with a high-volume, low-pressure (HVLP) spray gun.

A thinner is used to dissolve, dilute, suspend, or change the physical properties of other materials. At most Army bases except Fort Eustis, thinner MIL-T-81772 is used to dilute CARC and primer, in order to enhance ease of application, and to control the coating drying rate. Thinner MIL-T-81772 was used for the baseline LCI due to its wide-range use at Army facilities (Table 2-1). Thinner is also used prior to CARC painting to remove dust and grease from the vehicles that may interfere with proper paint adhesion. Fort Eustis used a thinner that is not recognized specifically as a CARC thinner until 1995. Checks with Fort Eustis determined they preferred the characteristics of the thinner they were using (A-A-857B); they claimed it performed better in the hot, humid weather found at Fort Eustis. However, Fort Eustis and Fort Campbell were contacted in 1996 and both facilities had stopped use of A-A-857B. Based on the telephone survey conducted, 11 of the 13 Army facilities contacted used another thinner (MIL-T-81772) which according to painting instructions of Department of the Army is the applicable solvent for the CARC used at Fort Eustis (MIL-C-53039A).

Since aluminum oxide is used as a blasting medium at Fort Eustis to remove CARC, it was selected for the baseline LCI. It is preferred over other blasting materials for the depainting process because of its high efficiency and low cost. Aluminum oxide is extremely hard and the crystal surface is covered with sharp angles, which makes it an ideal blast media for the removal of CARC from steel surfaces.

Table 2-1. Various CARC, Primers, and Thinners Used at Major Army Installations

U.S. Army Installations	State	CARC used			Primer used			Thinner used		
		MIL-C-53039	MIL-C-46168	MIL-C-22750	MIL-P-53022	MIL-P-53030	MIL-P-23377	A-A-857B	MIL-T-6095	MIL-T-81772
Anniston Army Depot	AL		X	X	X					X
Corpus Christi Army Depot	TX	X	X	X	X		X			X
Fort Benning	GA	X								X
Fort Bliss	TX	X					X			X
Fort Bragg	NC	X				X			X	
Fort Campbell	KY	X	X					X		X
Fort Devens	MA	X				X				X
Fort Eustis	VA	X			X			X		
Fort Hood	TX	X			X	X	X			X
Fort Knox	KY	X				X				X
Fort Lewis	WA	X								X
Red River Army Depot	TX	X	X	X	X					X
Fort Riley	KS	X								X

The products and techniques evaluated for the LCI were:

- CARC: MIL-C-53039A
- Primer: MIL-P-53022
- Thinner: MIL-T-81772
- Blasting Media: Aluminum oxide
- Blasting Technique: high pressure air blasting
- Painting Technique: HVLP spray painting

Additional limitations in scope were used to streamline the LCI. The study focused on evaluating the main process reactions and excluded the low concentration ingredients (less than 1 percent) and catalysts used in the process reactions. It was assumed that ingredients used in small concentrations have small environmental impact in the life cycle.

2.2 LCI Methodology

In developing the LCI, all of the principal ingredients used to produce the final products were identified. The specific chemicals were identified using Material Safety Data Sheets (MSDS) provided by the manufacturers. Literature research was then conducted to identify the processes used to make the principal ingredients and to identify the raw materials. This process was repeated until every raw material was traced back to a fundamental precursor (i.e., one identified as coming from the earth as an ore or a petroleum product). Appendix A contains process flowsheets for the production of each of these final products, and Appendix B contains the MSDSs.

Each process was reviewed to determine the process inputs and the outputs. Process inputs include raw materials, water, and energy (i.e., electrical, natural gas (as fuel[a]), oil and coal). Outputs include the end product atmospheric emissions, waterborne waste and solid waste. Atmospheric emissions are the total for all pollutant types, including criteria pollutants[b] and hazardous air pollutants (HAP). Solid waste totals include hazardous and non-hazardous waste streams.

2.3 LCI Data Development

For each manufacturing process in the life cycle, data were required for raw material usage, utility requirements, and waste generation. Many manufacturers would not divulge information, because they were suspicious about unsolicited attempts to obtain proprietary process information. Secondary sources of data, such as industry reports, EPA documents, and magazine articles are available but vary in quality, completeness and timeliness. In general, chemicals produced in large quantities tended to have better quality and more complete information. Where primary process information was missing, streamlining measures were taken, and engineering estimates and assumptions were made. With this approach, it was possible to develop an "order-of-magnitude" estimate for the CARC LCI.

A typical search for data began by consulting general reference books on industrial chemical production processes such as Kirk-Othmer *Encyclopedia of Chemical Technology* or the *Encyclopedia of Chemical Processing and Design*. These sources often provided the necessary information, such as the process descriptions, raw materials consumption or utilities requirements, generally in the form of industry averages. The next level of the search involved resources on particular subjects such as the *Handbook of Petrochemicals and Processes, The USEPA's Industrial Process Profiles for Environmental Use*, or the *Environmental Sources and Emissions Handbook*. Again, the data were given in industry averages or averages from a number of monitored plants.

Searches for reports, articles or other sources of information were undertaken in an attempt to fill remaining gaps in the data. These searches sometimes yielded EPA reports, EPA contracted reports, or industry trade magazine articles. Information published after 1974 was considered sufficiently current.

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a Natural gas used in manufacturing is shown as a raw material, not as an energy input.

b Criteria pollutants are volatile organic compounds (VOCs), sulfur oxides (SOx), nitrogen oxides (NOx), particulate matter (PM), inhalable particulate matter (PM_{10}), carbon monoxide (CO), and lead (Pb).

2.4 LCI Baseline Revisions and Enhancements

As part of the scoping activity for the LCIA, it was determined that several of the chemical components in the CARC life cycle described in the draft LCI (Hendricks et al., 1995) could be revised to fill in missing data or to provide more recent data on the manufacturing processes. Chemicals identified as most important for collection of additional LCI data were adiponitrile, cobalt chromite green, hexamethylenediamine, magnesium ferrite, phosgene, sodium cyanide, and sodium dichromate. Second tier chemicals included butyl acetate, butyl alcohol, and methyl isoamyl ketone. Additional chemicals derived closely from the crude oil and natural gas refining processes were not included in this ranked system, because they are part of the crude oil and natural gas extraction and refining models incorporated into the inventory model. This included aromatic 100, carbon monoxide, hydrogen, and propane.

Emissions for electrical production, crude oil refining, and natural gas production were taken from Battelle's LCI databases. The electrical production model calculates the pollutant loadings for the national electrical grid based on the fractions of power created from coal, hydrocarbons, nuclear, hydropower, wind, etc. The crude oil and natural gas models included detailed data on many of the primary refinery chemicals such as hydrogen, propane, aromatic 100, etc.

The next best readily available source for emissions data was to determine manufacturers of the chemicals of interest in Southern Research Institute's (SRI) (1993) *1993 Directory of Chemical Producers* and cross reference the manufacturer with 1993 Toxics Release Inventory (TRI) emission data. 1993 was the latest year for which both SRI and TRI data were both available. Production tables were available in the SRI directory for several chemicals of interest to the CARC study, thus allowing direct calculation of the emission rates per pound of product production.

The chemical producers listed in the SRI directory often produced several chemicals. Specific plants were selected for their production of only the chemical of interest of a small number of related products, thus minimizing the need for extensive allocation of the individual TRI facility emissions. Phosgene and sodium cyanide could be taken directly from the combination of the SRI/TRI data.

Hydrogen is produced from propane feedstock or as a co-product of chlorine/sodium hydroxide production. Analysis of the chlorine/sodium hydroxide manufacturing process required allocation of the emissions on a mass basis, thus allocating only a fraction of the emissions directly to the hydrogen production.

Adiponitrile and hexamethylenediamine production was more complicated in the selection of a plant to analyze and calculate the allocation of the emission streams. An analysis was performed on the SRI data to determine the relevant chemicals to the adiponitrile and hexamethylenediamine production processes and eliminate the unrelated process streams. TRI reportable releases were allocated on a mass basis to the appropriate process scheme.

Three of the butylated organic chemicals were analyzed together from the SRI/TRI data due to the close interlinkage of the processes as butyl aldehyde is a feedstock for the butyl alcohol process and butyl alcohol is a feedstock for the butyl acetate process with the addition of glacial acetic acid. The results were compared with the data existing in the model for completeness and consistency.

Several of the chemicals did not have production data to allow for proper emissions allocation on a per pound basis (e.g., sodium dichromate) and some of the organic chemicals were made in plants producing such a tremendous variety of chemicals that allocation would require an extensive understanding of the specific facility (e.g., methyl isoamyl ketone produced by Tennessee Eastman).

In addition, no emissions data were obtained for the production of isopropyl alcohol and butylcellosolve. Thus, the LCI data exclude emissions from manufacturing of these four chemicals.

Several chemicals were referenced in the *Merck Index* (Merck, 1983) and Aldrich Chemical Company's (Aldrich, 1992) *Catalog Handbook of Fine Chemicals* to other literature references. Energy requirements and emissions for the pigments cobalt chromite green and magnesium ferrite proved difficult. Data obtained could not be fit into the model. Cobalt chromite green was referenced by Merck (1983) to Gmelin's (1932 and 1961) *Handbook of Inorganic Chemistry*, printed in German. The process description indicated that airborne pollutants were the most common, but did not quantify the individual chemical pollutants which would then pass through various modern emission control devices.

Chemicals often may be manufactured in several ways. It was assumed the process diagrams (Appendix A) represented the typical method of manufacture of a given chemical and did not necessarily represent the documented process for each chemical in the CARC production process. Whenever possible, this same production methodology was utilized by examining the most common commercial production method(s). One exception was in the production of hydrogen, which in order to obtain readily separable data, used a caustic soda production process in which hydrogen is a co-product rather than the more common hydrocarbon derivation.

2.5 LCI Functional Unit

One of the first requirements during scoping activities for an LCA is the selection of a functional unit, so that resource use, energy use, and environmental releases from different life-cycle stages, or for different alternatives, can be expressed in the same units for comparative purposes. For the draft LCI, the functional unit selected was 1,000 gallons of CARC used. Paint application and depainting data were developed in units per 1,000 gallons of CARC used, which is slightly less than CARC produced due to spills and discarded old paint.

As part of the revisions and enhancements to the LCI data, this functional unit was reevaluated. Since the important requirement for any type of paint is the amount of materials (e.g., primer, thinner, and topcoat) required to produce a good finish over a specific area, 1,000 square feet (ft^2) was selected as the appropriate functional unit. Thus, quantities of materials required or emissions released from any process in the CARC life cycle are expressed relative to a functional unit of 1,000 ft^2 of painted surface. In the LCImA all alternatives are compared on an equivalent functional unit basis with adjustments made to the amounts of material, labor, and capital associated with each option required to paint one functional unit of surface.

2.6 LCI Data

The revised baseline LCI results are provided in Appendix C. The tables in this appendix are organized by the following inputs and outputs to the CARC life cycle: Resource and Energy Consumption, Air Emissions, Wastewater Emissions, and Solid Wastes. The totals for each resource or emission are further divided by (1) Raw Material Extraction plus Materials Manufacture Stages and (2) Use/Reuse/Maintenance Stage plus Disposal (depainting/painting activities at Fort Eustis). All data are reported in the quantity per functional unit (1,000 ft^2 of CARC painted surface). These LCI data are the basis for the LCIA and LCImA results.

3.0 Parameters Evaluated

3.1 Inventory Analysis

The inventory analysis used for the LCI consists of the inventory for the baseline CARC system and the inventories for each of the five alternatives. The percent compositions of the baseline topcoat, baseline and alternative primers, and baseline and alternative thinners are listed in Tables 3-1, 3-2, and 3-3.

Table 3-1. Percent Composition of Baseline CARC Topcoat

CHEMICAL CONSTITUENTS	MIL-C-53039A (Hentzen 383 Green Zenthane, 08605GUZ-GD) (%)
Methyl Isoamyl Ketone	23.8
Magnesium Ferrite Pigment	3.9
Aromatic Hydrocarbons[(a)]	1.5
Butyl Acetate	1.2
VM&P Naptha	4.8
Xylene	2.0
Cobalt Chromite Green Spinel Pigment	3.9
Trivalent Chrome	6.9
Hexamethylene Diisocyanate	26.0
Diatomaceous Silica Pigment	26.0
TOTAL	100

(a) Mix of C8s to C10s

Table 3-2. Percent Composition of Baseline and Alternative Primers

CHEMICAL CONSTITUENTS	BASELINE (Niles[a], 2-part epoxy, solvent thinned)		ALTERNATIVE (Deft, 2-part epoxy, water thinned)	
	53022A, 4-part[b] (%)	53022B, 1- part (%)	53030A, 4-part[b] (%)	53030B, 1-part (%)
Epoxy resin solids	22	23	16.03	71.17
Proprietary ingredients		2	0.10	0.06
TiO_2(c)	20		33.96	
Extenders (Pigment)[c]	18		27.85	
Xylene		11		
n-Butyl Acetate	26			
MIBK	2	28		
Zinc Phosphate	4			
Diethylenetriamine		8		
2-Ethoxyethanol		11		
n-Butyl Alcohol	8	17	10.83	
Aromatic hydrocarbon			11.26	4.13
Nitroethane				24.64
TOTAL	100	100	100	100

(a) Niles does not manufacture Mil-P-53030
(b) Note: The 4:1 mixture has not been pro-rated
(c) MSDS reports 38% proprietary ingredients, which were assumed to be divided between TiO_2 and pigment extenders, respectively, as 20% and 18%.

Table 3-3. Percent Composition of Baseline and Alternative Thinners

CHEMICAL CONSTITUENTS	BASELINE (CSD[a] designed for thinning aircraft coating, Mil-T-81772B) (%)	ALTERNATIVE (CSD designed for thinning dope and cellulose nitrate lacquer, Fed Std A-A-857B) (%)
MEK	30.5	12
Hexyl acetate mixed isomers	41.0	
Isobutyl acetate		31
Toluene	10.5	12
n-butyl acetate	11	
Xylenes	7.0	
Aliphatic petroleum distillates		16
n-butyl alcohol		11
Isopropyl alcohol		18
TOTALS	100	100

[a] CSD = Chemical Specialists & Development

As noted from the composition listings, most of the ingredients of the primer and thinner are qualitatively similar between the baseline and alternative formulations, with the differences arising in the amounts of each used. Exceptions are the use of nitromethane in the primer and the substitution of different members of the same class of compound (e.g. isobutyl instead of hexyl acetate in the thinner). Each of the differences was carried through the inventory analysis by creating new data modules where necessary or modifying others.

Inventories for each of the alternatives were constructed by modifying the baseline inventory to account for both differences in the type of ingredients and in the proportions of ingredients in the alternative primer and thinner as well as the changes in the transfer efficiency associated with the alternative spray gun. The resulting alternatives are also described below.

In general, preparing the inventory analysis for the alternative primer and thinner options consisted of a two-step process. The first step consisted of replacing certain data modules in the baseline inventory with those appropriate to the alternative formulations followed by adjustment of those modules that were qualitatively similar but proportionately different. In the case of the options involving the alternative gun, a further adjustment (decrease) was made in the overall amount of materials used to coat a functional unit area.

The only additional ingredient for which completely new data modules were required for the alternative primer was nitromethane. The MSDS for the alternative primer also listed aromatic hydrocarbons in distinction to the xylene shown for the baseline. However, because of the manner in which the refinery operations producing the aromatics occur, this distinction is not critical for the inventory. Further commentary on this issue regarding its effect on the impact assessment is discussed below. Additional data modules required for the thinner were isobutyl acetate, n-butyl alcohol, isobutyl alcohol, and aliphatic hydrocarbons. Of these, only the isobutyl acetate and aliphatic hydrocarbons are not ingredients anywhere in the baseline system. The isobutyl acetate is produced using the same chemical operations (Oxo process) as the n-butyl acetate in the baseline primer and therefore employed the same data sources and allocation procedures. Aliphatic hydrocarbons data were derived from Battelle's refinery module. In general, data necessary for preparing the inventory of the new chemical ingredients (and their precursors back to the raw materials) were collected in much the same manner and using primarily the same sources as those described for the baseline case.

3.2 Environmental Impact/Hazard Assessment

An LCIA (as defined by SETAC, 1993) involves the examination of potential and actual environmental and human health effects related to the use of resources (energy and materials) and environmental releases. An LCIA is divided into the following two stages: classification and characterization. In instances where the purpose of an LCA is the assessment of the current system (i.e., a baseline analysis) a valuation phase may logically be included in the LCIA (or optionally, as was done here, may be part of interpretation). Also, a normalization stage, which compares the contributed potential impact of the system under investigation to the overall environmental problem magnitude, may be added after characterization to place the system-level results in perspective relative to the regional, national, or global perspective of the impact. In order to compare the potential environmental impacts of each alternative with the baseline conditions, an LCIA was conducted on each alternative in the same fashion as the baseline.

Classification was conducted after scoping and is the process of linking or assigning data from the LCI (Hendricks et al., 1995) to individual stressor categories within the three major stressor categories of human health, ecological health, and resource depletion. This process included creation of complex stressor/impact chains because a single pollutant can have multiple impacts, and a primary impact can result in secondary (or greater) impacts as one impact results in another along the cascading impact chain.

Characterization involved the analysis and estimation of the magnitude of impacts for each of the stressor categories by multiplying equivalency factors times the quantity of a resource or pollutant associated with a functional unit of CARC. The equivalency analysis approach functions by converting a larger number of individual inventory items within a homogeneous inventory category into a single value expressed as an amount of a reference material. The procedure generally involves multiplying the appropriate equivalency factor by the quantity of a resource or pollutant associated with a functional unit of CARC and summing over all of the items in a classification category. Finally, valuation involved assigning relative values or weights to different impacts, so they can be integrated across impact categories for use by decision makers. The valuation method used in this study is known as the Analytical Hierarchy Process (AHP). AHP is a methodology for supporting decisions based on relative preferences (perceptions of importance) of pertinent factors. Preferences were expressed pairwise in a structured manner supported by a software package known as Expert Choice (EC). For the LCImA, the characterization involved the analysis and estimation of the magnitude of the potential for each CARC system alternative to contribute to impacts in each of the stressor categories.

Five levels of analysis have been suggested by SETAC for assessing the potential human health and ecological impacts of chemical releases associated with the life cycle of a product (SETAC, 1993). These five levels of impact analysis in increasing level of complexity, effort, and site-specificity can be grouped as site-independent or site-dependent. The LCIA approach used in this report focuses on a combination of the Level 2 and Level 3, site-independent approaches discussed below:

- Level 2 - Equivalency Assessment (data aggregated according to equivalency factors for individual impacts [e.g., ozone-depletion potential or acidification potential]; assumption is that less of the chemicals with the greatest impact potential is better)

- Level 3 - Toxicity, Persistence, and Bioaccumulation Potential (data are grouped based on physical, chemical, and toxicological properties of chemicals that determine exposure and type of effect; assumption is that less of the chemicals with the greatest impact potential is better).

3.2.1 Classification and Stressor/Impact Chains

The classification phase involved linking or assigning data from the LCI to individual stressor categories within the three major stressor categories of human health, ecological health, and resource depletion. Stressor/impact chains were developed by considering the energy, water, and raw material inputs to each life-cycle stage, as well as the air, water and solid waste emission outputs from each life-cycle stage. The inputs and outputs were then compared against lists of potential impacts (e.g., SETAC, 1993 and Heijungs, 1992a and 1992b), in order to develop stressor/impact chains.

3.2.2 Characterization

The characterization phase involved a site-independent evaluation of the magnitude of potential impacts caused by individual stressors. For chemical stressors, this took the form of a Level 2 and/or Level 3 assessment of the physical and chemical properties of each chemical to determine the potential hazard of that chemical.

For the Level 2 evaluation, a limited subset of the chemicals identified during the LCI had already been assigned impact equivalency units in published documents. Examples of groups of chemicals that have been evaluated for impact equivalency include nutrients, global warming gases, ozone depletion gases, acidification potential chemicals, and photochemical oxidant precursors (Heijungs, 1992a; Nordic Council, 1992).

New impact equivalency units were created for some chemicals identified in the baseline or alternative LCIs, by a modification of the Level 3 Toxicity, Persistence, and Bioaccumulation Potential Approach, by adapting the hazard ranking approach described in an EPA (1994) report. This included evaluation of impacts (e.g., toxicity to humans, fish, or wildlife) other than the impacts evaluated in Level 2, although a few chemicals with multiple impacts were evaluated by both the Level 2 and 3 approaches. Some data were obtained from the EPA (1994) report, which described a method for ranking and scoring chemicals by potential human health and environmental impacts. Toxicity or persistence data for chemicals not included in the EPA (1994) chemical ranking report were obtained from electronic non-bibliographic databases available through the Medical Literature and Analysis Retrieval System (MEDLARS) or Chemical Information Systems (CIS) clearinghouses. The MEDLARS clearinghouse is available through the National Library of Medicine and contains databases such as Registry of Toxic Effects of Chemical Substances (RTECS), Hazardous Substances Databank (HSDB), and Integrated Risk Information System (IRIS). The CIS clearinghouse is available from Chemical Information Systems and contains databases such as AQUIRE and ENVIROFATE. Toxicity data are available for humans and standard laboratory animals from IRIS, RTECS, and HSDB. AQUIRE contains data on toxicity of chemicals to aquatic animals.

Evaluation of the magnitude of resource depletion impacts associated with the life-cycle of CARC started with the resource use inventory information from the LCI (Hendricks et al, 1995). Resources included in the analysis involved both flow resources, such as water, and stock resources, such as minerals, primary energy sources (e.g., gas, oil, coal), and land. These impacts were evaluated from a sustainability (time-metric standpoint), which considers the time to exhaustion of the resource. Information on the world reserve base and production of minerals came from various U.S. Bureau of Mines publications. Information for energy sources came from the Energy Information Administration, U.S. Department of Energy.

3.2.3 Key Assumptions for LCIAs

Key assumptions regarding the LCIAs for the baseline and each alternative include the following:

- Evaluation of the primary impact for a particular impact category is assumed to be a good indicator of the true impact of concern, which is typically further down the stressor/impact chain (e.g., an increase in the acid precipitation potential is a good indicator of the loss of aquatic biodiversity, including sport fishing).

- The generic hazard evaluation criteria discussed in Section 4 are assumed to be useful indicators of the general impact potential and incorporate some of the factors dictating the magnitude of site-specific impacts (e.g., the criteria for human, terrestrial, and aquatic toxicity include consideration of chemical toxicity and persistence). However, the exposure dose and existing environmental conditions cannot be evaluated without site-specific modeling.

- The fact that equivalency factor information was not available for a few chemicals (e.g., the toxicity or persistence of some chemicals were not in the databases searched) is assumed to have an insignificant impact on comparable impact category scores for each of the alternatives (i.e., if the information for a particular chemical is missing for the baseline, it would also be missing for the alternatives).
- The consequences of having a specific compound in the inventory for one alternative (e.g., xylene) and a class of compounds (e.g., aromatic hydrocarbons) in another was investigated using a sensitivity analysis. By evaluating the chemistry of the contributing operation and/or ingredient group, it was possible to estimate which compound or compounds were likely members of the category. Data for the selected specific compounds were then substituted and the impact equivalencies recomputed to assess the overall effect on the comparison.

3.3 Economic Assessment

3.3.1 Methodology

The annualized costs estimated in this analysis were restricted to internal costs (i.e., cost associated with the Army's depainting and painting operations). These costs were further classified into direct and indirect costs. Direct costs are closely associated with the depainting and painting operations and include expenses related to capital expenditures for building, equipment, renovations, etc., and operating cost such as operating labor, materials, utilities, maintenance, and waste disposal. Indirect costs are costs which are incurred but might be spread across several facilities on base and (as was done in this analysis) included in labor overhead. Examples include items such as regulatory compliance (permitting, reporting, waste handling, waste tracking, training, monitoring and analysis, emergency preparedness, and medical surveillance), waste storage, insurance, penalties and fines, and personal injury and property damage liability.

External costs, for items such as the opportunity cost of the landfill where the waste is disposed (since the site could be put to other uses, some of which might have offered more to society) have not been included in the analysis. The advantage of this approach is that information on direct and indirect internal costs were available from the Army, suppliers, and private industry. Restricting the scope in this manner allowed efforts to be focused on developing data and data analysis.

The annualized cost to depaint and paint Army vehicles was estimated using a factored estimate approach. A base case and five alternative cases (Cases 2 through 6) were evaluated (see Table 1-1). Fort Eustis was selected as the baseline site, so its plant capacity; staffing; and paint, primer, thinner, and abrasive media usage rates were used to estimate typical costs.

The factored estimate costing procedure (Peters and Timmerhaus, 1991) provides a straightforward approach to preparing cost estimates with a medium level of accuracy. Capital costs are typically accurate within ±40 percent, and operating costs within ±30 percent. Preparation of a more accurate estimate requires development of a detailed design, complete equipment specification, acquisition of vendor quotes, etc.

Capital Costs

Capital costs were estimated for a facility capable of depainting and painting Army vehicles with CARC paints. At Fort Eustis, 3,096 gallons (gal) of CARC and 32,000 pounds (lbs) of aluminum oxide were used in 1993. The plant flowsheet is shown in Figure 3-1. Capital costs were estimated for depainting, marking and equipment preparation, primering, and CARC application operations for a new facility. The primary difference in capital costs for the base case and five alternatives was use of an expensive, but more effective "Alternative Gun." The turbine-HVLP gun was capable of significantly higher spray efficiencies (90 percent versus 60 percent level assumed for the baseline gun).

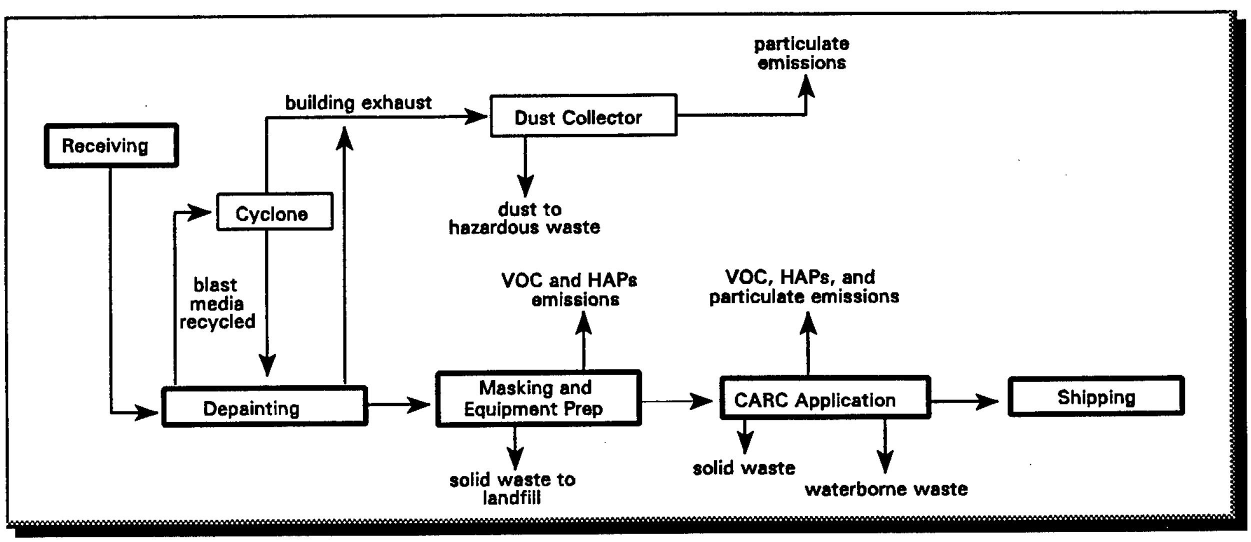


Figure 3-1. CARC application and depainting processes at Fort Eustis (from Hendricks, et al., 1995).

The factored estimate approach to estimating capital costs starts with purchased equipment. Each major item included in the design is identified, sized, and costed (using cost files, standard texts, vendor quotes, recent purchase information) to estimate the total delivered equipment costs. Then, a series of factors are applied to estimate other costs. The factors depend on the type of plant proposed, (e.g., the factors differ for a solid-solid handling plant versus a solid-liquid, or liquid-liquid facility). The factors for solid-solid processing were felt most appropriate for CARC depainting and painting. The factors were obtained from a standard engineering-economics text that has been found to provide reasonable estimates of capital costs (Peters and Timmerhaus, 1991).

Operating Costs

Operating costs are composed of the annual costs to operate the depainting and painting operations. They include raw materials, utilities, labor, supplies, maintenance, plant overhead, waste disposal, insurance, and regulatory compliance charges. At Fort Eustis, a team of five operates the depainting facility and a team of eight mans the painting facility. In 1993, 32,000 lbs of aluminum oxide abrasive and 3,096 gal of CARC were used to depaint and paint approximately 480 Army vehicles (Hendricks, et al., 1995; Cavender, et al., 1994).

To estimate operating costs, the quantity of raw materials, utilities, and labor used were estimated based on the experience at Fort Eustis. The effect of the alternative cases on these usage rates were also estimated. Appropriate factors were applied to convert the usage rates to annual costs (i.e., the gallons of CARC used per years were multiplied by the CARC purchase price). Other charges, such as for maintenance, plant overhead, etc, were estimated using factors (e.g., maintenance charges were estimated as a function of the estimated fixed capital investment). These factors were obtained from the same engineering-economics text (Peters and Timmerhaus, 1991).

Annualized Cost

Annualized costs equal the annual operating cost plus amortization of the fixed capital investment (FCI). There are many procedures employed to amortize capital costs. The factor used is usually dependent on the interest rate and time period selected. For this estimate, an annual charge was applied equivalent to making 12 monthly "mortgage" payments, at 6 percent interest over a loan life of 11 years to repay the base case FCI or the alternatives FCIs. The total annualized cost is then computed as:

Operating Cost, $/yr + Amortization, $/yr = Annualized cost, $/yr

This cost was also divided by the annual quantity of CARC painted surface to compute costs on a $/1000 ft^2 basis. The annual surface coated (619,000 ft^2) was estimated from the 1993 Fort Eustis CARC paint consumption level of 3,096 gallons and a calculated CARC usage rate of 5 gal/1,000 ft^2 (200 ft^2/gal).

3.3.2 Evaluated Parameters

Capital Costs

Depainting

A schematic of the depainting booth at Fort Eustis is presented in Figure 3-2. The depainting building is approximately 24 feet by 36 feet. Operations include receiving the 16-mesh aluminum oxide grit, feeding it to holding pots, and high-pressure air blasting through a nozzle to remove old paint and/or rust from steel substrates. Two induced draft fans are employed to transport paint chips and fine aluminum oxide dust suspended in the air to a series of dust collectors for dust removal. After the initial blasting, most of the media used is still large enough for reuse. This media and paint chips, flakes, masking tape, small pieces of debris, etc. are manually swept into floor grates. Screw conveyors in the grates move the media to a bucket elevator which discharges into a collection hopper. Media is discharged from the hopper and passed through an air stream. The lighter materials are picked up by the air and carried to a cyclone separator to remove the waste materials. The larger, heavier material drops to a storage hopper for reuse.

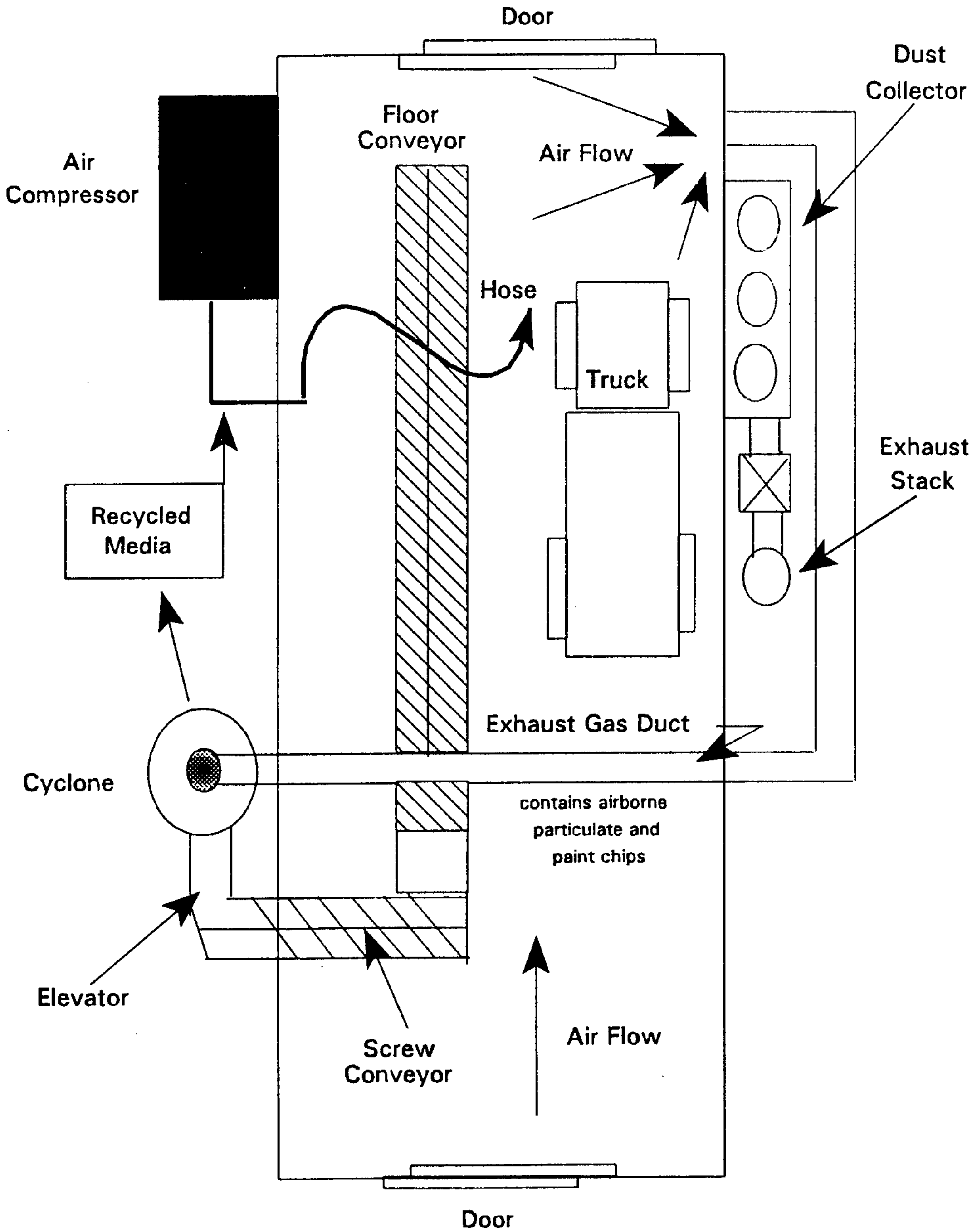


Figure 3-2. Fort Eustis depainting building (Cavender, et al., 1995).

The estimated purchased equipment costs for the depainting totaled $75,000 for the screw conveyor, cyclone, air wash system, platform, building ventilation blower, air compressor, depainting hoses, nozzles, etc., dust collector, and duct work. The building was estimated separately based on floor space (30 feet by 50 feet) and building type at $65,000. To these delivered purchased costs, factors described earlier were applied to estimate the direct cost, indirect cost, and fixed capital investment.

Painting

After depainting, the vehicles are hand-wiped with thinner to remove grease and dirt. Once cleaned, the vehicles are hand-masked with tape and paper before being moved into one of two downdraft painting booths.

In the base case, vehicles are first painted with a two-part epoxy primer (MIL-P-53022). The primer is composed of 80 percent part A and 20 percent part B, by volume. The primer is thinned with the base case thinner MIL-T-81772B prior to application. The primer is applied using the base case spray applicator a HVLP gun. The primed surface is allowed to dry for 2 hours before application of CARC. Alternative primers, thinners, and spray guns were also evaluated.

A single component CARC (MIL-C-53039A), Hentzen 08605 GUZ-GD, 1-part urethane, is applied using the base case applicator a HVLP gun. Prior to application the CARC is mixed with thinner to achieve the desired viscosity and drying time. After painting, the guns and hoses are cleaned with thinner at the end of each shift. The waste thinner is collected, allowed to settle, and reused. The collected sludge is disposed as hazardous waste. An alternative gun was also evaluated. It was assumed that the same type of gun was used for both primer and CARC application.

The purchased equipment costs for the painting operation totaled $35,000 for the building ventilation blower, duct work, water-wall collection system, and the dust collectors. The base case gun (HVLP) capital costs were estimated at two guns at $250 each plus $10,000 for a 30-horsepower (HP) air compressor and associated painting equipment. The cost for the alternative gun, a turbine HVLP gun, was $20,000 for four guns and all associated equipment. The difference in gun cost was the only significant capital cost difference between the baseline case and the five alternative cases. The building (24 feet by 36 feet) was estimated separately at $37,000. The factors noted before were applied to estimate FCI. The combined estimated capital cost was $547,000 for the depainting and painting facilities using the base case HVLP spray applicator, and $581,000 for the depainting and painting facilities using the alternative gun.

Operating Costs

Numerous assumptions were required to estimate operating costs. Unit costs for raw materials, utilities, labor, and waste disposal are provided below. The raw materials required and their unit costs are provided in Table 3-4. The only utility used in significant quantities was electricity. The unit cost was assumed to be $0.06/kilowatt (kW-hr). A labor rate of $25/man-hr was assumed. Supervisory labor and plant overhead charges were estimated as separate items using factors presented earlier.

Disposal costs for waste paint and primer, thinner sludge, etc. were estimated at $500/drum or $10/gal. Disposal charges for waste painting materials, tape, paper, filters, etc. were estimated at 100 percent of paint and primer waste disposal charges. Spent blasting media disposal costs were estimated at $0.58/lb (Mayer, 1994).

Table 3-4. Raw Material Unit Costs

Item	Description	Price	Reference
Topcoat	MIL-C-53039A, 1-part urethane	$36.00/gal	Miller, 1994
Base case Primer	MIL-P-53022, 2-part epoxy	$17.00/gal	Miller, 1994
Alternative Primer	MIL-P-53030, Deft 2-part epoxy	$20.33/gal	Taylor, 1995
Base case Thinner	MIL-T81772B	$15.00/gal	Taylor, 1995
Alternative Thinner	Fed. Std. A-A-857B	$15.00/gal	Taylor, 1995
Abrasive	16-mesh aluminum oxide	$0.25/lb	Skillen, 1994

Process Related Assumptions

Assumptions on work load, coating thickness, density, percent solids, coating efficiency, waste, dilution, coverage rate, work period, depainting rate and abrasive usage were estimated. These assumptions and information sources are presented in Table 3-5. The required materials for 619,000 ft^2 painted (primer and topcoat) per year, based on 190 painting days/year at Ft. Eustis were:

- 3,096 gal CARC/yr
- 1,827 gal primer/yr
- 1,627 gal thinner/yr
- 32,970 lb aluminum oxide abrasive/yr, and
- 73,972 lb spent abrasive/yr.

Since power and labor were anticipated to be significant cost factors, they were estimated in detail. Total power requirements were summarized at 94 HP (or HP equivalent) for the following operations:

- Painting building ventilation
- Painting building lights
- Painting building heating/air conditioning
- Air compressor for painting
- Air compressor for primering
- Depainting building ventilation
- Depainting building lights
- Depainting building heating/air conditioning
- Depainting pneumatic conveying
- Depainting air cleaner blower, and
- Air compressor for depainting blast nozzles.

Use of the alternative gun lowered total power usage to 72 HP. The difference results from the need to use a 30-HP air compressor for the HVLP spray application gun versus 7.5-HP for the alternative gun (turbine HVLP gun) (Bunnell, personal communication, 1995).

Table 3-5. Process Assumptions

Item	Description	Value	Reference
Workload	Painting 1000 ft^2/ day	3.26 1000-ft^2 units/day	Estimated based on LCI[a] 3,096 gal CARC used/yr
Topcoat with HVLP gun	Usage, gal/1000 ft^2	5.00 gal/1000 ft^2	Calculated
Topcoat with alternative gun	Usage, gal/1000 ft^2	3.66 gal/1000 ft^2	Calculated
Base case primer with HVLP gun	Usage, gal/1000 ft^2	2.50 gal/1000 ft^2	Calculated
Alternative primer with HVLP gun	Usage, gal/1000 ft^2	2.50 gal/1000 ft^2	Calculated
Base case primer with alternative gun	Usage, gal/1000 ft^2	1.805 gal/ 1000 ft^2	Calculated
Alternative primer with alternative gun	Usage, gal/1000 ft^2	1.805 gal/ 1000 ft^2	Calculated
Thinner with topcoat - HVLP gun	Usage, gal/1000 ft^2	1.625 gal/ 1000 ft^2	Calculated
Thinner with topcoat and base case or alternative primer - alternative gun	Usage, gal/1000 ft^2	1.625 gal/ 1000 ft^2	Calculated
HVLP gun with topcoat	Coverage, ft^2 topcoat/min	2.0 ft^2/min	(K. Taylor, Battelle, personal experience)
Alternative gun with topcoat	Coverage, ft^2 topcoat/min	3.0 ft^2/min	Calculated
HVLP gun with primer	Coverage, ft^2 primer/min	2.0 ft^2/min	(K. Taylor, Battelle, personal experience)
Alternative gun - base or alt. primer	Coverage, ft^2 primer/min	3.0 ft^2 /min	Calculated
Work factor, minutes painting day	Painting min/day	3,260 min/day	Calculated
Work factor, days painting/year	Painting day/yr	190.0 days/yr	Calculated
HVLP gun for topcoat	Guns required to paint 1000 ft^2 topcoat/day	0.2/1000 ft^2/day	Calculated
Alternative gun for topcoat	Guns required to paint 1000 ft^2 topcoat/day	0.13/1000 ft^2 /day	Calculated
HVLP gun - base or alternative primer	Guns required to apply primer 1000 ft^2/day	0.2/1000 ft^2/day	Calculated
Alternative gun for base case primer	Guns required to apply primer 1000 ft^2 /day	0.13/1000 ft^2 /day	Calculated
Alternative gun for alternative primer	Guns required to apply primer 1000 ft^2 /day	0.10/1000 ft^2 /day	Calculated
Depainting	Depainting rate, ft^2/min	1.1 ft^2/min	(Skillen, 1994, p 26)
Existing units average paint thickness	Thickness, mil paint removed	6.9 mil	Calculated
Density of old paint	Density, lb/gal	77.0 lb/ft^3	Calculated
Grit usage	Required grit, lb/lb paint removed	0.76 lb/lb paint removed	Calculated from LCI[a]

[a] Hendricks et al. (1995)
[b] Cavender et al. (1994)

Base case labor requirements were estimated at 110 man-hr/day for the 3,260 ft^2 of topcoat applied each working day at Fort Eustis. The rates by application were:

- Depainting (pre-strip preparation, depainting, post strip completion inspection and clean-up): 41 hours
- Primering (thin primer with thinner, preprimering preparation, apply primer, post primer application inspection and cleaning): 44 hours
- Topcoat (thin topcoat with thinner, apply top coat using HVLP gun, post topcoat application inspection and clean-up): 24 hours

This was reduced to an estimated 96 hours when the more efficient alternative gun was employed. Depainting time naturally stayed the same (41 hours), but preparation and primering dropped to 38 hours and topcoat application, inspection, and cleanup dropped to 17 hours.

3.4 Performance Assessment

The major technology driver for advances in coatings and in application equipment is the reduction of emissions of volatile organic compounds (VOCs). Coatings are currently being formulated that either reduce the level of solvent in the coating (high solids), eliminate the use of solvents (powder coating, 100% reactive-UV curable) or use water as a solvent or co-solvent (waterborne, waterthinned). The application equipment manufacturers are working with coatings manufacturers to allow the use of these reduced VOC coatings. High-solids systems require increased nozzle pressures to provide atomization of the high viscosity materials. Powders coatings require the use of electrostatic equipment which electrically charges the powder to provide an attractive force between the powder and the substrate. Waterborne coatings require the use of stainless systems to prevent corrosion.

At this time there is only one military specification (Mil-C-53039) approved for use as a CARC topcoat for the exterior of vehicles. This is a one-component, moisture-cured, solvent-based polyurethane. High-solids, water-based, and 100% reactive systems are currently being investigated. However, none of these systems are expected to receive approval in the short term according to personnel at Fort Belvoir (U. S. Army Coatings Research Facility) (Duncan, personal communication, 1995). Primers are limited to two military specifications (Mil-P-53022 and Mil-P-53030). Both system are two component epoxy-amine systems. Mil-P-53030 is a water-thinnable formulation.

Other formulations may exist that provide all of the necessary performance characteristics obtained from the currently used systems. However, without available supporting data, these systems can not be explored within the scope of this program.

3.4.1 Application Equipment

Electrostatic guns and HVLP guns are the two most commonly used market advances. Electrostatic guns charge atomized paint particles and use the attractive force of a grounded target to attract and hold the coating particle. This reduces both the amount of bounceback and overspray. Bounceback is due to high momentum particles not having enough attractive force upon impacting a target to inhibit the particle from bouncing off the target. Overspray is due to the turbulence involved in forcing a coating through a gun path toward a target. Both bounceback and overspray are reduced because the attractive force of the target allows for reduced forward pressure from the guns. The HVLP guns reduce the pressure or force on the particles, which reduces the amount of bounceback. However, HVLP guns often require a conversion zone which changes high pressure air into large volumes of low pressure which influences the amount of turbulence and the amount of overspray.

Transfer efficiency is the defining value of the ability of application equipment to minimize overspray and bounceback. Transfer efficiency is measured as the amount of coating that is applied to the surface over the total amount sprayed. Higher transfer efficiencies result in use of less material and thus less VOC release.

While manufacturers strive for increases in transfer efficiencies, the equipment must also continue to impart a quality coating on the target surface. The surface characteristics of the applied film are directly related to the atomization, and velocity of the applied coating particles. The effect of varying levels of atomization and velocities on proper film formation are reviewed in available literature, but will not be discussed in this review. The equipment must also allow for coating at a range of film thicknesses and coverage areas similar to that available from conventional application equipment.

3.4.2 Primers

Primers serve two basic functions which are corrosion protection and as tie layers which aid adhesion of topcoats. The area of corrosion is complex and will not be covered in detail in this discussion, as much literature is available on the subject (Wicks, 1987). However, in general the most common driver is electrochemical corrosion. Electrochemical corrosion is in turn a function of, but not limited to, the following: the type of metals involved, the environmental conditions present including humidity and salt levels, and mechanical stress found in the metal structure.

Adhesion is affected by both the materials used and the condition of the substrate. Most primers considered for use under CARC topcoats on steel consist of two-component, amine-cured, epoxy systems. The amine component is used because of strong hydrogen bonding that occurs with oxides formed on the steel surface. Epoxy-amine systems have been traditionally viewed as having excellent adhesion and hardness. However, they do not have the required environmental and chemical exposure resistance needed to be used as an external CARC topcoat. Therefore, these primers must also be reviewed in terms of the adhesive strength between the primer and a more environmentally durable polyurethane topcoat.

The condition of the substrate is important, because small levels of contaminates such as oils and greases can dramatically reduce the bonding of the primer. Systems with the greatest adhesion are often less dependent upon absolute cleanliness of the substrate and are therefore less susceptible to oversights in surface cleaning.

An additional performance related factor that can be included toward the selection of a primer is the ease of use of the primers. Two component systems require the blending of a base and a catalyst which initiates immediate crosslinking, which in turn results in increases in viscosity. Therefore, the systems must be applied before the reaction of the two components increases the viscosity beyond application limits. This rate of reaction is reported as the cure rate and is often more simply expressed in terms of a system's "pot life". "Pot life" is generally defined as the amount of time elapsed after initial mixing before the viscosity of the system doubles. The ease of cleanup of the primers can also be considered. Systems that require extensive use of solvents to clean gun lines require more effort than those that can be cleaned using water.

3.4.3 Thinners

There are three major factors associated with the selection of a solvent or thinner. The first is the solubility of the solute (i.e., the paint and/or resin) by the solvent. This factor is based on the compatibility of the solute and the solvent, which is demonstrated as the ability of the solute and the solvent to form a homogenous solution and it is often referred to in terms of the solubility parameter. The second factor is the viscosity reduction introduced by the addition of the solvent. The first two factors are related as the solvency of the thinner. Solvency is generally dominated by the viscosity of the solvent when low concentrations of resin are present. When higher concentrations of resin are introduced, then the solubility factor dominates the overall viscosity. However, the amount of thinner required to thin the paint and or primer are more commonly considered by end users than the individual contributions of solvency. The final factor is the evaporation rate of the resin and its affect on film formation. "If solvent evaporation is too fast, the film will not level nor wet the substrate well enough for good adhesion. If the solvent evaporation is too slow, the film will sag and perhaps become too thin. If solvent composition changes during evaporation, precipitation of the resin can occur, and the film will have no integrity" (Ellis, 1986). It is the effect of the evaporation rate on the film forming characteristics of the coating that are of primary concern and of which the most informative data can be obtained.

One additional factor that can also be considered is the level of purity of the thinners. Thinners with significant levels of contaminates such as water or solid particulates can affect the film characteristics of the coating.

3.4.4 Application Equipment Evaluation Parameters

Surface quality and transfer efficiency were selected as the two evaluation parameters. The ability of the application equipment to provide sufficient atomization and desired thickness levels and coverage areas were not chosen as evaluation parameters due to information provided by equipment manufacturers stating that these issues could be ignored assuming the proper selection of nozzles and tips.

Surface Quality

The ability of the application equipment to effectively apply CARC was ranked according to the surface quality of the applied coating. An acceptable finish is one with no visible application induced surface blemishes (e.g., orange peel, blistering). Data were obtained from published literature. Results were ranked in terms of acceptable and not acceptable, as follows:

2: Acceptable: No visible application induced surface blemishes
1: Not Acceptable: Noticeable surface blemishes requiring significant reformulation efforts such as addition of thinners, or surfactants.

Transfer Efficiency

Transfer efficiency (TE) was rated by definition as the percentage of paint applied to the target divided by the total paint sprayed. Data were obtained from published literature and communications with users. Results were reported from 0-100 percent, and were ranked as follows:

4: TE for alternative >20% + TE for baseline
3: TE for alternative >(10% to 20%) + TE for baseline
2: TE for alternative > (0% to 10%) + TE for baseline
1: TE for alternative < TE for baseline

The evaluation parameters Surface Quality and TE are weighted 2-1, respectively.

3.4.5 Primer Evaluation Parameters

The two major issues of primers are corrosion inhibition and adhesion. Cure rate was also identified as a possible selection parameter in the methodology section. Unfortunately, a lack of data for primers is available in terms of corrosion inhibition. However, as stated in the assumptions, the reviewed primers have all met military specification approval and thus are assumed to provide sufficient corrosion inhibition.

Adhesion is reviewed in terms of the level of cleaning of the substrate required for acceptable adhesion. Adhesion of the primer and the topcoat can also be affected by changes in environmental conditions and will thus be reviewed separately. Cure rate and ease of cleanup will be reviewed in respect to the impact on the painting schedule and the level of effort required.

Effect of Temperature and Humidity

Adhesion of the primer to the substrate and also the adhesion of the topcoat to the primer can be affected by differences in environmental conditions. Data were obtained from personal interviews with users. The level of impact of changes in temperature and humidity were reviewed, and the effect of each criterion was ranked according to the following scale:

Changes in humidity and temperature have:

4: No observable impact
3: Minimal impact not seen as having practical significance
2: Noticeable impact
1: Critical impact

Cure Rate

The rate of viscosity increase can induce limitations on the amount of primer that can be mixed at a given time if the cure rate is too fast. This results in an increase in time spent preparing the primer and also in maintaining flow in the application lines. Cure rates that are too slow can result in increased down time due to required waiting periods between coats.

The impact of the primer cure rate was reviewed. Data were obtained from personal interviews with users. Results were reported in terms of the following scale:

4: Cure rate had no effect on the painting schedule
3: Cure rate had minimal effect on the painting schedule
2: Cure rate had dramatic effect on the painting schedule
1: Cure rate had unacceptable effect on the painting schedule

Surface Pretreatment Requirements

The level of cleaning of the surface to be coated with primer was reviewed. Data were obtained from personal interviews with users. Results were reported in terms of the following scale:

4: no cleaning was required
3: minimal cleaning with dry rag required
2: minimal cleaning with solvent rag required
1: repeated cleaning with solvent rag required

Ease of Cleanup of the Primer

Primers were ranked in terms of ease of cleanup. Those that are easily thinned increase the ease of cleanup, which results in a decrease in time spent and in the use solvents. Data were obtained from personal interviews with users. Results were reported in terms of the following scale:

4: no effort required for cleanup
3: minimal effort required for cleanup
2: moderate effort required for cleanup
1: extreme effort required for cleanup

The evaluation parameters Effect of Temperature and Humidity, Cure Rate, Surface Pretreatment Requirements, and Ease of Cleanup of the Primer Changes are weighted 3-1-1-1, respectively.

3.4.6 Thinner Evaluation Parameters

Thinning Ratio or Thinner Effectiveness

Thinners were evaluated based on the percentage of thinner needed to dilute CARC to within sprayable viscosity limits. Data were obtained from personal interviews with users. Results were ranked as follows:

4: Thinning ratio for alternative > (50%) reduction
3: Thinning ratio for alternative > (25% to 50%) reduction
2: Thinning ratio for alternative ≥ (0% to 25%) reduction or no change
1: Thinning ratio for alternative > (0% to 25%) increase

Thus, the score for the baseline is 2.

Film Characteristics

Thinners were also ranked according to the ability of the thinner to provide an acceptable finish. Thinners that evaporate too slowly or too quickly can cause undesirable surface defects such as sagging or running and blushing, popping, and orange peel. Data were obtained from personal interviews with users. Results were reported in terms of level of surface flaws as follows:

4: No noticeable blemishes
3: Minimal blemishes not believed significant
2: Noticeable blemishes bordering acceptability
1: Unacceptable level of blemishes

The evaluation parameters Thinning Ratio or Thinner Effectiveness and Film Characteristics are weighted equally.

3.5 Valuation Procedure

Finally, as noted above, valuation involves assigning relative values or weights to different impacts, so they can be integrated across impact categories for use by decision makers. It should be recognized that this is largely a subjective process, albeit one that is informed by knowledge of the nature of the issues involved. The valuation method used in this study is known as the Analytical Hierarchy Process (AHP). AHP is a recognized methodology for supporting decisions based on relative preferences (importance) of pertinent factors (Saaty, 1990).

The AHP process involves a structured description of the hierarchical relationships among the problem elements, beginning with an overall goal statement and working down the branches of the tree through the major and minor decision criteria. Once the decision tree is defined, the actual assignment of the weight factors occurs. In this study, the assignment of weights was done as a group exercise. The advantages of the AHP method include its structured nature and the fact that the valuation process does not deal with the entire set of criteria at one time, an effort that would be overwhelming. Rather, preferences are expressed by the team in a pair-wise manner supported by a software package known as Expert Choice™ (EC). The four member team was asked to reach a consensus on the weight factors prior to their being entered into the model. Although divergences of preference could in principle be retained as separate sets of criteria, it was felt that for this application, a single internally consistent process would lead to clearer understanding of how the implementation of the results should proceed.

One of the key assumptions in applying the AHP method is that the environmental, cost, and performance perspectives of the four Battelle staff conducting the AHP to determine the assignment of weighting values for comparison of different impact criteria are assumed to be a reasonably good cross section of the views held by similar stakeholders in the decision process. Because the four staff included one cost engineer, one paints/coatings specialist, a civil engineer and an ecologist, we believe that the mix (and the resulting weights) are reasonable. Facility/production engineers and other "non-environmental" staff within the Army, however, may have derived somewhat different weight values.

4.0 Description and Screening of Improvement Options

4.1 Alternatives Identified/Selected

The scoping process conducted for the baseline and alternatives was designed to identify candidate improvement options that could be evaluated and implemented with a moderate amount of effort and within a reasonable timeframe. It was therefore determined that options requiring large changes in technology or overcoming major institutional barriers, for example, a modification to the MIL-SPEC, a significant change in Army purchasing practices, or a major capital acquisition, would not be included in the suite of candidate systems even though these might, in the long run, be very much better environmentally than those considered. The five alternatives selected (see Table 1-1) represent a mix of evolutionary, directional changes in paints and technology that individually and in combination represent an incremental improvement potential in the areas most directly affecting the environmental profile as determined by the baseline analysis.

Three of the alternatives consider the use of an alternative primer consisting of a water-thinned rather than a solvent-thinned formulation. Although primarily expected to reduce VOC releases during the painting operation, this substitution also offers potential changes in the entire life-cycle of the primer manufacture, use, and disposal. This alternative material is also combined with an alternative thinner in one scenario and with an alternative spray gun in another. The alternative thinner would be anticipated to offer further directional improvements in chemical emissions and the alternative gun application of both more paint on the surface as well as greater labor efficiency. Finally, the alternative thinner and gun systems can be used independently of the alternative primer, although any additive benefits (or costs) would not occur. The following section presents and discusses the factors comprising the improvement assessment process in each of the three target assessment areas.

4.2 Environmental Impact/Hazard Classification

Based on a scoping process using the LCI data that was revised and updated for the baseline and alternatives, and a review of stressor/impact chains for all resources used, and environmental releases from, the entire CARC life cycle, nine major environmental impact categories were selected for the streamlined LCIA described in this report. These nine impact categories include:

- photochemical oxidant creation potential (POCP; also called smog formation potential),
- ozone depletion potential (ODP; stratospheric ozone depletion),
- acidification potential (AP; acid rain/fog),
- global warming potential (GWP; also called greenhouse effect potential),
- human health inhalation toxicity (acute inhalation toxicity),
- terrestrial toxicity (acute oral wildlife toxicity),
- aquatic toxicity (acute fish toxicity),
- land use (for solid waste disposal), and
- natural resource depletion (including fossil fuels and minerals).

Stressor/impact networks for these nine major impacts are shown in Table 4-1. This table shows the secondary, tertiary, and quaternary impacts that can result from the primary impact used in the impact equivalency calculations. Thus, impacts to human health can result from several of these major impact categories (e.g., inhalation toxicity, smog formation, and ozone depletion). The potential for both positive and negative impacts were viewed from a global perspective. For example, global warming may increase food production in some areas (e.g., cold climates) and decrease food production in other areas (e.g., warm climates). Where the global net difference in positive and negative change for a single impact criterion was not clear, both types of impacts were listed for that criterion. Although other minor impacts are associated with the CARC life cycle, these major impact categories were expected to show significant differences between the alternatives to the base case selected for this LCImA. Many of the impacts selected for analysis were also identified in a document by Inform, Inc. titled "Stirring Up Innovation: Environmental Improvements in Paints and Adhesives" (Young et al., 1994). The Inform study was conducted with the cooperation of major paint manufacturing companies.

Table 4-1. Stressor/Impact Networks for Impacts of Primary Concern in CARC Life Cycle

Stressors	Primary Impact	Secondary Impact	Tertiary Impact	Quaternary Impact
CO_2 Carbon tetrachloride Trichloroethane	Global warming	Polar melt	Flooding/land loss	
		Soil moisture loss	Lower food production	
		Longer season	More food production	
		Forest loss/change	Decreases biodiversity and forest production	
		Change in wind and ocean patterns		
SO_x NO_x Ammonia Hydrochloric acid	Acid rain/fog	Building corrosion	Loss of infrastructure, loss of heritage resouces	
		Water quality (acidification)	Decreased aquatic biota reproduction and populations	Decreased biodiversity, decreased recreational and commercial fishing, decrease in water birds
		Vegetation effects	Agricultrual and terrestrial productivity effects	
		Soil effects	Vegetation effects	Agricultural and terrestrial productivity effects
<u>VOCs</u> Acetaldehyde Toluene Benzene n-Butane n-Octane n-Butyl Acetate Chloroform etc.	Ground-level ozone (smog) creaton by photochemical oxidants	Decreased visibility		
		Eye irritation		
		Respiratory tract problems and lung irritation	Morbidity	
		Vegetation damage	Decreased agricultural / terrestrial productivity	

Table 4-1. Stressor/Impact Networks for Impacts of Primary Concern in CARC Life Cycle (continued)

Stressors	Primary Impact	Secondary Impact	Tertiary Impact	Quaternary Impact
Ammonia Fluorine Xylene Chlorine Vinyl Chloride Phenol CO, etc.	Human health and inhalation toxicity	Morbidity or mortality		
<u>Heavy Metals</u> (Arsenic, cadmium, chromium, mercury) Ammonia Benzene Hydrochloric acid Phenol Sulfuric acid, etc.	Aquatic biota toxicity	Decreased aquatic plant and insect production and biodiversity	Decreased commercial or recreational fishing	
Coal use Iron ore use Magnsium ore use Petroleum use Thallium use Titanium use Water use Zinc use, etc.	Resource depletion	Resources unavailable for future generations		
<u>Heavy Metals</u> (Arsenic, cadmium, chromium, lead) Formaldehyde Sulfuric acid Hydrogen cyanide	Terrestrial animal toxicity	Decreased production and biodiversity	Decreased wildlife for hunting or viewing	
Carbon tetrachloride Trichloroethane	Stratospheric ozone depletion	Increased ultraviolet radiation penetration of Earth's atmosphere	Increased incidence of human skin cancer and ecosystem effects	
Bottom ash FGD solids Fly ash Hazardous waste Plutonium Slag Solid waste Uranium	Land use for disposal	Loss of terrestrial habitat for wildlife Decreased landfill space		

In order to combine data on individual chemicals or resources <u>within</u> an impact category, it was necessary to select existing, or develop new, impact equivalency factors as recommended by SETAC (1993) for a Level 2/3 LCIA. The equivalency factors for each impact category are listed in Table 4-2. The equivalency factors for POCP, AP, GWP, and ODP were taken from Heijungs et al. (1992b); the derivation of these factors is described in a companion document (Heijungs et al., 1992a). The general approach for calculation of equivalency factors for the three toxicity impact criteria was modified from an EPA (1994) document prepared by the University of Tennessee. Details for determining the equivalency factors for the three toxicity criteria, land use, and resource depletion are discussed below.

Table 4.2. Chemical Equivalency Factors for Major Impact Categories Associated with CARC LCA

CHEMICAL NAME	POCP*	ODP	AP**	GWP***	HH INHALATION TOXICITY	TERRESTRIAL TOXICITY	AQUATIC TOXICITY	LAND USE	RESOURCE DEPLETION
ACETALDEHYDE	0.527				7.44	3.255			
[redacted]									
ACETONITRILE					0	0.61	0		
ALDEHYDES	0.443				NA				
ALIPHATIC PETROLEUM DISTILATES									
ALUMINUM					15.6	0	0		
AMMONIA			1.88		5.7	9.03	21.85		
AROMATIC HYDROCARBONS (C8-C10)	0.761				NA				
AROMATIC SOLVENT	0.761								
ARSENIC						31.73	18.75		
BAUXITE									4
BENZENE	0.189				NA	0	14.07		
BORON							0		
BOTTOM ASH								2	
BUTANE (n-)	0.41				17.5				
BUTANE (iso-)	0.315				NA				
BUTYL ACETATE (n-)	0.323				8.49	0			
BUTYL ALCOHOL (BUTANOL)	0.196				0.95	6.18	0		
BUTYL CELLOSOLVE					12.29	7.59			
BUTYLENE OXIDE, 1,2-					NA	1.61	NA		
CADMIUM					2.25	21.03	36.25		
CARBON TETRACHLORIDE		1.08		1300	7.06	1.71	1.2		
CHLORIDE							NA		
CHLORINE					22.05	0	22.5		
CHLOROFORM	0.021				2.57	6.16	9.75		
CHROME OXIDE									2
CHROMIUM, TRIVALENT					0	19.29	16.63		
CO					4.47				
CO2				1	NA				
COAL									3
COBALT COMPOUNDS						20.96	31.75		
COBALT OXIDE									3
COPPER COMPOUNDS					0	12	30		
CUMENE					1.35	2.71			
CYCLOPARAFFINS, C-7					NA				
CYCLOPARAFFINS, C-8					NA				
DICHLORODIFLUOROMETHANE (CFC-12)		1		7100	0	1.33	NA		
DIETHEYLENETRIAMINE						5.27			
ETHANE	0.082				NA				
ETHYL BENZENE	0.593				3.19	0			
ETHYL CHLORIDE					0				
ETHYLENE	1				0	0			
ETHYLENE DICHLORIDE					7.32	4.89			
FGD SOLIDS								2	
FLY ASH								2	
FLUORINE					14.64				
FORMALDEHYDE					15.6	12.6			
HAZARDOUS WASTE								2	
HEAVY AROMATIC					NA				
HEPTANE (n-)	0.529				0	9.5			

Table 4.2. Chemical Equivalency Factors for Major Impact Categories Associated with CARC LCA (continued)

CHEMICAL NAME	POCP*	ODP	AP**	GWP***	HH INHALATION TOXICITY	TERRESTRIAL TOXICITY	AQUATIC TOXICITY	LAND USE	RESOURCE DEPLETION
HEXYL ACETATE					NA	0			
[redacted]									
HEXANE (n-)	0.421				0	0			
HYDROCHLORIC ACID			0.88		14.82	5.74	13.86		
HYDROGEN CYANIDE					30	30			
IRON						0	25		
IRON ORE									3
ISOBUTYL ACETATE	0.332								
ISOBUTYRALDEHYDE					1.86	1.86			
ISOPROPYL ALCOHOL					0	0.95			
KEROSENE						0			
LEAD					NA	5.75	25		
LIMESTONE									1
MAGNESIUM ORE									1
MAGNETITE									
MANGANESE ACETATE									
MERCURY							37.5		
METHANE	0.007				NA				
METHANOL	0.123				0	0	0		
METHOXYPROPANOL ACETATE									
METHYL ETHYL KETONE	0.473				1.4	1.86			
METHYL ISOAMYL KETONE	0.326				4	2.05	10.2		
METHYL ISOBUTYL KETONE	0.326				2.33	2.79			
METHYL PROPYL KETONE	0.326				NA	4.57			
NAPTHA, NM&P					NA				
NAPHTHALENE					26.45	3.17	19.57		
NATURAL GAS									4
NOX			0.7		NA				
NITRIC ACID					26.4	10.2	15.6		
NITROETHANE					NA				
NITROPROPANE, 2-					14.4	8.4	23.4		
OCTANE (n-)	0.493				0				
OIL & GREASE							NA		
ORGANIC ACIDS					NA		NA		
PENTANE (n-)	0.408				13.34				
PETROLEUM (CRUDE OIL)							NA		4
PHENOL					22.33	7.6	11.4		
PHOSGENE					12.5				
PHOSPHATE ROCK									3
PHOSPHORIC ACID					30	5.4	11.4		
PLUTONIUM (FISSILE & NONFISSILE)								NA	
PM					NA				
PM-10					NA				
PROPANE	0.42				NA				
PROPYL ACETATE	0.218				NA	0.87			
PROPYLENE	1.03								
SLAG								2	
SODA ASH									1
SODIUM							NA		
SODIUM CHLORIDE									1

Table 4-2. Chermical Equivalency Factors for Major Impact Categories Associated with CARC LCA (continued)

CHEMICAL NAME	POCP*	ODP	AP**	GWP***	HH INHALATION TOXICITY	TERRESTRIAL TOXICITY	AQUATIC TOXICITY	LAND USE	RESOURCE DEPLETION
SOLID WASTE								1.5	
SOX			1						
SILICA									1
SULFIDE							NA		
SULFURIC ACID						3.6	15		
SULFUR DIOXIDE									
THALLIUM									4
TITANIUM DIOXIDE									3
TOLUENE	0.563				2.04	0			
TRICHLOROETHANE (METHYL CHLOROFORM)	0.021	0.12		100	5.6	0			
URANIUM (235, 236, 238)						NA		NA	3
VINYL CHLORIDE					18.52	7.87			
VOC	0.397				NA				
WATER INPUT									NA
XYLENE	0.849				2.1	0.52	16.24		
ZINC						0	20.3		4

* POCP average is for appropriate chemical group (e.g., ketones, alcohols, etc.)

** Applies to air emissions only

*** Applies to air emissions only; factor is for 100-yr time period

NA = Data not available from on-line sources searched.

Equivalency factors for human health inhalation toxicity, terrestrial toxicity, and aquatic toxicity used in this LCIA incorporate both toxicity and persistence information (EPA, 1994) as recommended by SETAC (1993) for a Level 3 LCIA. The toxicity data used for each of these three impact criteria were as follows:

- human health inhalation toxicity - use the lowest rodent concentration lethal to 50% (LC_{50}) of exposed animals in parts per million (ppm) experimental or structured-activity relationship (SAR) value and convert to a 4-hr acute test basis,
- terrestrial toxicity - use the lowest rodent dose lethal to 50% (LD_{50}) of exposed animals in millligrams per kilogram (mg/kg) experimental or SAR value, and
- aquatic toxicity - use the lowest fish LC_{50} in milligrams per liter (mg/l) experimental or quantitative structure-activity relationship (QSAR) value for a 96-hr test.

In each case, the log of the toxicity data was used to establish a toxicity hazard value (HV). The HV was given a 0 or 5, respectively, if it was above or below a threshold value, as indicated in the EPA (1994) chemical ranking document. The HVs for toxicity data between these threshold values were determined from the formulas indicated in the EPA (1994) document. A similar approach was used to obtain the following three measures of persistence: biological oxygen demand (BOD) half-life, hydrolysis half-life, and bioconcentration factor (BCF). The natural log (ln) of the BOD and hydrolysis half-lives and the log of the BCF were used with the formulas in the EPA (1994) document to develop HVs from 1 to 2.5. The final equivalency factor for a chemical was based on the formula:

$$\text{Equivalency Factor} = (\text{toxicity HV})(\text{BOD HV} + \text{hydrolysis HV} + \text{BCF HV})$$

Thus, the maximum equivalency factor any chemical could have is (5) (2.5 + 2.5 + 2.5) = 37.5.

The equivalency factor for land use was the estimated density of each type of solid waste. Since the LCI data for solid wastes are expressed as weight/functional unit, multiplication of the weight and density gives an indication of the waste volume, and thus, the landfill volume required.

The equivalency factor for resource depletion was sustainability, which can be expressed as the world reserve base of a mineral or fossil fuel divided by the world annual production. The minerals information was obtained from the 1992 Minerals Yearbook: Volume I, Metals and Minerals (U.S. Bureau of Mines, 1992) or from more recent Minerals Commodity Summaries for individual minerals (U.S. Bureau of Mines, 1995a, 1995b, 1995c, 1995d, 1995e, 1995f, 1995g, 1995h, 1995i, 1995j, 1995k). The fuel data was based on U.S. reserves and production, and was obtained from the Energy Information Administration's Annual Energy Review for 1992 (U.S. Department of Energy, 1993). The sustainability value in years for a mineral or fuel was given an equivalency score of 1 to 5 based on the following scoring ranges:

Equivalency Score	Sustainability Scoring Ranges (years)
5	< 5
4	5-49
3	50-499
2	500-999
1	≥ 1,000

It should be noted that these scores do not take into account potential technological advancements for economically locating or mining natural resource deposits not currently included in the reserve base. Also, the scores do not consider the influence of increased recycling on decreasing the demand for remaining reserves (e.g., aluminum recycling reducing the demand for bauxite).

4.3 Economic Assessment

The economic assessment is based on calculation of the cost in dollars for depainting and painting one functional unit (1,000 ft^2) at Fort Eustis. The baseline case and the five alternative cases are evaluated. In addition to capital costs the annualized costs (consisting of the annual operating cost and amortization of the capital costs) are assessed. The primary cost components of the annualized costs are as follows:

- Raw Materials (includes topcoat, primer, thinner, and depainting abrasive)
- Utilities (electricity)
- Labor (operating, maintenance, and supervision)
- Operating Supplies
- Maintenance Supplies
- Laboratory Charges
- Plant Overhead
- Waste Disposal
- Insurance
- Regulatory Compliance
- Annual Operating Cost, and
- Capital Amortization.

4.4 Performance Assessment

In this section, all performance evaluation parameters (see Section 3) have been assigned a ranking system to discriminate between noticeable changes in performance. However, each ranking can include a range of performances. Since the baseline components discussed in this report will be compared to their alternatives in a subsequent report, it is likely that one of the baseline components and an alternative may be viewed to be alike in terms of practical considerations, and thus would fall within a given ranking. In this situation, if one system is believed to be slightly different, written descriptions will be used to describe the subtle differences. These descriptions have not been incorporated into the rankings discussed below.

Each set of evaluation parameters for application equipment, primers, or thinners was weighted in terms of importance. Therefore, a set that is weighted 2-1 would require a change of two ranking categories in the latter evaluation parameter to equal one change of rank in the higher weighted evaluation parameter.

4.4.1 Application Equipment

Initially, the selection of application equipment that does not require thinning of the CARC topcoat was thought to provide the best potential for improvements in reducing emissions without affecting performance. It was theorized that selection of application equipment that uses higher atomization pressure could reduce or eliminate the need for thinning of the CARC topcoat. It was assumed that some loss in transfer efficiency might occur, but that this would be offset by the elimination or reduction in thinner usage.

Unfortunately, due to the nature of the topcoat and its method of curing, the degree of thinning required is very dependent upon the environmental conditions in which the topcoat is applied. The topcoat cures upon exposure to airborne moisture. Therefore, under high humidity conditions an opened can of topcoat might cure to a solid block overnight. This rapid cure resulted in a wide variety of opinions as to the level of thinning required. While some application equipment manufacturers (Seffick, 1995) and some users believe that it is possible to apply the CARC topcoat without thinning, an equal number of opposing opinions were also found. At this time, no supporting literature has been found that can detail the techniques and equipment required to spray without thinning.

A second area of investigation was the use of improved housekeeping techniques. These techniques included using a gun cleaning bath that recycles solvents for multiple uses. Another technique would be the use of an inert gas "blanket" for purging moisture laden air from the topcoat cans to reduce the cure reaction in the can. This would increase the shelf-life of the topcoat and reduce the amount of thinner needed to maintain spraying viscosity. These alternatives were also eliminated due to a lack of information on the effectiveness of each technique.

The third and selected alternative was to reduce the amount of overspray by changing the application equipment. Electrostatic equipment was eliminated because of its inability to coat non-conductive surfaces. Therefore, it would be unable to coat the polymer sections of targets which are generally the most susceptible to chemical agent exposure.

There is a large pool of HVLP spraying equipment that shows a wide range of values of transfer efficiency. The turbine-powered Can-am system was chosen for analysis. This equipment was independently analyzed (Hughes Aircraft Company, 1991 as reported in Cavendar et al., 1994) against several other HVLP systems so side-by-side comparative information was available. This system is also currently used at several bases so additional user opinions could be obtained. The equipment uses a patented turbine technology to provide high volume low pressure air instead of the traditional method of using normal compressed air which passes through a conversion zone which in turn converts high pressure low volume air into HVLP. The turbine system thus reduces the amount of turbulence which decreases the amount of overspray. Bounceback of both HVLP technologies is minimal due to the low pressures involved.

4.4.2 Primers

Primer alternatives were limited to either selection of primers that fall within the same military specification (Mil-P-53022), but are made by alternative manufacturers, or to selection of a primer that falls within the only accepted alternative military specification (Mil-P-53030). Primers used for other materials were not considered because the information regarding adhesion to CARC topcoats would not be available. Due to the similarity of constituents used by different manufacturers when creating a primer for a given specification, it was decided that a review of the alternative specification would provide more substantial opportunity for improvement.

The alternative and the baseline are epoxy-polyamide systems. However, the alternative is water thinnable while the baseline can only be solvent thinned. While both primers do not generally require thinning for application, the baseline does require the use of a solvent for cleanup. The alternative can be cleaned with water. Unfortunately, the levels of solvent used for cleaning are not tracked as closely as those for thinning. Therefore, engineering judgements had to be made as to the level of reductions obtainable from the elimination of solvents for thinning. Since both systems have obtained military specification approval, they are expected to perform similarly in terms of adhesion and corrosion resistance.

4.4.3 Thinners

Thinner alternatives were again limited to selecting alternative manufacturers or selecting the only other currently used thinner which is classified under Federal Standard A-A-857B. Again, the choice was to select the alternative standard and not an alternative manufacturer. Thinner specifications describe the actual constituents required and the minimum or maximum levels which than can be used. Therefore, a comparison of thinners from different manufacturers would be unlikely to provide noticeable differences.

The baseline system is specifically designed as a thinner for aircraft coatings, while the alternative was designed as a dope and lacquer thinner. However, the lacquer thinner has been found to be an effective thinner of CARC by some who have used it (Ft. Eustis). The alternative thinner is currently being used at Ft. Eustis and believed to be effective. The performance of the thinners, like the primers, does appear to be dependent on the environmental conditions in which it is used.

5.0 Life Cycle Impact Assessment Results

5.1 Environmental Impact Characterization/Valuation

5.1.1 Impact Characterization

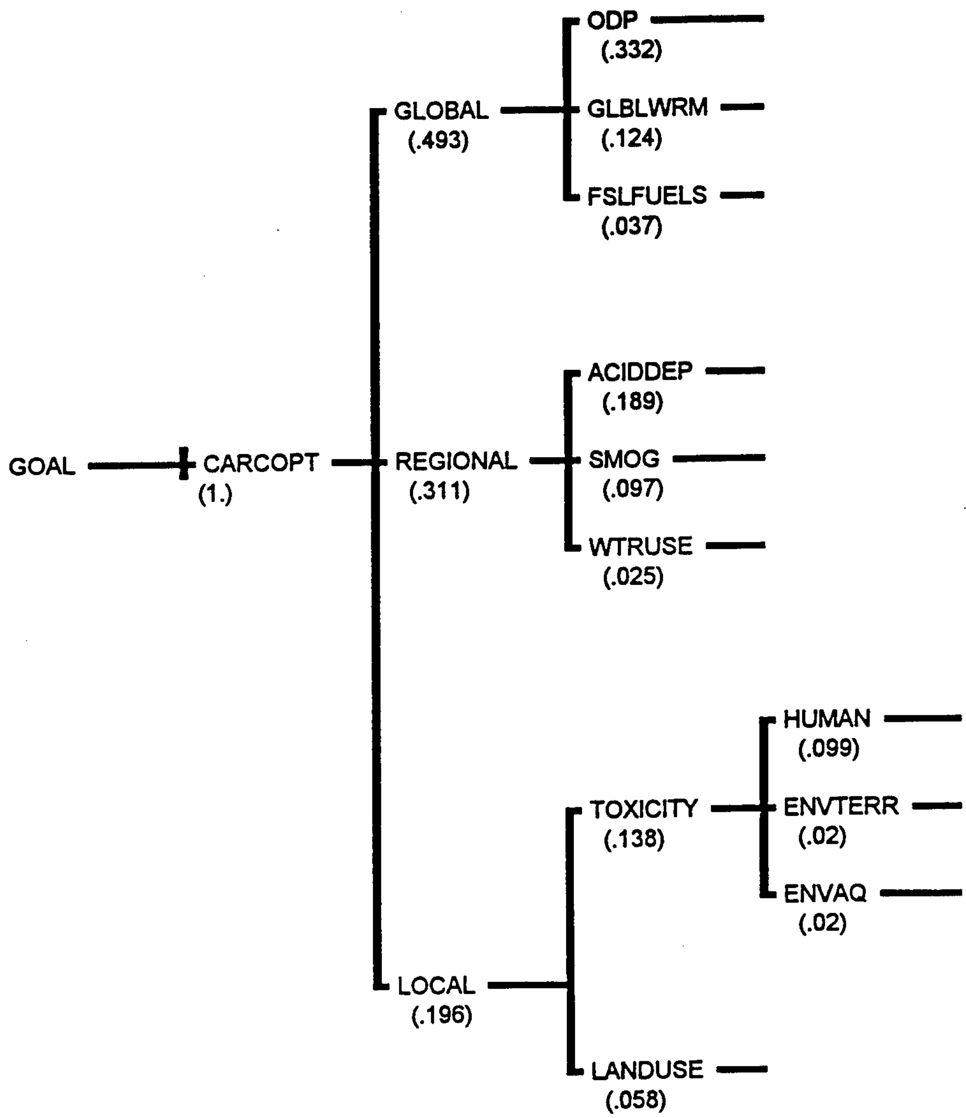
The environmental impact significance of each resource and emission from the CARC LCI data shown in Appendix C was characterized (evaluated) using the equivalency factors reported in Table 3-3. The importance of each individual resource or chemical within an impact category was determined by multiplying the equivalency factor times the inventory value in pounds per functional unit. The results of these calculations for each resource or emission are provided as "factored scores" within each of the nine impact categories in Appendix D (Tables D-1 through D-9). These "factored scores" are the basis for the environmental impact valuation results discussed below, which are combined with the results for the economic and performance assessments in arriving at the conclusions regarding primary improvement opportunities that are described in Section 7.

5.1.2 Impact Valuation

In order to make comparisons between impact categories, the factored scores were normalized within an impact category and a valuation process was conducted on the nine impact categories. Normalization of "factored scores" was accomplished within an impact category by using the highest "factored score" in an impact category. The resulting "normalized factored scores" for each inventory item, including the total for all resources or chemicals in each impact category, are provided in Appendix D. The impact category totals from the tables in Appendix D are also shown in Table 6, which summarizes the valuation results.

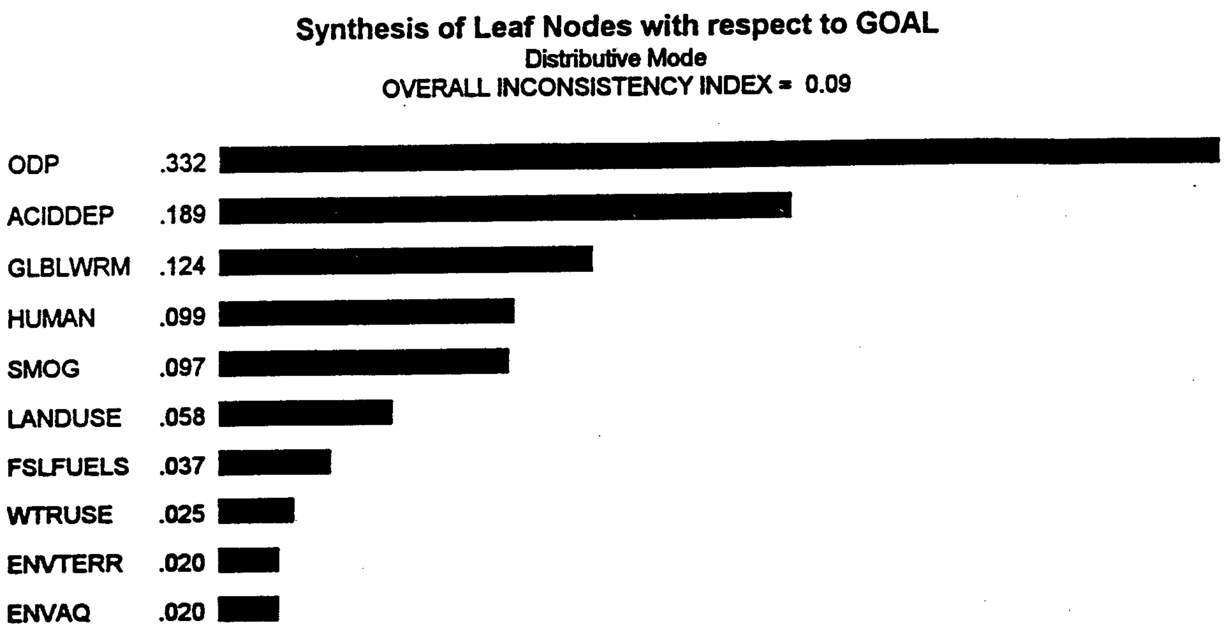
Valuation of the nine impact categories was conducted using the AHP. A team of four Battelle staff representing substantially different scientific disciplines (chemical engineer, water chemist, civil engineer, and ecologist) were used to select preferred impact categories in a structured manner supported by the EC software package. A hierarchy "tree" was constructed as shown in Figure 5-1, with the goal to choose the most important environmental categories as the main "branches" and the nine individual impact categories selected for the streamlined CARC LCIA as the "leaves" on the tree. Impact categories were first broken down on a spatial basis, according to their influence on a global, regional, or local basis. The result of this process is the calculation of the weighting factors shown in Figure 5-2, which indicate the relative importance of each of the nine impact categories. These results indicate that the impacts of greatest concern to this group are ozone depletion (weight = 0.332), global warming (weight = 0.124), and smog creation (weight = 0.189). Although water use was included in the valuation process, it was not included in the LCIA, because net water used for each process in the lifecycle was not determined, because water availability is plentiful in most areas of the U.S. associated with CARC life-cycle operations, and because water is typically treated and reused or released to the environment.

When the normalized factored scores for each impact category are multiplied by the AHP weighting factors for the same category, the results provide a relative environmental impact ranking among impact categories for the baseline conditions (Table 5-1). Based on the normalized, weighted, factored scores, the three impact categories with the greatest impact for the CARC life-cycle under baseline conditions are the same three impact categories identified to be of greatest concern by the AHP valuation process (i.e., ozone depletion = 0.362, acid deposition = 0.219, and global warming = 0.126). Thus, these are the impact areas with the greatest potential for reducing the overall environmental impact. However, it should be noted that all forms of toxicity (human, terrestrial, and aquatic) combined have a normalized, weighted, factored score of 0.316, which would make these combined impact subcategories second in overall potential for impact reduction.



Abbreviation	Definition
ACIDDEP	Acidic Materials Deposition
CARCOPT	Choose best CARC option
ENVAQ	Aquatic toxicity metrics
ENVTERR	Terrestrial toxicity metrics
FSLFUELS	Depletion of fossil fuels
GLBLWRM	Global warming potential
GLOBAL	Global level impacts
HUMAN	Various measures of human health toxicity
LANDUSE	Area of land "consumed"
LOCAL	Local scale impacts
ODP	Ozone depletion potential
REGIONAL	Regional to national scale impacts
SMOG	Photochemical smog formation potential
TOXICITY	Lethal or chronic toxicity effects
WTRUSE	Water consumption

Figure 5-1. Results of impact category valuation by the AHP (distributive mode).



Abbreviation	Definition
ODP	Ozone Depletion Potential
ACIDDEP	Acidic Materials Deposition
GLBLWRM	Global Warming Potential
HUMAN	Various measures of human health toxicity
SMOG	Photochemical Smog Formation Potential
LANDUSE	Area of land "consumed"
FSLFUELS	Depletion of Fossil Fuels
WTRUSE	Water Consumption
ENVTERR	Terrestrial toxicity metrics
ENVAQ	Aquatic toxicity metrics

Figure 5-2. Relative importance of nine primary impact categories based on AHP.

Table 5-1. Life Cycle Impact Valuation Calculations

	Spatial Scale	Impact Categories		AHP Weighting Factor	Normalized Factored Score	Weighted, Normalized, Factored Score			Baseline Score
CARCOPT									1.275
	GLOBAL							0.534	
		ODP		0.332	1.090		0.362		
		GLBLWRM		0.124	1.013		0.126		
		FSLFUELS		0.037	1.263		0.047		
	REGIONAL							0.334	
		ACIDDEP		0.189	1.198		0.226		
		SMOG		0.097	1.114		0.108		
		WTRUSE		0.025			0.000		
	LOCAL							0.406	
		TOXICITY					0.314		
			HUMAN	0.099	2.150	0.213			
			ENVTERR	0.020	3.799	0.076			
			ENVAQ	0.020	1.280	0.026			
		LANDUSE		0.058	1.577		0.091		

5.2 Economic Assessment

The estimated costs for CARC depainting and painting at Fort Eustis are shown in Table 5-2.

Table 5-2. Estimated Baseline FCI, Annual Operating Cost, and Annualized Costs

Fixed Capital Investment (FCI), $1,000	$516
Annual operating cost, $1,000	$1,797/yr (or $2,903/1,000 ft^2)
Annualized cost, $1,000	$1,845/yr (or $2,981/1,000 ft^2)

5.2.1 Fixed Capital Investment

The estimated baseline FCI, $516,000, was based on operations at Fort Eustis (Table 5-3).

Table 5-3. Estimated Baseline Fixed Capital Investment

Cost Item	Base Case	Basis
Purchased equipment (PE)	$120,500	100% of purchased equipment (PE) cost
PE installation	54,225	45% of PE cost
Instrument and control	10,845	9% of PE cost
Piping	19,280	15% of PE cost
Electrical	12,050	10% of PE cost
Building	102,000	$43 per ft^2, 24 ft x 36 ft adjusted
Yard improvement	15,665	13% of PE cost
Service facilities	48,200	40% of PE cost
Land	0	Provided by base
Total Direct Plant Cost	$382,765	
Engineering and supervision	39,765	33% of PE cost
Construction expense	46,995	39% of PE cost
Total Direct and Indirect Costs	$469,525	
Contractors fees	23,476	5% of direct and indirect costs
Contingency	23,476	5% of direct and indirect costs
Fixed Capital Investment	$516,478	

5.2.2 Annual Operating Cost

The estimated annual operating cost, $1,797,000/yr as shown in Table 5-4, was based on operations typical of Fort Eustis.

Table 5-4. Estimated Baseline Annual Operating Cost

Cost Item	Base Case	Basis
Raw Materials		
Basecase topcoat	$111,431	$36/gal
Basecase primer	31,096	$17/gal
Basecase thinner	24,437	$15/gal
Depainting grit	7,993	$0.25/lb
Utility		
Electricity	89,954	$0.06/kWhr
Labor		
Operating	520,296	$25/hr
Maintenance	13,524	3% of FCI
Supervision	78,044	15% of operating labor
Operating Supplies	78,044	15% of operating labor
Maintenance Supplies	18,031	4% of FCI
Laboratory Charges	78,044	15% of operating labor
Plant Overhead	367,118	60% of operating/maintenance labor
Waste Disposal		
Topcoat applied with HVLP gun	3,095	$10/gal
BP primer	1,829	$10/gal
Painting materials	4,924	100% of paint/primer disposal costs
Abrasive	42,904	$0.58/lb
Insurance	4,508	1% of FCI
Regulatory Compliance	52,030	10% of operating labor
Total Annual Operating Costs	$1,527,302	
per painted area	$3,240	per 1,000 ft^2
Capital amortization	42,220	9.37% FCI (11 yrs service @ 6%)
per painted area	$90	per 1,000 ft^2
Total cost	1,569,522	
per painted area	$3,330	per 1,000 ft^2

5.2.3 Annualized Cost

The estimated annualized cost, $1,845,000/yr, is the sum of the annual operating cost and amortization. Details are provided in Table 5-5.

Table 5-5. Annualized Baseline Cost

Cost Element	Value	
	$1,000/yr	$1,000/ft^2
Annual operating cost	1,797	2,903
Amortization	48	103
Annualized cost	1,845	2,981

5.3 Performance Assessment

5.3.1 Application Equipment

The evaluation parameter results for the baseline application equipment used at Fort Eustis, which is the MACH 1 HVLP spray gun with a 97-95 nozzle made by Binks, are as follows:

- Transfer Efficiency (TE): Rating 65% (Martin, personal communication, 1995; Miller, personal communication, 1995; Hughes Aircraft Company, 1991 as reported in Cavendar et al., 1994)

- Surface Quality: Rating Acceptable (Martin, personal communication, 1995; Miller, personal communication, 1995; Hughes Aircraft Company, 1991 as reported in Cavendar et al., 1994)

Transfer efficiency shows the most potential for significant improvement. Significant improvement in surface quality is not considered to be needed.

5.3.2 Primer

The baseline primer used at Fort Eustis is Mil-P-53022, which is a corrosion inhibiting, lead (Pb) and chromate free, epoxy coating, made by Niles. The evaluation parameter results for the baseline primer are as follows:

- Effect of Temperature and Humidity: Rating 3, minimal impact not seen as having practical significance (Hale, personal communication, 1995; Miller, personal communication, 1995)

- Cure Rate: Rating 3, cure rate had minimal affect on painting schedule (Hale, personal communication, 1995; Miller, personal communication, 1995)

- Surface Pretreatment Requirements: Rating 2, minimal cleaning with solvent rag required (Hale, personal communication, 1995; Miller, personal communication, 1995)

- Ease of Cleanup of the Primer: Rating 2, moderate effort required for cleanup (Hale, personal communication, 1995; Miller, personal communication, 1995)

Improvement in any of the three areas is possible. However, decreases in the primer's ranking in terms of effect of temperature and humidity would be viewed as most significant as is indicated by the weighting factor.

5.3.3 Thinners

The baseline thinner is Mil-T-81772B and is an aircraft coating made by CSD. The evaluation parameter results for the baseline thinner are as follows:

- Thinning Ratio or Thinner Effectiveness: 4:1 ratio for CARC:Thinner (Woody, personal communication, 1995; Miller, personal communication, 1995)

- Film Characteristics: Rating 3, minimal blemishes not believed significant (Woody, personal communication, 1995; Miller, personal communication, 1995)

The thinning ratio is seen as the most likely area for improvement.

6.0 Technical and Economic Evaluation of Improvements

This section provides the reader with the basis for analyzing each of the alternatives according to each of the three evaluation dimensions individually and then through the use of the valuation results, collectively. The LCA inventory results are presented first because in some cases an alternative may be possible to analyze on the basis of a "less is better" strategy, in cases where all or most of the inventory categories are lower than those of the baseline or current system. When this occurs, interpretation using the impact results becomes unnecessary. However, this is rarely the situation so the impact-based results are presented next. Finally, the results for the cost and performance elements are provided.

6.1 Inventory Analysis

Five alternatives were each evaluated against the baseline CARC system. Summary tables and graphs for the inventory results are provided below; additional details may be found in Appendix C. The baseline inventory results are summarized in Table 6-1. The first column in the table shows the total life-cycle aggregated information, the second column values are associated with the raw materials and manufacturing life-cycle stages, and the third column values are associated with depainting operations, application of the CARC at a base together with any disposal or recycling activities.

The first alternative utilized an alternative primer coupled with the baseline CARC topcoat and thinner. The baseline HVLP gun was used with both the primer and topcoat materials. The primary difference in the two primer formulations is the substitution of various solvents and the addition of more TiO_2 pigment to produce an alternative product capable of being water-thinned. The summary level inventory results shown in Table 6-2 indicate a combination of both increases and decreases in resource and energy consumption data relative to the baseline. A small decrease in resource consumption is noted for electricity, natural gas, steam, water, crude oil, refinery gases, oxygen and other minor components. Small increases were noted for fuel, sodium chloride, chlorine and the ilmenite and rumenite involved in the production of TiO_2. Use of phosphate and zinc ores was eliminated. Major categories of air emissions showed decreases in CO_2, VOC, PM, NO_x, hydrocarbons, and CO. There were slight increases in chlorine and methane. Water usage and discharges were also generally reduced including mobile ions, sodium, chloride, oil and grease, and boron. Increased water discharges were noted for titanium dioxide, chlorine and heavy metals including cadmium, lead, and chromium. Hazardous solid wastes were reduced slightly while several chemicals were added to the list from the production of nitroethane including acetaldehyde, methanol, 2-nitropropane, acetone, acetonitrile, nitric acid, and ammonia. Because these chemical emissions are different than those for the baseline, it is difficult to unequivocally interpret the inventory results alone with respect to trace emissions to air and water.

Table 6-1. Baseline CARC System Life Cycle Inventory Summary Results

LCI Components	Units	Baseline CARC System Quantity	CARC System Materials Manufacture Quantity	CARC System Use/Reuse Maintenance Quantity
Functional Unit (FU)	ft^2	1,000		
Resource and Energy Consumption				
Electricity	BTU/FU	8.3E+05	8.3E+05	0.0E+00
Natural gas	BTU/FU	1.4E+07	1.4E+07	0.0E+00
Steam	BTU/FU	5.9E+05	5.9E+05	0.0E+00
Water	lb/FU	4.4E+04	4.4E+04	0.0E+00
Fuel	lb/FU	3.9E+04	3.9E+04	0.0E+00
Crude oil	lb/FU	2.8E+03	2.8E+03	0.0E+00
Bauxite	lb/FU	8.4E+01	8.4E+01	0.0E+00
Air	lb/FU	7.6E+01	7.6E+01	0.0E+00
Refinery gases	lb/FU	7.2E+01	7.2E+01	0.0E+00
Sodium Chloride	lb/FU	4.3E+01	4.3E+01	0.0E+00
Oxygen	lb/FU	1.5E+01	1.5E+01	0.0E+00
Silica	lb/FU	1.4E+01	1.4E+01	0.0E+00
Chlorine	lb/FU	1.3E+01	1.3E+01	0.0E+00
Zinc ore	lb/FU	8.3E+00	8.3E+00	0.0E+00
Rumenite	lb/FU	6.1E+00	6.1E+00	0.0E+00
Sulfuric acid	lb/FU	6.0E+00	6.1E+00	0.0E+00
Limestone	lb/FU	4.7E+00	4.7E+00	0.0E+00
Chrome oxide	lb/FU	4.6E+00	4.6E+00	0.0E+00
Soda ash	lb/FU	2.6E+00	2.6E+00	0.0E+00
Ilmenite	lb/FU	2.4E+00	2.4E+00	0.0E+00
Magnesium ore	lb/FU	2.2E+00	2.2E+00	0.0E+00
Phosphate ore	lb/FU	2.1E+00	2.1E+00	0.0E+00
Iron ore	lb/FU	1.3E+00	1.3E+00	0.0E+00
Coke	lb/FU	1.1E+00	1.1E+00	0.0E+00
Colbalt oxide	lb/FU	1.0E+00	1.0E+00	0.0E+00
Magnetite	lb/FU	4.0E-01	4.0E-01	0.0E+00
Sodium hydroxide	lb/FU	3.2E-01	3.2E-01	0.0E+00
Coal	lb/FU	2.9E-01	2.9E-01	0.0E+00
Starch	lb/FU	2.1E-01	2.1E-01	0.0E+00
SiAl	lb/FU	5.4E-02	5.4E-02	0.0E+00
Phosphoric acid	lb/FU	4.8E-02	4.8E-02	0.0E+00
Hydrocarbons C8 to C10	lb/FU	1.7E-02	1.7E-02	0.0E+00
Hydropotential	m^3-m/FU	6.9E-03	6.9E-03	0.0E+00
Sulfur dioxide	lb/FU	2.2E-03	2.2E-03	0.0E+00
Residual Fuel Oil	lb/FU	4.9E-06	4.9E-06	0.0E+00
Distillate Fuel Oil	lb/FU	4.2E-07	4.2E-07	0.0E+00
Uranium	lb/FU	4.2E-09	4.1E-09	0.0E+00
Proprietary Primer Ingredients	lb/FU	0.0E+00	0.0E+00	0.0E+00
Air Emissions				
CO2	lb/FU	3.0E+02	3.0E+02	0.0E+00
Sox	lb/FU	2.2E+01	2.2E+01	0.0E+00
VOC	lb/FU	1.5E+01	1.5E+01	0.0E+00
NOx	lb/FU	6.1E+00	6.1E+00	0.0E+00
PM	lb/FU	6.0E+00	6.0E+00	0.0E+00
Hydrocarbons	lb/FU	3.3E+00	3.3E+00	0.0E+00
CO	lb/FU	1.4E+00	1.4E+00	0.0E+00
Chlorine	lb/FU	5.8E-01	5.8E-01	0.0E+00
MIAK	lb/FU	5.2E-01	7.1E-02	4.5E-01
Isobutyraldehyde	lb/FU	3.3E-01	3.3E-01	0.0E+00
PM10	lb/FU	3.1E-01	3.1E-01	0.0E+00
Methane	lb/FU	2.8E-01	2.8E-01	0.0E+00
Benzene	lb/FU	2.0E-01	2.0E-01	0.0E+00
Heavy Aromatics	lb/FU	2.0E-01	2.0E-01	0.0E+00
Butyl acetate	lb/FU	1.5E-01	0.0+00	1.5E-01
Toulene	lb/FU	1.3E-01	1.2E-01	1.4E-02
Acetaldehyde	lb/FU	8.9E-02	8.9E-02	0.0E+00
Heptane	lb/FU	8.6E-02	8.6E-02	0.0E+00

Table 6-1. Baseline CARC System Life Cycle Inventory Summary Results (continued)

LCI Components	Units	Baseline CARC System Quantity	CARC System Materials Manufacture Quantity	CARC System Use/Reuse Maintenance Quantity
Functional Unit (FU)	ft^2	1,000		
Propane	lb/FU	7.4E-02	7.4E-02	0.0E+00
Hexane	lb/FU	6.7E-02	6.7E-02	0.0E+00
Naptha	lb/FU	6.6E-02	0.0E+00	6.6E-02
n-Butane	lb/FU	5.9E-02	5.9E-02	0.0E+00
MEK	lb/FU	5.9E-02	2.0E-02	3.8E-02
Octane	lb/FU	5.7E-02	5.7E-02	0.0E+00
Hexyl acetate	lb/FU	5.6E-02	0.0E+00	5.6E-02
Xylene	lb/FU	5.6E-02	9.4E-03	4.7E-02
Ethane	lb/FU	4.7E-02	4.7E-02	0.0E+00
Pentane	lb/FU	4.3E-02	4.2E-02	0.0E+00
Butyl alcohol	lb/FU	3.4E-02	0.0E+00	3.4E-02
Fluorine	lb/FU	2.8E-02	2.8E-02	0.0E+00
Cumene	lb/FU	2.7E-02	2.7E-02	0.0E+00
Organic Acids	lb/FU	2.5E-02	2.5E-02	0.0E+00
MIBK	lb/FU	2.3E-02	1.1E-02	1.2E-02
Aromatic hydrocarbons	lb/FU	2.3E-02	4.0E-04	2.3E-02
Phenol	lb/FU	2.2E-02	2.2E-02	0.0E+00
Formaldehyde	lb/FU	2.1E-02	2.1E-02	0.0E+00
Aldehydes	lb/FU	1.9E-02	1.9E-02	0.0E+00
C-7 cycloparaffins	lb/FU	1.2E-02	1.2E-02	0.0E+00
Acetone	lb/FU	8.3E-03	8.3E-03	0.0E+00
Ethylene dichloride	lb/FU	7.7E-03	7.7E-03	0.0E+00
HCN	lb/FU	6.7E-03	6.7E-03	0.0E+00
C-8 cycloparafins	lb/FU	4.4E-03	4.4E-03	0.0E+00
Ethyl chloride	lb/FU	3.0E-03	3.0E-03	0.0E+00
Iso-Butane	lb/FU	2.9E-03	2.9E-03	0.0E+00
Carbon tetrachloride	lb/FU	2.8E-03	2.8E-03	0.0E+00
Ethylene	lb/FU	2.8E-03	2.8E-03	0.0E+00
Trichloroethane	lb/FU	2.3E-03	2.3E-03	0.0E+00
Ethylbenzene	lb/FU	2.2E-03	2.2E-03	0.0E+00
Vinyl chloride	lb/FU	1.4E-03	1.4E-03	0.0E+00
Chloroform	lb/FU	1.3E-03	1.3E-03	0.0E+00
Hydrochloric acid	lb/FU	1.3E-03	1.3E-03	0.0E+00
Lead	lb/FU	8.8E-04	8.8E-04	0.0E+00
Ammonia	lb/FU	6.2E-06	6.2E-06	0.0E+00
Kerosene	lb/FU	4.4E-09	4.4E-09	0.0E+00
Naththalene	lb/FU	0.0E+00	0.0E+00	0.0E+00
Methanol	lb/FU	0.0E+00	0.0E+00	0.0E+00
Butyl cellosolve	lb/FU	0.0E+00	0.0E+00	0.0E+00
Nitric acid	lb/FU	0.0E+00	0.0E+00	0.0E+00
Bromotrifluoromethane	lb/FU	0.0E+00	0.0E+00	0.0E+00
Nitroethane	lb/FU	0.0E+00	0.0E+00	0.0E+00
Dichlorodifluoromethane	lb/FU	0.0E+00	0.0E+00	0.0E+00
Sulfuric acid	lb/FU	0.0E+00	0.0E+00	0.0E+00
Bromochlorodifluoromethane	lb/FU	0.0E+00	0.0E+00	0.0E+00
Acetonitrile	lb/FU	0.0E+00	0.0E+00	0.0E+00
2-nitropropane	lb/FU	0.0E+00	0.0E+00	0.0E+00
1,2-butylene	lb/FU	0.0E+00	0.0E+00	0.0E+00
Propylene	lb/FU	0.0E+00	0.0E+00	0.0E+00
MPK	lb/FU	0.0E+00	0.0E+00	0.0E+00
Isopropyl alcohol	lb/FU	0.0E+00	0.0E+00	0.0E+00
Propyl acetate	lb/FU	0.0E+00	0.0E+00	0.0E+00
Aliphatic hydrocarbons	lb/FU	0.0E+00	0.0E+00	0.0E+00
Wastewater Emissions				
Wastewater	lb/FU	3.3E+03	3.3E+03	0.0E+00
WW reinj'd	lb/FU	1.6E+02	1.6E+02	0.0E+00
WW discharg.	lb/FU	7.1E+01	7.1E+01	0.0E+00
Mobile ions	lb/FU	3.5E+01	3.5E+01	0.0E+00

Table 6-1. Baseline CARC System Life Cycle Inventory Summary Results (continued)

LCI Components	Units	Baseline CARC System Quantity	CARC System Materials Manufacture Quantity	CARC System Use/Reuse Maintenance Quantity
Functional Unit (FU)	ft^2	1,000		
WW Injected	lb/FU	2.3E+01	2.3E+01	0.0E+00
Sodium	lb/FU	1.4E+01	1.4E+01	0.0E+00
Chloride	lb/FU	1.1E+01	1.1E+01	0.0E+00
Oil and Grease	lb/FU	3.6E-01	3.6E-01	0.0E+00
titanium dioxide	lb/FU	1.3E-01	1.3E-01	0.0E+00
Chlorine	lb/FU	3.9E-02	3.9E-02	0.0E+00
Boron	lb/FU	1.5E-02	1.5E-02	0.0E+00
Cadmium	lb/FU	5.0E-03	5.0E-03	0.0E+00
Lead	lb/FU	1.8E-03	1.8E-03	0.0E+00
Benzene	lb/FU	7.1E-04	7.1E-04	0.0E+00
Aluminum	lb/FU	5.9E-04	5.9E-04	0.0E+00
Chromium	lb/FU	5.5E-04	5.5E-04	0.0E+00
Vanadium	lb/FU	1.3E-04	1.3E-04	0.0E+00
Copper	lb/FU	4.1E-05	4.1E-05	0.0E+00
Zinc	lb/FU	4.1E-05	4.1E-05	0.0E+00
Arsenic	lb/FU	3.0E-05	3.0E-05	0.0E+00
Iron	lb/FU	8.1E-06	8.1E-06	0.0E+00
Mercury	lb/FU	6.1E-06	6.1E-06	0.0E+00
Thallium	lb/FU	5.2E-06	5.2E-06	0.0E+00
Dissolved Solids	lb/FU	6.8E-07	6.8E-07	0.0E+00
Magnesium	lb/FU	1.2E-07	1.2E-07	0.0E+00
Sulfuric Acid	lb/FU	9.4E-08	9.4E-08	0.0E+00
COD	lb/FU	4.5E-09	4.5E-09	0.0E+00
Suspended Solids	lb/FU	2.3E-09	2.3E-09	0.0E+00
BOD	lb/FU	1.4E-09	1.4E-09	0.0E+00
Acid	lb/FU	7.6E-10	7.6E-10	0.0E+00
Oil	lb/FU	7.6E-10	7.6E-10	0.0E+00
Metals	lb/FU	3.8E-10	3.8E-10	0.0E+00
Phenol	lb/FU	3.8E-10	3.8E-10	0.0E+00
Sulfide	lb/FU	3.8E-10	3.8E-10	0.0E+00
Ammonia	lb/FU	0.0E+00	0.0E+00	0.0E+00
Hydrogen cyanide	lb/FU	0.0E+00	0.0E+00	0.0E+00
Solid Wastes				
Hazardous Wastes	lb/FU	8.1E+01	2.3E+00	7.8E+01
Solid Wastes	lb/FU	6.2E+01	6.2E+01	0.0E+00
U238	lb/FU	5.4E-09	5.4E-09	0.0E+00
Fly Ash	lb/FU	2.0E-09	2.0E-09	0.0E+00
FGD Solids	lb/FU	7.9E-10	7.9E-10	0.0E+00
Bottom Ash	lb/FU	5.7E-10	5.7E-10	0.0E+00
Slag	lb/FU	2.2E-10	2.2E-10	0.0E+00
U235	lb/FU	4.5E-11	4.5E-11	0.0E+00
Pu (fissile)	lb/FU	3.7E-11	3.7E-11	0.0E+00
Fission Products	lb/FU	2.6E-11	2.6E-11	0.0E+00
Pu (nonfissile)	lb/FU	1.4E-11	1.4E-11	0.0E+00
U236	lb/FU	3.6E-12	3.6E-12	0.0E+00
Methanol	lb/FU	0.0E+00	0.0E+00	0.0E+00
Ammonia	lb/FU	0.0E+00	0.0E+00	0.0E+00
Nitric acid	lb/FU	0.0E+00	0.0E+00	0.0E+00
Naphathalene	lb/FU	0.0E+00	0.0E+00	0.0E+00
Formaldehyde	lb/FU	0.0E+00	0.0E+00	0.0E+00
2-nitropropane	lb/FU	0.0E+00	0.0E+00	0.0E+00
Acetonitrile	lb/FU	0.0E+00	0.0E+00	0.0E+00
Acetone	lb/FU	0.0E+00	0.0E+00	0.0E+00
Acetaldehyde	lb/FU	0.0E+00	0.0E+00	0.0E+00
Hydrogen cyanide	lb/FU	0.0E+00	0.0E+00	0.0E+00

Table 6-2. Alternative Primer CARC System Life Cycle Inventory Summary Results

LCI Components	Units	Baseline CARC System Quantity	CARC System Materials Manufacture Quantity	CARC System Use/Reuse Maintenance Quantity
Functional Unit (FU)	ft^2	1,000		
Resource and Energy Consumption				
Electricity	BTU/FU	7.6E+05	7.6E+05	0.0E+00
Natural gas	BTU/FU	1.3E+07	1.3E+07	0.0E+00
Steam	BTU/FU	5.4E+05	5.4E+05	0.0E+00
Fuel	lb/FU	6.4E+04	6.4E+04	0.0E+00
Water	lb/FU	4.0E+04	4.0E+04	0.0E+00
Crude oil	lb/FU	2.4E+03	2.4E+03	0.0E+00
Air	lb/FU	1.2E+02	1.2E+02	0.0E+00
Bauxite	lb/FU	8.4e+01	8.4e+01	0.0E+00
Refinery gases	lb/FU	6.7E+01	6.7E+01	0.0E+00
Sodium Chloride	lb/FU	4.3E+01	4.3E+01	0.0E+00
Chlorine	lb/FU	1.5E+01	1.5E+01	0.0E+00
Silica	lb/FU	1.3E+01	1.3E+01	0.0E+00
Oxygen	lb/FU	1.3E+01	1.3E+01	0.0E+00
Rumenite	lb/FU	9.9E+00	9.9E+00	0.0E+00
Sulfuric acid	lb/FU	8.2E+00	8.2E+00	0.0E+00
Limestone	lb/FU	4.7E+00	4.7E+00	0.0E+00
Chrome oxide	lb/FU	4.6E+00	4.6E+00	0.0E+00
Ilmenite	lb/FU	3.9E+00	3.9E+00	0.0E+00
Soda ash	lb/FU	2.6E+00	2.6E+00	0.0E+00
Magnesium ore	lb/FU	2.2E+00	2.2E+00	0.0E+00
Coke	lb/FU	1.8E+00	1.8E+00	0.0E+00
Iron ore	lb/FU	1.3E+00	1.3E+00	0.0E+00
Cobalt oxide	lb/FU	1.0E+00	1.0E+00	0.0E+00
Sodium hydroxide	lb/FU	5.3E-01	5.3E-01	0.0E+00
Magnetite	lb/FU	4.0E-01	4.0E-01	0.0E+00
Starch	lb/FU	2.1E-01	2.1E-01	0.0E+00
Hydrocarbons C8 to C10	lb/FU	9.2E-02	9.2E-02	0.0E+00
SiAl	lb/FU	8.8E-02	8.8E-02	0.0E+00
Phosphoric acid	m^3-m/FU	4.8E-02	4.8E-02	0.0E+00
Hydropotential	lb/FU	6.3E-03	6.3E-03	0.0E+00
Sulfur dioxide	lb/FU	2.2E-03	2.2E-03	0.0E+00
Coal	lb/FU	1.6E-05	1.6E-05	0.0E+00
Residual Fuel Oil	lb/FU	4.4E-06	4.4E-06	0.0E+00
Distillate Fuel Oil	lb/FU	3.9E-07	3.9E-07	0.0E+00
Uranium	lb/FU	3.8E-09	3.8E-09	0.0E+00
Phosphate ore	lb/FU	0.0E+00	0.0E+00	0.0E+00
Propritary Primer Ingredients	lb/FU	0.0E+00	0.0E+00	0.0E+00
Zinc ore	lb/FU	0.0E+00	0.0E+00	0.0E+00
Air Emissions				
CO2	lb/FU	2.7E+02	2.7E+02	0.0E+00
Sox	lb/FU	2.1E+01	2.1E+01	0.0E+00
VOC	lb/FU	1.4E+01	1.4E+01	0.0E+00
PM	lb/FU	6.0E+00	6.0E+00	0.0E+00
Nox	lb/FU	5.9E+00	5.9E+00	0.0E+00
Hydrocarbons	lb/FU	2.9E+00	2.9E+00	0.0E+00
CO	lb/FU	7.9E-01	7.9E-01	0.0E+00
Chlorine	lb/FU	5.9E-01	5.9E-01	0.0E+00
Isobutyraldehyde	lb/FU	3.3E-01	3.3E-01	0.0E+00
PM10	lb/FU	3.1E-01	3.1E-01	0.0E+00
Methane	lb/FU	2.4E-01	2.4E-01	0.0E+00
Benzene	lb/FU	2.0E-01	2.0E-01	0.0E+00
Heavy Aromatics	lb/FU	2.0E-01	2.0E-01	0.0E+00
Toulene	lb/FU	1.1E-01	1.1E-01	0.0E+00
Heptane	lb/FU	7.6E-02	7.6E-02	0.0E+00
MIAK	lb/FU	7.1E-02	7.1E-02	0.0E+00
Propane	lb/FU	6.6E-02	6.6E-02	0.0E+00
Hexane	lb/FU	5.9E-02	5.9E-02	0.0E+00

Table 6-2. Baseline CARC System Life Cycle Inventory Summary Results (continued)

LCI Components	Units	Baseline CARC System Quantity	CARC System Materials Manufacture Quantity	CARC System Use/Reuse Maintenance Quantity
Functional Unit (FU)	ft^2	1,000		
n-Butane	lb/FU	5.2E-02	5.2E-02	0.0E+00
Octane	lb/FU	5.1E-02	5.1E-02	0.0E+00
Xylene	lb/FU	4.3E-02	4.3E-02	0.0E+00
Ethane	lb/FU	4.2E-02	4.2E-02	0.0E+00
Butyl alcohol	lb/FU	4.2E-02	0.0E+00	4.2E-02
Acetaldehyde	lb/FU	4.0E-02	4.0E-02	0.0E+00
Aromatic hydrocarbons	lb/FU	3.8E-02	0.0E+00	3.8E-02
Pentane	lb/FU	3.7E-02	3.7E-02	0.0E+00
Cumene	lb/FU	2.3E-02	2.3E-02	0.0E+00
Organic Acids	lb/FU	2.2E-02	2.2E-02	0.0E+00
Phenol	lb/FU	2.1E-02	2.1E-02	0.0E+00
MEK	lb/FU	2.0E-02	2.0E-02	0.0E+00
Formaldehyde	lb/FU	1.9E-02	1.9E-02	0.0E+00
Aldehydes	lb/FU	1.7E-02	1.7E-02	0.0E+00
C-7 cycloparaffins	lb/FU	1.1E-02	1.1E-02	0.0E+00
Acetone	lb/FU	1.4E-03	1.4E-03	0.0E+00
HCN	lb/FU	6.8E-03	6.8E-03	0.0E+00
Ethylbenzene	lb/FU	4.5E-03	4.5E-03	0.0E+00
C-8 cycloparaffins	lb/FU	3.9E-03	3.9E-03	0.0E+00
Nitroethane	lb/FU	3.9E-03	0.0E+00	3.9E-03
Iso-Butane	lb/FU	2.6E-03	2.6E-03	0.0E+00
Hydrochloric acid	lb/FU	1.9E-03	1.9E-03	0.0E+00
Dichlorodifluoromethane	lb/FU	1.1E-03	1.1E-03	0.0E+00
Ammonia	lb/FU	8.9E-04	8.9E-04	0.0E+00
Naphthalene	lb/FU	6.43-04	6.43-04	0.0E+00
2-nitropropane	lb/FU	6.1E-04	6.1E-04	0.0E+00
Ethylene	lb/FU	5.6E-04	5.6E-04	0.0E+00
Acetonitrile	lb/FU	2.4E-05	2.4E-05	0.0E+00
Methanol	lb/FU	1.9E-05	1.9E-05	0.0E+00
Bromotrifluoromethane	lb/FU	8.3E-06	8.3E-06	0.0E+00
Nitric acid	lb/FU	5.5E-06	5.5E-06	0.0E+00
Bromochlorodifluoromethane	lb/FU	2.2E-06	2.2E-06	0.0E+00
1,2-butylene	lb/FU	7.0E-07	7.0E-07	0.0E+00
Kerosene	lb/FU	4.1E-09	4.1E-09	0.0E+00
Lead	lb/FU	9.1E-11	9.1E-11	0.0E+00
Hexyl acetate	lb/FU	0.0E+00	0.0E+00	0.0E+00
Propylene	lb/FU	0.0E+00	0.0E+00	0.0E+00
Sulfuric acid	lb/FU	0.0E+00	0.0E+00	0.0E+00
Ethyl chloride	lb/FU	0.0E+00	0.0E+00	0.0E+00
Vinyl chloride	lb/FU	0.0E+00	0.0E+00	0.0E+00
Isopropyl alcohol	lb/FU	0.0E+00	0.0E+00	0.0E+00
MPK	lb/FU	0.0E+00	0.0E+00	0.0E+00
Propyl acetate	lb/FU	0.0E+00	0.0E+00	0.0E+00
Naptha	lb/FU	0.0E+00	0.0E+00	0.0E+00
Butyl acetate	lb/FU	0.0E+00	0.0E+00	0.0E+00
Fluorine	lb/FU	0.0E+00	0.0E+00	0.0E+00
MIBK	lb/FU	0.0E+00	0.0E+00	0.0E+00
Trichloroethane	lb/FU	0.0E+00	0.0E+00	0.0E+00
Carbon tetrachloride	lb/FU	0.0E+00	0.0E+00	0.0E+00
Chloroform	lb/FU	0.0E+00	0.0E+00	0.0E+00
Butyl cellosolve	lb/FU	0.0E+00	0.0E+00	0.0E+00
Ethylene dichloride	lb/FU	0.0E+00	0.0E+00	0.0E+00
Aliphatic hydrocarbons	lb/FU	0.0E+00	0.0E+00	0.0E+00
Wastewater Emissions				
Wastewater	lb/FU	2.9E+03	2.9E+03	0.0E+00
WW Reinj'd	lb/FU	1.4E+02	1.4E+02	0.0E+00
WW Discharg.	lb/FU	6.3E+01	6.3E+01	0.0E+00
Mobile ions	lb/FU	3.1E+01	3.1E+01	0.0E+00

Table 6-2. Baseline CARC System Life Cycle Inventory Summary Results (continued)

LCI Components	Units	Baseline CARC System Quantity	CARC System Materials Manufacture Quantity	CARC System Use/Reuse Maintenance Quantity
Functional Unit (FU)	ft^2	1,000		
WW Injected	lb/FU	2.1E+01	2.1E+01	0.0E+00
Sodium	lb/FU	1.3E+01	1.3E+01	0.0E+00
Chloride	lb/FU	1.0E+01	1.0E+01	0.0E+00
Oil and Grease	lb/FU	3.1E-01	3.1E-01	0.0E+00
Titanium dioxide	lb/FU	2.1E-01	2.1E-01	0.0E+00
Chlorine	lb/FU	1.2E-01	1.2E-01	0.0E+00
Boron	lb/FU	1.3E-02	1.3E-02	0.0E+00
Cadmium	lb/FU	8.0E-03	8.0E-03	0.0E+00
Lead	lb/FU	2.9E-03	2.9E-03	0.0E+00
Aluminum	lb/FU	9.7E-04	9.7E-04	0.0E+00
Chromium	lb/FU	8.9E-04	8.9E-04	0.0E+00
Benzene	lb/FU	6.3E-04	6.3E-04	0.0E+00
Vanadium	lb/FU	2.1E-04	2.1E-04	0.0E+00
Copper	lb/FU	6.8E-05	6.8E-05	0.0E+00
Zinc	lb/FU	6.8E-05	6.8E-05	0.0E+00
Arsenic	lb/FU	2.6E-05	2.6E-05	0.0E+00
Iron	lb/FU	7.4E-06	7.4E-06	0.0E+00
Mercury	lb/FU	5.8E-06	5.8E-06	0.0E+00
Thallium	lb/FU	4.6E-06	4.6E-06	0.0E+00
Ammonia	lb/FU	1.7E-06	1.7E-06	0.0E+00
Dissolved Solids	lb/FU	6.3E-07	6.3E-07	0.0E+00
Magnesium	lb/FU	1.9E-07	1.9E-07	0.0E+00
Hydrogen cyanide	lb/FU	1.2E-07	1.2E-07	0.0E+00
Sulfuric Acid	lb/FU	8.6E-08	8.6E-08	0.0E+00
COD	lb/FU	4.1E-09	4.1E-09	0.0E+00
Suspended Solids	lb/FU	2.1E-09	2.1E-09	0.0E+00
BOD	lb/FU	1.3E-09	1.3E-09	0.0E+00
Oil	lb/FU	6.9E-10	6.9E-10	0.0E+00
Acid	lb/FU	6.9E-10	6.9E-10	0.0E+00
Metals	lb/FU	3.5E-10	3.5E-10	0.0E+00
Sulfide	lb/FU	3.5E-10	3.5E-10	0.0E+00
Phenol	lb/FU	3.5E-10	3.5E-10	0.0E+00
Solid Wastes	lb/FU	7.9E+01	9.8E-01	7.8E+01
Hazardous Wastes	lb/FU	6.2E+01	6.2E+01	0.0E+00
Solid Wastes	lb/FU	1.0E-02	1.0E-02	0.0E+00
Acetaldehyde	lb/FU	9.2E-03	9.2E-03	0.0E+00
Methanol	lb/FU	8.1E-03	8.1E-03	0.0E+00
2-nitropropane	lb/FU	5.6E-03	5.6E-03	0.0E+00
Acetone	lb/FU	4.6E-03	4.6E-03	0.0E+00
Acetonitrile	lb/FU	6.4E-04	6.4E-04	0.0E+00
Nitric acid	lb/FU	1.4E-04	1.4E-04	0.0E+00
Ammonia	lb/FU	8.0E-05	8.0E-05	0.0E+00
Formaldehyde	lb/FU	6.6E-06	6.6E-06	0.0E+00
Naphathalene	lb/FU	6.6E-06	6.6E-06	0.0E+00
Hydrogen cyanide	lb/FU	4.9E-09	4.9E-09	0.0E+00
U238	lb/FU	1.9E-09	1.9E-09	0.0E+00
Fly Ash	lb/FU	7.2E-10	7.2E-10	0.0E+00
FGD Solids	lb/FU	5.2E-10	5.2E-10	0.0E+00
Bottom Ash	lb/FU	2.0E-10	2.0E-10	0.0E+00
Slag	lb/FU	4.2E-11	4.2E-11	0.0E+00
U235	lb/FU	3.4E-11	3.4E-11	0.0E+00
Pu (fissile)	lb/FU	2.4E-11	2.4E-11	0.0E+00
Fission Products	lb/FU	1.3E-11	1.3E-11	0.0E+00
Pu (nonfissile)	lb/FU	3.3E-12	3.3E-12	0.0E+00
U236	lb/FU			
	lb/FU			

The second alternative involved the substitution of the turbine HVLP gun for the standard HVLP gun. All of the materials used were those included in the baseline scenario. This alternative resulted in significantly lower levels of resource consumption, energy usage, and emissions than the baseline (Table 6-3). This is a direct result of the more efficient use of materials and energy. Because a much higher percentage of the CARC sprayed actually ends up on the vehicle surface, not only are the emissions during the application reduced but also the upstream consequences of manufacturing materials that never get applied are eliminated.

The third alternative combines the alternative primer with the alternative gun (Table 6-4). As might be expected, this option shows even greater reductions in energy and resources than the previous alternatives where the primer and gun substitutions were considered independently. In the case of emissions, the picture was mixed. The alternative primer emissions comprise both different compounds than are present in the baseline primer and different amounts of those compounds that are ingredients in common. Thus, the inventory data alone cannot be interpreted in an unequivocal fashion. For those emissions that are in common, some decreased and some increased. The overall amounts decreased but by a smaller amount than for the previous alternative.

The fourth alternative utilized an alternative thinner along with the baseline topcoat, primer, and gun (Table 6-5). The primary difference in the thinners is a reduction and substitution of the acetate-based solvents and the addition of more alcohol-based solvents. The results for this scenario indicate reduced resource and energy demands for electricity, steam, water, crude oil, bauxite, air, residual and distillate fuel oils compared to the data shown for the baseline. Major categories of air emissions showed reduced CO_2 and hydrocarbons with slightly increased SO_x. The data also showed lower water usage and discharge rates in addition to reduced mobile ions, chloride, oil and grease and other minor constituents. Solid wastes showed reductions in the minor categories, but little change was indicated in the amounts of general hazardous and solid wastes.

Table 6-3. Alternative Gun CARC System Life Cycle Inventory Summary Results

LCI Components	Units	Baseline CARC System Quantity	CARC System Materials Manufacture Quantity	CARC System Use/Reuse Maintenance Quantity
Functional Unit (FU)	ft^2	1,000		
Resource and Energy Consumption				
Electricity	BTU/FU	6.1E+05	6.1E+05	0.0E+00
Natural gas	BTU/FU	1.0E+07	1.0E+07	0.0E+00
Steam	BTU/FU	4.6E+05	4.6E+05	0.0E+00
Water	lb/FU	3.2E+04	3.2E+04	0.0E+00
Fuel	lb/FU	2.8E+04	2.8E+04	0.0E+00
Crude oil	lb/FU	2.0E+03	2.0E+03	0.0E+00
Bauxite	lb/FU	8.4E+01	8.4E+01	0.0E+00
Air	lb/FU	5.5E+01	5.5E+01	0.0E+00
Refinery gases	lb/FU	5.2E+01	5.2E+01	0.0E+00
Sodium Chloride	lb/FU	3.1E+01	3.1E+01	0.0E+00
Oxygen	lb/FU	1.1E+01	1.1E+01	0.0E+00
Silica	lb/FU	9.9E+00	9.9E+00	0.0E+00
Chlorine	lb/FU	9.5E+00	9.5E+00	0.0E+00
Zinc ore	lb/FU	6.0E+00	6.0E+00	0.0E+00
Limestone	lb/FU	4.7E+00	4.7E+00	0.0E+00
Rumenite	lb/FU	4.4E+00	4.4E+00	0.0E+00
Sulfuric acid	lb/FU	4.4E+00	4.4E+00	0.0E+00
Chrome oxide	lb/FU	3.3E+00	3.3E+00	0.0E+00
Soda ash	lb/FU	2.6E+00	2.6E+00	0.0E+00
Ilmenite	lb/FU	1.7E+00	1.7E+00	0.0E+00
Magnesium ore	lb/FU	1.6E+00	1.6E+00	0.0E+00
Phosphate ore	lb/FU	1.5E+00	1.5E+00	0.0E+00
Iron ore	lb/FU	9.3E-01	9.3E-01	0.0E+00
Coke	lb/FU	7.7E-01	7.7E-01	0.0E+00
Cobalt oxide	lb/FU	7.2E-01	7.2E-01	0.0E+00
Magnetite	lb/FU	2.9E-01	2.9E-01	0.0E+00
Sodium hydroxide	lb/FU	2.3E-01	2.3E-01	0.0E+00
Coal	lb/FU	2.1E-01	2.1E-01	0.0E+00
Starch	lb/FU	2.1E-01	2.1E-01	0.0E+00
SiAl	lb/FU	3.9E-02	3.9E-02	0.0E+00
Phosphoric acid	lb/FU	3.4E-02	3.4E-02	0.0E+00
Hydrocarbons C8 to C10	lb/FU	1.2E-02	1.2E-02	0.0E+00
Hydropotential	m^3-m/FU	5.0E-03	5.0E-03	0.0E+00
Sulfur dioxide	lb/FU	1.6E-03	1.6E-03	0.0E+00
Residual Fuel Oil	lb/FU	3.5E-06	3.5E-06	0.0E+00
Distillate Fuel Oil	lb/FU	3.1E-07	3.1E-07	0.0E+00
Uranium	lb/FU	3.0E-09	3.0E-09	0.0E+00
Proprietary Primer Ingredients	lb/FU	0.0E+00	0.0E+00	0.0E+00
Air Emissions				
CO2	lb/FU	2.2E+02	2.2E+02	0.0E+00
SOx	lb/FU	2.1E+01	2.1E+01	0.0E+00
VOC	lb/FU	1.1E+01	1.1E+01	0.0E+00
PM	lb/FU	4.4E+00	4.4E+00	0.0E+00
NOx	lb/FU	4.4E+00	4.4E+00	0.0E+00
Hydrocarbons	lb/FU	2.4E+00	2.4E+00	0.0E+00
CO	lb/FU	1.0E+00	1.0E+00	0.0E+00
Chlorine	lb/FU	4.2E-01	4.2E-01	0.0E+00
PM10	lb/FU	2.9E-01	2.9E-01	0.0E+00
MIAK	lb/FU	2.9E-01	5.1E-02	2.4E-01
Isobutyraldehyde	lb/FU	2.6E-01	2.6E-01	0.0E+00
Methane	lb/FU	2.0E-01	2.0E-01	0.0E+00
Benzene	lb/FU	1.5E-01	1.5E-01	0.0E+00
Heavy Aromatics	lb/FU	1.4E-01	1.4E-01	0.0E+00
Toluene	lb/FU	9.8E-02	9.0E-02	8.7E-03
Butyl acetate	lb/FU	7.9E-02	0.0E+00	7.9E-02
Acetaldehyde	lb/FU	6.6E-02	6.6E-02	0.0E+00
Heptane	lb/FU	6.3E-02	6.3E-02	0.0E+00
Propane	lb/FU	5.4E-02	5.4E-02	0.0E+00
Hexane	lb/FU	4.9E-02	4.9E-02	0.0E+00
n-Butane	lb/FU	4.3E-02	4.3E-02	0.0E+00
Octane	lb/FU	4.2E-02	4.2E-02	0.0E+00

Table 6-3. Alternative Gun CARC System Life Cycle Inventory Summary Results (continued)

LCI Components	Units	Baseline CARC System Quantity	CARC System Materials Manufacture Quantity	CARC System Use/Reuse Maintenance Quantity
Functional Unit (FU)	ft^2	1,000		
MEK	lb/FU	4.0E-02	1.6E-02	2.4E-02
Hexyl acetate	lb/FU	3.5E-02	0.0E+00	3.5E-02
Ethane	lb/FU	3.5E-02	3.5E-02	0.0E+00
Naphtha	lb/FU	3.4E-02	0.0E+00	3.4E-02
Xylene	lb/FU	3.2E-02	6.8E-03	2.5E-02
Pentane	lb/FU	3.0E-02	3.0E-02	0.0E+00
Fluorine	lb/FU	2.0E-02	2.0E-02	0.0E+00
Cumene	lb/FU	1.9E-02	1.9E-02	0.0E+00
Organic Acids	lb/FU	1.8E-02	1.8E-02	0.0E+00
Butyl alcohol	lb/FU	1.8E-02	0.0E+00	1.8E-02
Phenol	lb/FU	1.6E-02	1.6E-02	0.0E+00
Formaldehyde	lb/FU	1.5E-02	1.5E-02	0.0E+00
MIBK	lb/FU	1.4E-02	8.0E-03	6.4E-03
Aldehydes	lb/FU	1.4E-02	1.4E-02	0.0E+00
Aromatic hydrocarbons	lb/FU	1.2E-02	2.9E-04	1.2E-02
C-7 cycloparaffins	lb/FU	8.8E-03	8.8E-03	0.0E+00
Acetone	lb/FU	6.1E-03	6.1E-03	0.0E+00
Ethylene dichloride	lb/FU	5.6E-03	5.6E-03	0.0E+00
HCN	lb/FU	4.9E-03	4.9E-03	0.0E+00
C-8 cycloparaffins	lb/FU	3.2E-03	3.2E-03	0.0E+00
Ethyl chloride	lb/FU	2.2E-03	2.2E-03	0.0E+00
Iso-Butane	lb/FU	2.1E-03	2.1E-03	0.0E+00
Ethylene	lb/FU	2.1E-03	2.1E-03	0.0E+00
Carbon tetrachloride	lb/FU	2.0E-03	2.0E-03	0.0E+00
Trichloroethane	lb/FU	1.7E-03	1.7E-03	0.0E+00
Ethylbenzene	lb/FU	1.6E-03	1.6E-03	0.0E+00
Vinyl chloride	lb/FU	1.0E-03	1.0E-03	0.0E+00
Chloroform	lb/FU	9.7E-04	9.7E-04	0.0E+00
Hydrochloric acid	lb/FU	9.5E-04	9.5E-04	0.0E+00
Lead	lb/FU	6.3E-04	6.3E-04	0.0E+00
Ammonia	lb/FU	4.5E-06	4.5E-06	0.0E+00
Kerosene	lb/FU	3.2E-09	3.2E-09	0.0E+00
Naphthalene	lb/FU	0.0E+00	0.0E+00	0.0E+00
Methanol	lb/FU	0.0E+00	0.0E+00	0.0E+00
Butyl cellosolve	lb/FU	0.0E+00	0.0E+00	0.0E+00
Nitric acid	lb/FU	0.0E+00	0.0E+00	0.0E+00
Bromotrifluoromethane	lb/FU	0.0E+00	0.0E+00	0.0E+00
Nitroethane	lb/FU	0.0E+00	0.0E+00	0.0E+00
Dichlorodifluoromethane	lb/FU	0.0E+00	0.0E+00	0.0E+00
Sulfuric acid	lb/FU	0.0E+00	0.0E+00	0.0E+00
Bromochlorodifluoromethane	lb/FU	0.0E+00	0.0E+00	0.0E+00
Acetonitrile	lb/FU	0.0E+00	0.0E+00	0.0E+00
2-nitropropane	lb/FU	0.0E+00	0.0E+00	0.0E+00
1,2-butylene	lb/FU	0.0E+00	0.0E+00	0.0E+00
Propylene	lb/FU	0.0E+00	0.0E+00	0.0E+00
MPK	lb/FU	0.0E+00	0.0E+00	0.0E+00
Isopropyl alcohol	lb/FU	0.0E+00	0.0E+00	0.0E+00
Propyl acetate	lb/FU	0.0E+00	0.0E+00	0.0E+00
Aliphatic hydrocarbons	lb/FU	0.0E+00	0.0E+00	0.0E+00
Wastewater Emissions				
Wastewater	lb/FU	2.4E+03	2.4E+03	0.0E+00
WW Reinj'd	lb/FU	1.2E+02	1.2E+02	0.0E+00
WW Discharg.	lb/FU	5.2E+01	5.2E+01	0.0E+00
Mobile ions	lb/FU	2.5E+01	2.5E+01	0.0E+00
WW Injected	lb/FU	1.7E+01	1.7E+01	0.0E+00
Sodium	lb/FU	1.1E+01	1.1E+01	0.0E+00
Chloride	lb/FU	8.3E+00	8.3E+00	0.0E+00
Oil and Grease	lb/FU	2.6E-01	2.6E-01	0.0E+00
Titanium dioxide	lb/FU	9.4E-02	9.4E-02	0.0E+00
Chlorine	lb/FU	2.8E-02	2.8E-02	0.0E+00
Boron	lb/FU	1.1E-02	1.1E-02	0.0E+00
Cadmium	lb/FU	3.6E-03	3.6E-03	0.0E+00

Table 6-3. Alternative Gun CARC System Life Cycle Inventory Summary Results (continued)

LCI Components	Units	Baseline CARC System Quantity	CARC System Materials Manufacture Quantity	CARC System Use/Reuse Maintenance Quantity
Functional Unit (FU)	ft^2	1,000		
Lead	lb/FU	1.3E-03	1.3E-03	0.0E+00
Benzene	lb/FU	5.2E-04	5.2E-04	0.0E+00
Aluminum	lb/FU	4.3E-04	4.3E-04	0.0E+00
Chromium	lb/FU	4.0E-04	4.0E-04	0.0E+00
Vanadium	lb/FU	9.4E-05	9.4E-05	0.0E+00
Copper	lb/FU	3.0E-05	3.0E-05	0.0E+00
Zinc	lb/FU	3.0E-05	3.0E-05	0.0E+00
Arsenic	lb/FU	2.2E-05	2.2E-05	0.0E+00
Iron	lb/FU	5.9E-06	5.9E-06	0.0E+00
Mercury	lb/FU	4.4E-06	4.4E-06	0.0E+00
Thallium	lb/FU	3.8E-06	3.8E-06	0.0E+00
Dissolved Solids	lb/FU	5.0E-07	5.0E-07	0.0E+00
Magnesium	lb/FU	8.5E-08	8.5E-08	0.0E+00
Sulfuric Acid	lb/FU	6.8E-08	6.8E-08	0.0E+00
COD	lb/FU	3.3E-09	3.3E-09	0.0E+00
Suspended Solids	lb/FU	1.7E-09	1.7E-09	0.0E+00
BOD	lb/FU	9.9E-10	9.9E-10	0.0E+00
Acid	lb/FU	5.5E-10	5.5E-10	0.0E+00
Oil	lb/FU	5.5E-10	5.5E-10	0.0E+00
Metals	lb/FU	2.7E-10	2.7E-10	0.0E+00
Phenol	lb/FU	2.7E-10	2.7E-10	0.0E+00
Sulfide	lb/FU	2.7E-10	2.7E-10	0.0E+00
Ammonia	lb/FU	0.0E+00	0.0E+00	0.0E+00
Hydrogen cyanide	lb/FU	0.0E+00	0.0E+00	0.0E+00
Solid Wastes				
Hazardous Wastes	lb/FU	8.0E+01	1.7E+00	7.8E+01
Solid Wastes	lb/FU	5.3E+01	5.3E+01	0.0E+00
U238	lb/FU	3.9E-09	3.9E-09	0.0E+00
Fly Ash	lb/FU	1.5E-09	1.5E-09	0.0E+00
FGD Solids	lb/FU	5.7E-10	5.7E-10	0.0E+00
Bottom Ash	lb/FU	4.1E-10	4.1E-10	0.0E+00
Slag	lb/FU	1.6E-10	1.6E-10	0.0E+00
U235	lb/FU	3.3E-11	3.3E-11	0.0E+00
Pu (fissile)	lb/FU	2.7E-11	2.7E-11	0.0E+00
Fission Products	lb/FU	1.9E-11	1.9E-11	0.0E+00
Pu (nonfissile)	lb/FU	1.0E-11	1.0E-11	0.0E+00
U236	lb/FU	2.6E-12	2.6E-12	0.0E+00
Methanol	lb/FU	0.0E+00	0.0E+00	0.0E+00
Ammonia	lb/FU	0.0E+00	0.0E+00	0.0E+00
Nitric acid	lb/FU	0.0E+00	0.0E+00	0.0E+00
Naphathalene	lb/FU	0.0E+00	0.0E+00	0.0E+00
Formaldehyde	lb/FU	0.0E+00	0.0E+00	0.0E+00
2-nitropropane	lb/FU	0.0E+00	0.0E+00	0.0E+00
Acetonitrile	lb/FU	0.0E+00	0.0E+00	0.0E+00
Acetone	lb/FU	0.0E+00	0.0E+00	0.0E+00
Acetaldehyde	lb/FU	0.0E+00	0.0E+00	0.0E+00
Hydrogen cyanide	lb/FU	0.0E+00	0.0E+00	0.0E+00

Table 6-4. Alternative Primer & Gun CARC System Life Cycle Inventory Summary Results

LCI Components	Units	Baseline CARC System Quantity	CARC System Materials Manufacture Quantity	CARC System Use/Reuse Maintenance Quantity
Functional Unit (FU)	ft^2	1,000		
Resource and Energy Consumption				
Electricity	BTU/FU	5.6E+05	5.6E+05	0.0E+00
Natural gas	BTU/FU	9.3E+06	9.3E+06	0.0E+00
Steam	BTU/FU	4.3E+05	4.3E+05	0.0E+00
Fuel	lb/FU	4.6E+04	4.6E+04	0.0E+00
Water	lb/FU	2.9E+04	2.9E+04	0.0E+00
Crude oil	lb/FU	1.8E+03	1.8E+03	0.0E+00
Air	lb/FU	9.0E+01	9.0E+01	0.0E+00
Bauxite	lb/FU	8.4E+01	8.4E+01	0.0E+00
Refinery gases	lb/FU	4.9E+01	4.9E+01	0.0E+00
Sodium Chloride	lb/FU	3.1E+01	3.1E+01	0.0E+00
Chlorine	lb/FU	1.1E+01	1.1E+01	0.0E+00
Silica	lb/FU	9.7E+00	9.7E+00	0.0E+00
Oxygen	lb/FU	9.6E+00	9.6E+00	0.0E+00
Rumenite	lb/FU	7.2E+00	7.2E+00	0.0E+00
Sulfuric acid	lb/FU	5.9E+00	5.9E+00	0.0E+00
Limestone	lb/FU	4.7E+00	4.7E+00	0.0E+00
Chrome oxide	lb/FU	3.3E+00	3.3E+00	0.0E+00
Ilmenite	lb/FU	2.8E+00	2.8E+00	0.0E+00
Soda ash	lb/FU	2.6E+00	2.6E+00	0.0E+00
Magnesium ore	lb/FU	1.6E+00	1.6E+00	0.0E+00
Coke	lb/FU	1.3E+00	1.3E+00	0.0E+00
Iron ore	lb/FU	9.7E-01	9.7E-01	0.0E+00
Cobalt oxide	lb/FU	7.2E-01	7.2E-01	0.0E+00
Sodium hydroxide	lb/FU	3.8E-01	3.8E-01	0.0E+00
Magnetite	lb/FU	2.9E-01	2.9E-01	0.0E+00
Starch	lb/FU	2.1E-01	2.1E-01	0.0E+00
Hydrocarbons C8 to C10	lb/FU	6.6E-02	6.6E-02	0.0E+00
SiAl	lb/FU	6.3E-02	6.3E-02	0.0E+00
Phosphoric acid	lb/FU	3.4E-02	3.4E-02	0.0E+00
Hydropotential	m^3-m/FU	4.6E-03	4.6E-03	0.0E+00
Sulfur dioxide	lb/FU	1.6E-03	1.6E-03	0.0E+00
Coal	lb/FU	1.2E-05	1.2E-05	0.0E+00
Residual Fuel Oil	lb/FU	3.2E-06	3.2E-06	0.0E+00
Distillate Fuel Oil	lb/FU	2.8E-07	2.8E-07	0.0E+00
Uranium	lb/FU	2.8E-09	2.8E-09	0.0E+00
Phosphate ore	lb/FU	0.0E+00	0.0E+00	0.0E+00
Proprietary Primer Ingredients	lb/FU	0.0E+00	0.0E+00	0.0E+00
Zinc ore	lb/FU	0.0E+00	0.0E+00	0.0E+00
Air Emissions				
CO2	lb/FU	2.0E+02	2.0E+02	0.0E+00
SOx	lb/FU	2.1E+01	2.1E+01	0.0E+00
VOC	lb/FU	1.0E+01	1.0E+01	0.0E+00
PM	lb/FU	4.4E+00	4.4E+00	0.0E+00
NOx	lb/FU	4.3E+00	4.3E+00	0.0E+00
Hydrocarbons	lb/FU	2.1E+00	2.1E+00	0.0E+00
CO	lb/FU	5.8E-01	5.8E-01	0.0E+00
Chlorine	lb/FU	4.2E-01	4.2E-01	0.0E+00
PM10	lb/FU	2.9E-01	2.9E-01	0.0E+00
Isobutyraldehyde	lb/FU	2.6E-01	2.6E-01	0.0E+00
Methane	lb/FU	1.8E-01	1.8E-01	0.0E+00
Benzene	lb/FU	1.5E-01	1.5E-01	0.0E+00
Heavy Aromatics	lb/FU	1.4E-01	1.4E-01	0.0E+00
Toluene	lb/FU	8.8E-02	8.8E-02	0.0E+00
Heptane	lb/FU	5.5E-02	5.5E-02	0.0E+00
MIAK	lb/FU	5.1E-02	5.1E-02	0.0E+00
Propane	lb/FU	4.8E-02	4.8E-02	0.0E+00
Hexane	lb/FU	4.3E-02	4.3E-02	0.0E+00
n-Butane	lb/FU	3.8E-02	3.8E-02	0.0E+00
Octane	lb/FU	3.7E-02	3.7E-02	0.0E+00
Acetaldehyde	lb/FU	3.1E-02	3.1E-02	0.0E+00
Xylene	lb/FU	3.1E-02	3.1E-02	0.0E+00
Ethane	lb/FU	3.1E-02	3.1E-02	0.0E+00
Pentane	lb/FU	2.7E-02	2.7E-02	0.0E+00
Butyl alcohol	lb/FU	2.2E-02	0.0E+00	2.2E-02

Table 6-4. Alternative Primer & Gun CARC System Life Cycle Inventory Summary Results (cont.)

LCI Components	Units	Baseline CARC System Quantity	CARC System Materials Manufacture Quantity	CARC System Use/Reuse Maintenance Quantity
Functional Unit (FU)	ft^2	1,000		
Aromatic hydrocarbons	lb/FU	2.0E-02	0.0E+00	2.0E-02
Cumene	lb/FU	1.6E-02	1.6E-02	0.0E+00
MEK	lb/FU	1.6E-02	1.6E-02	0.0E+00
Organic Acids	lb/FU	1.6E-02	1.6E-02	0.0E+00
Phenol	lb/FU	1.5E-02	1.5E-02	0.0E+00
Formaldehyde	lb/FU	1.4E-02	1.4E-02	0.0E+00
Aldehydes	lb/FU	1.2E-02	1.2E-02	0.0E+00
C-7 cycloparaffins	lb/FU	7.8E-03	7.8E-03	0.0E+00
Acetone	lb/FU	5.4E-03	5.4E-03	0.0E+00
HCN	lb/FU	4.9E-03	4.9E-03	0.0E+00
Ethylbenzene	lb/FU	3.2E-03	3.2E-03	0.0E+00
C-8 cycloparaffins	lb/FU	2.9E-03	2.9E-03	0.0E+00
Nitroethane	lb/FU	2.0E-03	0.0E+00	2.0E-03
Iso-Butane	lb/FU	1.9E-03	1.9E-03	0.0E+00
Hydrochloric acid	lb/FU	1.4E-03	1.4E-03	0.0E+00
Dichlorodifluoromethane	lb/FU	8.0E-04	8.0E-04	0.0E+00
Ammonia	lb/FU	6.4E-04	6.4E-04	0.0E+00
Naphthalene	lb/FU	4.6E-04	4.6E-04	0.0E+00
2-nitropropane	lb/FU	4.4E-04	4.4E-04	0.0E+00
Ethylene	lb/FU	4.3E-04	4.3E-04	0.0E+00
Acetonitrile	lb/FU	1.7E-05	1.7E-05	0.0E+00
Methanol	lb/FU	1.4E-05	1.4E-05	0.0E+00
Bromotrifluoromethane	lb/FU	6.0E-06	6.0E-06	0.0E+00
Nitric acid	lb/FU	4.0E-06	4.0E-06	0.0E+00
Bromochlorodifluoromethane	lb/FU	1.6E-06	1.6E-06	0.0E+00
1,2-butylene	lb/FU	5.0E-07	5.0E-07	0.0E+00
Kerosene	lb/FU	3.0E-09	3.0E-09	0.0E+00
Lead	lb/FU	6.6E-11	6.6E-11	0.0E+00
Hexyl acetate	lb/FU	0.0E+00	0.0E+00	0.0E+00
Propylene	lb/FU	0.0E+00	0.0E+00	0.0E+00
Sulfuric acid	lb/FU	0.0E+00	0.0E+00	0.0E+00
Ethyl chloride	lb/FU	0.0E+00	0.0E+00	0.0E+00
Vinyl chloride	lb/FU	0.0E+00	0.0E+00	0.0E+00
Isopropyl alcohol	lb/FU	0.0E+00	0.0E+00	0.0E+00
MPK	lb/FU	0.0E+00	0.0E+00	0.0E+00
Propyl acetate	lb/FU	0.0E+00	0.0E+00	0.0E+00
Naphtha	lb/FU	0.0E+00	0.0E+00	0.0E+00
Butyl acetate	lb/FU	0.0E+00	0.0E+00	0.0E+00
Fluorine	lb/FU	0.0E+00	0.0E+00	0.0E+00
MIBK	lb/FU	0.0E+00	0.0E+00	0.0E+00
Trichloroethane	lb/FU	0.0E+00	0.0E+00	0.0E+00
Carbon tetrachloride	lb/FU	0.0E+00	0.0E+00	0.0E+00
Chloroform	lb/FU	0.0E+00	0.0E+00	0.0E+00
Butyl cellosolve	lb/FU	0.0E+00	0.0E+00	0.0E+00
Ethylene dichloride	lb/FU	0.0E+00	0.0E+00	0.0E+00
Aliphatic hydrocarbons	lb/FU	0.0E+00	0.0E+00	0.0E+00
Wastewater Emissions				
Wastewater	lb/FU	2.1E+03	2.1E+03	0.0E+00
WW Reinj'd	lb/FU	1.0E+02	1.0E+02	0.0E+00
WW Discharg.	lb/FU	4.6E+01	4.6E+01	0.0E+00
Mobile ions	lb/FU	2.3E+01	2.3E+01	0.0E+00
WW Injected	lb/FU	1.5E+01	1.5E+01	0.0E+00
Sodium	lb/FU	9.3E+00	9.3E+00	0.0E+00
Chloride	lb/FU	7.4E+00	7.4E+00	0.0E+00
Oil and Grease	lb/FU	2.3E-01	2.3E-01	0.0E+00
Titanium dioxide	lb/FU	1.5E-01	1.5E-01	0.0E+00
Chlorine	lb/FU	8.7E-02	8.7E-02	0.0E+00
Boron	lb/FU	9.8E-03	9.8E-03	0.0E+00
Cadmium	lb/FU	5.7E-03	5.7E-03	0.0E+00
Lead	lb/FU	2.1E-03	2.1E-03	0.0E+00
Aluminum	lb/FU	7.0E-04	7.0E-04	0.0E+00
Chromium	lb/FU	6.4E-04	6.4E-04	0.0E+00
Benzene	lb/FU	4.6E-04	4.6E-04	0.0E+00
Vanadium	lb/FU	1.5E-04	1.5E-04	0.0E+00
Copper	lb/FU	4.9E-05	4.9E-05	0.0E+00

Table 6-4. Alternative Primer & Gun CARC System Life Cycle Inventory Summary Results (cont.)

LCI Components	Units	Baseline CARC System Quantity	CARC System Materials Manufacture Quantity	CARC System Use/Reuse Maintenance Quantity
Functional Unit (FU)	ft^2	1,000		
Zinc	lb/FU	4.9E-05	4.9E-05	0.0E+00
Arsenic	lb/FU	1.9E-05	1.9E-05	0.0E+00
Iron	lb/FU	5.4E-06	5.4E-06	0.0E+00
Mercury	lb/FU	4.2E-06	4.2E-06	0.0E+00
Thallium	lb/FU	3.4E-06	3.4E-06	0.0E+00
Ammonia	lb/FU	1.3E-06	1.3E-06	0.0E+00
Dissolved Solids	lb/FU	4.6E-07	4.6E-07	0.0E+00
Magnesium	lb/FU	1.4E-07	1.4E-07	0.0E+00
Hydrogen cyanide	lb/FU	8.4E-08	8.4E-08	0.0E+00
Sulfuric Acid	lb/FU	6.3E-08	6.3E-08	0.0E+00
COD	lb/FU	3.0E-09	3.0E-09	0.0E+00
Suspended Solids	lb/FU	1.6E-09	1.6E-09	0.0E+00
BOD	lb/FU	9.1E-10	9.1E-10	0.0E+00
Acid	lb/FU	5.0E-10	5.0E-10	0.0E+00
Oil	lb/FU	5.0E-10	5.0E-10	0.0E+00
Metals	lb/FU	2.5E-10	2.5E-10	0.0E+00
Phenol	lb/FU	2.5E-10	2.5E-10	0.0E+00
Sulfide	lb/FU	2.5E-10	2.5E-10	0.0E+00
Solid Wastes				
Hazardous Wastes	lb/FU	7.9E+01	7.0E-01	7.8E+01
Solid Wastes	lb/FU	5.3E+01	5.3E+01	0.0E+00
Acetaldehyde	lb/FU	7.5E-03	7.5E-03	0.0E+00
Methanol	lb/FU	6.6E-03	6.6E-03	0.0E+00
2-nitropropane	lb/FU	5.8E-03	5.8E-03	0.0E+00
Acetone	lb/FU	4.0E-03	4.0E-03	0.0E+00
Acetonitrile	lb/FU	3.3E-03	3.3E-03	0.0E+00
Nitric acid	lb/FU	4.6E-04	4.6E-04	0.0E+00
Ammonia	lb/FU	1.0E-04	1.0E-04	0.0E+00
Formaldehyde	lb/FU	5.7E-05	5.7E-05	0.0E+00
Naphathalene	lb/FU	4.8E-06	4.8E-06	0.0E+00
Hydrogen cyanide	lb/FU	4.8E-06	4.8E-06	0.0E+00
U238	lb/FU	3.6E-09	3.6E-09	0.0E+00
Fly Ash	lb/FU	1.4E-09	1.4E-09	0.0E+00
FGD Solids	lb/FU	5.2E-10	5.2E-10	0.0E+00
Bottom Ash	lb/FU	3.8E-10	3.8E-10	0.0E+00
Slag	lb/FU	1.4E-10	1.4E-10	0.0E+00
U235	lb/FU	3.0E-11	3.0E-11	0.0E+00
Pu (fissile)	lb/FU	2.5E-11	2.5E-11	0.0E+00
Fission Products	lb/FU	1.7E-11	1.7E-11	0.0E+00
Pu (nonfissile)	lb/FU	9.5E-12	9.5E-12	0.0E+00
U236	lb/FU	2.4E-12	2.4E-12	0.0E+00

Table 6-5. Alternative Thinner CARC System Life Cycle Inventory Summary Results

LCI Components	Units	Baseline CARC System Quantity	CARC System Materials Manufacture Quantity	CARC System Use/Reuse Maintenance Quantity
Functional Unit (FU)	ft^2	1,000		
Resource and Energy Consumption				
Electricity	BTU/FU	7.7E+05	7.7E+05	0.0E+00
Natural gas	BTU/FU	1.3E+07	1.3E+07	0.0E+00
Steam	BTU/FU	5.5E+05	5.5E+05	0.0E+00
Water	lb/FU	4.0E+04	4.0E+04	0.0E+00
Fuel	lb/FU	3.9E+04	3.9E+04	0.0E+00
Crude oil	lb/FU	2.4E+03	2.4E+03	0.0E+00
Bauxite	lb/FU	8.4E+01	8.4E+01	0.0E+00
Air	lb/FU	7.6E+01	7.6E+01	0.0E+00
Refinery gases	lb/FU	6.8E+01	6.8E+01	0.0E+00
Sodium Chloride	lb/FU	4.3E+01	4.3E+01	0.0E+00
Oxygen	lb/FU	1.4E+01	1.4E+01	0.0E+00
Silica	lb/FU	1.4E+01	1.4E+01	0.0E+00
Chlorine	lb/FU	1.3E+01	1.3E+01	0.0E+00
Zinc ore	lb/FU	8.3E+00	8.3E+00	0.0E+00
Rumenite	lb/FU	6.1E+00	6.1E+00	0.0E+00
Sulfuric acid	lb/FU	6.0E+00	6.0E+00	0.0E+00
Limestone	lb/FU	4.7E+00	4.7E+00	0.0E+00
Chrome oxide	lb/FU	4.6E+00	4.6E+00	0.0E+00
Soda ash	lb/FU	2.6E+00	2.6E+00	0.0E+00
Ilmenite	lb/FU	2.4E+00	2.4E+00	0.0E+00
Magnesium ore	lb/FU	2.2E+00	2.2E+00	0.0E+00
Phosphate ore	lb/FU	2.1E+00	2.1E+00	0.0E+00
Iron ore	lb/FU	1.3E+00	1.3E+00	0.0E+00
Coke	lb/FU	1.1E+00	1.1E+00	0.0E+00
Cobalt oxide	lb/FU	1.0E+00	1.0E+00	0.0E+00
Magnetite	lb/FU	4.0E-01	4.0E-01	0.0E+00
Sodium hydroxide	lb/FU	3.2E-01	3.2E-01	0.0E+00
Coal	lb/FU	2.9E-01	2.9E-01	0.0E+00
Starch	lb/FU	2.1E-01	2.1E-01	0.0E+00
SiAl	lb/FU	5.4E-02	5.4E-02	0.0E+00
Phosphoric acid	lb/FU	4.8E-02	4.8E-02	0.0E+00
Hydrocarbons C8 to C10	lb/FU	1.7E-02	1.7E-02	0.0E+00
Hydropotential	m^3-m/FU	6.3E-03	6.3E-03	0.0E+00
Sulfur dioxide	lb/FU	2.2E-03	2.2E-03	0.0E+00
Residual Fuel Oil	lb/FU	4.5E-06	4.5E-06	0.0E+00
Distillate Fuel Oil	lb/FU	3.9E-07	3.9E-07	0.0E+00
Uranium	lb/FU	3.8E-09	3.8E-09	0.0E+00
Proprietary Primer Ingredients	lb/FU	0.0E+00	0.0E+00	0.0E+00
Air Emissions				
CO2	lb/FU	2.7E+02	2.7E+02	0.0E+00
SOx	lb/FU	2.1E+01	2.1E+01	0.0E+00
VOC	lb/FU	1.4E+01	1.4E+01	0.0E+00
PM	lb/FU	5.9E+00	5.9E+00	0.0E+00
NOx	lb/FU	5.9E+00	5.9E+00	0.0E+00
Hydrocarbons	lb/FU	3.0E+00	3.0E+00	0.0E+00
CO	lb/FU	1.3E+00	1.3E+00	0.0E+00
Chlorine	lb/FU	5.8E-01	5.8E-01	0.0E+00
MIAK	lb/FU	5.2E-01	7.1E-02	4.5E-01
PM10	lb/FU	3.1E-01	3.1E-01	0.0E+00
Methane	lb/FU	2.5E-01	2.5E-01	0.0E+00
Heavy Aromatics	lb/FU	2.0E-01	2.0E-01	0.0E+00
Butyl acetate	lb/FU	1.4E-01	0.0E+00	1.4E-01
Benzene	lb/FU	1.1E-01	1.1E-01	0.0E+00
Heptane	lb/FU	7.6E-02	7.6E-02	0.0E+00
Propane	lb/FU	6.6E-02	6.6E-02	0.0E+00
Naphtha	lb/FU	6.6E-02	0.0E+00	6.6E-02
Hexane	lb/FU	5.9E-02	5.9E-02	0.0E+00
Acetaldehyde	lb/FU	5.4E-02	5.4E-02	0.0E+00
n-Butane	lb/FU	5.3E-02	5.3E-02	0.0E+00
Octane	lb/FU	5.1E-02	5.1E-02	0.0E+00
Xylene	lb/FU	4.7E-02	9.3E-03	3.7E-02
Ethane	lb/FU	4.2E-02	4.2E-02	0.0E+00

Table 6-5. Alternative Thinner CARC System Life Cycle Inventory Summary Results (continued)

LCI Components	Units	Baseline CARC System Quantity	CARC System Materials Manufacture Quantity	CARC System Use/Reuse Maintenance Quantity
Functional Unit (FU)	ft^2	1,000		
Pentane	lb/FU	3.7E-02	3.7E-02	0.0E+00
Butyl alcohol	lb/FU	3.6E-02	0.0E+00	3.6E-02
Fluorine	lb/FU	2.8E-02	2.8E-02	0.0E+00
Cumene	lb/FU	2.7E-02	2.7E-02	0.0E+00
Toluene	lb/FU	2.4E-02	2.2E-02	1.6E-03
MIBK	lb/FU	2.3E-02	1.1E-02	1.2E-02
Aromatic hydrocarbons	lb/FU	2.3E-02	4.0E-04	2.3E-02
Organic Acids	lb/FU	2.2E-02	2.2E-02	0.0E+00
Phenol	lb/FU	2.2E-02	2.2E-02	0.0E+00
Formaldehyde	lb/FU	1.9E-02	1.9E-02	0.0E+00
Aldehydes	lb/FU	1.7E-02	1.7E-02	0.0E+00
C-7 cycloparaffins	lb/FU	1.1E-02	1.1E-02	0.0E+00
Ethylene dichloride	lb/FU	7.7E-03	7.7E-03	0.0E+00
Acetone	lb/FU	7.4E-03	7.4E-03	0.0E+00
HCN	lb/FU	6.7E-03	6.7E-03	0.0E+00
C-8 cycloparaffins	lb/FU	3.9E-03	3.9E-03	0.0E+00
Ethyl chloride	lb/FU	3.0E-03	3.0E-03	0.0E+00
Carbon tetrachloride	lb/FU	2.8E-03	2.8E-03	0.0E+00
Iso-Butane	lb/FU	2.6E-03	2.6E-03	0.0E+00
Ethylene	lb/FU	2.5E-03	2.5E-03	0.0E+00
Trichloroethane	lb/FU	2.3E-03	2.3E-03	0.0E+00
MEK	lb/FU	2.2E-03	7.8E-04	1.5E-03
Isopropyl alcohol	lb/FU	2.1E-03	0.0E+00	2.1E-03
Ethylbenzene	lb/FU	2.1E-03	2.1E-03	0.0E+00
Aliphatic hydrocarbons	lb/FU	1.7E-03	0.0E+00	1.7E-03
Vinyl chloride	lb/FU	1.4E-03	1.4E-03	0.0E+00
Chloroform	lb/FU	1.3E-03	1.3E-03	0.0E+00
Hydrochloric acid	lb/FU	1.3E-03	1.3E-03	0.0E+00
Propylene	lb/FU	1.1E-03	1.1E-03	0.0E+00
Lead	lb/FU	8.8E-04	8.8E-04	0.0E+00
Sulfuric acid	lb/FU	8.3E-05	8.3E-05	0.0E+00
Ammonia	lb/FU	6.2E-06	6.2E-06	0.0E+00
Kerosene	lb/FU	4.1E-09	4.1E-09	0.0E+00
Hexyl acetate	lb/FU	0.0E+00	0.0E+00	0.0E+00
Dichlorodifluoromethane	lb/FU	0.0E+00	0.0E+00	0.0E+00
Nitroethane	lb/FU	0.0E+00	0.0E+00	0.0E+00
Nitric acid	lb/FU	0.0E+00	0.0E+00	0.0E+00
Naphthalene	lb/FU	0.0E+00	0.0E+00	0.0E+00
Methanol	lb/FU	0.0E+00	0.0E+00	0.0E+00
Bromochlorodifluoromethane	lb/FU	0.0E+00	0.0E+00	0.0E+00
Bromotrifluoromethane	lb/FU	0.0E+00	0.0E+00	0.0E+00
Isobutyraldehyde	lb/FU	0.0E+00	0.0E+00	0.0E+00
Acetonitrile	lb/FU	0.0E+00	0.0E+00	0.0E+00
2-nitropropane	lb/FU	0.0E+00	0.0E+00	0.0E+00
1,2-butylene	lb/FU	0.0E+00	0.0E+00	0.0E+00
Propyl acetate	lb/FU	0.0E+00	0.0E+00	0.0E+00
Butyl cellosolve	lb/FU	0.0E+00	0.0E+00	0.0E+00
MPK	lb/FU	0.0E+00	0.0E+00	0.0E+00
Wastewater Emissions				
Wastewater	lb/FU	3.0E+03	3.0E+03	0.0E+00
WW Reinj'd	lb/FU	1.4E+02	1.4E+02	0.0E+00
WW Discharg.	lb/FU	6.4E+01	6.4E+01	0.0E+00
Mobile ions	lb/FU	3.1E+01	3.1E+01	0.0E+00
WW Injected	lb/FU	2.1E+01	2.1E+01	0.0E+00
Sodium	lb/FU	1.3E+01	1.3E+01	0.0E+00
Chloride	lb/FU	1.0E+01	1.0E+01	0.0E+00
Oil and Grease	lb/FU	3.2E-01	3.2E-01	0.0E+00
Titanium dioxide	lb/FU	1.3E-01	1.3E-01	0.0E+00
Chlorine	lb/FU	3.9E-02	3.9E-02	0.0E+00
Boron	lb/FU	1.3E-02	1.3E-02	0.0E+00
Cadmium	lb/FU	4.9E-03	4.9E-03	0.0E+00
Lead	lb/FU	1.8E-03	1.8E-03	0.0E+00
Benzene	lb/FU	6.3E-04	6.3E-04	0.0E+00

Table 6-5. Alternative Thinner CARC System Life Cycle Inventory Summary Results (continued)

LCI Components	Units	Baseline CARC System Quantity	CARC System Materials Manufacture Quantity	CARC System Use/Reuse Maintenance Quantity
Functional Unit (FU)	ft^2	1,000		
Aluminum	lb/FU	5.9E-04	5.9E-04	0.0E+00
Chromium	lb/FU	5.5E-04	5.5E-04	0.0E+00
Vanadium	lb/FU	1.3E-04	1.3E-04	0.0E+00
Copper	lb/FU	4.1E-05	4.1E-05	0.0E+00
Zinc	lb/FU	4.1E-05	4.1E-05	0.0E+00
Arsenic	lb/FU	2.6E-05	2.6E-05	0.0E+00
Iron	lb/FU	7.4E-06	7.4E-06	0.0E+00
Mercury	lb/FU	5.5E-06	5.5E-06	0.0E+00
Thallium	lb/FU	4.7E-06	4.7E-06	0.0E+00
Dissolved Solids	lb/FU	6.3E-07	6.3E-07	0.0E+00
Magnesium	lb/FU	1.2E-07	1.2E-07	0.0E+00
Sulfuric Acid	lb/FU	8.7E-08	8.7E-08	0.0E+00
COD	lb/FU	4.2E-09	4.2E-09	0.0E+00
Suspended Solids	lb/FU	2.2E-09	2.2E-09	0.0E+00
BOD	lb/FU	1.3E-09	1.3E-09	0.0E+00
Acid	lb/FU	7.0E-10	7.0E-10	0.0E+00
Oil	lb/FU	7.0E-10	7.0E-10	0.0E+00
Metals	lb/FU	3.5E-10	3.5E-10	0.0E+00
Phenol	lb/FU	3.5E-10	3.5E-10	0.0E+00
Sulfide	lb/FU	3.5E-10	3.5E-10	0.0E+00
Ammonia	lb/FU	0.0E+00	0.0E+00	0.0E+00
Hydrogen cyanide	lb/FU	0.0E+00	0.0E+00	0.0E+00
Solid Wastes				
Hazardous Wastes	lb/FU	8.1E+01	2.3E+00	7.8E+01
Solid Wastes	lb/FU	6.2E+01	6.2E+01	0.0E+00
U238	lb/FU	5.0E-09	5.0E-09	0.0E+00
Fly Ash	lb/FU	1.9E-09	1.9E-09	0.0E+00
FGD Solids	lb/FU	7.2E-10	7.2E-10	0.0E+00
Bottom Ash	lb/FU	5.3E-10	5.3E-10	0.0E+00
Slag	lb/FU	2.0E-10	2.0E-10	0.0E+00
U235	lb/FU	4.2E-11	4.2E-11	0.0E+00
Pu (fissile)	lb/FU	3.4E-11	3.4E-11	0.0E+00
Fission Products	lb/FU	2.4E-11	2.4E-11	0.0E+00
Pu (nonfissile)	lb/FU	1.3E-11	1.3E-11	0.0E+00
U236	lb/FU	3.3E-12	3.3E-12	0.0E+00
Methanol	lb/FU	0.0E+00	0.0E+00	0.0E+00
Ammonia	lb/FU	0.0E+00	0.0E+00	0.0E+00
Nitric acid	lb/FU	0.0E+00	0.0E+00	0.0E+00
Naphathalene	lb/FU	0.0E+00	0.0E+00	0.0E+00
Formaldehyde	lb/FU	0.0E+00	0.0E+00	0.0E+00
2-nitropropane	lb/FU	0.0E+00	0.0E+00	0.0E+00
Acetonitrile	lb/FU	0.0E+00	0.0E+00	0.0E+00
Acetone	lb/FU	0.0E+00	0.0E+00	0.0E+00
Acetaldehyde	lb/FU	0.0E+00	0.0E+00	0.0E+00
Hydrogen cyanide	lb/FU	0.0E+00	0.0E+00	0.0E+00

The fifth and final alternative utilized both an alternative thinner and alternative primer combined with the baseline gun (Table 6-6). As expected, the combined alternatives showed reduced resource and energy consumption in many areas including electricity, natural gas, steam, water, crude oil, air, and refinery gases. Increases were seen in fuel, sodium chloride, chlorine, rumenite, ilmenite mainly from the TiO_2 production stages. Major air emissions categories showed the expected reductions in CO_2, VOC, PM, NO_x, hydrocarbons, and CO. Slight increases were noted in minor organic chemical releases. Water usage and emissions were generally reduced, but increases were noted in the heavy metal content. Solid wastes were generally reduced with the exception of those from the nitroethane production processes.

The comparison of energy usage across the alternatives in comparison with the baseline is shown in Figure 6-1. This again illustrates the preferability of Alternative 2 (turbine HVLP gun) and Alternative 3 (gun plus primer substitution). A consistent reinforcement of this is observed in the solid/hazardous waste (Figure 6-2) and air pollutant (Figure 6-3) graphs as well.

6.2 Environmental Impact/Hazard Characterization

6.2.1 Impact Characterization

The environmental impact significance of the resource and emission data from the baseline and each alternative CARC LCI was characterized (evaluated) using the same set of equivalency factors derived during the baseline analysis (see Table 4-2). The importance of each individual resource or chemical within an impact category was determined by multiplying the equivalency factor times the inventory value in pounds per functional unit. The results of these calculations for each resource or emission are provided as "factored scores" within each of the nine impact categories in Appendix D. These "factored scores" are the basis for the environmental impact valuation results, which combine the results for the economic and performance assessments and the values from the AHP weighting factors in arriving at the conclusions regarding the best improvement opportunity.

The potential environmental impacts associated with each of the alternatives can be evaluated by comparing the normalized, factored, impact scores for each of the nine major impact categories (Table 6-7). As indicated by the bold scores in Table 6-7, the CARC system with the most (7 out of 9) low scores (least potential impacts) in each impact category is the option with both the alternative primer (water-thinned) and alternative spray gun (turbine). Use of the alternative gun decreases the use rates of topcoat, primer, and thinner, which reduces the potential environmental impact in all nine of the impact categories compared to the baseline.

Table 6-6. Alternative Primer and Thinner CARC System Life Cycle Inventory Summary Results

LCI Components	Units	Baseline CARC System Quantity	CARC System Materials Manufacture Quantity	CARC System Use/Reuse Maintenance Quantity
Functional Unit (FU)	ft^2	1,000		
Resource and Energy Consumption				
Electricity	BTU/FU	7.7E+05	7.4E+05	3.1E+04
Natural gas	BTU/FU	1.3E+07	1.3E+07	3.5E-03
Steam	BTU/FU	5.0E+05	5.0E+05	4.1E+03
Fuel	lb/FU	6.4E+04	6.4E+04	0.0E+00
Water	lb/FU	4.1E+04	4.1E+04	0.0E+00
Crude oil	lb/FU	2.6E+03	2.3E+03	2.6E+02
Air	lb/FU	1.2E+02	1.2E+02	0.0E+00
Bauxite	lb/FU	8.4E+01	8.4E+01	0.0E+00
Refinery gases	lb/FU	6.4E+01	6.4E+01	0.0E+00
Sodium Chloride	lb/FU	4.3E+01	4.3E+01	0.0E+00
Chlorine	lb/FU	1.5E+01	1.5E+01	0.0E+00
Silica	lb/FU	1.3E+01	1.3E+01	0.0E+00
Oxygen	lb/FU	1.2E+01	1.2E+01	0.0E+00
Rumenite	lb/FU	9.9E+00	9.9E+00	0.0E+00
Sulfuric acid	lb/FU	8.2E+00	8.2E+00	0.0E+00
Limestone	lb/FU	4.7E+00	4.7E+00	0.0E+00
Chrome oxide	lb/FU	4.6E+00	4.6E+00	0.0E+00
Ilmenite	lb/FU	3.9E+00	3.9E+00	0.0E+00
Soda ash	lb/FU	2.6E+00	2.6E+00	0.0E+00
Magnesium ore	lb/FU	2.2E+00	2.2E+00	0.0E+00
Coke	lb/FU	1.8E+00	1.8E+00	0.0E+00
Iron ore	lb/FU	1.3E+00	1.3E+00	0.0E+00
Cobalt oxide	lb/FU	1.0E+00	1.0E+00	0.0E+00
Sodium hydroxide	lb/FU	5.3E-01	5.3E-01	0.0E+00
Magnetite	lb/FU	4.0E-01	4.0E-01	0.0E+00
Starch	lb/FU	2.1E-01	2.1E-01	0.0E+00
SiAl	lb/FU	8.8E-02	8.8E-02	0.0E+00
Phosphoric acid	lb/FU	4.8E-02	4.8E-02	0.0E+00
Hydrocarbons C8 to C10	lb/FU	1.7E-02	1.7E-02	0.0E+00
Hydropotential	m^3-m/FU	6.4E-03	6.1E-03	2.5E-04
Sulfur dioxide	lb/FU	2.2E-03	2.2E-03	0.0E+00
Coal	lb/FU	1.6E-05	1.5E-05	0.0E+00
Residual Fuel Oil	lb/FU	4.5E-06	4.3E-06	0.0E+00
Distillate Fuel Oil	lb/FU	3.9E-07	3.8E-07	0.0E+00
Uranium	lb/FU	3.8E-09	3.7E-09	0.0E+00
Phosphate ore	lb/FU	0.0E+00	0.0E+00	0.0E+00
Proprietary Primer Ingredients	lb/FU	0.0E+00	0.0E+00	0.0E+00
Zinc ore	lb/FU	0.0E+00	0.0E+00	0.0E+00
Air Emissions				
CO2	lb/FU	2.9E+02	2.6E+02	2.7E+01
SOx	lb/FU	2.1E+01	2.1E+01	3.2E-02
VOC	lb/FU	1.3E+01	1.3E+01	0.0E+00
NOx	lb/FU	6.0E+00	5.8E+00	1.9E-01
PM	lb/FU	6.0E+00	6.0E+00	0.0E+00
Hydrocarbons	lb/FU	3.1E+00	2.8E+00	3.1E-01
CO	lb/FU	8.3E-01	7.6E-01	7.0E-02
Chlorine	lb/FU	5.9E-01	5.9E-01	0.0E+00
MIAK	lb/FU	5.2E-01	7.1E-02	4.5E-01
PM10	lb/FU	3.1E-01	3.1E-01	0.0E+00
Benzene	lb/FU	2.7E-01	2.7E-01	0.0E+00
Methane	lb/FU	2.6E-01	2.3E-01	2.6E-02
Heavy Aromatics	lb/FU	2.0E-01	2.0E-01	0.0E+00
Toluene	lb/FU	1.9E-01	1.9E-01	1.4E-03
Heptane	lb/FU	8.1E-02	7.3E-02	8.0E-03
Propane	lb/FU	7.0E-02	6.3E-02	6.9E-03
Naphtha	lb/FU	6.6E-02	0.0E+00	6.6E-02
Hexane	lb/FU	6.3E-02	5.7E-02	6.2E-03
Aromatic hydrocarbons	lb/FU	6.1E-02	0.0E+00	6.1E-02
n-Butane	lb/FU	5.6E-02	5.0E-02	5.5E-03
Octane	lb/FU	5.4E-02	4.9E-02	5.3E-03
Xylene	lb/FU	4.7E-02	8.9E-03	3.8E-02
Ethane	lb/FU	4.5E-02	4.0E-02	4.4E-03

Table 6-6. Alternative Primer and Thinner CARC System Life Cycle Inventory Summary Results (cont.)

LCI Components	Units	Baseline CARC System Quantity	CARC System Materials Manufacture Quantity	CARC System Use/Reuse Maintenance Quantity
Functional Unit (FU)	ft^2	1,000		
Butyl alcohol	lb/FU	4.2E-02	0.0E+00	4.2E-02
Pentane	lb/FU	3.9E-02	3.5E-02	3.9E-03
Butyl acetate	lb/FU	2.4E-02	0.0E+00	2.4E-02
Organic Acids	lb/FU	2.3E-02	2.1E-02	2.3E-03
Cumene	lb/FU	2.3E-02	2.3E-02	0.0E+00
Phenol	lb/FU	2.1E-02	2.1E-02	0.0E+00
Formaldehyde	lb/FU	2.0E-02	1.8E-02	1.9E-03
Aldehydes	lb/FU	1.8E-02	1.6E-02	1.8E-03
C-7 cycloparaffins	lb/FU	1.1E-02	1.0E-02	1.1E-03
Acetone	lb/FU	7.9E-03	7.1E-03	7.7E-04
HCN	lb/FU	6.8E-03	6.8E-03	0.0E+00
Acetaldehyde	lb/FU	6.2E-03	6.2E-03	0.0E+00
Hexyl acetate	lb/FU	5.5E-03	0.0E+00	5.5E-03
MEK	lb/FU	4.5E-03	7.8E-04	3.7E-03
C-8 cycloparaffins	lb/FU	4.2E-03	3.8E-03	4.1E-04
Nitroethane	lb/FU	3.9E-03	0.0E+00	3.9E-03
Iso-Butane	lb/FU	2.8E-03	2.5E-03	2.7E-04
Hydrochloric acid	lb/FU	1.9E-03	1.9E-03	0.0E+00
Ethylbenzene	lb/FU	1.8E-03	1.8E-03	0.0E+00
Propylene	lb/FU	1.1E-03	1.1E-03	0.0E+00
Dichlorodifluoromethane	lb/FU	1.1E-03	1.1E-03	0.0E+00
Ammonia	lb/FU	8.9E-04	8.9E-04	0.0E+00
Naphthalene	lb/FU	6.4E-04	6.4E-04	0.0E+00
2-nitropropane	lb/FU	6.1E-04	6.1E-04	0.0E+00
Ethylene	lb/FU	2.9E-04	2.9E-04	0.0E+00
Sulfuric acid	lb/FU	8.3E-05	8.3E-05	0.0E+00
Acetonitrile	lb/FU	2.4E-05	2.4E-05	0.0E+00
Methanol	lb/FU	1.9E-05	1.9E-05	0.0E+00
Bromotrifluoromethane	lb/FU	8.3E-06	8.3E-06	0.0E+00
Nitric acid	lb/FU	5.5E-06	5.5E-06	0.0E+00
Bromochlorodifluoromethane	lb/FU	2.2E-06	2.2E-06	0.0E+00
1,2-butylene	lb/FU	7.0E-07	7.0E-07	0.0E+00
Kerosene	lb/FU	4.1E-09	3.9E-09	0.0E+00
Lead	lb/FU	9.2E-11	8.8E-11	0.0E+00
Ethyl chloride	lb/FU	0.0E+00	0.0E+00	0.0E+00
Vinyl chloride	lb/FU	0.0E+00	0.0E+00	0.0E+00
Fluorine	lb/FU	0.0E+00	0.0E+00	0.0E+00
MPK	lb/FU	0.0E+00	0.0E+00	0.0E+00
Propyl acetate	lb/FU	0.0E+00	0.0E+00	0.0E+00
Isopropyl alcohol	lb/FU	0.0E+00	0.0E+00	0.0E+00
MIBK	lb/FU	0.0E+00	0.0E+00	0.0E+00
Isobutyraldehyde	lb/FU	0.0E+00	0.0E+00	0.0E+00
Trichloroethane	lb/FU	0.0E+00	0.0E+00	0.0E+00
Carbon tetrachloride	lb/FU	0.0E+00	0.0E+00	0.0E+00
Chloroform	lb/FU	0.0E+00	0.0E+00	0.0E+00
Butyl cellosolve	lb/FU	0.0E+00	0.0E+00	0.0E+00
Ethylene dichloride	lb/FU	0.0E+00	0.0E+00	0.0E+00
Aliphatic hydrocarbons	lb/FU	0.0E+00	0.0E+00	0.0E+00
Wastewater Emissions				
Wastewater	lb/FU	3.0E+03	3.0E+03	0.0E+00
WW Reinj'd	lb/FU	1.5E+02	1.4E+02	1.5E+01
WW Discharg.	lb/FU	6.7E+01	6.1E+01	6.6E+00
Mobile ions	lb/FU	3.3E+01	3.0E+01	3.2E+00
WW Injected	lb/FU	2.2E+01	2.0E+01	2.2E+00
Sodium	lb/FU	1.4E+01	1.2E+01	1.3E+00
Chloride	lb/FU	1.1E+01	9.7E+00	1.1E+00
Oil and Grease	lb/FU	3.3E-01	3.0E-01	3.3E-02
Titanium dioxide	lb/FU	2.1E-01	2.1E-01	0.0E+00
Chlorine	lb/FU	1.2E-01	1.2E-01	0.0E+00
Boron	lb/FU	1.4E-02	1.3E-02	1.4E-03
Cadmium	lb/FU	8.0E-03	8.0E-03	0.0E+00
Lead	lb/FU	2.9E-03	2.9E-03	0.0E+00
Aluminum	lb/FU	9.7E-04	9.7E-04	0.0E+00

Table 6-6. Alternative Primer and Thinner CARC System Life Cycle Inventory Summary Results (cont.)

LCI Components	Units	Baseline CARC System Quantity	CARC System Materials Manufacture Quantity	CARC System Use/Reuse Maintenance Quantity
Functional Unit (FU)	ft^2	1,000		
Chromium	lb/FU	8.9E-04	8.9E-04	0.0E+00
Benzene	lb/FU	6.7E-04	6.1E-04	0.0E+00
Vanadium	lb/FU	2.1E-04	2.1E-04	0.0E+00
Copper	lb/FU	6.8E-05	6.8E-05	0.0E+00
Zinc	lb/FU	6.8E-05	6.8E-05	0.0E+00
Arsenic	lb/FU	2.8E-05	2.5E-05	0.0E+00
Iron	lb/FU	7.5E-06	7.2E-06	0.0E+00
Mercury	lb/FU	6.1E-06	5.6E-06	0.0E+00
Thallium	lb/FU	4.9E-06	4.4E-06	0.0E+00
Ammonia	lb/FU	1.7E-06	1.7E-06	0.0E+00
Dissolved Solids	lb/FU	6.3E-07	6.1E-07	0.0E+00
Magnesium	lb/FU	1.9E-07	1.9E-07	0.0E+00
Hydrogen cyanide	lb/FU	1.2E-07	1.2E-07	0.0E+00
Sulfuric Acid	lb/FU	8.7E-08	8.4E-08	0.0E+00
COD	lb/FU	4.2E-09	4.0E-09	0.0E+00
Suspended Solids	lb/FU	2.2E-09	2.1E-09	0.0E+00
BOD	lb/FU	1.3E-09	1.2E-09	0.0E+00
Oil	lb/FU	7.0E-10	6.7E-10	0.0E+00
Acid	lb/FU	7.0E-10	6.7E-10	0.0E+00
Metals	lb/FU	3.5E-10	3.4E-10	0.0E+00
Sulfide	lb/FU	3.5E-10	3.4E-10	0.0E+00
Phenol	lb/FU	3.5E-10	3.4E-10	0.0E+00
Solid Wastes				
Hazardous Wastes	lb/FU	7.9E+01	9.8E-01	7.8E+01
Solid Wastes	lb/FU	6.2E+01	6.2E+01	0.0E+00
Acetaldehyde	lb/FU	1.0E-02	1.0E-02	0.0E+00
Methanol	lb/FU	9.2E-03	9.2E-03	0.0E+00
2-nitropropane	lb/FU	8.1E-03	8.1E-03	0.0E+00
Acetone	lb/FU	5.6E-03	5.6E-03	0.0E+00
Acetonitrile	lb/FU	4.6E-03	4.6E-03	0.0E+00
Nitric acid	lb/FU	6.4E-04	6.4E-04	0.0E+00
Ammonia	lb/FU	1.4E-04	1.4E-04	0.0E+00
Formaldehyde	lb/FU	8.0E-05	8.0E-05	0.0E+00
Naphathalene	lb/FU	6.6E-06	6.6E-06	0.0E+00
Hydrogen cyanide	lb/FU	6.6E-06	6.6E-06	0.0E+00
U238	lb/FU	4.8E-09	4.8E-09	0.0E+00
Fly Ash	lb/FU	1.8E-09	1.8E-09	0.0E+00
FGD Solids	lb/FU	7.0E-10	7.0E-10	0.0E+00
Bottom Ash	lb/FU	5.1E-10	5.1E-10	0.0E+00
Slag	lb/FU	1.9E-10	1.9E-10	0.0E+00
U235	lb/FU	4.0E-11	4.0E-11	0.0E+00
Pu (fissile)	lb/FU	3.3E-11	3.3E-11	0.0E+00
Fission Products	lb/FU	2.3E-11	2.3E-11	0.0E+00
Pu (nonfissile)	lb/FU	1.3E-11	1.3E-11	0.0E+00
U236	lb/FU	3.2E-12	3.2E-12	0.0E+00

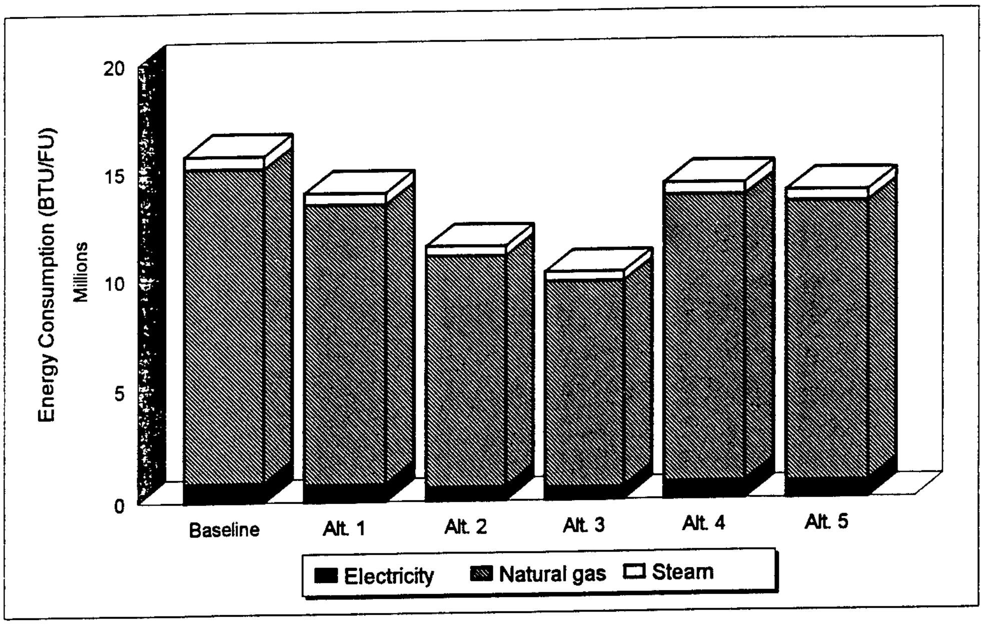


Figure 6-1. Energy consumption by type.

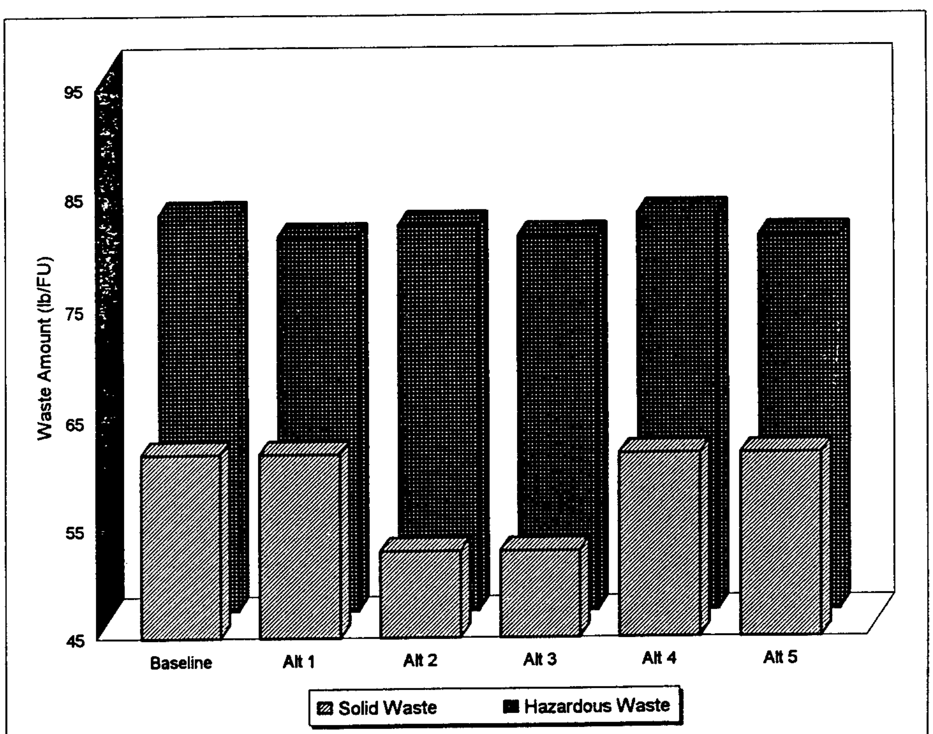


Figure 6-2. Solid/hazardous waste.

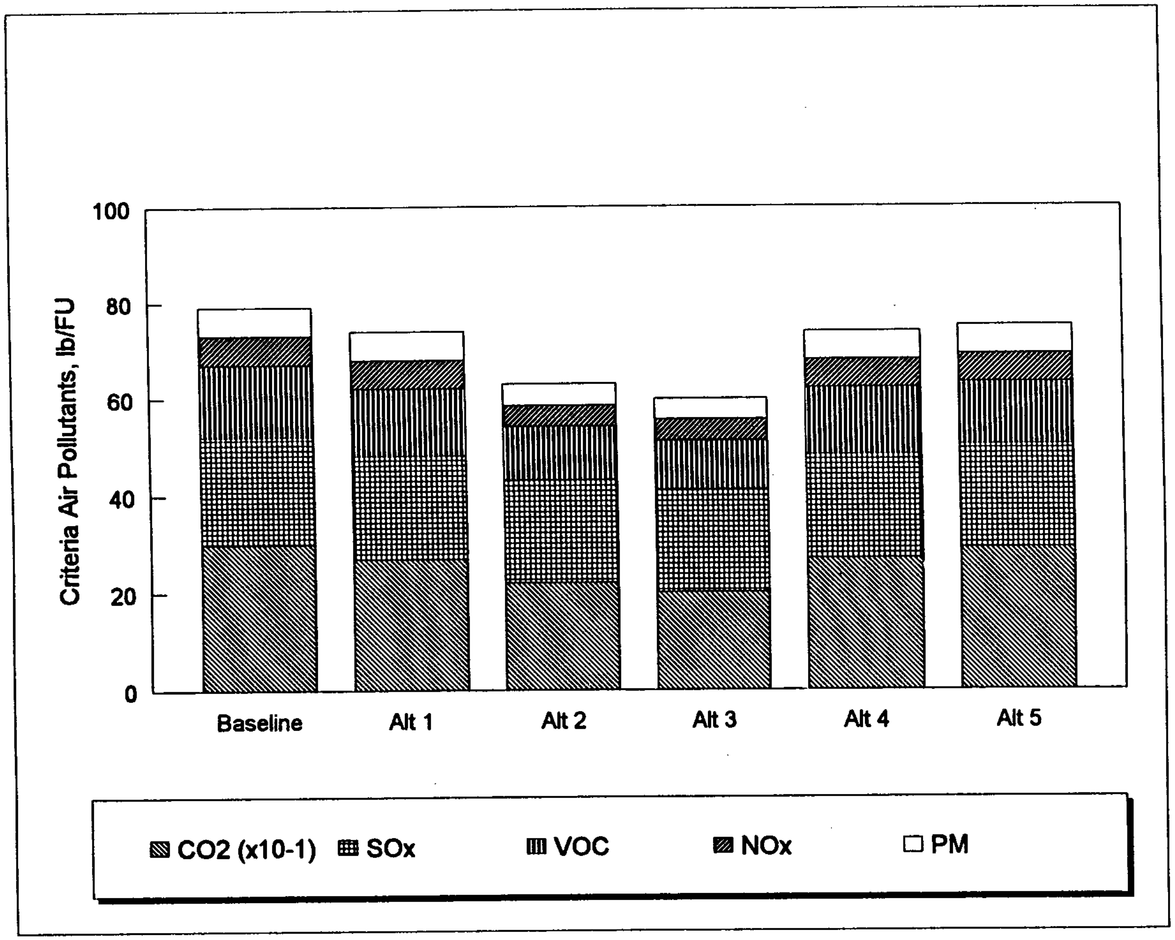


Figure 6-3. Criteria air pollutants

Table 6-7. Comparison of Normalized, Factored Environmental Impact Scores for the Baseline and Alternative CARC Systems

Spatial Scale	Impact Categories**	IMPACT SCORES FOR CARC SYSTEMS (best scores for each impact category in bold)					
		BASELINE	ALTERNATIVE PRIMER	ALTERNATIVE GUN	ALTERNATIVE PRIMER & GUN	ALTERNATIVE THINNER	ALTERNATIVE PRIMER & THINNER
GLOBAL							
	ODP	1.090	0.367	0.799	**0.265**	1.106	0.367
	GLBLWRM	1.013	0.927	0.739	**0.677**	0.905	0.984
	FSLFUELS	1.263	1.121	0.929	**0.827**	1.133	1.180
REGIONAL							
	ACIDDEP	1.198	1.173	1.116	**1.098**	1.187	1.175
	SMOG	1.114	0.993	0.800	**0.721**	1.035	0.992
	WTRUSE						
LOCAL							
	TOXICITY						
	HUMAN	2.150	1.612	1.510	**1.172**	1.999	1.793
	ENVTERR	3.799	2.635	2.565	**1.906**	2.923	2.862
	ENVAQ	1.280	3.537	**0.929**	2.554	1.279	3.540
	LANDUSE	1.577	1.585	**1.493**	1.497	1.577	1.585

* The normalized factored score for an impact category equals the sum for each chemical of the product of inventory quantity times equivalency factor.

** ODP = Ozone Depletion Potential, GLBLWRM = Global Warming Potential, FSLFUELS = Fossil Fuel & Mineral Depletion Potential ACIDDEP = Acid Deposition Potential, SMOG = Smog Creation Potential, WTRUSE = Water Use, HUMAN = Human Health Toxicity Potential, ENVTERR = Terrestrial Wildlife Toxicity Potential, ENVAQ = Aquatic Biota Toxicity Potential, LANDUSE = Land Use for Waste Disposal

The scores for all three of the global scale impact categories were lowest in the option involving the alternative primer and spray gun. The normalized, factored, impact scores for ozone depletion potential suggest that this impact category is reduced by using the alternative primer and spray gun, which is the result of a reduction in the emission of carbon tetrachloride and trichloroethane during manufacture of ingredients for the alternative versus baseline primers. However, the ozone depletion impact from the baseline primer is expected to be eliminated in the near future as the manufacturer eliminates trichloroethane, which is used during manufacture. The normalized, factored, impact scores for global warming potential suggest that this impact category is reduced by using the alternative primer and spray gun, which is the result of a reduction in the emission of carbon tetrachloride, CO_2, and trichloroethane during manufacture of ingredients for the alternative versus baseline primer. There is also a reduction in the normalized, factored, impact score for natural resource use (e.g. fossil fuels, phosphate rock, and zinc) with use of the alternative primer and spray gun, associated with the decreased manufacture of intermediate materials.

The scores for the two relevant regional scale impact categories were lowest in the option involving the alternative primer and spray gun. There is a decrease in the normalized, factored, impact score for acid deposition potential with use of the alternative primer & gun, mainly due to a decrease in all acid deposition precursor emissions, resulting from decreased use rates of topcoat, primer, and thinner. There is also a decrease in the smog creation potential score with the use of the alternative primer and spray gun, mainly due to a decrease in release of total VOC emissions (chemical species not available) during manufacture of ingredients for the alternative versus baseline primer, as well as decreased use rates of topcoat, primer, and thinner associated with use of the alternative spray gun.

Of the three toxicity impact categories considered, human health and terrestrial wildlife toxicity impact potentials showed the greatest reduction for the option involving the alternative primer and spray gun. Aquatic biota toxicity, however, was lowest with the option involving the baseline primer and alternative spray gun. There is a decrease in the normalized, factored, impact score for human toxicity potential associated with the manufacture of intermediate materials for the alternative versus baseline primer, which is the result of a reduction in the emission of several toxic materials (e.g., acetaldehyde, n-butane, n-butyl acetate, chlorine, CO, ethylene dichloride, fluorine, isobutyraldehyde, MIAK, MIBK, and n-pentane) during manufacture of ingredients for the alternative primer or during drying of the primer after application. There is a decrease in the normalized, factored, impact score for terrestrial wildlife toxicity potential associated with the manufacture of intermediate materials for the alternative versus baseline primer, which is the result of a reduction in the emission of several toxic materials (e.g., n-heptane, isobutyraldehyde, and MIAK) during manufacture of ingredients for the alternative primer or during drying of the primer after application. Use of the alternative primer, even with the alternative gun, is worse than the baseline in the aquatic toxicity impact area. This is due to the increase in cadmium and chlorine in the wastewater associated with manufacture of the ingredients for the alternative primer. However, use of the alternative gun with the baseline primer gives the lowest potential impact score for aquatic biota.

The local scale impact of land use resulting from waste disposal shows the greatest reduction in potential impact score for two alternatives: the alternative gun and the alternative gun with alternative primer. This is associated with a reduction in the quantity of hazardous and nonhazardous waste from manufacturing of different ingredients for the alternative primer and from decreased use rates of topcoat, primer, and thinner resulting from use of the alternative spray gun.

6.2.2 Sensitivity Analysis

One of the considerations in conducting an LCA is the integration of the understanding of the uncertainties in the information with the results. In this case the uncertainties in the inventory data were overlaid with the possible uncertainties introduced in the impact assessment. To assess the possible consequences, if any, on the results of having missing or incorrect equivalency factors, a sensitivity analysis was performed. In this analysis, the details of which are provided in Appendix E, two value substitutions were made for the equivalency factors. One situation occurred where the baseline CARC system contained a specific chemical species, for example toluene, and the alternative formulation simply identified a chemical category, for example aromatic hydrocarbons. To test the effect of this on the impact scores, a worst case scenario consisting of selecting the most adverse equivalency factor appropriate to the impact category (ozone depletion, global warming, toxicity, etc.) was chosen and the modeling calculations repeated. The resulting values were then compared to the "expected" value and a percentage difference computed. Although large differences in any one environmental category could occur if this scenario were true, the overall environmental impact scores varied by an average of 5.4% with a range from 3.2% for Alternative 4 (alternative thinner) to 8.6% for Alternative 5 (alternative thinner and primer). Thus, the analyzed results are considered to be acceptable to within about 5 to 6% when the effect of factor specificity is concerned.

A second type of uncertainty arises if an equivalency factor is known for one component of the baseline system and completely unknown for a substitute. In this case the alternative could be favored simply because more adverse impacts were loading onto the baseline system. This situation did not occur for any constuents considered to contribute in significant mass quantities to the overall impact, but should be kept in mind in applying the valuation procedure in general.

A third type of uncertainty exists that was not evaluated directly. This uncertainty pertains to the variability in the equivalency factor themselves. For example, the basis for global warming equivalencies is the modeling of climatological effects of insertion of a known amount of a global warming gas into the atmosphere. The impact potential is followed by tracking its chemistry through time and integrating the incremental effect over periods of 20 to 500 years. Uncertainty exists in the models and the understanding of the basic chemistry. The overall magnitude of the uncertainties have been estimated by the international or regional bodies responsible for creating the equivalency factors. In a comparative analysis of this type the uncertainties would be expected to affect both the baseline and alternatives.

6.3 Economic Assessment

The estimated costs for CARC depainting and painting are summarized in Table 6-8. Fort Eustis costs are represented by the baseline cost. Costs for five alternative systems are also presented.

6.3.1 Fixed Capital Investment

The estimated baseline FCI, $516,000, was based on operations at Fort Eustis. A breakdown of the estimated FCI costs for CARC depainting and painting is shown in Table 6-9. Fort Eustis costs are represented by the baseline cost. Costs for five alternative systems are also presented.

Table 6-8. Estimated FCI, Annual Operating Cost, and Anualized Costs

	Baseline	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5
Fixed Capital Investment (FCI), $1000	516	516	548	548	516	516
Annual operating cost						
$1000/yr	1,797	1,788	1,574	1,565	1,797	1,787
$/1000 ft^2	2,903	2,888	2,542	2,928	2,901	2,885
Annualized cost						
$1000/yr	1,845	1,837	1,625	1,616	1,845	1,835
$/1000 ft^2	2,981	2,966	2,625	2,611	2,979	2,963

6.3.2 Annual Operating Cost

The estimated annual baseline operating cost, based on operations typical of Fort Eustis, is $1,797,000/yr. Details for the basecase and the five alternative systems are shown in Table 6-10.

6.3.3 Annualized Cost

The estimated baseline annualized cost, $1,797,000/yr, is the sum of the annual operating cost and amortization at Ft. Eustis. Annualized cost for the baseline case and five alternative systems are summarized in Table 6-11.

Table 6-9. Estimated Baseline Fixed Capital Investment

Cost Item	Baseline	Alt. 2	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Basis[a]
Purchased equipment	120,500	120,500	130,000	130,000	120,500	120,500	100% of PE
PE installation	54,225	54,225	58,500	58,500	54,225	54,225	45% of PE cost
Instrument and control	10,845	10,845	11,700	11,700	10,845	10,845	9% of PE cost
Piping	19,280	19,280	20,800	20,800	19,280	19,280	15% of PE cost
Electrical	12,050	12,050	13,000	13,000	12,050	12,050	10% of PE cost
Building	102,000	102,000	102,000	102,000	102,000	102,000	$43 per sq ft
Yard improvement	15,665	15,665	16,900	16,900	15,665	15,665	13% of PE cost
Service facilities	48,200	48,200	52,000	52,000	48,200	48,200	40% of PE cost
Land	0	0	0	0	0	0	
Total Direct Plant Cost	382,765	382,765	404,900	404,900	382,765	382,765	
Engineering and	39,765	39,765	42,900	42,900	39,765	39,765	33% of PE cost
Construction expense	46,995	46,995	50,700	50,700	46,995	46,995	39% of PE cost
Total Direct and Indirect	469,525	469,525	498,500	498,500	469,525	469,525	
Contractors fees	23,476	23,476	24,925	24,925	23,476	23,476	5% of direct
Contingency	23,476	23,476	24,925	24,925	23,476	23,476	5% of direct
Fixed Capital	516,478	516,478	548,350	548,350	516,478	516,478	

(a) Peters and Timmerhaus, 1991

Table 6-10. Estimated Annual Operating Cost

Cost Item	Baseline	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Basis
Raw Materials							
Basecase topcoat	111,456	111,456	81,586	81,586	111,456	111,456	$36/gal[a]
Basecase primer	26,316	0.00	26,316	0.00	26,316	0.00	$17/gal[a]
Alternative primer	0.00	22,727	0.00	22,727	0.00	22,727	$20.33/gal[a]
Basecase thinner	15,093	15,093	15,093	15,093	0.00	0.00	$15/gal[a]
Alternative thinner	0.00	0.00	0.00	0.00	15,093	15,093	$15/gal[a]
Depainting grit	7,992	7,992	7,992	7,992	7,992	7,992	$0.25/lb[a]
Utility							
Electricity	1,053	1,053	1,053	807	807	1,053	$0.06/kWhr
Labor							
Operating	683,700	682,410	597,700	596,410	683,700	682,410	$25/hr[b]
Maintenance	15,493	15,493	16,451	16,451	15,493	15,493	3% of FCI[c]
Supervision	102,555	102,363	89,655	89,462	102,555	102,362	15% of operating labor[c]
Operating Supplies	102,555	102,363	89,655	89,462	102,555	102,362	15% of operating labor[c]
Maintenance Supplies	20,657	20,657	20,657	20,657	20,657	20,657	4% of FCI[c]
Laboratory Charges	102,555	102,362	89,655	89,462	102,555	102,362	15% of operating labor[c]
Plant Overhead	481,049	480,159	422,283	421,393	481,049	480,159	60% of operating/ maintenance labor[c]

Table 6-10. Estimated Annual Operating Costs (continued)

Cost Item	Baseline	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Basis
Waste Disposal							
Topcoat applied with HVLP gun	3,095	3,095			3,095	3,095	$10/gal[b]
Topcoat applied with improved gun			2,064	2,064			
BP primer	1,829		1,829		1,829		$10/gal[b]
AP primer		1,829		1,829			
Painting materials	4,924	4,924	3,893	3,893	4,924	3,095	100% of paint/primer disposal costs[b]
Abrasive	42,904	42,904	42,904	42,904	42,904	42,904	$0.58/lb[a]
Insurance	5,165	5,165	5,484	5,484	5,165	5,165	1% of FC[c]I
Regulatory Compliance	68,370	68,241	59,770	59,641	68,370	68,241	10% of operating labor[c]
Total Annual Operating Costs	1,796,760	1,788,453	1,574,039	1,565,488	1,796,516	1,786,624	
per painted area	2,703	2,888	2,542	2,928	2,901	2,885	per 1,000 ft^2
Capital amortization	48,369	48,369	51,358	51,358	48,369	48,369	9.37% FCI (11 yrs service @ 6%)
per painted area	78	78	83	83	78	78	per 1,000 ft^2
Total cost	1,845,129	1,836,822	1,625,397	1,616,846	1,844,855	1,834,993	
per painted area	2,981	2,966	2,625	2,611	2,979	2,963	per 1,000 ft^2

(a) See Table 6 for basis references.
(b) Assumed based on standard values/practices.
(c) Peters and Timmerhaus, 1991.

Table 6-11. Annualized Cost

Cost Element	Baseline	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5
Annual operating cost:						
\$1000/yr	1,797	1,788	1,974	1,565	1,797	1,787
\$/1000 ft^2	2,903	2,888	2,542	2,928	2,901	2,885
Amortization:						
\$1000/yr	48	48	51	51	48	48
\$/1000 ft^2	78	78	83	83	78	78
Annualized cost:						
\$1000/yr	1,845	1,837	1,625	1,616	1,845	1,835
\$/1000 ft^2	2,981	2,966	2,025	2,611	2,979	2,963

6.4 Performance Evaluation

Descriptions of the scoring ranks for each of the performance evaluation parameters were provided in Section 4.

6.4.1 Application Equipment

The Can-am system was reviewed independently and was found to provide a transfer efficiency of 90%, while maintaining acceptable surface quality. This is an increase in transfer efficiency of approximately 38%. The surface characteristics of the topcoat were found to be acceptable. It is being or has been used at several bases including Tobyhanna. Training for use of the alternative is believed to be minimal (< one day per man). However, due to some equipment failures at Tobyhanna they have not been able to completely rely on this system. There is insufficient supplemental information to determine if equipment failure is a point of major consideration.

The substantial improvement in transfer efficiency without noticeable loss in surface quality make the turbine HVLP system, or similar increased efficiency systems, appropriate for recommendation based on performance.

Surface Quality

Baseline — Acceptable (Martin, 1995; Miller, 1995; Hughes Aircraft Company, 1991 as reported in Cavendar et al., 1994)
Rating: 2

Alternative — Acceptable (Tierney, 1995; Hughes Aircraft Company, 1991 as reported in Cavendar et al., 1994)
Rating: 2

Transfer Efficiency (TE)

Baseline — T.E= 65% (Martin, 1995; Miller, 1995; Hughes Aircraft Company, 1991 as reported in Cavendar et al., 1994)
Rating: 2

Alternative T.E. = 90% (Tierney, 1995; Hughes Aircraft Company, 1991 as reported in Cavendar et al., 1994, Bunnell, 1995)
Rating: 4

Ranking Delta
Surface Quality: 0 weight = 2
Transfer Efficiency: 2 weight = 1
Total after weighting: (2*0+1*2)/3 = +2/3

6.4.2 Primers

The performance of the two primers (Baseline MIL-P-53022, Niles; Alternative MIL-P-53030, Deft) was viewed differently by different sources. Some users (Miller, 1995) expressed concern about adhesion between the primer and the topcoat, while others were not aware of this as a significant concern (Ewalt, 1995). It is not clear as to why there were occasional primer-topcoat adhesion problems. However, it is likely that different environmental conditions had some impact. Most paints, including primers, react differently to varying environmental conditions. One primer might perform better than a second primer when applied in a cool dry environment, but fail dramatically when applied under hot, humid conditions. Efforts to contact additional users (Ft. Hood: Chief Warrant Officer Ferrell, Sgt. Abrahamson and others) of both primers were unsuccessful due to their commitments. Further collection of opinions may have provided useful information, but could not be accomplished at this time.

Using the water thinnable alternative may require some minimal changes in application procedures, such as longer wait times between coats. This is needed because water used to thin the primer must evaporate before the topcoat is applied. Presence of water in the primer could cause premature curing of the topcoat and an inferior bond. Also, since the alternative primer is moisture thinnable, it is likely that under humid conditions it would absorb environmental moisture which would extend the wait time before the topcoat could be applied.

To appropriately analyze the effectiveness of the baseline and the alternative primer, a blind side-by-side comparison on similar targets under a range of temperature and humidity conditions should be made. Small test panels could be painted with both of the primers and a topcoat. The manufacturers' application recommendations should be strictly followed. If the adhesion between the two primers does not vary, then the improved ease of cleanup using water does make the alternative primer appropriate for recommendation based upon performance factors.

Effect of Temperature and Humidity
Baseline Rating: 3, minimal impact not seen as having practical significance (Miller,1995; Duncan, 1995)

Alternative Rating: 2.5, a range of opinions describe the level of impact as a 2 and a 3 depending on the source (Miller, 1995; Duncan,1995, Ewalt,1995)

Cure Rate
Baseline Rating: 3, cure rate had minimal effect on the painting schedule (Hale, 1995; Miller,1995)

Alternative Rating: 3, cure rate had minimal effect on the painting schedule (Miller,1995; Duncan, 1995; Ewalt, 1995)

Surface Pretreatment Requirements

Baseline Rating: 2, minimal cleaning with solvent rag required (Hale, 1995; Miller, 1995)

Alternative Rating: 2, minimal cleaning with solvent rag required (Miller, 1995; Duncan, 1995; Ewalt, 1995)

Ease of Primer Cleanup

Baseline Rating: 2, moderate effort required for cleanup (Hale, 1995; Miller, 1995)

Alternative Rating: 3, minimal effort required for cleanup (Miller, 1995, Duncan, 1995, Ewalt, 1995)

Ranking Delta

Effect of Temperature and Humidity: weight = 3
Cure Rate: weight = 1
Surface Pretreatment Requirements: weight = 1
Ease of Primer Cleanup: weight = 1
Total after weighting: (3*(-0.5)+1*0+1*0+1*0)/6 = -0.25.

6.4.3 Thinners

The performance of the two thinners (Baseline: Mil-T-81772B; Alternative: Federal Standard A-A-857B) varied from user to user. The effects of environmental differences are again believed to be the reason for differences in performance opinions. Differences in the ability to thin the topcoat were not discernable. However, the effect on the surface characteristics of the topcoat was noticeable. The effect of the thinner on the appearance and performance of the topcoat needs to be evaluated by each base to determine the impact on the topcoat for their specific conditions. The amount of thinner required is not expected to be affected dramatically by the selection of either of the two thinners.

Even if the alternative thinner is found to be unacceptable for use with the topcoat it should be considered for use in cleaning of the guns and hoses. Since, the thinning effectiveness of the two thinners is similar, the alternative can be recommended for use as a cleaning solvent at a minimum based on performance. The use of the thinner in conjunction with the topcoat needs to be determined on a base by base comparison.

Thinning Ratio or Thinner Effectiveness

Baseline 4:1 ratio for CARC: Thinner (Woody, 1995; Miller, 1995)
Rating: 2

Alternative 4:1 ratio for CARC: Thinner (Woody, 1995; Miller, 1995)
Rating: 2

Film Characteristics

Rating: 3, minimal blemishes not believed significant (Woody, 1995; Miller, 1995)

Rating: 2.5, a range of opinions make describe the level of impact as a 2 and a 3 depending on the source (Woody, 1995; Miller,1995)

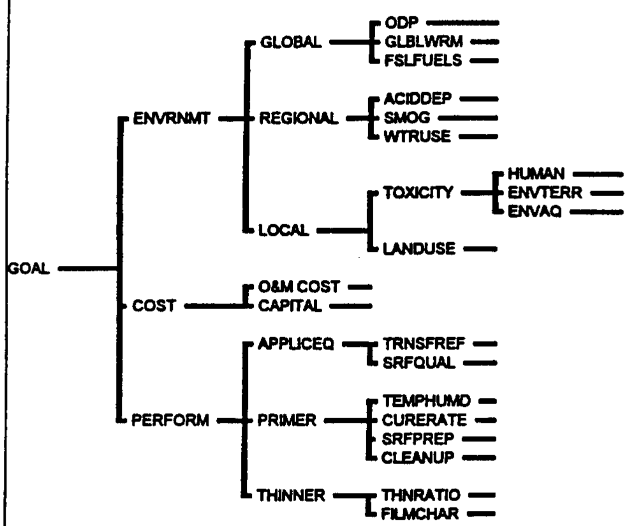
Ranking Delta

Effectiveness: weight = 1
Film Characteristics: weight = 1
Total after weighting: (1*0+1*(-0.5))/2 = -0.25.

6.5 Valuation Process

The valuation process was conducted in a step-wise fashion, beginning with the construction of the hierarchy tree and continuing with the environmental, cost, and performance weighting, respectively. The "final" decision hierarchy is shown in Figure 6-4. The term "final" in quotes is used to ensure that the reader understands that the structure of the hierarchy is determined by the analyst and the technical team. There is no single correct hierarchy, only decision structures that appear to make sense in analyzing the weights to be assigned. Each of the three major decision dimensions, environment, cost, and performance, are shown at the topmost level of the hierarchy. In turn these are further divided according to criteria and subcriteria within each of the areas. The environmental criteria are first grouped by spatial/temporal scales into global (long term), regional (intermediate term), and local (short to intermediate) term issues.

This arrangement provides a useful framework for consideration of elements that would be important at the facility versus larger, national to societal levels. Within the global, regional and local criteria, further subdivision is made to facilitate assigning preferences in an intuitive manner. Within the cost dimension, only two criteria were identified, corresponding to the variable (O&M) versus fixed (capitalized) cost categories. Further breakdown within each of these criteria was not felt to offer additional potential for assignment of the weights. Finally, the performance dimension criteria were divided according to the application equipment, primer, or thinner component and then further into specific performance subcriteria relevant to each component.



Abbreviation	Definition
ACIDDEP	Acidic Materials Deposition
APPLICEQ	Relative performance of equipment for applying CARC
CAPITAL	Annualized (6 yr amort) cost of facilities and capital equipment
CARCOPT	Choose best CARC option
CLEANUP	Amount of effort needed for cleanup
COST	Direct cost elements (excludes externalities)
CURERATE	Effect of primer cure rate on schedule
CURERTE	Effect of primer cure rate on schedule
ENVAQ	Aquatic toxicity metrics
ENVRNMT	Environmental issues associated with CARC system
ENVTERR	Terrestrial toxicity metrics
FILMCHAR	Effect of thinner on surface quality e.g. blemishes
FSLFUELS	Depletion of Fossil Fuels
GLBLWRM	Global Warming Potential
GLOBAL	Global Level Impacts
HUMAN	Various measures of human health toxicity
LANDUSE	Area of land "consumed"
LOCAL	Local Scale Impacts
O&M COST	Annualized o&m costs including materials
ODP	Ozone Depletion Potential
PERFORM	Aspects of material/system functional behavior/efficiency
PRIMER	Performance characteristics of primer systems
REGIONAL	Regional to National Scale Impacts
SMOG	Photochemical Smog Formation Potential
SRFPREP	Extent of surface treatment needed
SRFQUAL	Effect of application equipment on surface quality
TEMPHUMD	Effect of temperature and humidity on primer system
THINNER	Performance characteristics of thinner systems
THNRATIO	Need for thinning prior to use
Toxicity	Lethal or Chronic Toxicity Effects
TRNSFREF	Application efficiency of equipment used
WTRUSE	Water Consumption

Figure 6-4. Structure of the analytic hierarchy for CARC alternatives.

The results of the weighting exercise assigned 65% of the value to the environmental dimension, 24% to the performance aspects, and 11% to the cost (Figure 6-5). This result should be viewed in the light of the scoping process where the threshold criteria were anticipated to result in alternatives that performed adequately and did not differ markedly in cost. Further tracing the weighting process into the three major branches indicates that global environmental issues were assigned approximately 32% of weight, or about half of the overall environmental contribution. Regional and local issues received 20% and 13%, respectively. In the cost branch, the O&M costs were considered approximately 3 times as important as the capital costs. Again, it should be borne in mind that the scoping exercise almost guaranteed that none of the alternatives would require and major capital expenditure. Finally, in the performance branch the primer was considered the most important with the thinner and gun receiving about equal consideration.

In each case the procedure for applying the valuation process to the impact assessment results was to create a "ruler" by normalizing the baseline impact scores to the highest value in each category. Then, the values for an alternative could be measured relative to that score. This produces a set of values that is internally consistent to the decision being made, but neither guarantees the metric is theoretically as robust as possible (i.e., its ability to differentiate alternatives in principle could be greater) nor allows decisions made in one setting to be compared to those made in another. As an example, recommendations made regarding CARC alternatives in this effort would not be comparable to those made about procuring plating equipment if that decision was made using a set of normalizing factors derived as part of that decision process.

6.6 Overall Improvement Assessment Results

The application of the valuation weights to the normalized impact scores is summarized in Tables 6-12 through 6-17 for the baseline and each of the alternatives. The score summaries (lower is preferable) are shown below in decreasing order:

Baseline:	1.191
Alternative Thinner:	1.134 (Alternative 4)
Alternative Primer:	1.019 (Alternative 1)
Alternative Thinner and Primer:	1.016 (Alternative 5)
Alternative Gun:	1.006 (Alternative 2)
Alternative Primer and Gun:	0.898 (Alternative 3).

These results indicate that the use of the alternative gun makes the largest potential improvement for an alternative that changes only a single factor, and combining this with the alternative primer results in the best CARC option. Therefore, it is recommended that the next phase of the effort include the demonstration of the alternative primer and gun combination. Also, a further scenario consisting of the alternative thinner, primer, and gun should be analyzed to assess whether this combination may be even better than the primer/gun combination.

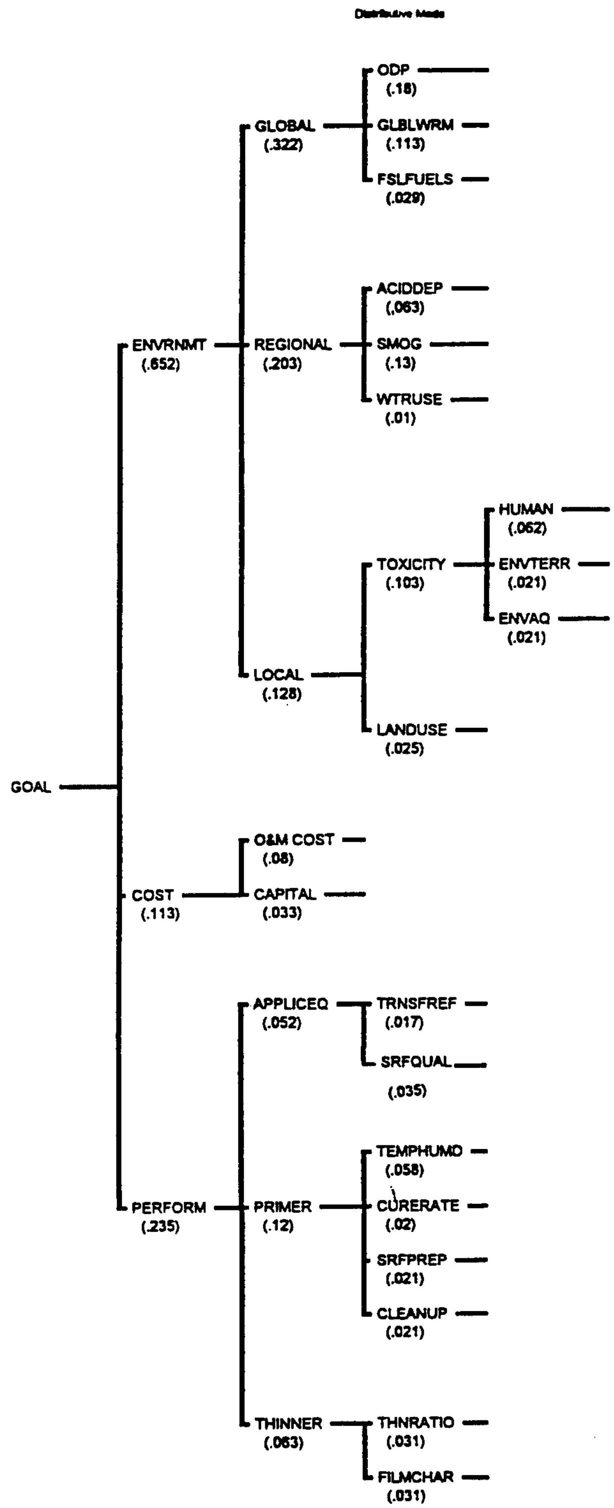


Figure 6-5. Overall weights derived for the valuation of CARC alternatives

Table 6-12. Life Cycle Impact Valuation Calculations for Baseline

Scale	Issues ------->			AHP Weighting Factor	Normalized Factored Score	Weighted Normalized Factored Score			Baseline Score
CARCOPT									1.191
	GLOBAL							0.347	
		ODP		0.17983	1.090		0.196		
		GLBLWRM		0.11328	1.013		0.115		
		FSLFUELS		0.02855	1.263		0.036		
	REGIONAL							0.220	
		ACIDDEP		0.06253	1.198		0.075		
		SMOG		0.13007	1.114		0.145		
		WTRUSE		0.01002			0.000		
	LOCAL							0.276	
		TOXICITY					0.237		
			HUMAN	0.06155	2.150	0.132			
			ENVTERR	0.02052	3.799	0.078			
			ENVAQ	0.02052	1.280	0.026			
		LANDUSE		0.02507	1.577		0.040		
	COST							0.113	
		O&M COST		0.08027	1.000		0.080		
		CAPITAL		0.03274	1.000		0.033		
	PERFORM							0.235	
		APPLICEQ					0.052		
			TRNSFRE	0.01713	1.000	0.017			
			SRFQUAL	0.03522	1.000	0.035			
		PRIMER					0.120		
			TEMPHUM	0.05841	1.000	0.058			
			CURERAT	0.02013	1.000	0.020			
			SRFPREP	0.02072	1.000	0.021			
			CLEANUP	0.02057	1.000	0.021			
		THINNER					0.063		
			THNRATIO	0.03144	1.000	0.031			
			FILMCHAR	0.03144	1.000	0.031			

Table 6-13. Life Cycle Impact Valuation Calculations for Alternative Primer

Scale	Issues ------->		AHP Weighting Factor	Normalized Factored Score	Weighted Normalized Factored Score			Alternative No. 1 Score
CARCOPT								1.019
GLOBAL							0.203	
	ODP		0.17983	0.367		0.066		
	GLBLWRM		0.11328	0.927		0.105		
	FSLFUELS		0.02855	1.121		0.032		
REGIONAL							0.203	
	ACIDDEP		0.06253	1.173		0.073		
	SMOG		0.13007	0.993		0.129		
	WTRUSE		0.01002			0.000		
LOCAL							0.266	
	TOXICITY					0.226		
		HUMAN	0.06155	1.612	0.099			
		ENVTERR	0.02052	2.635	0.054			
		ENVAQ	0.02052	3.537	0.073			
	LANDUSE		0.02507	1.585		0.040		
COST							0.113	
	O&M COST		0.08027	0.995		0.080		
	CAPITAL		0.03274	1.000		0.033		
PERFORM							0.236	
	APPLICEQ					0.052		
		TRNSFRE	0.01713	1.000	0.017			
		SRFQUAL	0.03522	1.000	0.035			
	PRIMER					0.120		
		TEMPHUM	0.05841	0.833	0.049			
		CURERAT	0.02013	1.000	0.020			
		SRFPREP	0.02072	1.000	0.021			
		CLEANUP	0.02057	1.500	0.031			
	THINNER					0.063		
		THNRATIO	0.03144	1.000	0.031			
		FILMCHAR	0.03144	1.000	0.031			

Table 6-14. Life Cycle Impact Valuation Calculations for Alternative Gun

Scale	Issues ------->		AHP Weighting Factor	Normalized Factored Score	Weighted Normalized Factored Score			Alternative No. 2 Score
CARCOPT								1.006
GLOBAL							0.254	
	ODP		0.17983	0.799		0.144		
	GLBLWRM		0.11328	0.739		0.084		
	FSLFUELS		0.02855	0.929		0.027		
REGIONAL							0.174	
	ACIDDEP		0.06253	1.116		0.070		
	SMOG		0.13007	0.800		0.104		
	WTRUSE		0.01002			0.000		
LOCAL							0.202	
	TOXICITY					0.165		
		HUMAN	0.06155	1.510	0.093			
		ENVTERR	0.02052	2.565	0.053			
		ENVAQ	0.02052	0.925	0.019			
	LANDUSE		0.02507	1.493		0.037		
COST							0.105	
	O&M COST		0.08027	0.876		0.070		
	CAPITAL		0.03274	1.064		0.035		
PERFORM							0.271	
	APPLICEQ					0.088		
		TRNSFRE	0.01713	1.000	0.017			
		SRFQUAL	0.03522	2.000	0.070			
	PRIMER					0.120		
		TEMPHUM	0.05841	0.833	0.049			
		CURERAT	0.02013	1.000	0.020			
		SRFPREP	0.02072	1.000	0.021			
		CLEANUP	0.02057	1.500	0.031			
	THINNER					0.063		
		THNRATIO	0.03144	1.000	0.031			
		FILMCHAR	0.03144	1.000	0.031			

Table 6-15. Life Cycle Impact Valuation Calculations for Alternative Primer and Gun

Scale	Issues ------->		AHP Weighting Factor	Normalized Factored Score	Weighted Normalized Factored Score			Alternative No. 3 Score
CARCOPT								0.898
GLOBAL							0.148	
	ODP		0.17983	0.265		0.048		
	GLBLWRM		0.11328	0.677		0.077		
	FSLFUELS		0.02855	0.827		0.024		
REGIONAL							0.162	
	ACIDDEP		0.06253	1.098		0.069		
	SMOG		0.13007	0.721		0.094		
	WTRUSE		0.01002			0.000		
LOCAL							0.201	
	TOXICITY					0.164		
		HUMAN	0.06155	1.172	0.072			
		ENVTERR	0.02052	1.906	0.039			
		ENVAQ	0.02052	2.554	0.052			
	LANDUSE		0.02507	1.497		0.038		
COST							0.116	
	O&M COST		0.08027	1.009		0.081		
	CAPITAL		0.03274	1.064		0.035		
PERFORM							0.271	
	APPLICEQ					0.088		
		TRNSFRE	0.01713	1.000	0.017			
		SRFQUAL	0.03522	2.000	0.070			
	PRIMER					0.120		
		TEMPHUM	0.05841	0.833	0.049			
		CURERAT	0.02013	1.000	0.020			
		SRFPREP	0.02072	1.000	0.021			
		CLEANUP	0.02057	1.500	0.031			
	THINNER					0.063		
		THNRATIO	0.03144	1.000	0.031			
		FILMCHAR	0.03144	1.000	0.031			

Table 6-16. Life Cycle Impact Valuation Calculations for Alternative Thinner

Scale	Issues ------->		AHP Weighting Factor	Normalized Factored Score	Weighted Normalized Factored Score			Alternative No. 4 Score
CARCOPT								1.134
GLOBAL							0.334	
	ODP		0.17983	1.106		0.199		
	GLBLWRM		0.11328	0.905		0.103		
	FSLFUELS		0.02855	1.133		0.032		
REGIONAL							0.209	
	ACIDDEP		0.06253	1.187		0.074		
	SMOG		0.13007	1.035		0.135		
	WTRUSE		0.01002			0.000		
LOCAL							0.249	
	TOXICITY					0.209		
		HUMAN	0.06155	1.997	0.123			
		ENVTERR	0.02052	2.918	0.060			
		ENVAQ	0.02052	1.279	0.026			
	LANDUSE		0.02507	1.577		0.040		
COST							0.113	
	O&M COST		0.08027	0.999		0.080		
	CAPITAL		0.03274	1.000		0.033		
PERFORM							0.230	
	APPLICEQ					0.052		
		TRNSFRE	0.01713	1.000	0.017			
		SRFQUAL	0.03522	1.000	0.035			
	PRIMER					0.120		
		TEMPHUM	0.05841	1.000	0.058			
		CURERAT	0.02013	1.000	0.020			
		SRFPREP	0.02072	1.000	0.021			
		CLEANUP	0.02057	1.000	0.021			
	THINNER					0.058		
		THNRATIO	0.03144	1.000	0.031			
		FILMCHAR	0.03144	0.833	0.026			

Table 6-17. Life Cycle Impact Valuation Calculations for Alternative Primer and Thinner

Scale	Issues ------->			AHP Weighting Factor	Normalized Factored Score	Weighted Normalized Factored Score			Alternative No. 5 Score
CARCOPT									1.016
	GLOBAL							0.198	
		ODP		0.17983	0.367		0.066		
		GLBLWRM		0.11328	0.893		0.101		
		FSLFUELS		0.02855	1.086		0.031		
	REGIONAL							0.202	
		ACIDDEP		0.06253	1.168		0.073		
		SMOG		0.13007	0.989		0.129		
		WTRUSE		0.01002			0.000		
	LOCAL							0.274	
		TOXICITY					0.234		
			HUMAN	0.06155	1.700	0.105			
			ENVTERR	0.02052	2.767	0.057			
			ENVAQ	0.02052	3.538	0.073			
		LANDUSE		0.02507	1.585		0.040		
	COST							0.113	
		O&M COST		0.08027	0.994		0.080		
		CAPITAL		0.03274	1.000		0.033		
	PERFORM							0.230	
		APPLICEQ					0.052		
			TRNSFRE	0.01713	1.000	0.017			
			SRFQUAL	0.03522	1.000	0.035			
		PRIMER					0.120		
			TEMPHUM	0.05841	0.833	0.049			
			CURERAT	0.02013	1.000	0.020			
			SRFPREP	0.02072	1.000	0.021			
			CLEANUP	0.02057	1.500	0.031			
		THINNER					0.058		
			THNRATIO	0.03144	1.000	0.031			
			FILMCHAR	0.03144	0.833	0.026			

7.0 Implementation Plan

Previous sections have developed information on the environmental, cost, and performance aspects of five alternative CARC systems and combined this information through the use of a valuation process to provide an overall prioritization of the screened options. The results indicated that certain of the options provide significantly lower environmental hazard potential with minimal impact on cost and no discernable performance impairment. However, in order to implement the findings, there may be non-technical and non-economic issues to be dealt with. These areas include a lack of demonstrated application of the alternative in actual production operations, considerations relating to procurement practices of either materials or capital, and any incremental training of operators to use and properly dispose of the alternative equipment and materials. This section addresses these types of considerations.

7.1 Performance Demonstration

Performance demonstration refers to the actual painting of vehicles using the alternative system(s). Although the constraints established during the scoping exercise should be sufficient to ensure a reasonably high probability of success in implementing the alternative gun and/or primer system, it will likely be necessary to demonstrate their effectiveness prior to widespread adoption by the Army.

7.1.1 Application Equipment

The manufacturer should be able to recommend and demonstrate the necessary gun, nozzle, tip, and pressures for optimum coating with minimal thinning of all used coatings (primer and topcoat along with other non-CARC related coatings). Some manufacturers demonstrate the capabilities of a piece of equipment with a generic paint that highlights the optimum range of the equipment. Therefore, it is advisable that the manufacturer is instructed that the equipment will not be purchased without a demonstration of its use with the paints that are to be applied. Issues such as power and space requirements should also be discussed at this time. Any necessary modifications to the analysis should be incorporated before a final decison is made.

7.1.2 Primer

The major issue of the alternative primer is adhesion to the CARC topcoat. The level of adhesion between the primer and the topcoat can be influenced both by local environmental conditions and variations in topcoats amongst the different manufacturers. To determine local influences, the currently used primer and the alternative primer should be applied to test panels according to the manufacturer's recommendations. Topcoats should then be applied over the primers. Once the topcoat has been applied and allowed to cure, a cross-hatch adhesion test (ASTM D3359) should be used to check for adhesion between the primer and the topcoat. This procedure should be repeated periodically to test for the effects of changing environmental conditions. If any negative effects are noticed, then the temperature and humidity conditions should be noted along with any other changes in procedures that may have occurred. If the primer is found to perform poorly under certain conditions, then it may need to be limited to seasonal use. Again, any implications of this should be factored back into the analysis.

7.1.3 Thinner

A purchase of one gallon of the alternative thinner can easily be used for a performance evaluation. The thinner should be added to the CARC topcoat material until sprayable viscosity is achieved. The thinned topcoat should then be applied to a primed test panel. The surface should then be visually compared to a surface topcoated using the baseline thinner or currently used thinner. This procedure should also be repeated periodically to test for influences of changes in environmental conditions.

Comparisons of the change in viscosity of the currently used CARC topcoat due to equal additions of baseline or alternative thinner can also be measured. Typically, the difference in the effect on viscosity has not been noticeable. However, variations in topcoat formulations between manufacturers may result in more significant differences in thinner effectiveness. It is unlikely that the amount of alternative thinner will be measurably higher than that of the baseline. However, based on the foregoing analysis, if the amount of alternative thinner required is more than a modest percentage greater than that of the baseline, it will no longer provide a detectable advantage in terms of an environmental benefit.

7.2 Procurement Considerations

This implementation issue area addresses two considerations. One, if the alternative involves a capital item acquisition, it would be desirable to explore what steps might be necessary to justify its purchase and also to understand who would make the decision, particularly when the painting operations may not be performed by Army personnel. Second, if the materials used are not those currently being procured, it should be questioned how much of an issue it would be to change the procurement specification, especially if the initial cost is higher. Responses to these questions from the base personnel were used to formulate the information provided below. It should be noted that an exhaustive survey was not performed. It is possible that some locations may have more stringent requirements than those cited. However, the information presented is believed to be reasonably representative.

7.2.1 Application Equipment

The acquisition of a turbine HVLP system should require no approval beyond acceptance of the item managers involved. The item managers for the painted targets have the ultimate approval for how an item is painted. However, as long as the coated parts meet quality standards, the specific components or methods used are generally not an issue. Therefore, once the alternatives have been found acceptable via the performance demonstration, there should not be additional approval requirements.

The purchase price of a turbine system (approximately $20,000 for four guns and a turbine) is significantly more than that of traditional HVLP equipment and thus merits additional considerations. This price and the presence of some information suggesting possible reliability problems may justify requesting or requiring a lease option. A lease would allow for the investigation of new equipment as it becomes available. Due to the competitive nature of the equipment manufacturers market, it is likely that other, less expensive equivalent turbine systems will be marketed in the next few years. Also, a service agreement which includes next day loaner equipment might prove invaluable, since the occurrence of downtime at key periods cannot be accepted.

7.2.2 Primers and Thinners

The primer and the thinner should also require no approval beyond the acceptance of the item managers. This acceptance should be received after the two alternatives have passed the performance demonstrations. Since both the alternative thinner and primers are either Military-Specified or Federal-Standard-Approved, they should be obtainable through the standard procurement channels. The Federal Stock Classes (FSCs), National Item Identification Number

(NIINs), manufacturer's CAGE numbers and Part Name/Number of the materials reviewed are available in the MSDSs provided.

7.3 Training Requirements

7.3.1 Application Equipment

The alternative application equipment, the Can-am turbine HVLP system, has been used at several locations and found to require only a few hours per man of familiarization. Safety concerns should be similar to those of standard HVLP equipment with the additional concerns of slightly larger air lines and the turbine itself. However, a demonstration by the manufacturer which includes discussions of safety and technique issues should still be utilized.

7.3.2 Primers and Thinners

There are no known new special handling requirements or training issues associated with the alternative primer or the alternative thinner. The same safety methods that are used for the current baselines should be followed. MSDS sheets should be read by each user and special consideration should be taken in the case of users who have sensitivities to certain chemicals. The primer is an amine-cured epoxy like the baseline and these systems have been associated with increased sensitivity among some users over time. The differences in the manufacturing of the alternative epoxy-amine system may have an effect on the rate of sensitization.

Some minor alterations in the application equipment's setup may be required to achieve optimum performance for the alternatively thinned topcoat and the alternative primer. The primer may also require slightly different application thicknesses or drying times between recoats. This information is available from the manufacturers. Finally, the thinner might change the curing rate of the topcoat and minor changes in scheduling may be required.

8.0 Conclusions

The analysis undertaken during the study leads to conclusions in two areas:, LCImA methodology and specific findings of the CARC case study. In the former, the results of the effort indicate:

- an LCA-based methodology for DfE is viable and leads to both broader and more cohesive insights into the tradeoffs among decision elements,

- the use of a valuation methodology, although not essential, makes it easier for the decision maker to identifiy preferred alternatives,

- aspects of the LCImA methodology are still limited in two ways; one, the analytic framework associated with the impact characterization could benefit from additional refinement efforts relative to the normalization step and two, there are data gaps and deficiencies in both the inventory and the impact assessment that must be carefully assessed before conclusions are drawn,

- the DfE approach, while applicable to the development of processes/procedures and their implementation, likely would fit better with a true LCA-based design exercise for a product.

In the area of application to the CARC case study, the following conclusions are drawn:

- the LCImA effort provided an excellent framework for the analysis -- CARC specialists, cost engineers, and environmental scientists were able to coherently address and integrate the various aspects of their work into a combined analysis that clearly identifies the tradeoffs involved,

- of the five alternatives considered, two of them (alternative gun and a combination of alternative primer and gun) demonstrate the potential for clear environmental improvement; the remaining three exhibit slight improvements that are not significant within the uncertainty of the analysis,

- when cost and performance are considered simultaneously with environment, the same two alternatives emerge as the preferred candidates for implementation but the degree of differentiation relative to the baseline is less. This may be understood in the light of the valuation process which assigns a level of influence in the final analysis to each of the three improvement assessment dimensions. When considered alone, environmental factors obviously exert all of the differentiating ability. When cost and performance considerations are added, the nature of the scoping process in this application limited the alternatives to those that were not expected to be strongly differentiable on these two dimensions. Thus, when the combined influence ascribed to these factors (35%) is considered, the overall differentiation magnitude is decreased. Nevertheless, Alternative 3 (primer and gun) still clearly emerges as the recommended implementation choice followed by Alternative 2 (gun only).

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APPENDIX A
PROCESS FLOW DIAGRAMS

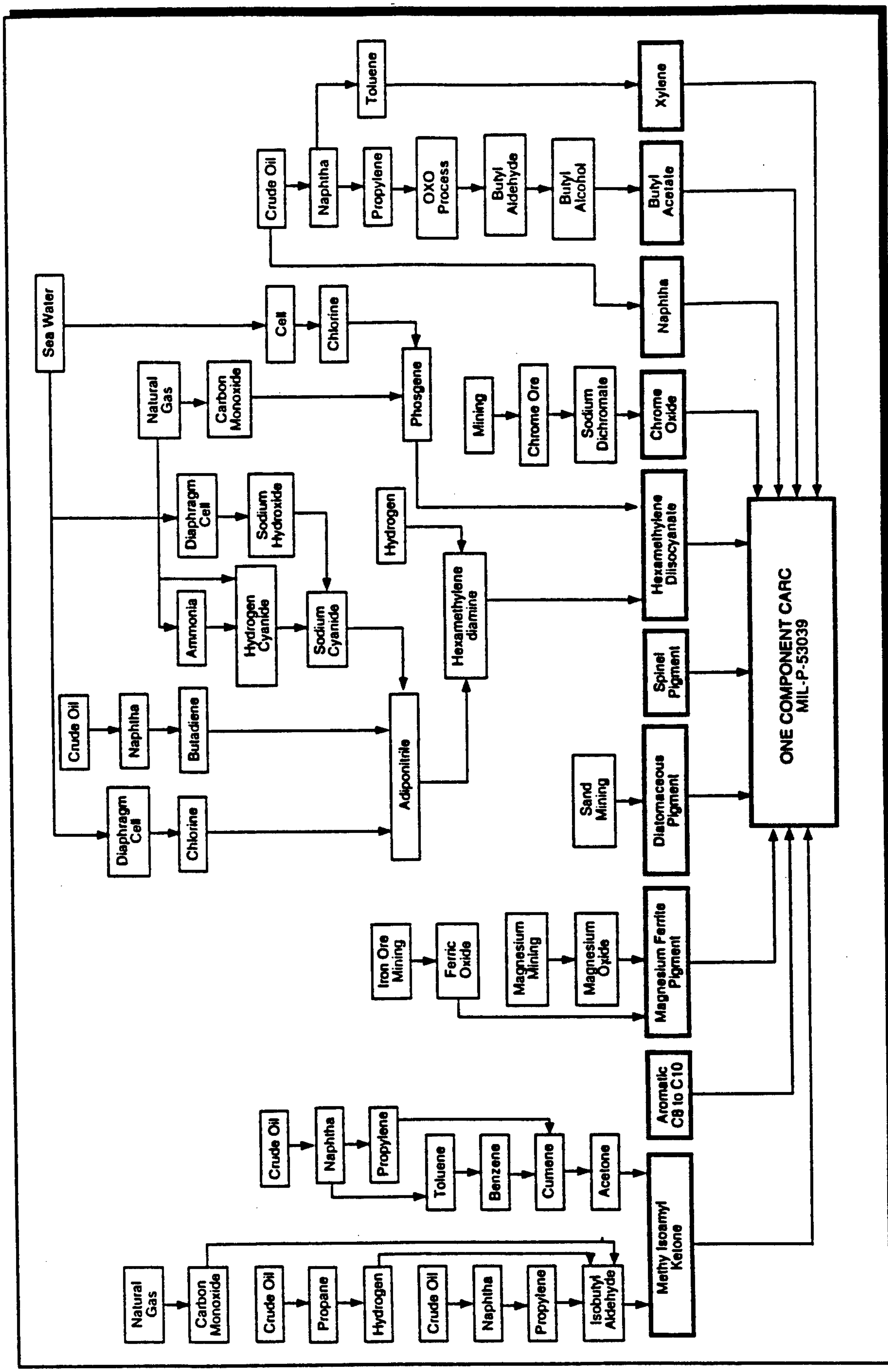

Figure A-1. Process flowsheet for one-component CARC

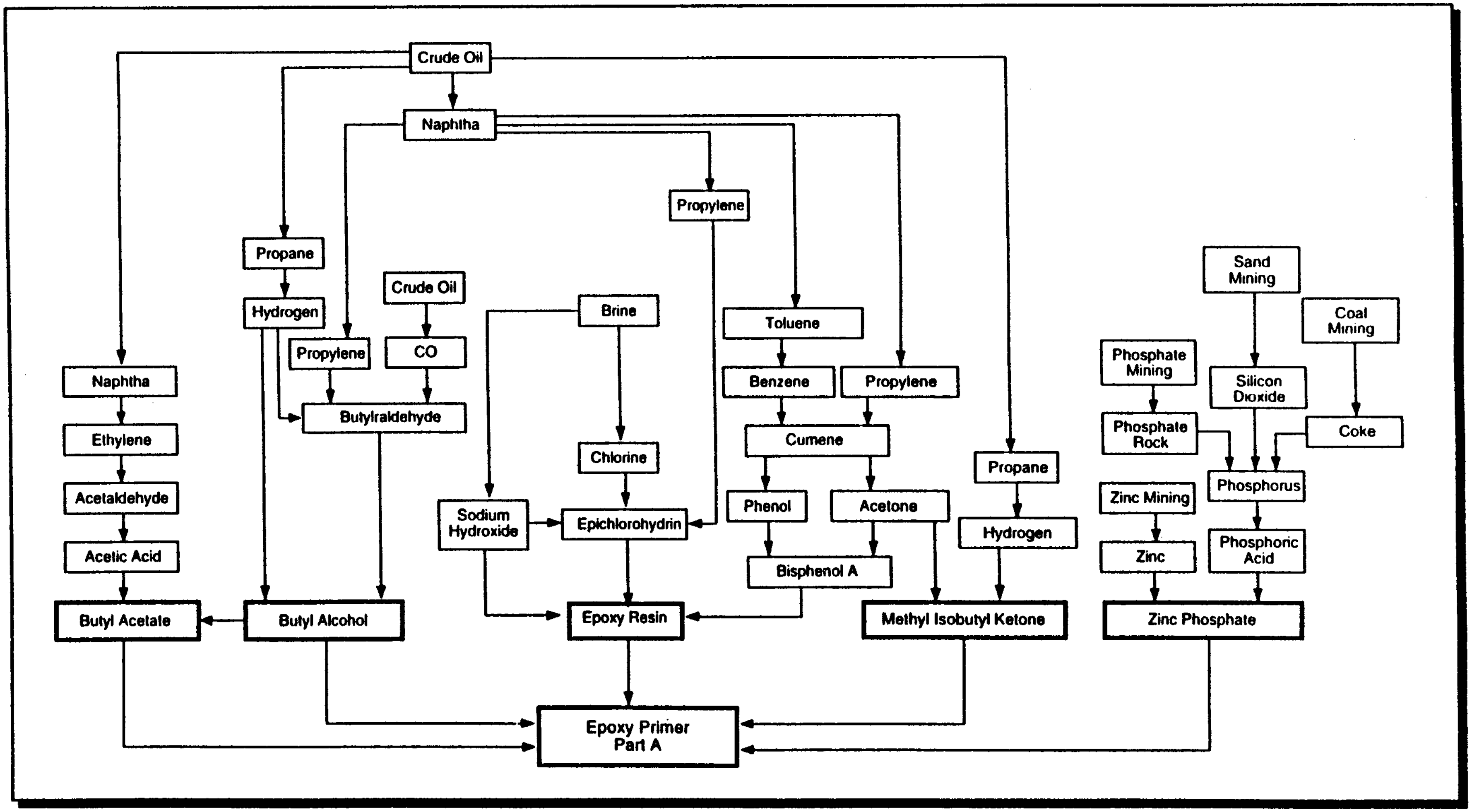

Figure A-2. Process flowsheet for Part A, baseline primer

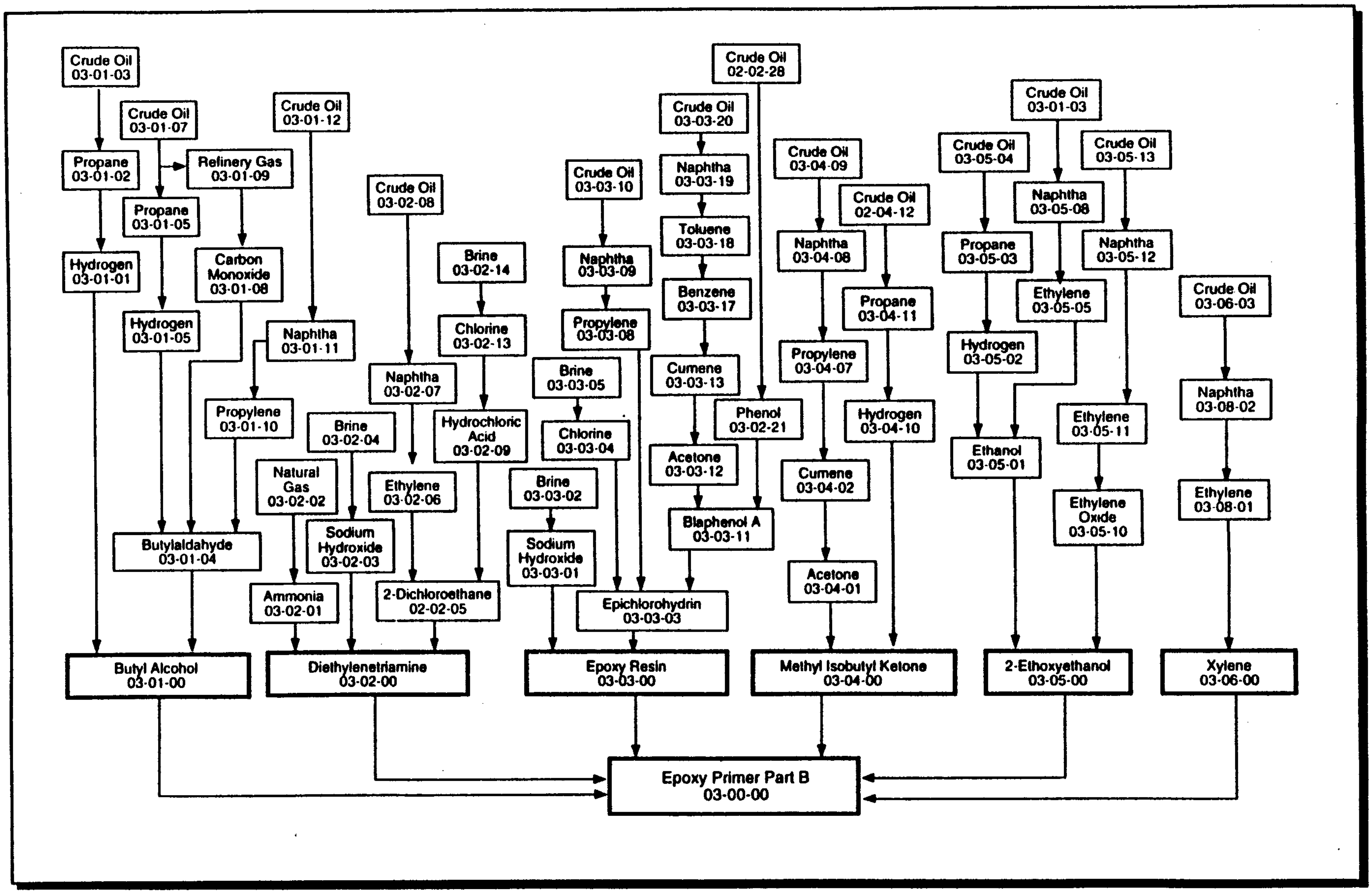

Figure A-3. Process flowsheet for Part B, baseline primer

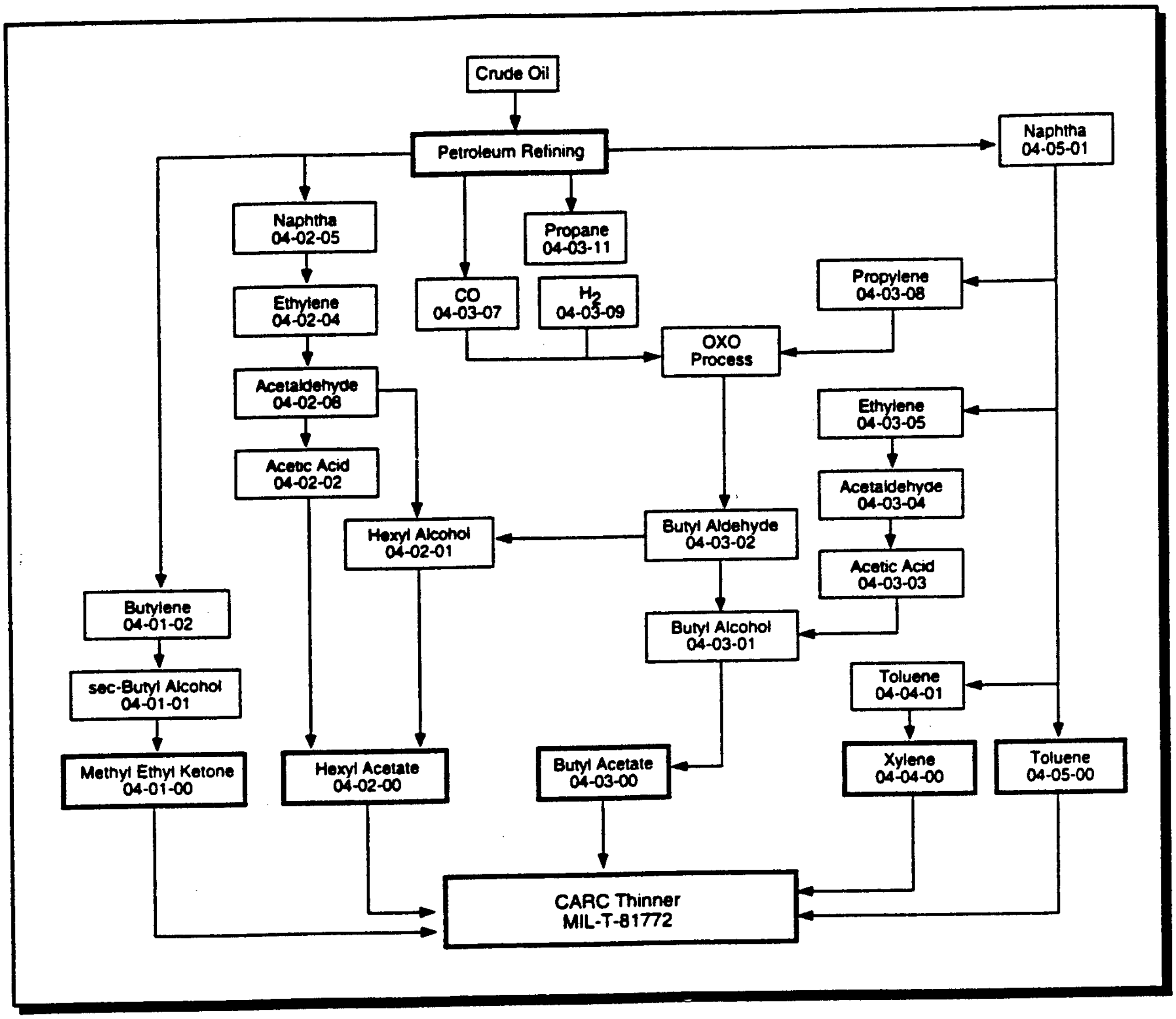

Figure A-4. Process flowsheet for baseline thinner

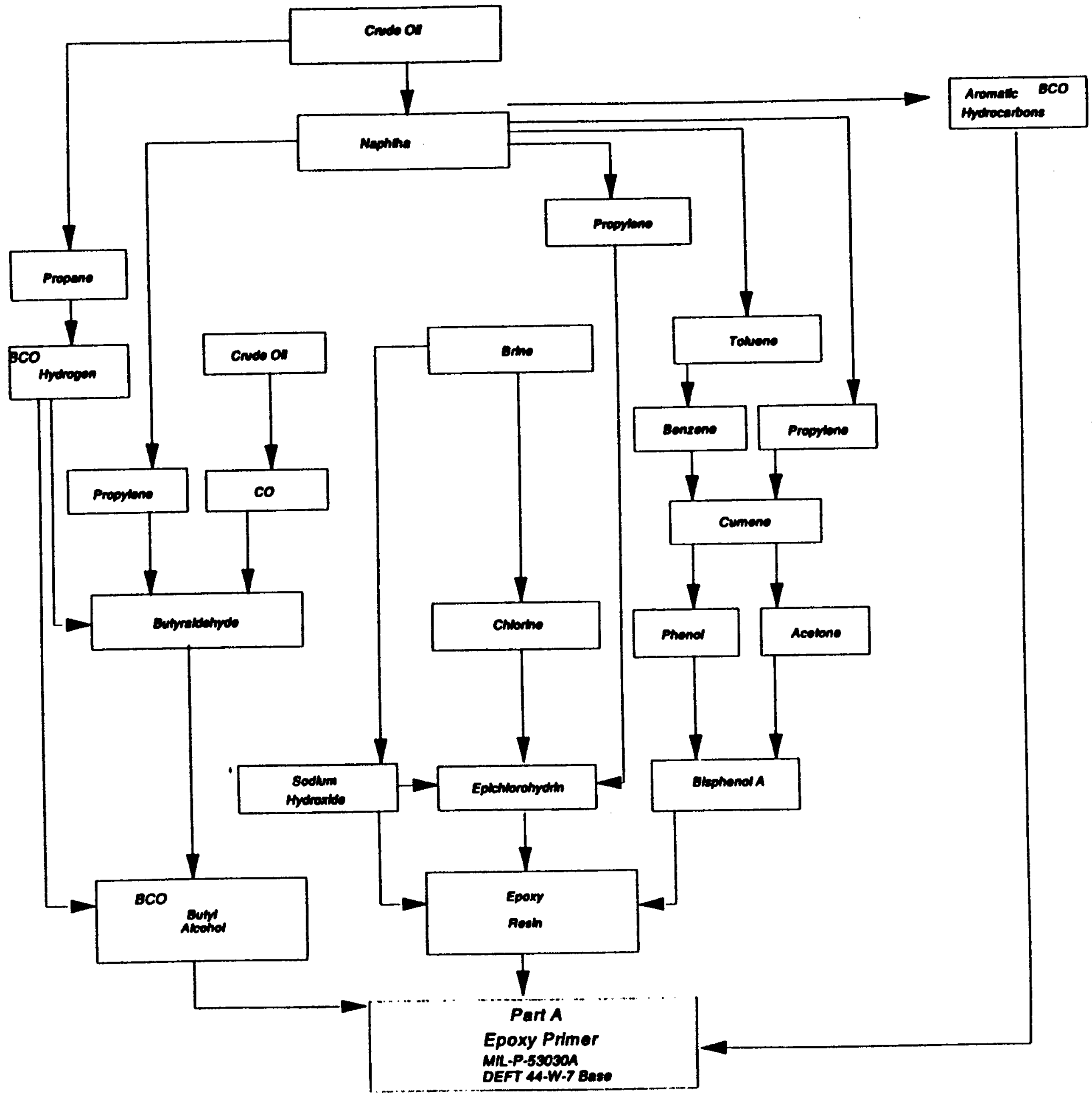

Figure A-5. Process Flowsheet for Part A, Alternative Primer (BCO=data obtained by Battelle Columbus Operations; all other data from PES)

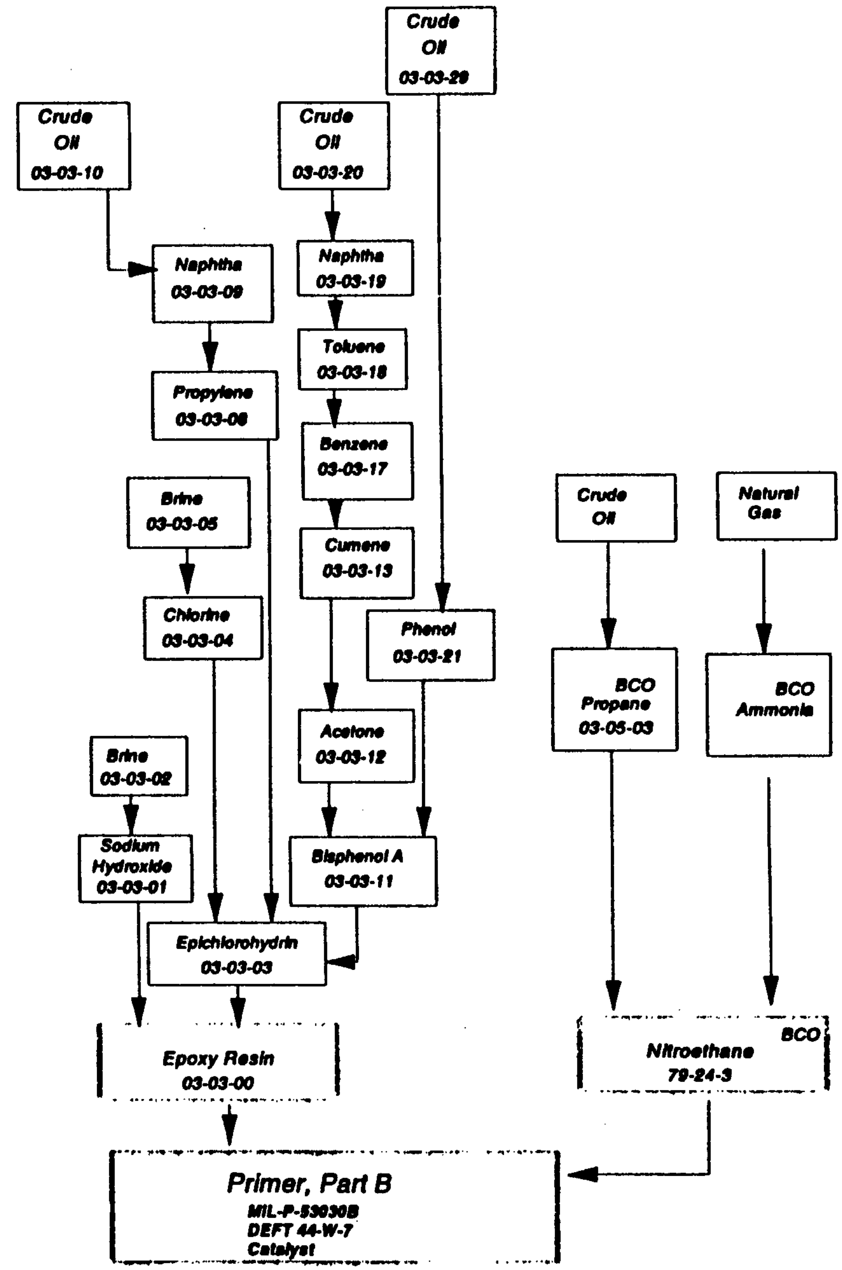

Figure A-6. Process Flowsheet for Part B, Alternative Primer (BCO=data obtained by Battelle Columbus Operations; all other data from PES)

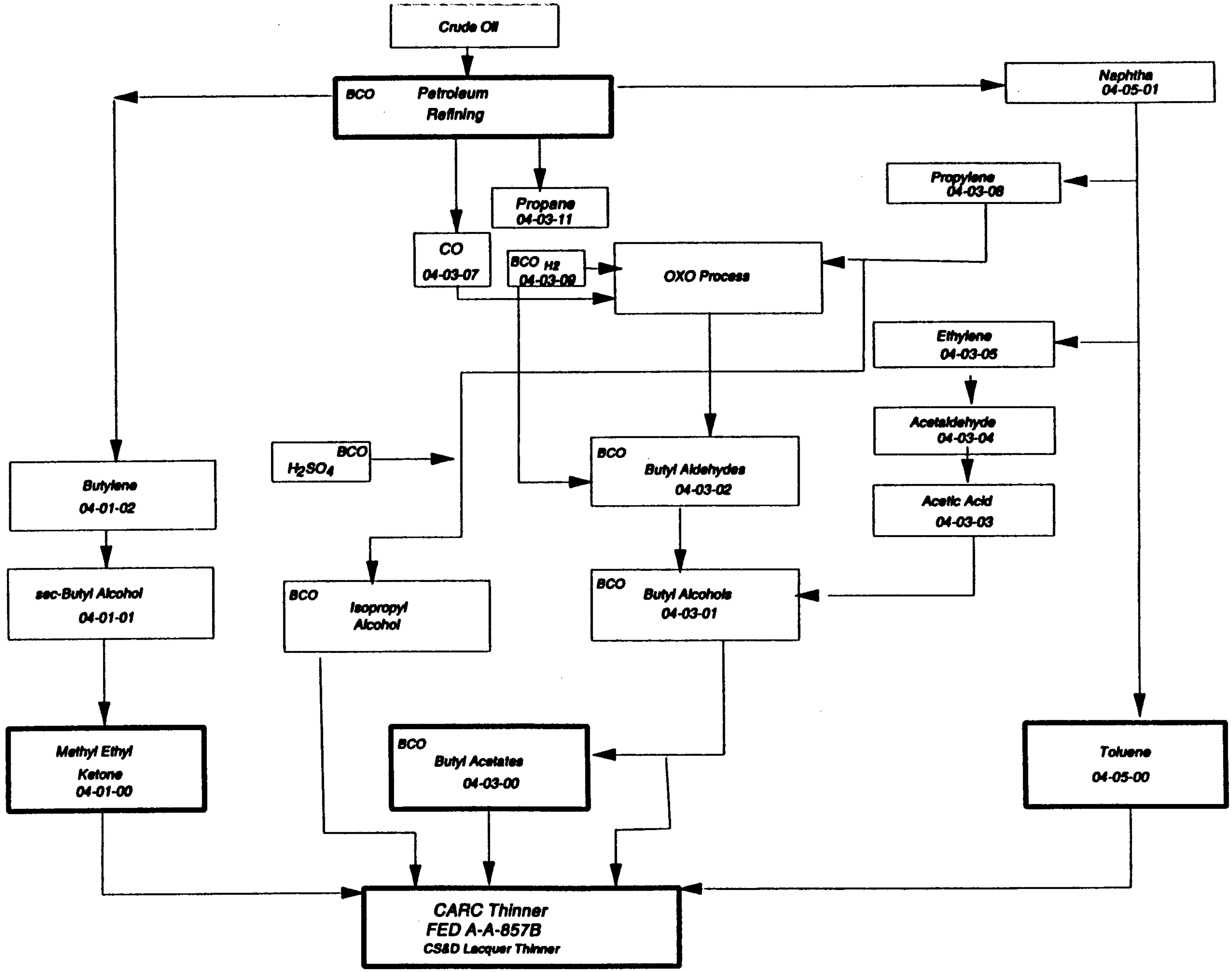

Figure A-7. Process Flowsheet for Alternative Thinner (BCO=data obtained by Battelle Columbus Operations; all other data from PES)

APPENDIX B
MATERIAL SAFETY DATA SHEETS (MSDSs)

CARC PAINT

MATERIAL SAFETY DATA SHEET

0860SGUZ-GD

FOR COATINGS, RESINS AND RELATED MATERIALS

Prepared By- JANE FREEMAN
Date of Preparation- 04-26-93
Manufacturer: Hentzen Coatings, Inc.
Address : 6937 West Mill Road
Milwaukee, Wisconsin 53218

Telephone #: (414)353-4200 Night: Not Available
Emergency #: (414)353-4200 Night: (800)424-9300 (Chemtrec)

****

SECTION I -- PRODUCT IDENTIFICATION

Manufacturer's Code Identification: 0860SGUZ Contract #GS-10F-52323
Product Class: ALIPHATIC POLYISOCYANATE NSN 8010-01-229-7547
Trade Name: 383 GREEN ZENTHANE, MIL-C-53039A

HMIS Information: Health- 2* Flammability- 3
Reactivity- 1 Personal Protective Equipment-

Hazardous Item per Fed. Std. 313C, Paragraph 3.3B : Yes

****

SECTION II -- HAZARDOUS INGREDIENTS

METHYL ISOAMYL KETONE SOLVENT
01 CAS# 110-12-3
% BY WT: 23.787

EXPOSURE LIMIT:
ACGIH TLV/TWA 50 PPM
OSHA PEL 50 PPM
OTHER INFORMATION RTECS #MP3850000

MAGNESIUM-FERRITE PIGMENT
02 CAS# 12068-86-9
% BY WT: 1 - 5

EXPOSURE LIMIT:
ACGIH TLV/TWA 15 MG/M3
OSHA PEL 10 MG/M3
OTHER LIMITS (NUISANCE DUST)
OTHER INFORMATION NO RTECS # FOUND

SILICA PIGMENT
03 CAS# 14808-60-7
% BY WT: 20 - 30

EXPOSURE LIMIT:
ACGIH TLV/TWA 0.1 MG/M3
OSHA PEL 0.1 MG/M3

****

SECTION II -- HAZARDOUS INGREDIENTS

OTHER INFORMATION RTECS #VV7330000

HOMOPOLYMER OF HEXAMETHYLENE DIISOCYANATE
04 CAS# 28182-81-2
% BY WT: 20 - 30

EXPOSURE LIMIT:

*EXACT PERCENTAGE:	EXACT PERCENTAGE IS A TRADE SECRET
ACGIH TLV/TWA	NOT ESTABLISHED
OSHA PEL	NOT ESTABLISHED
OTHER LIMITS	MFR.'S TWA = 0.5 MG/M3, STEL = 1.0 MG/M3
OTHER INFORMATION	NO RTECS # FOUND

TRIVALENT CHROME
05 (INSOLUBLE) CAS# 7440-47-3
% BY WT: 6.866

EXPOSURE LIMIT:

ACGIH TLV/TWA	0.5 MG/M3
OSHA PEL	0.5 MG/M3
OTHER INFORMATION	RTECS #GB4200000

INORGANIC SPINEL PIGMENT
06 CAS# NOT AVAIL.
% BY WT: 1 - 5

EXPOSURE LIMIT:

ACGIH TLV/TWA	NOT ESTABLISHED
OSHA PEL	NOT ESTABLISHED
OTHER LIMITS	NOT LISTED BY OSHA OR ACGIH.
OTHER INFORMATION	NO RTECS # FOUND

AROMATIC HYDROCARBONS
(MIXTURE OF C8'S TO C10'S)
07 CAS# 64742-95-6
% BY WT: 1.498

EXPOSURE LIMIT:

ACGIH TLV/TWA	NOT ESTABLISHED
OSHA PEL	NOT ESTABLISHED
OTHER LIMITS	100 PPM = MFR.'S LIMIT
OTHER INFORMATION	NO RTECS # FOUND

BUTYL ACETATE SOLVENT
08 CAS# 123-86-4
% BY WT: 1.194

EXPOSURE LIMIT:

ACGIH TLV/TWA	150 PPM
OSHA PEL	150 PPM

SECTION II -- HAZARDOUS INGREDIENTS

OTHER LIMITS	200 PPM = STEL
OTHER INFORMATION	RTECS #AF7350000

HEXAMETHYLENE DIISOCYANATE MONOMER
09 CAS# 822-06-0
% BY WT: 0.048

EXPOSURE LIMIT:

ACGIH TLV/TWA	0.005 PPM
OSHA PEL	0.005 PPM
OTHER INFORMATION	RTECS #MO1740000

VM&P NAPHTHA SOLVENT
10 CAS# 64742-89-8
% BY WT: 4.795

EXPOSURE LIMIT:

ACGIH TLV/TWA	300 PPM
OSHA PEL	300 PPM
OTHER INFORMATION	RTECS #SE7555000

XYLENE SOLVENT
11 CAS# 1330-20-7
% BY WT: 2.040

EXPOSURE LIMIT:

ACGIH TLV/TWA	100 PPM
OSHA PEL	100 PPM
OTHER LIMITS	STEL = 150 PPM
OTHER INFORMATION	RTECS #ZE2100000

This product contains no known carcinogens that are reportable.

SECTION III -- PHYSICAL DATA

Boiling Range: High- 418.0 F (214°C) Low- 344.0 F (118°C)
Vapor Pressure: 15.00 mm Hg at 68 F
Vapor Density: Heavier Than Air
Evaporation Rate: Faster than Butyl Acetate
Weight per Gallon: 10.29
Specific Gravity: 1.23
% Nonexempt Solvent by Volume: 51.53
% Nonexempt Solvent by Weight: 33.94
VOC: 3.488 Lbs/Gal 418.542 Grams/Liter
Appearance: Opaque Liquid
Odor: Solvent Odor
Odor Threshhold: 0.1 PPM
pH: Not Applicable Viscosity: 63 - 68 Krebs Units

Freezing Point: Not Available
Water Solubility: REACTS WITH WATER
Coefficient of Water/Oil Distribution: Not Available

SECTION IV -- FIRE AND EXPLOSION HAZARD DATA

Flammability Classification: Class 1B DOT: Flammable Liquid
Actual Flashpoint TCC: 54.0 F (12°C)
Explosion Level: Lower- 0.9 Upper- 8.2
Auto Ignition Temperature: 450.0 F (232°C)
Decomposition Temperature: 400F (204C)
Melting point: Not Applicable
Magnetism & Corrosion Rate: Not Applicable
EXTINGUISHING MEDIA: (X)-FOAM (X)-ALCOHOL FOAM (X)-CO2
(X)-DRY CHEMICAL ( )-WATER FOG ( )-OTHER
UNUSUAL FIRE AND EXPLOSION HAZARDS: Keep containers tightly closed. Isolate from heat, electrical equipment, sparks and open flame. Closed container may explode when exposed to extreme heat or burst when contaminated with water (CO2 evolved). Do not apply to hot surfaces. Never use welding or cutting torch on or near drum (even empty) because product (even residue) can ignite explosively.
SPECIAL FIRE FIGHTING PROCEDURES: Full protective equipment with self-contained breathing apparatus should be worn. During a fire, irritating and highly toxic gases (see Reactivity Data) and smoke are present from the decomposition/combustion products.

SECTION V -- REACTIVITY DATA

NEUTRALIZING AGENT: 0% - 10% Ammonium Hydroxide, 2% - 5% Detergent and the balance is water; or a solution of MIACT Corp.'s Tergitol TMN-10 (20%) and water (80%).
STABILITY: ( ) - UNSTABLE (X) - STABLE
HAZARDOUS POLYMERIZATION ( ) - WILL OCCUR (X) - WILL NOT OCCUR
HAZARDOUS DECOMPOSITION PRODUCTS: BY FIRE: CO2, CO, oxides of Nitrogen, traces of Hydrogen Cyanide, Hexamethylene Diisocyanate.
CONDITIONS TO AVOID: Contamination with water, epoxy catalysts, alcohols, glycol ethers, bases, metal complexes or other active materials. Once the material has been exposed to any of the above or atmospheric moisture, do not seal container as hazardous CO2 gas could build up in the container resulting in rapid depressurization.
INCOMPATIBILITY: See CONDITIONS TO AVOID.

SECTION VI -- HEALTH HAZARD DATA

EFFECTS OF OVEREXPOSURE:
TO VAPOR AND/OR MIST: Can cause irritation to skin, eyes and respiratory tract (nose, throat, lungs). Symptoms may be watering eyes, dryness of throat, coughing, headache, tightness in chest or burning sensation. Headache, dizziness or nausea may be experienced by some as a result of exposure to solvents.
PRIMARY ROUTES OF ENTRY: DERMAL and INHALATION

system damage, liver and kidney damage.
Chronic overexposure to isocyanate containing products may lead to respiratory sensitization characterized by asthma-like symptoms and/or skin sensitization characterized by allergic dermatitis which may include rash, itching, hives and swelling of the extremities.
Based upon laboratory animal data, IARC has listed Silica as a "Probable Human Carcinogen". May cause lung injury if respiratory protection is not used.
Some reports have associated repeated and prolonged contact with Trivalent Chrome to dermatitis. Avoid contact with eyes, skin and clothing. Wash thoroughly after handling.
EMERGENCY AND FIRST AID PROCEDURES: INHALATION: Remove from exposure. Restore breathing. Keep warm and quiet. Notify a physician.
EYES: Flush immediately with large amounts of running water for at least 15 minutes while lifting eyelids. Take to a physician for treatment.
SKIN: Wash affected areas with soap and water. Remove contaminated clothing. Wash before reuse. Consult a physician if irritation develops or persists.
INGESTION: If swallowed, CALL A PHYSICIAN OR POISON CONTROL CENTER IMMEDIATELY.
MEDICAL CONDITIONS PRONE TO AGGRAVATION BY EXPOSURE: Asthma and other respiratory ailments; chemical sensitization.

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SECTION VII -- PRECAUTIONS FOR SAFE HANDLING AND USE

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED: Evacuate non-essential personnel. Remove all sources of ignition (flames, hot surfaces, electrical, static or frictional sparks). Ventilate area. Avoid breathing vapors. Cover spill with inert absorbent. Pour liquid decontaminant over spillage--allow to react for at least 10 minutes; collect material in open containers--add further amounts of decontamination solution. Remove containers to safe place--cover loosely. Wash down area with decontaminant and flush spill area with water.
WASTE DISPOSAL METHODS: Dispose of in accordance with local, state and Federal regulations. Decontaminate containers prior to disposal.
PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING: Do not store above 120 F or below 32 F. Store large quantities in buildings designed to comply with OSHA 1910.106. Keep away from sparks and open flame. Keep containers tightly closed and protect from moisture. If moisture enters container, pressure can build up due to reaction producing CO2 which can cause sealed container to pressurize and burst. Do not reseal if contamination is suspected.
OTHER PRECAUTIONS: Do not take internally. Containers should be grounded when pouring. Avoid free fall of liquid in excess of a few inches. Use with adequate ventilation and respiratory equipment. Emptied containers may retain hazardous residue or explosive vapors. Follow all precautions in this data sheet until container is thoroughly cleaned or destroyed.

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SECTION VIII -- CONTROL MEASURES

RESPIRATORY PROTECTION: The Surgeon General requires airline respirators to be used unless air sampling shows exposure to be below OSHA limits. Then, either chemical cartridge respirators or airline respirators are required. The same precautions should be used during mixing or any operations where paint fumes would be present.
VENTILATION: Provide general dilution or local exhaust ventilation in volume and pattern to keep the air contaminant concentration below current applicable OSHA safety and health requirements in the mixing, application and curing areas; and to remove decomposition products during welding and flame cutting on surfaces coated with this product.
PROTECTIVE GLOVES: Chemical resistant gloves.
EYE PROTECTION: Use safety eyewear with splash guards and side shields.
OTHER PROTECTIVE EQUIPMENT: Wear protective clothing to keep skin contact at a minimum.
HYGIENIC PRACTICES: Wash hands and any exposed skin thoroughly before eating or smoking. Smoke in designated areas only.

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SECTION IX -- TRANSPORTATION

APPLICABLE REGULATION: 49 CFR 171 SHIPPING NAME: PAINT
ID #: UN1263 REPORTABLE QUANTITY: 100 lbs. HAZARD CLASS: 3
LABEL: FLAMMABLE LIQUID UNIT CONTAINER: CN (Five Gallons)
DOT SPECIFICATION CONTAINER: 24 Gage Steel
DOT EXEMPTION: NONE
LIMITED QUANTITY: YES
U.S. POSTAL SERVICE: Will not handle
NET EXPLOSIVE WEIGHT: Not Applicable
AEROSOL PROPELLANTS: Not Applicable

DISPOSAL INFORMATION:
EPA HAZARDOUS WASTE NUMBER/CODE: D001
HAZARDOUS WASTE CHARACTERISTICS: Ignitable
DISPOSAL METHODS: Incineration

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SECTION X -- SECTION 313 TOXIC CHEMICALS

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This product contains the following toxic chemicals subject to the reporting requirements of Section 313 of the Emergency Planning and Community Right-To-Know Act of 1986 and of 40 CFR 372:

Chemical	CAS Number	Weight %
TRIVALENT CHROME	7440-47-3	6.866
XYLENE SOLVENT	1330-20-7	2.040

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FROM OUR RAW MATERIAL SUPPLIERS AND OTHER SOURCES AND IS BELIEVED TO BE RELIABLE. THIS DATA IS NOT TO BE TAKEN AS A WARRANTY OR REPRESENTATION FOR WHICH HENTZEN COATINGS, INC. ASSUMES LEGAL RESPONSIBILITY.

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DOD Hazardous Materials Information System
DoD 6050.5-L
AS OF April 1995

FSC: 8010
NIIN: 00D002882
Manufacturer's CAGE: 02388
Part No. Indicator: A
Part Number/Trade Name: N-1088A WHITE EPOXY PRIMER

Primer Part A

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General Information

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Item Name: WHITE EPOXY PRIMER
Manufacturer's Name: NILES CHEMICAL PAINT CO.
Manufacturer's Street: 225 FORT STREET
Manufacturer's P. O. Box: 307
Manufacturer's City: NILES
Manufacturer's State: MI
Manufacturer's Country: US
Manufacturer's Zip Code: 49120
Manufacturer's Emerg Ph #: 800-627-1948, 219-236-5856
Manufacturer's Info Ph #: 616-683-3377
Distributor/Vendor # 1:
Distributor/Vendor # 1 Cage:
Distributor/Vendor # 2:
Distributor/Vendor # 2 Cage:
Distributor/Vendor # 3:
Distributor/Vendor # 3 Cage:
Distributor/Vendor # 4:
Distributor/Vendor # 4 Cage:
Safety Data Action Code:
Safety Focal Point: G
Record No. For Safety Entry: 001
Tot Safety Entries This Stk#: 001
Status: SE
Date MSDS Prepared: 23AUG92
Safety Data Review Date: 29OCT92
Supply Item Manager: GSA
MSDS Preparer's Name: MIKE LICHATOWICH
Preparer's Company:
Preparer's St Or P. O. Box:
Preparer's City:
Preparer's State:
Preparer's Zip Code:
Other MSDS Number:
MSDS Serial Number: BPCGR
Specification Number: MIL-P-53022B
Spec Type, Grade, Class:
Hazard Characteristic Code: F3
Unit Of Issue: EA
Unit Of Issue Container Qty: UNKNOWN
Type Of Container: UNKNOWN
Net Unit Weight: UNKNOWN

Report for NIIN: 00D002882

NRC/State License Number: N/R
Net Explosive Weight:
Net Propellant Weight-Ammo: N/R
Coast Guard Ammunition Code:

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Ingredients/Identity Information

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Proprietary: NO
Ingredient: N-BUTYL ACETATE (SARA III)
Ingredient Sequence Number: 01
Percent: 26
Ingredient Action Code:
Ingredient Focal Point: G
NIOSH (RTECS) Number: AF7350000
CAS Number: 123-86-4
OSHA PEL: 150 PPM/200 STEL
ACGIH TLV: 150 PPM/200STEL;9192
Other Recommended Limit: NONE SPECIFIED

Proprietary: NO
Ingredient: EPOXY RESIN
Ingredient Sequence Number: 02
Percent: 22
Ingredient Action Code:
Ingredient Focal Point: G
NIOSH (RTECS) Number: 1000131ER
CAS Number: 25036-25-3
OSHA PEL: NOT ESTABLISHED
ACGIH TLV: NOT ESTABLISHED
Other Recommended Limit: 5 MG/M3 TLV

Proprietary: NO
Ingredient: N-BUTYL ALCOHOL (SARA III)
Ingredient Sequence Number: 03
Percent: 8
Ingredient Action Code:
Ingredient Focal Point: G
NIOSH (RTECS) Number: EO1400000
CAS Number: 71-36-3
OSHA PEL: 100 PPM
ACGIH TLV: S, C 50 PPM; 9293
Other Recommended Limit: NONE SPECIFIED

Proprietary: NO
Ingredient: ZINC PHOSPHATE
Ingredient Sequence Number: 04
Percent: 4
Ingredient Action Code:
Ingredient Focal Point: G
NIOSH (RTECS) Number: 1001478ZP
CAS Number: UNKNOWN
OSHA PEL: NOT ESTABLISHED
GIH TLV: NOT ESTABLISHED

Report for NIIN: 00D002882

Other Recommended Limit: NONE SPECIFIED

Proprietary: NO
Ingredient: METHYL ISOBUTYL KETONE (SARA III)
Ingredient Sequence Number: 05
Percent: 2
Ingredient Action Code:
Ingredient Focal Point: G
NIOSH (RTECS) Number: SA9275000
CAS Number: 108-10-1
OSHA PEL: 100 PPM/75 STEL
ACGIH TLV: 50 PPM/75 STEL; 9293
Other Recommended Limit: NONE SPECIFIED

Proprietary: NO
Ingredient: PROPRIETARY INGREDIENTS
Ingredient Sequence Number: 06
Percent: BALANCE
Ingredient Action Code:
Ingredient Focal Point: G
NIOSH (RTECS) Number: 1004255PI
CAS Number: UNKNOWN
OSHA PEL: NOT ESTABLISHED
ACGIH TLV: NOT ESTABLISHED
Other Recommended Limit: NONE SPECIFIED

Physical/Chemical Characteristics

Appearance And Odor: LIQUID, ODOR OF SOLVENTS.
Boiling Point: 242F,117C
Melting Point: UNKNOWN
Vapor Pressure (MM Hg/70 F): UNKNOWN
Vapor Density (Air=1): > AIR
Specific Gravity: 1.347
Decomposition Temperature: UNKNOWN
Evaporation Rate And Ref: SLOWER THAN ETHER
Solubility In Water: SLIGHT
Percent Volatiles By Volume: 59.63
Viscosity:
pH: N/K
Radioactivity:
Form (Radioactive Matl):
Magnetism (Milligauss):
Corrosion Rate (IPY): MINIMAL
Autoignition Temperature:

Fire and Explosion Hazard Data

Flash Point: 72.0F,22.2C
Flash Point Method: TCC
Lower Explosive Limit: 1.4
Upper Explosive Limit: 11.0
tinguishing Media: DRY CHEMICAL, FOAM, CARBON DIOXIDE.

Report for NIIN: 00D002882

Special Fire Fighting Proc: WEAR SCBA WITH FULL FACEPIECE IN POSITIVE PRESS MODE/FULL PROTECT CLOTHES. USE H2O TO COOL CLOSED CONTAINERS TO PREVENT PRESS BUILDUP, AUTOIGNITION, EXPLOSION.
Unusual Fire And Expl Hazrds: VAPORS ARE HEAVIER THAN AIR AND MAY TRAVEL ALONG GROUND TO IGNITION SOURCE. CLOSED CONTAINERS MAY EXPLODE WHEN EXPOSED TO EXTREME HEAT.

Reactivity Data

Stability: YES
Cond To Avoid (Stability): MATERIAL IS STABLE UNDER REASONABLE CONDITIONS OF STORAGE AND USE. AVOID HIGH TEMPERATURES AND SHOCK FROM DROPPING.
Materials To Avoid: NITRATES, STRONG OXIZIDERS, ALKALIS, ACIDS.
Hazardous Decomp Products: CAN PRODUCE CARBON MONOXIDE AND/OR CARBON DIOXIDE.
Hazardous Poly Occur: NO
Conditions To Avoid (Poly): WILL NOT OCCUR.

Health Hazard Data

LD50-LC50 Mixture: UNKNOWN
Route Of Entry - Inhalation: YES
Route Of Entry - Skin: YES
Route Of Entry - Ingestion: YES
Health Haz Acute And Chronic: EYES: SEVERE IRRITATION, BLURRED VISION. SKIN: HARMFULL IF ABSORBED THROUGH SKIN. CAN BE ABSORBED IN TOXIC AMOUNTS FROM PROLONGED EXPOSURES. INHALATION: NASAL AND RESPRIRATORY IRRITATION, CNS DEPRESSION, NAUSEA, UNCONSCIOUSNESS, ASPHYXIATION. INGESTION: GI IRRITATION, ABDOMINAL PAIN, NAUSEA, VOMITING, DIARRHEA.
Carcinogenicity - NTP: NO
Carcinogenicity - IARC: NO
Carcinogenicity - OSHA: NO
Explanation Carcinogenicity: NOT LISTED BY NTP, IARC, OSHA.
Signs/Symptoms Of Overexp: EYES: SEVERE IRRITATION. TEARING, REDNESS, BLURRED VISION. INHALATION: NASAL AND RESPIRATORY IRRITATION, CNS DEPRESSION, DIZZINESS, DROWSINESS, WEAKNESS, FATIGUE, CONFUSION, NAUSEA, HEADACHE, VERTIGO. POSSIBLE UNCONSCIOUSNESS, EVEN ASPHYXIATION. INGESTION: GI IRRITATION, ABDOMINAL PAIN, NAUSEA, VOMITING, DIARRHEA.
Med Cond Aggravated By Exp: NONE KNOWN.
Emergency/First Aid Proc: EYES: FLUSH WITH LARGE AMOUNTS OF WATER. GET MEDICAL ATTENTION. SKIN: REMOVE CONTAMINATED CLOTHING. FLUSH AREA WITH LARGE AMOUNTS OF WATER. INHALATION: MOVE TO FRESH AIR. IF NOT BREATHING GIVE CPR. GET MEDICAL ATTENTION. INGESTION: DRINK 1 OR 2 GLASSES OF WATER. DO NOT INDUCE VOMITING. GET MEDICAL ATTENTION.

Precautions for Safe Handling and Use

Steps If Matl Released/Spill: ELIMINATE ALL IGNIT SOURCES. ABSORB WITH INERT MATERIAL SUCH AS CLAY, SOIL OR A COMMERCIALLY AVAILABLE ABSORBENT. SHOVEL RECLAIMED LIQUID/ABSORBENT INTO RECOVERY/SALVAGE DRUM OR TANK TRUCK FOR DISPOSAL. DIKE LARGE SPILLS TO PREVENT RUNOFF.
Neutralizing Agent: NONE SPECIFIED BY MANUFACTURER.
Waste Disposal Method: DISPOSE OF WASTE IN ACCORDANCE WITH APPLICABLE

Report for NIIN: 00D002882

LOCAL, STATE AND FEDERAL REGUATIONS.
PRecautions-Handling/Storing: AVOID STORAGE IN HIGH TEMPERATURE AREAS OR NEAR FIRE OR OPEN FLAME. KEEP CONTAINERS CLOSED. AVOID ROUGH HANDLING AND PROTECT FROM PHYSICAL DAMAGE.
Other Precautions: CONTAINERS OF THIS MATERIAL MAY BE HAZARDOUS WHEN EMPTY. DO NOT WELD OR FLAME CUT ON EMPTY DRUMS.

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Control Measures

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Respiratory Protection: WEAR APPROPRIATE PROPERLY FITTED HALF-MASK/FULL FACEPIECE RESPIRATOR DURING AND AFTER APPLICATION UNLESS AIR MONITORING DEMONSTRATES VAPOR/MIST LEVELS ARE BELOW APPLICABLE LIMITS .FOLLOW RESPIRATOR MANUFACTURES DIRECTIONS FOR USE.
Ventilation: SUFFICIENT VENTILATION TO KEEP AIR CONCENTRATION BELOW PERMISSIBLE EXPOSURE LIMITS. VENT VAPOS WHEN BAKING FINISHES.
Protective Gloves: NITRILE OR VITON GLOVES
Eye Protection: CHEM GOGGLES,SAFETY GLASSES,FACESHIELD.
Other Protective Equipment: NITRILE OR VITON CLOTHING AS NEEDED TO PREVENT SKIN CONTACT.
Work Hygienic Practices: WASH AFTER HANDLING AND BEFORE EATING, DRINKING, SMOKING, OR USING RESTROOM. LAUNDER CONTAMINATED CLOTHING BEFORE REUSE.
Suppl. Safety & Health Data: CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH THIS MATERIAL.

DOD Hazardous Materials Information System
DoD 6050.5-L
AS OF April 1995

Primer Part B

FSC: 8010
NIIN: 00D002883
Manufacturer's CAGE: 02388
Part No. Indicator: A
Part Number/Trade Name: N-1088BM 4:1 BLEND

General Information

Item Name: ENAMEL,EPOXY,YELLOW
Manufacturer's Name: NILES CHEMICAL PAINT CO.
Manufacturer's Street: 225 FORT STREET
Manufacturer's P. O. Box: 307
Manufacturer's City: NILES
Manufacturer's State: MI
Manufacturer's Country: US
Manufacturer's Zip Code: 49120
Manufacturer's Emerg Ph #: 800-627-1948, 219-236-5656
Manufacturer's Info Ph #: 616-683-3377
Distributor/Vendor # 1:
Distributor/Vendor # 1 Cage:
Distributor/Vendor # 2:
Distributor/Vendor # 2 Cage:
Distributor/Vendor # 3:
Distributor/Vendor # 3 Cage:
Distributor/Vendor # 4:
Distributor/Vendor # 4 Cage:
Safety Data Action Code:
Safety Focal Point: G
Record No. For Safety Entry: 001
Tot Safety Entries This Stk#: 001
Status: SE
Date MSDS Prepared: 23SEP92
Safety Data Review Date: 28OCT92
Supply Item Manager: GSA
MSDS Preparer's Name: MIKE LICHATOWICH
Preparer's Company:
Preparer's St Or P. O. Box:
Preparer's City:
Preparer's State:
Preparer's Zip Code:
Other MSDS Number:
MSDS Serial Number: BPCGS
Specification Number: MIL-P-53022B
Spec Type, Grade, Class:
Hazard Characteristic Code: F4
Unit Of Issue: EA
Unit Of Issue Container Qty: UNKNOWN
Type Of Container: UNKNOWN
Net Unit Weight: UNKNOWN

Report for NIIN: 00D002883

NRC/State License Number: N/R
Net Explosive Weight:
Net Propellant Weight-Ammo: N/R
Coast Guard Ammunition Code:

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Ingredients/Identity Information

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Proprietary: NO
Ingredient: METHYL ISOBUTYL KETONE (SARA III)
Ingredient Sequence Number: 01
Percent: 28
Ingredient Action Code:
Ingredient Focal Point: G
NIOSH (RTECS) Number: SA9275000
CAS Number: 108-10-1
OSHA PEL: 100 PPM/75 STEL
ACGIH TLV: 50 PPM/75 STEL; 9293
Other Recommended Limit: NONE SPECIFIED

Proprietary: NO
Ingredient: EPOXY RESIN
Ingredient Sequence Number: 02
Percent: 23
Ingredient Action Code:
Ingredient Focal Point: G
NIOSH (RTECS) Number: 1000131ER
CAS Number: UNKNOWN
OSHA PEL: NOT ESTABLISHED
ACGIH TLV: NOT ESTABLISHED
Other Recommended Limit: NONE SPECIFIED

Proprietary: NO
Ingredient: N-BUTYL ALCOHOL (SARA III)
Ingredient Sequence Number: 03
Percent: 17
Ingredient Action Code:
Ingredient Focal Point: G
NIOSH (RTECS) Number: EO1400000
CAS Number: 71-36-3
OSHA PEL: 100 PPM
ACGIH TLV: S, C 50 PPM; 9293
Other Recommended Limit: NONE SPECIFIED

Proprietary: NO
Ingredient: 2-ETHOXYETHANOL (EGEE) (SARA III)
Ingredient Sequence Number: 04
Percent: 11
Ingredient Action Code:
Ingredient Focal Point: G
NIOSH (RTECS) Number: KK8050000
CAS Number: 110-80-5
OSHA PEL: S,200 PPM
GIH TLV: S, 5 PPM; 9192

Report for NIIN: 00D002883

Other Recommended Limit: NONE SPECIFIED

Proprietary: NO
Ingredient: XYLENES (O-,M-,P- ISOMERS) (SARA III)
Ingredient Sequence Number: 05
Percent: 11
Ingredient Action Code:
Ingredient Focal Point: G
NIOSH (RTECS) Number: ZE2100000
CAS Number: 1330-20-7
OSHA PEL: 100 PPM/150 STEL
ACGIH TLV: 100 PPM/150STEL;9192
Other Recommended Limit: NONE SPECIFIED

Proprietary: NO
Ingredient: DIETHYLENE TRIAMINE
Ingredient Sequence Number: 06
Percent: 8
Ingredient Action Code:
Ingredient Focal Point: G
NIOSH (RTECS) Number: IE1225000
CAS Number: 111-40-0
OSHA PEL: 1 PPM
ACGIH TLV: S, 1 PPM; 9192
Other Recommended Limit: NONE SPECIFIED

Proprietary: NO
Ingredient: PROPRIETARY INGREDIENTS
Ingredient Sequence Number: 07
Percent: BALANCE
Ingredient Action Code:
Ingredient Focal Point: G
NIOSH (RTECS) Number: 1004255PI
CAS Number: UNKNOWN
OSHA PEL: NOT ESTABLISHED
ACGIH TLV: NOT ESTABLISHED
Other Recommended Limit: NONE SPECIFIED

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Physical/Chemical Characteristics

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Appearance And Odor: LIQUID, ODOR OF SOLVENTS
Boiling Point: 242F,117C
Melting Point: UNKNOWN
Vapor Pressure (MM Hg/70 F): UNKNOWN
Vapor Density (Air=1): > AIR
Specific Gravity: 0.905
Decomposition Temperature: UNKNOWN
Evaporation Rate And Ref: SLOWER THAN ETHER
Solubility In Water: SLIGHT
Percent Volatiles By Volume: 74.70
Viscosity:
pH: N/K
Radioactivity:

Report for NIIN: 00D002883

Form (Radioactive Matl):
Magnetism (Milligauss):
Corrosion Rate (IPY): MINIMAL
Autoignition Temperature:

Fire and Explosion Hazard Data

Flash Point: 73.0F,22.8C
Flash Point Method: TCC
Lower Explosive Limit: 1.0
Upper Explosive Limit: 14
Extinguishing Media: DRY CHEMICAL, FOAM, CO2
Special Fire Fighting Proc: WEAR SCBA WITH FULL FACEPIECE IN POS PRESS MODE/FULL PROTECT CLOTHES.USE H20 TO COOL CLOSED CONTAINERS TO PREVENT PRESS BUILDUP AND AUTOIGNITION OR EXPLOSION.
Unusual Fire And Expl Hazrds: VAPORS ARE HEAVIER THAN AIR AND MAY TRAVEL ALONG GROUND TO IGNITION SOURCE. ISOLATE FROM HEAT, IGNITION SOURCES. APPLICATION TO HOT SURFACES NEED SPECIAL CARE.

Reactivity Data

Stability: YES
Cond To Avoid (Stability): HIGH TEMPERATURES, IGNITION SOURCES. SHOCK FROM DROPPING.
Materials To Avoid: STRONG OXIDIZERS
Hazardous Decomp Products: CAN PRODUCE CARBON MONOXIDE AND/OR CARBON DIOXIDE.
Hazardous Poly Occur: NO
Conditions To Avoid (Poly): WILL NOT OCCUR.

Health Hazard Data

LD50-LC50 Mixture: UNKNOWN
Route Of Entry - Inhalation: YES
Route Of Entry - Skin: YES
Route Of Entry - Ingestion: YES
Health Haz Acute And Chronic: EYES: SEVERE IRRITATION, BLURRED VISION. SKIN: HARMFULL IF ABSORBED THROUGH SKIN. CAN BE ABSORBED IN TOXIC AMOUNTS FROM PROLONGED EXPOSURES. INHALATION: NASAL AND RESPIRATORY IRRITATION, CNS DEPRESSION, NAUSEA, UNCONSCIOUSNESS, ASPHYXIATION. INGESTION: GI IRRITATION, ABDOMINAL PAIN, NAUSEA, VOMITING, DIARRHEA.
Carcinogenicity - NTP: NO
Carcinogenicity - IARC: NO
Carcinogenicity - OSHA: NO
Explanation Carcinogenicity: NOT LISTED BY NTP, IARC, OR OSHA.
Signs/Symptoms Of Overexp: EYES: SEVERE IRRITATION. TEARING, REDNESS, BLURRED VISION. INHALATION: NASAL AND RESPIRATORY IRRITATION, CNS DEPRESSION, DIZZINESS, DROWSINESS, WEAKNESS, FATIGUE, CONFUSION, NAUSEA, HEADACHE, VERTIGO. POSSIBLE UNCONSCIOUSNESS, EVEN ASPHYXIATION. INGESTION: GI IRRITATION, ABDOMINAL PAIN, NAUSEA, VOMITING, DIARRHEA.
Med Cond Aggravated By Exp: NONE KNOWN.
Emergency/First Aid Proc: EYES: FLUSH WITH LARGE AMOUNTS OF WATER. GET MEDICAL ATTENTION. SKIN: REMOVE CONTAMINATED CLOTHING. FLUSH AREA WITH

LARGE AMOUNTS OF WATER. INHALATION: MOVE TO FRESH AIR. IF NOT BREATHING GIVE CPR. GET MEDICAL ATTENTION. INGESTION: DRINK 1 OR 2 GLASSES OF WATER. DO NOT INDUCE VOMITING. GET MEDICAL ATTENTION.

Precautions for Safe Handling and Use

Steps If Matl Released/Spill: ELIMINATE ALL IGNITION SOURCES. ABSORB WITH INERT MATERIAL SUCH AS CLAY, SOIL OR A COMMERCIALLY AVAILABLE ABSORBENT. SHOVEL RECLAIMED LIQUID/ABSORBENT INTO RECOVERY/SALVAGE DRUM OR TANK TRUCK FOR DISPOSAL. DIKE LARGE SPILLS TO PREVENT RUNOFF.
Neutralizing Agent: NONE SPECIFIED BY MANUFACTURER.
Waste Disposal Method: DISPOSE OF WASTE IN ACCORDANCE WITH APPLICABLE LOCAL, STATE AND FEDERAL REGUATIONS.
Precautions-Handling/Storing: AVOID STORAGE IN HIGH TEMPERATURE AREAS OR NEAR FIRE OR OPEN FLAME. KEEP CONTAINERS CLOSED. AVOID ROUGH HANDLING AND PROTECT FROM PHYSICAL DAMAGE.
Other Precautions: CONTAINERS OF THIS MATERIAL MAY BE HAZARDOUS WHEN EMPTY. DO NOT WELD OR FLAME CUT ON EMPTY DRUMS.

Control Measures

Respiratory Protection: WEAR APPROPRIATE PROPERLY FITTED HALF-MASK/FULL FACEPIECE RESPIRATOR DURING AND AFTER APPLICATION UNLESS AIR MONITORING DEMONSTRATES VAPOR/MIST LEVELS ARE BELOW APPLICABLE LIMITS. FOLLOW RESPIRATOR MANUFACTURES DIRECTIONS FOR USE.
Ventilation: SUFFICIENT VENTILATION TO KEEP AIR CONCENTRATION BELOW PERMISSIBLE EXPOSURE LIMITS. VENT VAPORS WHEN BAKING FINISHES.
Protective Gloves: NITRILE OR VITON GLOVES.
Eye Protection: CHEM GOGGLES,SAFETY GLASSES,FACESHIELD.
Other Protective Equipment: NITRILE OR VITON CLOTHING AS NEEDED TO PREVENT SKIN CONTACT.
Work Hygienic Practices: WASH AFTER HANDLING AND BEFORE EATING, DRINKING, SMOKING, OR USING RESTROOM. LAUNDER CONTAMINATED CLOTHING BEFORE REUSE.
Suppl. Safety & Health Data: CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH THIS MATERIAL.

DOD Hazardous Materials Information System
DoD 6050.5-L
AS OF April 1995

FSC: 8010
NIIN: 001818079
Manufacturer's CAGE: 5W216
Part No. Indicator: B
Part Number/Trade Name: THINNER AIRCRAFT COATING

General Information

Item Name: THINNER, AIRCRAFT COATING, POLYURETHANE *
Manufacturer's Name: CHEMICAL SPECIALISTS & DEVELOPMENT *
Manufacturer's Street: #5 HACKBERRY LANE *
Manufacturer's P. O. Box: N/K *
Manufacturer's City: CUT & SHOOT *
Manufacturer's State: TX *
Manufacturer's Country: US *
Manufacturer's Zip Code: 77303 *
Manufacturer's Emerg Ph #: 800-424-9300 *
Manufacturer's Info Ph #: 409-756-1065 *
Distributor/Vendor # 1:
Distributor/Vendor # 1 Cage:
Distributor/Vendor # 2:
Distributor/Vendor # 2 Cage:
Distributor/Vendor # 3:
Distributor/Vendor # 3 Cage:
Distributor/Vendor # 4:
Distributor/Vendor # 4 Cage:
Safety Data Action Code: C
Safety Focal Point: G
Record No. For Safety Entry: 008
Tot Safety Entries This Stk#: 010
Status: FM *
Date MSDS Prepared: 01SEP90 *
Safety Data Review Date: 03FEB94 *
Supply Item Manager: GSA *
MSDS Preparer's Name: DAVID SHIPP *
Preparer's Company: CHEMICAL SPECIALISTS & DEVELOPMENT *
Preparer's St Or P. O. Box: #5 HACKBERRY LANE *
Preparer's City: CUT & SHOOT *
Preparer's State: TX *
Preparer's Zip Code: 77303 *
Other MSDS Number:
MSDS Serial Number: BJZSK
Specification Number: MIL-T-81772B * Baseline used in LCI
Spec Type, Grade, Class: TYPE I *
Hazard Characteristic Code: F3 *
Unit Of Issue: CN
Unit Of Issue Container Qty: 5 GAL CAN
Type Of Container: METAL
Net Unit Weight: N/K

Report for NIIN: 001818079

NRC/State License Number: N/K
Net Explosive Weight: N/K
Net Propellant Weight-Ammo: N/K
Coast Guard Ammunition Code: N/K

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Ingredients/Identity Information

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Proprietary: NO
Ingredient: METHYL ETHYL KETONE (2-BUTANONE) (MEK) (SARA III)
Ingredient Sequence Number: 01
Percent: 30.5
Ingredient Action Code:
Ingredient Focal Point: G
NIOSH (RTECS) Number: EL6475000
CAS Number: 78-93-3
OSHA PEL: 200 PPM/300 STEL
ACGIH TLV: 200 PPM/300STEL 9192
Other Recommended Limit: NONE SPECIFIED

Proprietary: NO
Ingredient: HEXYL ACETATE MIXED ISOMERS
Ingredient Sequence Number: 02
Percent: 41.0
Ingredient Action Code:
Ingredient Focal Point: G
NIOSH (RTECS) Number: 1004009HA
CAS Number: 88230-35-7
OSHA PEL: N/K
ACGIH TLV: N/K
Other Recommended Limit: 50 PPM 8 HOUR TWA

Proprietary: NO
Ingredient: TOLUENE (SARA III)
Ingredient Sequence Number: 03
Percent: 10.5
Ingredient Action Code:
Ingredient Focal Point: G
NIOSH (RTECS) Number: XS5250000
CAS Number: 108-88-3
OSHA PEL: 200 PPM/150 STEL
ACGIH TLV: 50 PPM; 9293
Other Recommended Limit: NONE SPECIFIED

Proprietary: NO
Ingredient: N-BUTYL ACETATE (SARA III)
Ingredient Sequence Number: 04
Percent: 11.0
Ingredient Action Code:
Ingredient Focal Point: G
NIOSH (RTECS) Number: AF7350000
CAS Number: 123-86-4
OSHA PEL: 150 PPM/200 STEL
ACGIH TLV: 150 PPM/200STEL;9192

Report for NIIN: 001818079

Other Recommended Limit: NONE SPECIFIED

Proprietary: NO
Ingredient: XYLENES (O-,M-,P- ISOMERS) (SARA III)
Ingredient Sequence Number: 05
Percent: 7.0
Ingredient Action Code:
Ingredient Focal Point: G
NIOSH (RTECS) Number: ZE2100000
CAS Number: 1330-20-7
OSHA PEL: 100 PPM/150 STEL
ACGIH TLV: 100 PPM/150STEL;9192
Other Recommended Limit: NOT SPECIFIED

Physical/Chemical Characteristics

Appearance And Odor: CLEAR, LITTLE IF ANY COLOR; CHARACTERISTIC ODOR *
Boiling Point: 179F,82C *
Melting Point: -20F,-29C *
Vapor Pressure (MM Hg/70 F): 35.1 MMHG *
Vapor Density (Air=1): 3.4 *
Specific Gravity: 0.850 *
Decomposition Temperature: N/K *
Evaporation Rate And Ref: SLOWER THAN ETHER *
Solubility In Water: MODERATE *
Percent Volatiles By Volume: 100 *
Viscosity: N/K
pH: N/K *
Radioactivity: N/K
Form (Radioactive Matl): N/K
Magnetism (Milligauss): N/K
Corrosion Rate (IPY): NONE *
Autoignition Temperature: N/K

Fire and Explosion Hazard Data

Flash Point: 20 F/-6.7 C *
Flash Point Method: N/K *
Lower Explosive Limit: 1.0 *
Upper Explosive Limit: N/K *
Extinguishing Media: REGULAR FOAM OR CARBON DIOXIDE OR DRY CHEMICAL *
Special Fire Fighting Proc: WEAR SELF CONTAINED BREATHING APPARATUS W/ FULL FACEPIECE OPERATED IN POSITIVE PRESS DEMAND MODE. VAPOR MAY TRAVEL TO IGNITE SOURCES DISTANT FROM HANDLING POINT *
Unusual Fire And Expl Hazrds: NEVER WELD, USE CUTTING TORCH ON OR NEAR DRUM(EVEN EMPTY)CAN IGNITE EXPLOSIVELY. ALL 5 GAL PAIL & LARGE METAL CONTAINERS GROUND/BOND WHEN TRANSFERING MATERIAL. *

Reactivity Data

Stability: YES *
Cond To Avoid (Stability): N/K *
Materials To Avoid: AVOID CONTACT WITH STRONG OXIDIZING AGENTS *

Hazardous Decomp Products: MAY FORM TOXIC MATERIALS. CARBON DIOXIDE & CARBON MONOXIDE, VARIOUS HYDROCARBONS, ETC. *
Hazardous Poly Occur: NO *
Conditions To Avoid (Poly): N/K *

Health Hazard Data

LD50-LC50 Mixture: N/K *
Route Of Entry - Inhalation: YES *
Route Of Entry - Skin: YES *
Route Of Entry - Ingestion: NO *
Health Haz Acute And Chronic: OVEREXPOSURE MAY CAUSE CARDIAC ABNORMALITY & LIVER ABNORMALITY. ASPIRATION OF MATERIAL INTO THE LUNGS DUE TO VOMITING CAN CAUSE CHEMICAL PNEUMONITIS WHICH CAN BE FATAL. *
Carcinogenicity - NTP: N/K *
Carcinogenicity - IARC: N/K *
Carcinogenicity - OSHA: N/K *
Explanation Carcinogenicity: N/K *
Signs/Symptoms Of Overexp: EYES:IRRIT, REDNESS, TEARING. SKIN: PROLONGED/REPEATED CONTACT CAN CAUSE MODERATE IRRIT, DEFATT, DERMATITIS. EXCESSIVE INHALE:NASAL & RESPIRATORY IRRIT, CENTRAL NERVOUS SYSTEM, DIZZINESS, WEAKNESS, FATIGUE, NAUSEA, HEADACHE & POSSIBLE UNCONSCIOUSNESS & EVEN DEATH. SWALLOW:GASTROINTESTINAL IRRIT, NAUSEA, VOMIT & DIARRHE *
Med Cond Aggravated By Exp: N/K *
Emergency/First Aid Proc: SKIN:THOROUGHLY WASH AREA W/SOAP & WATER. REMOVE CONTAM CLOTHES. LAUNDER CONTAM CLOTHES BEFORE REUSE. EYES:FLUSH WITH LARGE AMOUNTS OF WATER, LIFTING UPPER & LOWER LIDS, GET MED ATTN. SWALLOWED:DO NOT INDUCE VOMITING, KEEP PERSON WARM, QUIET & GET MEDICAL ATTENTION. BREATH:REMOVE PERSON TO FRESH AIR. IF BREATH IS DIFF ADMIN OXYGEN. BREATH HAS STOPPED GIVE CPR. KEEP PERSON WARM, QUIET, GET MED ATTN *

Precautions for Safe Handling and Use

Steps If Matl Released/Spill: SM:ABSORB LIQ ON PAPER,VERMICULITE,FLOOR ABSORBENT. LG:ELIM ALL IGNITE SOURCES. NO PERSONS W/OUT WEARING PROTECTIVE EQUIP. STOP AT SOURCE. DIKE AREA TO PREVENT SPREAD, PUMP LIQ TO SALVAGE TANK. TAKE UP REST W/SAND,CLAY,ETC. SHOVEL INTO CONTAINERS. *
Neutralizing Agent: N/K *
Waste Disposal Method: DISPOSE OF IN ACCORDANCE WITH ALL LOCAL, STATE AND FEDERAL REGULATIONS. PREVENT RUN-OFF TO SEWERS, STREAMS OR OTHER BODIES OF WATER. IF RUN-OFF OCCURS, NOTIFY PROPER AUTHORITIES AS REQUIRED, THAT A SPILL HAS OCCURRED. *
Precautions-Handling/Storing: CONTAINERS MAY BE HAZARDOUS WHEN EMPTIED. SINCE EMPTIES RETAIN PRODUCT RESIDUES(VAPOR,LIQUID,SOLID)ALL HAZARD PRECAUTIONS GIVEN MUST BE OBSERVED. *
Other Precautions: N/K *

Control Measures

Respiratory Protection: NIOSH/MSHA APPROVED AIR SUPPLIED RESPIRATOR IS ADVISED IN ABSENCE OF PROPER ENVIRONMENTAL CONTROL. OSHA REGS ALSO PERMIT OTHER NIOSH/MSHA RESPIRATORS (NEGATIVE PRESSURE TYPE) UNDER SPECIFIED CONDITIONS. SEE YOUR SAFETY EQUIPMENT SUPPLIER. *

Report for NIIN: 001818079

Ventilation: PROVIDE SUFFICIENT MECHANICAL (GENERAL &/OR LOCAL EXHAUST) VENTILATION *
Protective Gloves: WEAR RESISTANT GLOVES:POLYETHYLENE *
Eye Protection: CHEM SPLASH GOGGLES OR SAFETY GLASSES *
Other Protective Equipment: TO PREVENT REPEATED OR PROLONGED SKIN CONTACT, WEAR IMPERVIOUS CLOTHING & BOOTS *
Work Hygienic Practices: REMOVE CONTAMINATED CLOTHING. LAUNDER CONTAMINATED CLOTHING BEFORE RE-USE. *
Suppl. Safety & Health Data: N/K *

DEFT PRIMER PART A

Product Code = 44-W-7 Base

Product Description = MIL-P-53030
Epoxy Polyamid Water
Reducable Primer

In order to dispose of this material properly according to state and federal regulations, the following information is submitted.

Raw Material Used	Percent of Formula by Weight
1. Resin (Solids)	16.03
2. Additives (Solids)	0.10
3. Pigments	
a) Titanium Dioxide	33.96
b) Extenders	27.85
4. Solvents	
a) Butanol	10.80
b) Aeromatic hydrocarbon	11.26
Total	100.0

DEFT PRIMER PART B

Product Code = 44-W-7 Catalyst

Product Description = MIL-P-53030
Epoxy Polyamid
Catalyst Component

In order to dispose of this material properly according to state and federal regulations, the following information is submitted.

Raw Material Used	Percent of Formula by Weight
1. Resin (Solids)	71.17
2. Additives (Solids)	0.06
3. Solvents	
a) Nitroethane	24.64
b) Aeromatic hydrocarbon	4.13
Total	100.0

DOD Hazardous Materials Information System
DoD 6050.5-L
AS OF April 1995

FSC: 8010
NIIN: 001605788
Manufacturer's CAGE: 5W216
Part No. Indicator: C
Part Number/Trade Name: THINNER DOPE & LACQUER CELLULOSE NITRATE

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General Information

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Item Name: THINNER, DOPE & LACQUER, CELLULOSE NITRATE
Manufacturer's Name: CHEMICAL SPECIALISTS & DEVELOPMENT
Manufacturer's Street: #5 HACKBERRY LANE
Manufacturer's P. O. Box: N/K
Manufacturer's City: CUT & SHOOT
Manufacturer's State: TX
Manufacturer's Country: US
Manufacturer's Zip Code: 77303
Manufacturer's Emerg Ph #: 800-424-9300
Manufacturer's Info Ph #: 409-756-1065
Distributor/Vendor # 1:
Distributor/Vendor # 1 Cage:
Distributor/Vendor # 2:
Distributor/Vendor # 2 Cage:
Distributor/Vendor # 3:
Distributor/Vendor # 3 Cage:
Distributor/Vendor # 4:
Distributor/Vendor # 4 Cage:
Safety Data Action Code:
Safety Focal Point: G
Record No. For Safety Entry: 008
Tot Safety Entries This Stk#: 017
Status: FE
Date MSDS Prepared: 01SEP90
Safety Data Review Date: 12MAR91
Supply Item Manager: GSA
MSDS Preparer's Name: DAVID SHIPP
Preparer's Company: CHEMICAL SPECIALISTS & DEVELOPMENT
Preparer's St Or P. O. Box: #5 HACKBERRY LANE
Preparer's City: CUT & SHOOT
Preparer's State: TX
Preparer's Zip Code: 77303
Other MSDS Number:
MSDS Serial Number: BJZRZ
Specification Number: A-A-857B   Used by Ft. Eustis
Spec Type, Grade, Class: N/K
Hazard Characteristic Code: N/
Unit Of Issue: CN
Unit Of Issue Container Qty: 5 GAL CAN
Type Of Container: METAL
Net Unit Weight: N/K

Report for NIIN: 001605788

NRC/State License Number: N/K
Net Explosive Weight: N/K
Net Propellant Weight-Ammo: N/K
Coast Guard Ammunition Code: N/K

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Ingredients/Identity Information

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Proprietary: NO
Ingredient: ISOPROPYL ALCOHOL (SARA III)
Ingredient Sequence Number: 01
Percent: 18
Ingredient Action Code:
Ingredient Focal Point: G
NIOSH (RTECS) Number: NT8050000
CAS Number: 67-63-0
OSHA PEL: 400 PPM/500 STEL
ACGIH TLV: 400 PPM/500STEL;9192
Other Recommended Limit: NONE SPECIFIED

Proprietary: NO
Ingredient: ISOBUTYL ACETATE (SARA III)
Ingredient Sequence Number: 02
Percent: 31
Ingredient Action Code:
Ingredient Focal Point: G
NIOSH (RTECS) Number: AI4025000
CAS Number: 110-19-0
OSHA PEL: 150 PPM
ACGIH TLV: 150 PPM; 9192
Other Recommended Limit: NONE SPECIFIED

Proprietary: NO
Ingredient: ALIPHATIC PETROLEUM DISTILLATES (NIOSH 350 MG/CUM-8 HOUR TIME WEIGHT AVERAGE, 1800 MG/CUM BY 15 MINUTES SAMPLE)
Ingredient Sequence Number: 03
Percent: 16
Ingredient Action Code:
Ingredient Focal Point: G
NIOSH (RTECS) Number: DE3030000
CAS Number: 64742-89-8
OSHA PEL: 300 PPM
ACGIH TLV: 300 PPM
Other Recommended Limit: NONE SPECIFIED

Proprietary: NO
Ingredient: METHYL ETHYL KETONE (2-BUTANONE) (MEK) (SARA III)
Ingredient Sequence Number: 04
Percent: 12
Ingredient Action Code:
Ingredient Focal Point: G
NIOSH (RTECS) Number: EL6475000
CAS Number: 78-93-3
OSHA PEL: 200 PPM/300 STEL

Report for NIIN: 001605788

ACGIH TLV: 200 PPM/300STEL 9192
Other Recommended Limit: NONE SPECIFIED

Proprietary: NO
Ingredient: TOLUENE (SARA III)
Ingredient Sequence Number: 05
Percent: 12
Ingredient Action Code:
Ingredient Focal Point: G
NIOSH (RTECS) Number: XS5250000
CAS Number: 108-88-3
OSHA PEL: 200 PPM/150 STEL
ACGIH TLV: 50 PPM; 9293
Other Recommended Limit: NONE SPECIFIED

Proprietary: NO
Ingredient: N-BUTYL ALCOHOL (SARA III)
Ingredient Sequence Number: 06
Percent: 11
Ingredient Action Code:
Ingredient Focal Point: G
NIOSH (RTECS) Number: EO1400000
CAS Number: 71-36-3
OSHA PEL: 100 PPM
ACGIH TLV: S, C 50 PPM; 9293
Other Recommended Limit: NONE SPECIFIED

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Physical/Chemical Characteristics

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Appearance And Odor: CLEAR, LITTLE IF ANY COLOR; CHARACTERISTIC ODOR
Boiling Point: 175F,79C
Melting Point: -20F,-29C
Vapor Pressure (MM Hg/70 F): 70 MMHG
Vapor Density (Air=1): 3.0
Specific Gravity: 0.824
Decomposition Temperature: N/K
Evaporation Rate And Ref: SLOWER THAN ETHER
Solubility In Water: MODERATE
Percent Volatiles By Volume: 100
Viscosity: N/K
pH: N/K
Radioactivity: N/K
Form (Radioactive Matl): N/K
Magnetism (Milligauss): N/K
Corrosion Rate (IPY): NONE
Autoignition Temperature: N/K

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Fire and Explosion Hazard Data

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Flash Point: 10 F/-12.2 C
Flash Point Method: N/K
Lower Explosive Limit: 1.2
Upper Explosive Limit: N/K

Extinguishing Media: REGULAR FOAM OR CARBON DIOXIDE OR DRY CHEMICAL
Special Fire Fighting Proc: WEAR SELF CONTAINED BREATHING APPARATUS W/ FULL FACEPIECE OPERATED IN POSITIVE PRESS DEMAND MODE. VAPOR MAY TRAVEL TO IGNITE SOURCES DISTANT FROM HANDLING POINT
Unusual Fire And Expl Hazrds: NEVER WELD, USE CUTTING TORCH ON OR NEAR DRUM(EVEN EMPTY)CAN IGNITE EXPLOSIVELY. ALL 5 GAL PAIL & LARGE METAL CONTAINERS GROUND/BOND WHEN TRANSFERRING MATERIAL

Reactivity Data

Stability: YES
Cond To Avoid (Stability): N/K
Materials To Avoid: AVOID CONTACT WITH STRONG OXIDIZING AGENTS.
Hazardous Decomp Products: MAY FORM TOXIC MATERIALS. CARBON DIOXIDE & CARBON MONOXIDE, VARIOUS HYDROCARBONS, ETC.
Hazardous Poly Occur: NO
Conditions To Avoid (Poly): N/K

Health Hazard Data

LD50-LC50 Mixture: N/K
Route Of Entry - Inhalation: YES
Route Of Entry - Skin: YES
Route Of Entry - Ingestion: NO
Health Haz Acute And Chronic: OVEREXPOSURE LIVER ABNORMALITIES &/OR EYE DAMAGE. ASPIRATION OF MATERIAL INTO THE LUNGS DUE TO VOMITING CAN CAUSE CHEMICAL PNEUMONITIS WHICH CAN BE FATAL.
Carcinogenicity - NTP: N/K
Carcinogenicity - IARC: N/K
Carcinogenicity - OSHA: N/K
Explanation Carcinogenicity: N/K
Signs/Symptoms Of Overexp: EYES:IRRIT, REDNESS, TEARING. SKIN: PROLONGED/REPEATED CONTACT CAN CAUSE MODERATE IRRIT, DEFATT, DERMATITIS. EXCESSIVE INHALE:NASAL & RESPIRATORY IRRIT, CENTRAL NERVOUS SYSTEM, DIZZINESS, WEAKNESS, FATIGUE, NAUSEA, HEADACHE & POSSIBLE UNCONSCIOUSNESS & EVEN DEATH. SWALLOW:GASTROINTESTINAL IRRIT, NAUSEA, VOMIT & DIARRHEA
Med Cond Aggravated By Exp: N/K
Emergency/First Aid Proc: SKIN:THOROUGHLY WASH AREA W/SOAP & WATER. REMOVE CONTAM CLOTHES. LAUNDER CONTAM CLOTHES BEFORE REUSE. EYES:FLUSH WITH LARGE AMOUNTS OF WATER, LIFTING UPPER & LOWER LIDS, GET MED ATTN. SWALLOWED:DO NOT INDUCE VOMITING, KEEP PERSON WARM, QUIET & GET MEDICAL ATTENTION. BREATH:REMOVE PERSON TO FRESH AIR. IF BREATH IS DIFF ADMIN OXYGEN. BREATH HAS STOPPED GIVE CPR. KEEP PERSON WARM, QUIET, GET MED ATTN

Precautions for Safe Handling and Use

Steps If Matl Released/Spill: SM:ABSORB LIQ ON PAPER,VERMICULITE,FLOOR ABSORBENT. LG:ELIM ALL IGNITE SOURCES. NO PERSONS W/OUT WEARING PROTECTIVE EQUIP. STOP AT SOURCE. DIKE AREA TO PREVENT SPREAD, PUMP LIQ TO SALVAGE TANK. TAKE UP REST W/SAND,CLAY,ETC. SHOVEL INTO CONTAINERS.*
Neutralizing Agent: N/K
Waste Disposal Method: DISPOSE OF IN ACCORDANCE WITH ALL LOCAL, STATE AND FEDERAL REGULATIONS. * PREVENT RUN-OFF TO SEWERS, STREAMS OR OTHER BODIES

OF WATER. IF RUN-OFF OCCURS, NOTIFY PROPER AUTHORITIES AS REQUIRED, THAT A SPILL HAS OCCURRED.
Precautions-Handling/Storing: CONTAINERS MAY BE HAZARDOUS WHEN EMPTIED. SINCE EMPTIES RETAIN PRODUCT RESIDUES(VAPOR,LIQUID,SOLID)ALL HAZARD PRECAUTIONS GIVEN MUST BE OBSERVED.
Other Precautions: N/K

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Control Measures

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Respiratory Protection: NIOSH/MSHA APPROVED AIR SUPPLIED RESPIRATOR IS ADVISED IN ABSENCE OF PROPER ENVIRONMENTAL CONTROL. OSHA REGS ALSO PERMIT OTHER NIOSH/MSHA RESPIRATORS (NEGATIVE PRESSURE TYPE) UNDER SPECIFIED CONDITIONS. SEE YOUR SAFETY EQUIPMENT SUPPLIER.
Ventilation: PROVIDE SUFFICIENT MECHANICAL (GENERAL &/OR LOCAL EXHAUST) VENTILATION
Protective Gloves: NITRILE RUBBER, POLYETHYLENE
Eye Protection: CHEM SPLASH GOGGLES OR SAFETY GLASSES
Other Protective Equipment: TO PREVENT REPEATED OR PROLONGED SKIN CONTACT, WEAR IMPERVIOUS CLOTHING & BOOTS
Work Hygienic Practices: REMOVE CONTAMINATED CLOTHING. LAUNDER CONTAMINATED CLOTHING BEFORE RE-USE.
Suppl. Safety & Health Data: N/K

Table C-1

Baseline CARC System Life Cycle Inventory Summary Results

Notes: = User Input

Inventory numbers for individual CARC System components do not include emissions and energy or materials consumption for electric power generation. The "Baseline CARC System" numbers do include electric power generation data.

LCI Components	Units	Thinned TC Quantity	Top Coat Quantity	Thinner Quantity	Primer Quantity	Prim. Pt. A Quantity	Prim. Pt. B Quantity	Baseline CARC System Units	Baseline CARC System Quantity
Usage Rate	ft^2/gal.	200			400				
Volumetric Mixing Ratio	CARC:thin.		4	1					
Volumetric Mixing Ratio	Pt. A:Pt. B					4	1		
Specific Gravity				0.85		1.7498	1.128		
Unit Weight	lb/gal.		10.29	7.089		14.59333	9.40752		
Usage Rate	lb/ft^2		0.05145	0.01152		0.029187	0.004704		
Functional Unit (FU)								ft^2	1000
Resource and Energy Consumption									
Electricity	BTU/lb		10813.64	5881.702		5176.439	12217.84	BTU/FU	832681.5
Natural gas	BTU/lb		177054.9	115627		83911.35	293983.5	BTU/FU	14348909
Steam	BTU/lb		6454.894	3576.371		2511.59	2840.313	BTU/FU	588191.3
Water	lb/lb		486.9277	329.4671		352.796	967.3135	lb/FU	43695.19
Crude oil	lb/lb		33.01711	27.95911		17.41074	47.54899	lb/FU	2752.657
Oxygen	lb/lb		0.078344	0.156721		0.279948	0.304434	lb/FU	15.43913
Refinery gases	lb/lb		1.234477	0.293007		0.161095		lb/FU	71.59119
Cobalt oxide	lb/lb		0.0195					lb/FU	1.003275
Chrome oxide	lb/lb		0.0885					lb/FU	4.553325
Silica	lb/lb		0.26			0.0096		lb/FU	13.6572
Iron ore	lb/lb		0.023108			0.003184		lb/FU	1.281821
Magnetite	lb/lb		0.007703					lb/FU	0.396294
Magnesium ore	lb/lb		0.043719					lb/FU	2.249343
Sodium Chloride	lb/lb		0.504494			0.486484	0.622545	lb/FU	43.08366
Phosphoric acid	lb/lb		0.000926					lb/FU	0.047642
Sulfuric acid	lb/lb		0.052292			0.114823		lb/FU	6.041725
Sulfur dioxide	lb/lb		0.000044					lb/FU	0.002242
Hydrocarbons C8 to C10	lb/lb		0.00033	0		0	0	lb/FU	0.016979
Proprietary Primer Ingredients	lb/lb					0		lb/FU	0
Chlorine	lb/lb					0.39417	0.362135	lb/FU	13.20812
Coal	lb/lb					0.009997		lb/FU	0.291794
Phosphate ore	lb/lb					0.07168		lb/FU	2.092124

BCBPBTBG.WK4

Zinc ore	lb/lb			0.286		lb/FU	8.347482
Uranium						lb/FU	4.1E-09
Distillate Fuel Oil						lb/FU	4.2E-07
Residual Fuel Oil						lb/FU	4.9E-06
Hydropotential						m^3-m/FU	0.006874
Ilmenite	lb/lb			0.080544		lb/FU	2.350849
Rumenite	lb/lb			0.207659		lb/FU	6.060934
Air	lb/lb			2.606004		lb/FU	76.06144
Coke	lb/lb			0.036754		lb/FU	1.072732
Sodium hydroxide	lb/lb			0.011026		lb/FU	0.32182
SiAl	lb/lb			0.001838		lb/FU	0.053637
Fuel	lb/lb			1340.221		lb/FU	39117.03
Starch						lb/FU	0.209911
Soda ash						lb/FU	2.623886
Limestone						lb/FU	4.653024
Bauxite						lb/FU	83.96435
Air Emissions							
CO	lb/lb	0.011166	0.008917	0.02184	0.01517	lb/FU	1.386005
PM	lb/lb	0.108338	0.005423	0.001525	0.004981	lb/FU	6.006696
SOx	lb/lb	0.006263	0.010748	0.058562	0.110646	lb/FU	21.58427
VOC	lb/lb	0.234812	0.073978	0.058768	0.077079	lb/FU	15.01133
Benzene	lb/lb	0.001902	0.008641	0.000125	0.000476	lb/FU	0.203287
Toluene	lb/lb	0.000249	0.009874	0.000065	0.000251	lb/FU	0.129614
Ethylbenzene	lb/lb	0.000025	9.7E-06	0.000017	0.000064	lb/FU	0.002209
Xylene	lb/lb	0.000889	0.000835	0.000018	0.000064	lb/FU	0.056203
Cumene	lb/lb	0.000242		0.00033	0.001	lb/FU	0.026791
Phenol	lb/lb	0.000242		0.000153	0.001	lb/FU	0.021642
Heavy Aromatics	lb/lb	0.003835				lb/FU	0.197299
NOx	lb/lb	0.103415	0.020305	0.01309	0.034568	lb/FU	6.099323
PM10	lb/lb	0.001298		5.9E-06	9.8E-07	lb/FU	0.310462
Acetaldehyde	lb/lb	0.000076	0.003166	0.00165	0	lb/FU	0.08855
Ethylene	lb/lb	3.6E-06	0.000033	0.000077		lb/FU	0.002808
HCN	lb/lb	0.000131			0	lb/FU	0.006726
Chlorine	lb/lb	0.005808		0.007967	0.009633	lb/FU	0.576658
MEK	lb/lb	0	0.005098	0	0	lb/FU	0.058732
Isobutyraldehyde	lb/lb		0.028462			lb/FU	0.327885
Acetone	lb/lb	0.0001	0.000085	0.000053	0.000144	lb/FU	0.008342
Ammonia	lb/lb			2.1E-07	0	lb/FU	6.2E-06
Fluorine	lb/lb			0.00096		lb/FU	0.02802
Lead	lb/lb			0.00003		lb/FU	0.000876

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MIBK	lb/lb	0	0	0.000383	0.002559	lb/FU	0.023224
Isopropyl alcohol	lb/lb	0	0	0	0	lb/FU	0
MIAK	lb/lb	0.010193	0	0	0	lb/FU	0.524453
Aromatic hydrocarbons	lb/lb	0.000438	0	0	0.000084	lb/FU	0.022925
Butyl acetate	lb/lb	0.000442	0.001316	0.003828	0	lb/FU	0.1496
Naphtha	lb/lb	0.001281	0	0	0	lb/FU	0.065909
Propyl acetate	lb/lb	0	0	0	0	lb/FU	0
MPK	lb/lb	0	0	0	0	lb/FU	0
Butyl cellosolve	lb/lb	0	0	0	0	lb/FU	0
Hexyl acetate	lb/lb	0	0.00489	0	0	lb/FU	0.056332
CO2	lb/lb	3.523738	2.983926	2.08293	5.074648	lb/FU	300.3368
Hexane	lb/lb	0.000798	0.000676	0.000421	0.00115	lb/FU	0.066568
Heptane	lb/lb	0.001028	0.000871	0.000542	0.001481	lb/FU	0.08571
Octane	lb/lb	0.000687	0.000582	0.000363	0.00099	lb/FU	0.057316
C-7 cycloparaffins	lb/lb	0.000145	0.000123	0.000076	0.000209	lb/FU	0.012075
C-8 cycloparaffins	lb/lb	0.000053	0.000045	0.000028	0.000076	lb/FU	0.004414
Pentane	lb/lb	0.000499	0.000422	0.000263	0.000718	lb/FU	0.041566
Methane	lb/lb	0.003311	0.002804	0.001746	0.004769	lb/FU	0.276078
Ethane	lb/lb	0.00057	0.000482	0.0003	0.00082	lb/FU	0.047482
Propane	lb/lb	0.000893	0.000757	0.000471	0.001287	lb/FU	0.074485
n-Butane	lb/lb	0.000708	0.000599	0.000373	0.001019	lb/FU	0.05901
Iso-Butane	lb/lb	0.000035	0.00003	0.000019	0.000051	lb/FU	0.002943
Formaldehyde	lb/lb	0.000251	0.000213	0.000132	0.000362	lb/FU	0.020946
Hydrocarbons	lb/lb	0.039831	0.033729	0.021004	0.057362	lb/FU	3.320748
Aldehydes	lb/lb	0.000232	0.000196	0.000122	0.000334	lb/FU	0.019324
Organic Acids	lb/lb	0.000295	0.00025	0.000156	0.000425	lb/FU	0.024594
Kerosene						lb/FU	4.4E-09
Carbon tetrachloride	lb/lb				0.000599	lb/FU	0.002818
Chloroform	lb/lb				0.000284	lb/FU	0.001337
Ethyl chloride	lb/lb				0.000637	lb/FU	0.002999
Ethylene dichloride	lb/lb				0.001647	lb/FU	0.007745
Trichloroethane	lb/lb				0.000487	lb/FU	0.00229
Vinyl chloride	lb/lb				0.000303	lb/FU	0.001428
Hydrochloric acid	lb/lb			0.000041	0.000029	lb/FU	0.00132
Sulfuric acid	lb/lb	0			0	lb/FU	0
Propylene	lb/lb	0			0	lb/FU	0
1,2-butylene					0	lb/FU	0
2-nitropropane					0	lb/FU	0
Acetonitrile					0	lb/FU	0
Bromochlorodifluoromethane					0	lb/FU	0
Bromotrifluoromethane					0	lb/FU	0

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Dichlorodifluoromethane					0	lb/FU	0
Methanol					0	lb/FU	0
Naphthalene					0	lb/FU	0
Nitric acid					0	lb/FU	0
Butyl alcohol		0	0	0.001081	0.000574	lb/FU	0.03424
Nitroethane		0	0	0	0	lb/FU	0
Aliphatic hydrocarbons		0	0	0	0	lb/FU	0
Wastewater Emissions							
Wastewater	lb/lb	34.85286	34.39827	24.87046	89.14841	lb/FU	3334.696
WW Reinj'd	lb/lb	1.939361	1.642264	1.022673	2.792936	lb/FU	161.6858
WW Discharg.	lb/lb	0.857607	0.726227	0.452237	1.235067	lb/FU	71.49923
WW Injected	lb/lb	0.281159	0.238087	0.148262	0.404906	lb/FU	23.44037
Arsenic	lb/lb	3.5E-07	3.0E-07	1.9E-07	5.1E-07	lb/FU	0.00003
Benzene	lb/lb	8.6E-06	7.2E-06	4.5E-06	0.000012	lb/FU	0.000713
Boron	lb/lb	0.000182	0.000154	0.000096	0.000262	lb/FU	0.015167
Sodium	lb/lb	0.172821	0.146346	0.091133	0.248885	lb/FU	14.40818
Chloride	lb/lb	0.136437	0.115536	0.071947	0.196488	lb/FU	11.37488
Mobile ions	lb/lb	0.418408	0.354311	0.220637	0.602563	lb/FU	34.88296
Oil and Grease	lb/lb	0.00426	0.003607	0.002246	0.006134	lb/FU	0.355131
Cadmium	lb/lb	2.9E-06	2.5E-06	0.000164	4.2E-06	lb/FU	0.004971
Chromium	lb/lb	2.6E-07	2.2E-07	0.000018	3.8E-07	lb/FU	0.000554
Mercury	lb/lb	6.6E-08	5.6E-08	5.3E-08	9.6E-08	lb/FU	6.1E-06
Thallium	lb/lb	6.3E-08	5.3E-08	3.3E-08	9.0E-08	lb/FU	5.2E-06
Sulfuric Acid						lb/FU	9.4E-08
Iron				0.000263		lb/FU	8.1E-06
Dissolved Solids						lb/FU	6.8E-07
Suspended Solids						lb/FU	2.3E-09
COD						lb/FU	4.5E-09
Phenol						lb/FU	3.8E-10
Sulfide						lb/FU	3.8E-10
Oil						lb/FU	7.6E-10
Acid						lb/FU	7.6E-10
Metals						lb/FU	3.8E-10
BOD						lb/FU	1.4E-09
Vanadium				4.5E-06		lb/FU	0.00013
Zinc				1.4E-06		lb/FU	0.000041
Copper				1.4E-06		lb/FU	0.000041
Aluminum				0.00002		lb/FU	0.000591
Titanium dioxide				0.004455		lb/FU	0.130028
Lead				0.000061		lb/FU	0.001773

Magnesium				4.1E-09		lb/FU	1.2E-07
Chlorine					0.008326	lb/FU	0.039165
Ammonia					0	lb/FU	0
Hydrogen cyanide					0	lb/FU	0
Solid Wastes							
Solid Wastes	lb/lb	0.27641	0.000753	0.593655	0.551663	lb/FU	62.14026
Hazardous Wastes	lb/lb	0.000132		0.07913	0.000264	lb/FU	80.80762
Fly Ash						lb/FU	2.0E-09
Bottom Ash						lb/FU	5.7E-10
Slag						lb/FU	2.2E-10
FGD Solids						lb/FU	7.9E-10
U238						lb/FU	5.4E-09
U236						lb/FU	3.6E-12
U235						lb/FU	4.5E-11
Pu (fissile)						lb/FU	3.7E-11
Pu (nonfissile)						lb/FU	1.4E-11
Fission Products						lb/FU	2.6E-11
2-nitropropane					0	lb/FU	0
Acetaldehyde					0	lb/FU	0
Acetone					0	lb/FU	0
Acetonitrile					0	lb/FU	0
Formaldehyde					0	lb/FU	0
Methanol					0	lb/FU	0
Naphathalene					0	lb/FU	0
Nitric acid					0	lb/FU	0
Ammonia					0	lb/FU	0
Hydrogen cyanide					0	lb/FU	0

Table C-2

Alternative Primer CARC System Life Cycle Inventory Summary Results

Notes: [redacted] = User Input

Inventory numbers for individual CARC System components do not include emissions and energy or materials consumption for electric power generation. The "Baseline CARC System" numbers do include electric power generation data.

LCI Components	Units	Thinned TC Quantity	Top Coat Quantity	Thinner Quantity	Primer Quantity	Prim. Pt. A Quantity	Prim. Pt. B Quantity		Baseline CARC System Units	Baseline CARC System Quantity
Usage Rate	ft^2/gal.	[redacted]			[redacted]					
Volumetric Mixing Ratio	CARC:thin.		[redacted]							
Volumetric Mixing Ratio	Pt. A:Pt. B					[redacted]				
Specific Gravity				[redacted]						
Unit Weight	lb/gal.		[redacted]	7.089		14.25706	9.411273			
Usage Rate	lb/ft^2		0.05145	0.01152		0.028514	0.004706	0.004706		
Functional Unit (FU)									ft^2	[redacted]
Resource and Energy Consumption										
Electricity	BTU/lb		10813.64	5881.702		2849.335	12368.93		BTU/FU	763573.7
Natural gas	BTU/lb		177054.9	115627		44822.11	199001.2		BTU/FU	12731376
Steam	BTU/lb		6454.894	3576.371		696.0441	3090.297		BTU/FU	535913.5
Water	lb/lb		486.9277	329.4671		248.7911	907.1772		lb/FU	40210.77
Crude oil	lb/lb		33.01711	27.95911		8.404271	37.31328		lb/FU	2436.041
Oxygen	lb/lb		0.078344	0.156721		0.214204	0.266878		lb/FU	13.19986
Refinery gases	lb/lb		1.234477	0.293007		0			lb/FU	66.88931
Cobalt oxide	lb/lb		0.0195						lb/FU	1.003275
Chrome oxide	lb/lb		0.0885						lb/FU	4.553325
Silica	lb/lb		0.26			0			lb/FU	13.377
Iron ore	lb/lb		0.023108			0.00534			lb/FU	1.341152
Magnetite	lb/lb		0.007703						lb/FU	0.396294
Magnesium ore	lb/lb		0.043719						lb/FU	2.249343
Sodium Chloride	lb/lb		0.504494			0.35447	1.573775		lb/FU	43.46918
Phosphoric acid	lb/lb		0.000926						lb/FU	0.047642
Sulfuric acid	lb/lb		0.052292			0.192562			lb/FU	8.181103
Sulfur dioxide	lb/lb		0.000044						lb/FU	0.002242
Hydrocarbons C8 to C10	lb/lb		0.00033	0		0.002477	0.000909		lb/FU	0.091889
Proprietary Primer Ingredients	lb/lb					0			lb/FU	0
Chlorine	lb/lb					0.332521	1.120572		lb/FU	14.75451
Coal	lb/lb					0			lb/FU	0.000016
Phosphate ore	lb/lb					0			lb/FU	0

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Zinc ore	lb/lb			0		lb/FU	0
Uranium						lb/FU	3.8E-09
Distillate Fuel Oil						lb/FU	3.9E-07
Residual Fuel Oil						lb/FU	4.4E-06
Hydropotential						m^3-m/FU	0.006304
Ilmenite	lb/lb			0.135076		lb/FU	3.851554
Rumenite	lb/lb			0.348251		lb/FU	9.930038
Air	lb/lb			4.370365		lb/FU	124.6166
Coke	lb/lb			0.061637		lb/FU	1.757529
Sodium hydroxide	lb/lb			0.018491		lb/FU	0.527259
SiAl	lb/lb			0.003082		lb/FU	0.087876
Fuel	lb/lb			2247.6		lb/FU	64088.07
Starch						lb/FU	0.209911
Soda ash						lb/FU	2.623886
Limestone						lb/FU	4.653024
Bauxite						lb/FU	83.96435
Air Emissions							
CO	lb/lb	0.011166	0.008917	0.002361	0.01018	lb/FU	0.792424
PM	lb/lb	0.108338	0.005423	0.000465	0.001296	lb/FU	5.958093
SOx	lb/lb	0.006263	0.010748	0.047286	0.113662	lb/FU	21.20602
VOC	lb/lb	0.234812	0.073978	0.01991	0.083488	lb/FU	13.89406
Benzene	lb/lb	0.001902	0.008641	0.000077	0.000342	lb/FU	0.201201
Toluene	lb/lb	0.000249	0.008641	0.000029	0.000126	lb/FU	0.11377
Ethylbenzene	lb/lb	0.000025	9.7E-06	0.000094	0.000078	lb/FU	0.004459
Xylene	lb/lb	0.000164	9.7E-06	0.001132	0.000459	lb/FU	0.042969
Cumene	lb/lb	0.000242		0.000204	0.000904	lb/FU	0.022511
Phenol	lb/lb	0.000242		0.000138	0.000904	lb/FU	0.020629
Heavy Aromatics	lb/lb	0.003835				lb/FU	0.197299
NOx	lb/lb	0.103415	0.020305	0.00685	0.027098	lb/FU	5.877492
PM10	lb/lb	0.001298		0	0	lb/FU	0.310286
Acetaldehyde	lb/lb	0.000076	0.003166	0	0.000015	lb/FU	0.04046
Ethylene	lb/lb	3.6E-06	0.000033	0		lb/FU	0.000559
HCN	lb/lb	0.000131			0.000014	lb/FU	0.00679
Chlorine	lb/lb	0.005808		0.00581	0.025757	lb/FU	0.585689
MEK	lb/lb	0	0.001769	0	0	lb/FU	0.020379
Isobutyraldehyde	lb/lb		0.028462			lb/FU	0.327885
Acetone	lb/lb	0.0001	0.000085	0.000025	0.000123	lb/FU	0.007429
Ammonia	lb/lb			0	0.000189	lb/FU	0.000887
Fluorine	lb/lb			0		lb/FU	0
Lead	lb/lb			0		lb/FU	9.1E-11

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MIBK	lb/lb	0	0	0	0	lb/FU	0
Isopropyl alcohol	lb/lb	0	0	0	0	lb/FU	0
MIAK	lb/lb	0.00138	0	0	0	lb/FU	0.071022
Aromatic hydrocarbons	lb/lb	0	0	0.001315	0.000121	lb/FU	0.038055
Butyl acetate	lb/lb	0	0	0	0	lb/FU	0
Naphtha	lb/lb	0	0	0	0	lb/FU	0
Propyl acetate	lb/lb	0	0	0	0	lb/FU	0
MPK	lb/lb	0	0	0	0	lb/FU	0
Butyl cellosolve	lb/lb	0	0	0	0	lb/FU	0
Hexyl acetate	lb/lb	0	0	0	0	lb/FU	0
CO2	lb/lb	3.523738	2.983926	1.273899	3.982246	lb/FU	270.7341
Hexane	lb/lb	0.000798	0.000676	0.000203	0.000902	lb/FU	0.058911
Heptane	lb/lb	0.001028	0.000871	0.000262	0.001162	lb/FU	0.075852
Octane	lb/lb	0.000687	0.000582	0.000175	0.000777	lb/FU	0.050724
C-7 cycloparaffins	lb/lb	0.000145	0.000123	0.000037	0.000164	lb/FU	0.010686
C-8 cycloparaffins	lb/lb	0.000053	0.000045	0.000013	0.00006	lb/FU	0.003907
Pentane	lb/lb	0.000499	0.000422	0.000127	0.000563	lb/FU	0.036785
Methane	lb/lb	0.003311	0.002804	0.000843	0.003742	lb/FU	0.244323
Ethane	lb/lb	0.00057	0.000482	0.000145	0.000644	lb/FU	0.04202
Propane	lb/lb	0.000893	0.000757	0.000227	0.00101	lb/FU	0.065917
n-Butane	lb/lb	0.000708	0.000599	0.00018	0.0008	lb/FU	0.052223
Iso-Butane	lb/lb	0.000035	0.00003	9.0E-06	0.00004	lb/FU	0.002604
Formaldehyde	lb/lb	0.000251	0.000213	0.000064	0.00036	lb/FU	0.018896
Hydrocarbons	lb/lb	0.039831	0.033729	0.010139	0.045014	lb/FU	2.93879
Aldehydes	lb/lb	0.000232	0.000196	0.000059	0.000262	lb/FU	0.017101
Organic Acids	lb/lb	0.000295	0.00025	0.000075	0.000333	lb/FU	0.021765
Kerosene						lb/FU	4.1E-09
Carbon tetrachloride	lb/lb				0	lb/FU	0
Chloroform	lb/lb				0	lb/FU	0
Ethyl chloride	lb/lb				0	lb/FU	0
Ethylene dichloride	lb/lb				0	lb/FU	0
Trichloroethane	lb/lb				0	lb/FU	0
Vinyl chloride	lb/lb				0	lb/FU	0
Hydrochloric acid	lb/lb			0.000068	0	lb/FU	0.001937
Sulfuric acid	lb/lb	0			0	lb/FU	0
Propylene	lb/lb	0			0	lb/FU	0
1,2-butylene					1.5E-07	lb/FU	7.0E-07
2-nitropropane					0.000129	lb/FU	0.000608
Acetonitrile					5.1E-06	lb/FU	0.000024
Bromochlorodifluoromethane					4.7E-07	lb/FU	2.2E-06
Bromotrifluoromethane					1.8E-06	lb/FU	8.3E-06

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Dichlorodifluoromethane					0.000234	lb/FU	0.001101
Methanol					4.0E-06	lb/FU	0.000019
Naphthalene					0.000137	lb/FU	0.000643
Nitric acid					1.2E-06	lb/FU	5.5E-06
Butyl alcohol		0	0	0.001463	0	lb/FU	0.041712
Nitroethane		0	0	0	0.000822	lb/FU	0.003868
Aliphatic hydrocarbons		0	0	0	0	lb/FU	0
Wastewater Emissions							
Wastewater	lb/lb	34.85286	34.39827	14.92556	66.26652	lb/FU	2926.862
WW Reinj'd	lb/lb	1.939361	1.642264	0.493651	2.19171	lb/FU	143.0884
WW Discharg.	lb/lb	0.857607	0.726227	0.218298	0.969199	lb/FU	63.27526
WW Injected	lb/lb	0.281159	0.238087	0.071567	0.317743	lb/FU	20.74422
Arsenic	lb/lb	3.5E-07	3.0E-07	9.0E-08	4.0E-07	lb/FU	0.000026
Benzene	lb/lb	8.6E-06	7.2E-06	2.2E-06	9.7E-06	lb/FU	0.000631
Boron	lb/lb	0.000182	0.000154	0.000046	0.000206	lb/FU	0.013422
Sodium	lb/lb	0.172821	0.146346	0.04399	0.195308	lb/FU	12.75092
Chloride	lb/lb	0.136437	0.115536	0.034729	0.154191	lb/FU	10.06652
Mobile Ions	lb/lb	0.418408	0.354311	0.106503	0.472851	lb/FU	30.87066
Oil and Grease	lb/lb	0.00426	0.003607	0.001084	0.004814	lb/FU	0.314283
Cadmium	lb/lb	2.9E-06	2.5E-06	0.000272	3.3E-06	lb/FU	0.007961
Chromium	lb/lb	2.6E-07	2.2E-07	0.000031	3.0E-07	lb/FU	0.000891
Mercury	lb/lb	6.6E-08	5.6E-08	4.7E-08	7.5E-08	lb/FU	5.8E-06
Thallium	lb/lb	6.3E-08	5.3E-08	1.6E-08	7.1E-08	lb/FU	4.6E-06
Sulfuric Acid						lb/FU	8.6E-08
Iron				0.000441		lb/FU	7.4E-06
Dissolved Solids						lb/FU	6.3E-07
Suspended Solids						lb/FU	2.1E-09
COD						lb/FU	4.1E-09
Phenol						lb/FU	3.5E-10
Sulfide						lb/FU	3.5E-10
Oil						lb/FU	6.9E-10
Acid						lb/FU	6.9E-10
Metals						lb/FU	3.5E-10
BOD						lb/FU	1.3E-09
Vanadium				7.5E-06		lb/FU	0.000213
Zinc				2.4E-06		lb/FU	0.000068
Copper				2.4E-06		lb/FU	0.000068
Aluminum				0.000034		lb/FU	0.000968
Titanium dioxide				0.007471		lb/FU	0.213034
Lead				0.000102		lb/FU	0.002905

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Magnesium						6.8E-09			lb/FU	1.9E-07
Chlorine							0.025756		lb/FU	0.1212
Ammonia							3.7E-07		lb/FU	1.7E-06
Hydrogen cyanide							2.5E-08		lb/FU	1.2E-07
Solid Wastes										
Solid Wastes	lb/lb		0.27641	0.000753		0.442818	1.513695		lb/FU	61.96762
Hazardous Wastes	lb/lb		0.000132			0.03396	0		lb/FU	79.46515
Fly Ash									lb/FU	1.9E-09
Bottom Ash									lb/FU	5.2E-10
Slag									lb/FU	2.0E-10
FGD Solids									lb/FU	7.2E-10
U238									lb/FU	4.9E-09
U236									lb/FU	3.3E-12
U235									lb/FU	4.2E-11
Pu (fissile)									lb/FU	3.4E-11
Pu (nonfissile)									lb/FU	1.3E-11
Fission Products									lb/FU	2.4E-11
2-nitropropane							0.001717		lb/FU	0.008078
Acetaldehyde							0.002214		lb/FU	0.010417
Acetone							0.001188		lb/FU	0.00559
Acetonitrile							0.000969		lb/FU	0.004561
Formaldehyde							0.000017		lb/FU	0.00008
Methanol							0.001951		lb/FU	0.009182
Naphathalene							1.4E-06		lb/FU	6.6E-06
Nitric acid							0.000137		lb/FU	0.000643
Ammonia							0.00003		lb/FU	0.000142
Hydrogen cyanide							1.4E-06		lb/FU	6.6E-06

Table C-3

Alternative Gun CARC System Life Cycle Inventory Summary Results

Notes: = User Input

Inventory numbers for individual CARC System components do not include emissions and energy or materials consumption for electric power generation. The "Baseline CARC System" numbers do include electric power generation data.

LCI Components	Units	Thinned TC Quantity	Top Coat Quantity	Thinner Quantity	Primer Quantity	Prim. Pt. A Quantity	Prim. Pt. B Quantity	Baseline CARC System Units	Baseline CARC System Quantity
Usage Rate	ft^2/gal.	[illegible]			[illegible]				
Volumetric Mixing Ratio	CARC:thin.		[illegible]						
Volumetric Mixing Ratio	Pt. A:Pt. B					[illegible]	[illegible]		
Specific Gravity				[illegible]		[illegible]	[illegible]		
Unit Weight	lb/gal.		[illegible]	7.089		14.59333	9.40752		
Usage Rate	lb/ft^2		0.037147	0.009038		0.021073	0.003396		
Functional Unit (FU)								ft^2	[illegible]
Resource and Energy Consumption									
Electricity	BTU/lb		10813.64	5881.702		5176.439	12217.84	BTU/FU	605433
Natural gas	BTU/lb		177054.9	115627		83911.35	293983.5	BTU/FU	10464120
Steam	BTU/lb		6454.894	3576.371		2511.59	2840.313	BTU/FU	462896.2
Water	lb/lb		486.9277	329.4671		352.796	967.3135	lb/FU	31785.09
Crude oil	lb/lb		33.01711	27.95911		17.41074	47.54899	lb/FU	2007.554
Oxygen	lb/lb		0.078344	0.156721		0.279948	0.304434	lb/FU	11.25989
Refinery gases	lb/lb		1.234477	0.293007		0.161095		lb/FU	51.90009
Cobalt oxide	lb/lb		0.0195					lb/FU	0.724367
Chrome oxide	lb/lb		0.0885					lb/FU	3.28751
Silica	lb/lb		0.26			0.0096		lb/FU	9.860521
Iron ore	lb/lb		0.023108			0.003184		lb/FU	0.925477
Magnetite	lb/lb		0.007703					lb/FU	0.286125
Magnesium ore	lb/lb		0.043719					lb/FU	1.62403
Sodium Chloride	lb/lb		0.504494			0.486484	0.622545	lb/FU	31.10627
Phosphoric acid	lb/lb		0.000926					lb/FU	0.034398
Sulfuric acid	lb/lb		0.052292			0.114823		lb/FU	4.362129
Sulfur dioxide	lb/lb		0.000044					lb/FU	0.001619
Hydrocarbons C8 to C10	lb/lb		0.00033	0		0	0	lb/FU	0.012259
Proprietary Primer Ingredients	lb/lb					0		lb/FU	0
Chlorine	lb/lb					0.39417	0.362135	lb/FU	9.536152
Coal	lb/lb					0.009997		lb/FU	0.210675
Phosphate ore	lb/lb					0.07168		lb/FU	1.510513

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Zinc ore	lb/lb			0.286		lb/FU	6.026878
Uranium						lb/FU	3.0E-09
Distillate Fuel Oil						lb/FU	3.1E-07
Residual Fuel Oil						lb/FU	3.5E-06
Hydropotential						m^3-m/FU	0.004998
Ilmenite	lb/lb			0.080544		lb/FU	1.697312
Rumenite	lb/lb			0.207659		lb/FU	4.375992
Air	lb/lb			2.606004		lb/FU	54.91632
Coke	lb/lb			0.036754		lb/FU	0.774512
Sodium hydroxide	lb/lb			0.011026		lb/FU	0.232354
SIAI	lb/lb			0.001838		lb/FU	0.038726
Fuel	lb/lb			1340.221		lb/FU	28242.48
Starch						lb/FU	0.209911
Soda ash						lb/FU	2.623886
Limestone						lb/FU	4.653024
Bauxite						lb/FU	83.96435
Air Emissions							
CO	lb/lb	0.011166	0.008917	0.02184	0.01517	lb/FU	1.007117
PM	lb/lb	0.108338	0.005423	0.001525	0.004981	lb/FU	4.424783
SOx	lb/lb	0.006263	0.010748	0.058562	0.110646	lb/FU	20.98633
VOC	lb/lb	0.234812	0.073978	0.058768	0.077079	lb/FU	10.89153
Benzene	lb/lb	0.001902	0.008641	0.000125	0.000476	lb/FU	0.152999
Toluéne	lb/lb	0.000249	0.009608	0.000065	0.000251	lb/FU	0.098296
Ethylbenzene	lb/lb	0.000025	9.7E-06	0.000017	0.000064	lb/FU	0.001602
Xylene	lb/lb	0.000687	0.000657	0.000018	0.000064	lb/FU	0.03208
Cumene	lb/lb	0.000242		0.00033	0.001	lb/FU	0.019343
Phenol	lb/lb	0.000242		0.000153	0.001	lb/FU	0.015625
Heavy Aromatics	lb/lb	0.003835				lb/FU	0.14245
NOx	lb/lb	0.103415	0.020305	0.01309	0.034568	lb/FU	4.418342
PM10	lb/lb	0.001298		5.9E-06	9.8E-07	lb/FU	0.291845
Acetaldehyde	lb/lb	0.000076	0.003166	0.00165	0	lb/FU	0.066215
Ethylene	lb/lb	3.6E-06	0.000033	0.000077		lb/FU	0.002051
HCN	lb/lb	0.000131			0	lb/FU	0.004856
Chlorine	lb/lb	0.005808		0.007967	0.009633	lb/FU	0.416345
MEK	lb/lb	0	0.004381	0	0	lb/FU	0.039595
Isobutyraldehyde	lb/lb		0.028462			lb/FU	0.257241
Acetone	lb/lb	0.0001	0.000085	0.000053	0.000144	lb/FU	0.006084
Ammonia	lb/lb			2.1E-07	0	lb/FU	4.5E-06
Fluorine	lb/lb			0.00096		lb/FU	0.02023
Lead	lb/lb			0.00003		lb/FU	0.000632

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MIBK	lb/lb	0	0	0.000309	0.002299	lb/FU	0.014318
Isopropyl alcohol	lb/lb	0	0	0	0	lb/FU	0
MIAK	lb/lb	0.007743	0	0	0	lb/FU	0.287645
Aromatic hydrocarbons	lb/lb	0.000316	0	0	0.000084	lb/FU	0.01203
Butyl acetate	lb/lb	0.000319	0.001032	0.002764	0	lb/FU	0.079413
Naphtha	lb/lb	0.000925	0	0	0	lb/FU	0.034357
Propyl acetate	lb/lb	0	0	0	0	lb/FU	0
MPK	lb/lb	0	0	0	0	lb/FU	0
Butyl cellosolve	lb/lb	0	0	0	0	lb/FU	0
Hexyl acetate	lb/lb	0	0.003836	0	0	lb/FU	0.034673
CO2	lb/lb	3.523738	2.983926	2.08293	5.074648	lb/FU	218.9921
Hexane	lb/lb	0.000798	0.000676	0.000421	0.00115	lb/FU	0.048549
Heptane	lb/lb	0.001028	0.000871	0.000542	0.001481	lb/FU	0.06251
Octane	lb/lb	0.000687	0.000582	0.000363	0.00099	lb/FU	0.041802
C-7 cycloparaffins	lb/lb	0.000145	0.000123	0.000076	0.000209	lb/FU	0.008807
C-8 cycloparaffins	lb/lb	0.000053	0.000045	0.000028	0.000076	lb/FU	0.00322
Pentane	lb/lb	0.000499	0.000422	0.000263	0.000718	lb/FU	0.030315
Methane	lb/lb	0.003311	0.002804	0.001746	0.004769	lb/FU	0.201348
Ethane	lb/lb	0.00057	0.000482	0.0003	0.00082	lb/FU	0.034629
Propane	lb/lb	0.000893	0.000757	0.000471	0.001287	lb/FU	0.054323
n-Butane	lb/lb	0.000708	0.000599	0.000373	0.001019	lb/FU	0.043037
Iso-Butane	lb/lb	0.000035	0.00003	0.000019	0.000051	lb/FU	0.002146
Formaldehyde	lb/lb	0.000251	0.000213	0.000132	0.000362	lb/FU	0.015276
Hydrocarbons	lb/lb	0.039831	0.033729	0.021004	0.057362	lb/FU	2.421871
Aldehydes	lb/lb	0.000232	0.000196	0.000122	0.000334	lb/FU	0.014093
Organic Acids	lb/lb	0.000295	0.00025	0.000156	0.000425	lb/FU	0.017937
Kerosene						lb/FU	3.2E-09
Carbon tetrachloride	lb/lb				0.000599	lb/FU	0.002034
Chloroform	lb/lb				0.000284	lb/FU	0.000965
Ethyl chloride	lb/lb				0.000637	lb/FU	0.002165
Ethylene dichloride	lb/lb				0.001647	lb/FU	0.005592
Trichloroethane	lb/lb				0.000487	lb/FU	0.001654
Vinyl chloride	lb/lb				0.000303	lb/FU	0.001031
Hydrochloric acid	lb/lb			0.000041	0.000029	lb/FU	0.000953
Sulfuric acid	lb/lb	0			0	lb/FU	0
Propylene	lb/lb	0			0	lb/FU	0
1,2-butylene					0	lb/FU	0
2-nitropropane					0	lb/FU	0
Acetonitrile					0	lb/FU	0
Bromochlorodifluoromethane					0	lb/FU	0
Bromotrifluoromethane					0	lb/FU	0

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Dichlorodifluoromethane					0	lb/FU	0
Methanol					0	lb/FU	0
Naphthalene					0	lb/FU	0
Nitric acid					0	lb/FU	0
Butyl alcohol		0	0	0.00078	0.000414	lb/FU	0.017849
Nitroethane		0	0	0	0	lb/FU	0
Aliphatic hydrocarbons		0	0	0	0	lb/FU	0
Wastewater Emissions							
Wastewater	lb/lb	34.85286	34.39827	24.87046	89.14841	lb/FU	2432.414
WW Reinj'd	lb/lb	1.939361	1.642264	1.022673	2.792936	lb/FU	117.9198
WW Discharg.	lb/lb	0.857607	0.726227	0.452237	1.235067	lb/FU	52.14546
WW Injected	lb/lb	0.281159	0.238087	0.148262	0.404906	lb/FU	17.09541
Arsenic	lb/lb	3.5E-07	3.0E-07	1.9E-07	5.1E-07	lb/FU	0.000022
Benzene	lb/lb	8.6E-06	7.2E-06	4.5E-06	0.000012	lb/FU	0.00052
Boron	lb/lb	0.000182	0.000154	0.000096	0.000262	lb/FU	0.011061
Sodium	lb/lb	0.172821	0.146346	0.091133	0.248885	lb/FU	10.5081
Chloride	lb/lb	0.136437	0.115536	0.071947	0.196488	lb/FU	8.295869
Mobile Ions	lb/lb	0.418408	0.354311	0.220637	0.602563	lb/FU	25.44066
Oil and Grease	lb/lb	0.00426	0.003607	0.002246	0.006134	lb/FU	0.259003
Cadmium	lb/lb	2.9E-06	2.5E-06	0.000164	4.2E-06	lb/FU	0.003591
Chromium	lb/lb	2.6E-07	2.2E-07	0.000018	3.8E-07	lb/FU	0.0004
Mercury	lb/lb	6.6E-08	5.6E-08	5.3E-08	9.6E-08	lb/FU	4.4E-06
Thallium	lb/lb	6.3E-08	5.3E-08	3.3E-08	9.0E-08	lb/FU	3.8E-06
Sulfuric Acid						lb/FU	6.8E-08
Iron				0.000263		lb/FU	5.9E-06
Dissolved Solids						lb/FU	5.0E-07
Suspended Solids						lb/FU	1.7E-09
COD						lb/FU	3.3E-09
Phenol						lb/FU	2.7E-10
Sulfide						lb/FU	2.7E-10
Oil						lb/FU	5.5E-10
Acid						lb/FU	5.5E-10
Metals						lb/FU	2.7E-10
BOD						lb/FU	9.9E-10
Vanadium				4.5E-06		lb/FU	0.000094
Zinc				1.4E-06		lb/FU	0.00003
Copper				1.4E-06		lb/FU	0.00003
Aluminum				0.00002		lb/FU	0.000427
Titanium dioxide				0.004455		lb/FU	0.09388
Lead				0.000061		lb/FU	0.00128

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Magnesium						4.1E-09			lb/FU	8.5E-08
Chlorine							0.008326		lb/FU	0.028275
Ammonia							0		lb/FU	0
Hydrogen cyanide							0		lb/FU	0
Solid Wastes										
Solid Wastes	lb/lb		0.27641	0.000753		0.593655	0.551663		lb/FU	52.64637
Hazardous Wastes	lb/lb		0.000132			0.07913	0.000264		lb/FU	80.16332
Fly Ash									lb/FU	1.5E-09
Bottom Ash									lb/FU	4.1E-10
Slag									lb/FU	1.6E-10
FGD Solids									lb/FU	5.7E-10
U238									lb/FU	3.9E-09
U236									lb/FU	2.6E-12
U235									lb/FU	3.3E-11
Pu (fissile)									lb/FU	2.7E-11
Pu (nonfissile)									lb/FU	1.0E-11
Fission Products									lb/FU	1.9E-11
2-nitropropane							0		lb/FU	0
Acetaldehyde							0		lb/FU	0
Acetone							0		lb/FU	0
Acetonitrile							0		lb/FU	0
Formaldehyde							0		lb/FU	0
Methanol							0		lb/FU	0
Naphathalene							0		lb/FU	0
Nitric acid							0		lb/FU	0
Ammonia							0		lb/FU	0
Hydrogen cyanide							0		lb/FU	0

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Table C-4

Alternative Gun and Primer CARC System Life Cycle Inventory Summary Results

Notes: = User Input

Inventory numbers for individual CARC System components do not include emissions and energy or materials consumption for electric power generation. The "Baseline CARC System" numbers do include electric power generation data.

LCI Components	Units	Thinned TC Quantity	Top Coat Quantity	Thinner Quantity	Primer Quantity	Prim. Pt. A Quantity	Prim. Pt. B Quantity	Baseline CARC System Units	Baseline CARC System Quantity
Usage Rate	ft^2/gal.	[illegible]			[illegible]				
Volumetric Mixing Ratio	CARC:thin.		[illegible]	[illegible]					
Volumetric Mixing Ratio	Pt. A:Pt. B					[illegible]	[illegible]		
Specific Gravity				[illegible]					
Unit Weight	lb/gal.		[illegible]	7.089		14.25706	9.411273		
Usage Rate	lb/ft^2		0.037147	0.009038		0.020587	0.003397		
Functional Unit (FU)								ft^2	[illegible]
Resource and Energy Consumption									
Electricity	BTU/lb		10813.64	5881.702		2849.335	12368.93	BTU/FU	555534.6
Natural gas	BTU/lb		177054.9	115627		44822.11	199001.2	BTU/FU	9296248
Steam	BTU/lb		6454.894	3576.371		696.0441	3090.297	BTU/FU	425151
Water	lb/lb		486.9277	329.4671		248.7911	907.1772	lb/FU	29269.17
Crude oil	lb/lb		33.01711	27.95911		8.404271	37.31328	lb/FU	1778.953
Oxygen	lb/lb		0.078344	0.156721		0.214204	0.266878	lb/FU	9.643088
Refinery gases	lb/lb		1.234477	0.293007		0		lb/FU	48.50533
Cobalt oxide	lb/lb		0.0195					lb/FU	0.724367
Chrome oxide	lb/lb		0.0885					lb/FU	3.28751
Silica	lb/lb		0.26			0		lb/FU	9.65822
Iron ore	lb/lb		0.023108			0.00534		lb/FU	0.968313
Magnetite	lb/lb		0.007703					lb/FU	0.286125
Magnesium ore	lb/lb		0.043719					lb/FU	1.62403
Sodium Chloride	lb/lb		0.504494			0.35447	1.573775	lb/FU	31.38402
Phosphoric acid	lb/lb		0.000926					lb/FU	0.034398
Sulfuric acid	lb/lb		0.052292			0.192562		lb/FU	5.90674
Sulfur dioxide	lb/lb		0.000044					lb/FU	0.001619
Hydrocarbons C8 to C10	lb/lb		0.00033	0		0.002477	0.000909	lb/FU	0.066343
Proprietary Primer Ingredients	lb/lb					0		lb/FU	0
Chlorine	lb/lb					0.332521	1.120572	lb/FU	10.65219
Coal	lb/lb					0		lb/FU	0.000012
Phosphate ore	lb/lb					0		lb/FU	0

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Zinc ore	lb/lb			0		lb/FU	0
Uranium						lb/FU	2.8E-09
Distillate Fuel Oil						lb/FU	2.8E-07
Residual Fuel Oil						lb/FU	3.2E-06
Hydropotential						m^3-m/FU	0.004586
Ilmenite	lb/lb			0.135076		lb/FU	2.780808
Rumenite	lb/lb			0.348251		lb/FU	7.16945
Air	lb/lb			4.370365		lb/FU	89.97271
Coke	lb/lb			0.061637		lb/FU	1.268929
Sodium hydroxide	lb/lb			0.018491		lb/FU	0.380679
SiAl	lb/lb			0.003082		lb/FU	0.063446
Fuel	lb/lb			2247.6		lb/FU	46271.34
Starch						lb/FU	0.209911
Soda ash						lb/FU	2.623886
Limestone						lb/FU	4.653024
Bauxite						lb/FU	83.96435
Air Emissions							
CO	lb/lb	0.011166	0.008917	0.002361	0.01018	lb/FU	0.578551
PM	lb/lb	0.108338	0.005423	0.000465	0.001296	lb/FU	4.389692
SOx	lb/lb	0.006263	0.010748	0.047286	0.113662	lb/FU	20.71323
VOC	lb/lb	0.234812	0.073978	0.01991	0.083488	lb/FU	10.08484
Benzene	lb/lb	0.001902	0.008641	0.000077	0.000342	lb/FU	0.151493
Toluene	lb/lb	0.000249	0.008641	0.000029	0.000126	lb/FU	0.088369
Ethylbenzene	lb/lb	0.000025	9.7E-06	0.000094	0.000078	lb/FU	0.003226
Xylene	lb/lb	0.000164	9.7E-06	0.001132	0.000459	lb/FU	0.03103
Cumene	lb/lb	0.000242		0.000204	0.000904	lb/FU	0.016253
Phenol	lb/lb	0.000242		0.000138	0.000904	lb/FU	0.014894
Heavy Aromatics	lb/lb	0.003835				lb/FU	0.14245
NOx	lb/lb	0.103415	0.020305	0.00685	0.027098	lb/FU	4.258177
PM10	lb/lb	0.001298		0	0	lb/FU	0.291718
Acetaldehyde	lb/lb	0.000076	0.003166	0	0.000015	lb/FU	0.031493
Ethylene	lb/lb	3.6E-08	0.000033	0		lb/FU	0.000427
HCN	lb/lb	0.000131			0.000014	lb/FU	0.004903
Chlorine	lb/lb	0.005808		0.00581	0.025757	lb/FU	0.422855
MEK	lb/lb	0	0.001769	0	0	lb/FU	0.015988
Isobutyraldehyde	lb/lb		0.028462			lb/FU	0.257241
Acetone	lb/lb	0.0001	0.000085	0.000025	0.000123	lb/FU	0.005425
Ammonia	lb/lb			0	0.000189	lb/FU	0.00064
Fluorine	lb/lb			0		lb/FU	0
Lead	lb/lb			0		lb/FU	6.6E-11

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MIBK	lb/lb	0	0	0	0	lb/FU	0
Isopropyl alcohol	lb/lb	0	0	0	0	lb/FU	0
MIAK	lb/lb	0.00138	0	0	0	lb/FU	0.051278
Aromatic hydrocarbons	lb/lb	0	0	0.000949	0.000087	lb/FU	0.019837
Butyl acetate	lb/lb	0	0	0	0	lb/FU	0
Naphtha	lb/lb	0	0	0	0	lb/FU	0
Propyl acetate	lb/lb	0	0	0	0	lb/FU	0
MPK	lb/lb	0	0	0	0	lb/FU	0
Butyl cellosolve	lb/lb	0	0	0	0	lb/FU	0
Hexyl acetate	lb/lb	0	0	0	0	lb/FU	0
CO2	lb/lb	3.523738	2.983926	1.273899	3.982246	lb/FU	197.6185
Hexane	lb/lb	0.000798	0.000676	0.000203	0.000902	lb/FU	0.043021
Heptane	lb/lb	0.001028	0.000871	0.000262	0.001162	lb/FU	0.055392
Octane	lb/lb	0.000687	0.000582	0.000175	0.000777	lb/FU	0.037042
C-7 cycloparaffins	lb/lb	0.000145	0.000123	0.000037	0.000164	lb/FU	0.007804
C-8 cycloparaffins	lb/lb	0.000053	0.000045	0.000013	0.00006	lb/FU	0.002853
Pentane	lb/lb	0.000499	0.000422	0.000127	0.000563	lb/FU	0.026863
Methane	lb/lb	0.003311	0.002804	0.000843	0.003742	lb/FU	0.17842
Ethane	lb/lb	0.00057	0.000482	0.000145	0.000644	lb/FU	0.030686
Propane	lb/lb	0.000893	0.000757	0.000227	0.00101	lb/FU	0.048137
n-Butane	lb/lb	0.000708	0.000599	0.00018	0.0008	lb/FU	0.038136
Iso-Butane	lb/lb	0.000035	0.00003	9.0E-06	0.00004	lb/FU	0.001902
Formaldehyde	lb/lb	0.000251	0.000213	0.000064	0.00036	lb/FU	0.013796
Hydrocarbons	lb/lb	0.039831	0.033729	0.010139	0.045014	lb/FU	2.146092
Aldehydes	lb/lb	0.000232	0.000196	0.000059	0.000262	lb/FU	0.012488
Organic Acids	lb/lb	0.000295	0.00025	0.000075	0.000333	lb/FU	0.015894
Kerosene						lb/FU	3.0E-09
Carbon tetrachloride	lb/lb				0	lb/FU	0
Chloroform	lb/lb				0	lb/FU	0
Ethyl chloride	lb/lb				0	lb/FU	0
Ethylene dichloride	lb/lb				0	lb/FU	0
Trichloroethane	lb/lb				0	lb/FU	0
Vinyl chloride	lb/lb				0	lb/FU	0
Hydrochloric acid	lb/lb			0.000068	0	lb/FU	0.001398
Sulfuric acid	lb/lb	0			0	lb/FU	0
Propylene	lb/lb	0			0	lb/FU	0
1,2-butylene					1.5E-07	lb/FU	5.0E-07
2-nitropropane					0.000129	lb/FU	0.000439
Acetonitrile					5.1E-06	lb/FU	0.000017
Bromochlorodifluoromethane					4.7E-07	lb/FU	1.6E-06
Bromotrifluoromethane					1.8E-06	lb/FU	6.0E-06

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Dichlorodifluoromethane					0.000234	lb/FU	0.000795
Methanol					4.0E-06	lb/FU	0.000014
Naphthalene					0.000137	lb/FU	0.000464
Nitric acid					1.2E-06	lb/FU	4.0E-06
Butyl alcohol		0	0	0.001056	0	lb/FU	0.021743
Nitroethane		0	0	0	0.000593	lb/FU	0.002016
Aliphatic hydrocarbons		0	0	0	0	lb/FU	0
Wastewater Emissions							
Wastewater	lb/lb	34.85286	34.39827	14.92556	66.26652	lb/FU	2137.951
WW Reinj'd	lb/lb	1.939361	1.642264	0.493651	2.19171	lb/FU	104.4923
WW Discharg.	lb/lb	0.857607	0.726227	0.218298	0.969199	lb/FU	46.20763
WW Injected	lb/lb	0.281159	0.238087	0.071567	0.317743	lb/FU	15.14875
Arsenic	lb/lb	3.5E-07	3.0E-07	9.0E-08	4.0E-07	lb/FU	0.000019
Benzene	lb/lb	8.6E-06	7.2E-06	2.2E-06	9.7E-06	lb/FU	0.000461
Boron	lb/lb	0.000182	0.000154	0.000046	0.000206	lb/FU	0.009802
Sodium	lb/lb	0.172821	0.146346	0.04399	0.195308	lb/FU	9.311538
Chloride	lb/lb	0.136437	0.115536	0.034729	0.154191	lb/FU	7.351215
Mobile Ions	lb/lb	0.418408	0.354311	0.106503	0.472851	lb/FU	22.54372
Oil and Grease	lb/lb	0.00426	0.003607	0.001084	0.004814	lb/FU	0.22951
Cadmium	lb/lb	2.9E-06	2.5E-06	0.000272	3.3E-06	lb/FU	0.00575
Chromium	lb/lb	2.6E-07	2.2E-07	0.000031	3.0E-07	lb/FU	0.000643
Mercury	lb/lb	6.6E-08	5.6E-08	4.7E-08	7.5E-08	lb/FU	4.2E-06
Thallium	lb/lb	6.3E-08	5.3E-08	1.6E-08	7.1E-08	lb/FU	3.4E-06
Sulfuric Acid						lb/FU	6.3E-08
Iron				0.000441		lb/FU	5.4E-06
Dissolved Solids						lb/FU	4.6E-07
Suspended Solids						lb/FU	1.6E-09
COD						lb/FU	3.0E-09
Phenol						lb/FU	2.5E-10
Sulfide						lb/FU	2.5E-10
Oil						lb/FU	5.0E-10
Acid						lb/FU	5.0E-10
Metals						lb/FU	2.5E-10
BOD						lb/FU	9.1E-10
Vanadium				7.5E-06		lb/FU	0.000154
Zinc				2.4E-06		lb/FU	0.000049
Copper				2.4E-06		lb/FU	0.000049
Aluminum				0.000034		lb/FU	0.000699
Titanium dioxide				0.007471		lb/FU	0.15381
Lead				0.000102		lb/FU	0.002097

Magnesium						6.8E-09			lb/FU	1.4E-07
Chlorine							0.025756		lb/FU	0.087495
Ammonia							3.7E-07		lb/FU	1.3E-06
Hydrogen cyanide							2.5E-08		lb/FU	8.4E-08
Solid Wastes										
Solid Wastes	lb/lb		0.27641	0.000753		0.442818	1.513695		lb/FU	52.52113
Hazardous Wastes	lb/lb		0.000132			0.03396	0		lb/FU	79.19405
Fly Ash									lb/FU	1.4E-09
Bottom Ash									lb/FU	3.8E-10
Slag									lb/FU	1.4E-10
FGD Solids									lb/FU	5.2E-10
U238									lb/FU	3.6E-09
U236									lb/FU	2.4E-12
U235									lb/FU	3.0E-11
Pu (fissile)									lb/FU	2.5E-11
Pu (nonfissile)									lb/FU	9.5E-12
Fission Products									lb/FU	1.7E-11
2-nitropropane							0.001717		lb/FU	0.005832
Acetaldehyde							0.002214		lb/FU	0.00752
Acetone							0.001188		lb/FU	0.004036
Acetonitrile							0.000969		lb/FU	0.003292
Formaldehyde							0.000017		lb/FU	0.000057
Methanol							0.001951		lb/FU	0.006628
Naphathalene							1.4E-06		lb/FU	4.8E-06
Nitric acid							0.000137		lb/FU	0.000464
Ammonia							0.00003		lb/FU	0.000103
Hydrogen cyanide							1.4E-06		lb/FU	4.8E-06

Table C-5

Alternative Thinner CARC System Life Cycle Inventory Summary Results

Notes: [illegible] = User Input

Inventory numbers for individual CARC System components do not include emissions and energy or materials consumption for electric power generation. The "Baseline CARC System" numbers do include electric power generation data.

LCI Components	Units	Thinned TC Quantity	Top Coat Quantity	Thinner Quantity	Primer Quantity	Prim. Pt. A Quantity	Prim. Pt. B Quantity	Baseline CARC System Units	Baseline CARC System Quantity
Usage Rate	ft^2/gal.	[illegible]			[illegible]				
Volumetric Mixing Ratio	CARC:thin.		[illegible]	[illegible]					
Volumetric Mixing Ratio	Pt. A:Pt. B					[illegible]	[illegible]		
Specific Gravity				[illegible]		[illegible]	[illegible]		
Unit Weight	lb/gal.		[illegible]	6.87216		14.59333	9.40752		
Usage Rate	lb/ft^2		0.05145	0.001117		0.029187	0.004704		
Functional Unit (FU)								ft^2	[illegible]
Resource and Energy Consumption									
Electricity	BTU/lb		10813.64	3020.153		5176.439	12217.84	BTU/FU	768296.9
Natural gas	BTU/lb		177054.9	48511.73		83911.35	293983.5	BTU/FU	13071060
Steam	BTU/lb		6454.894	275.1648		2511.59	2840.313	BTU/FU	547298.8
Water	lb/lb		486.9277	153.6514		352.796	967.3135	lb/FU	40071.31
Crude oil	lb/lb		33.01711	17.0792		17.41074	47.54699	lb/FU	2449.64
Oxygen	lb/lb		0.078344	0.097628		0.279948	0.304434	lb/FU	13.74273
Refinery gases	lb/lb		1.234477	0.192075		0.161095		lb/FU	68.43024
Cobalt oxide	lb/lb		0.0195					lb/FU	1.003275
Chrome oxide	lb/lb		0.0885					lb/FU	4.553325
Silica	lb/lb		0.26			0.0096		lb/FU	13.6572
Iron ore	lb/lb		0.023108			0.003184		lb/FU	1.281821
Magnetite	lb/lb		0.007703					lb/FU	0.396294
Magnesium ore	lb/lb		0.043719					lb/FU	2.249343
Sodium Chloride	lb/lb		0.504494			0.486484	0.622545	lb/FU	43.08366
Phosphoric acid	lb/lb		0.000926					lb/FU	0.047642
Sulfuric acid	lb/lb		0.052292			0.114823		lb/FU	6.041725
Sulfur dioxide	lb/lb		0.000044					lb/FU	0.002242
Hydrocarbons C8 to C10	lb/lb		0.00033	0		0	0	lb/FU	0.016979
Proprietary Primer Ingredients	lb/lb					0		lb/FU	0
Chlorine	lb/lb					0.39417	0.362135	lb/FU	13.20812
Coal	lb/lb					0.009997		lb/FU	0.291793
Phosphate ore	lb/lb					0.07168		lb/FU	2.092124

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Zinc ore	lb/lb			0.286		lb/FU	8.347482
Uranium						lb/FU	3.8E-09
Distillate Fuel Oil						lb/FU	3.9E-07
Residual Fuel Oil						lb/FU	4.5E-06
Hydropotential						m^3-m/FU	0.006343
Ilmenite	lb/lb			0.080544		lb/FU	2.350849
Rumenite	lb/lb			0.207659		lb/FU	6.060934
Air	lb/lb			2.606004		lb/FU	76.06144
Coke	lb/lb			0.036754		lb/FU	1.072732
Sodium hydroxide	lb/lb			0.011026		lb/FU	0.32182
SIAI	lb/lb			0.001838		lb/FU	0.053637
Fuel	lb/lb			1340.221		lb/FU	39117.03
Starch						lb/FU	0.209911
Soda ash						lb/FU	2.623886
Limestone						lb/FU	4.653024
Bauxite						lb/FU	83.96435
Air Emissions							
CO	lb/lb	0.011166	0.005387	0.02184	0.01517	lb/FU	1.289302
PM	lb/lb	0.108338	0.00298	0.001525	0.004981	lb/FU	5.947552
SOx	lb/lb	0.006263	0.03401	0.058562	0.110646	lb/FU	21.49843
VOC	lb/lb	0.234812	0.045559	0.058768	0.077079	lb/FU	14.20999
Benzene	lb/lb	0.001902	0.005872	0.000125	0.000476	lb/FU	0.110301
Toluene	lb/lb	0.000249	0.007122	0.000065	0.000251	lb/FU	0.023822
Ethylbenzene	lb/lb	0.000025	0	0.000017	0.000064	lb/FU	0.002098
Xylene	lb/lb	0.000889	0.000825	0.000018	0.000064	lb/FU	0.047505
Cumene	lb/lb	0.000242		0.00033	0.001	lb/FU	0.026791
Phenol	lb/lb	0.000242		0.000153	0.001	lb/FU	0.021642
Heavy Aromatics	lb/lb	'0.003835				lb/FU	0.197299
NOx	lb/lb	0.103415	0.012404	0.01309	0.034568	lb/FU	5.879257
PM10	lb/lb	0.001298		5.9E-06	9.8E-07	lb/FU	0.310462
Acetaldehyde	lb/lb	0.000076	0.001967	0.00165	0	lb/FU	0.054276
Ethylene	lb/lb	3.6E-06	0.000092	0.000077		lb/FU	0.002535
HCN	lb/lb	0.000131			0	lb/FU	0.006726
Chlorine	lb/lb	0.005808		0.007967	0.009633	lb/FU	0.576658
MEK	lb/lb	0	0.004025	0	0	lb/FU	0.004495
Isobutyraldehyde	lb/lb		0			lb/FU	0
Acetone	lb/lb	0.0001	0.000052	0.000053	0.000144	lb/FU	0.007423
Ammonia	lb/lb			2.1E-07	0	lb/FU	6.2E-06
Fluorine	lb/lb			0.00096		lb/FU	0.02802
Lead	lb/lb			0.00003		lb/FU	0.000876

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MIBK	lb/lb	0	0	0.000383	0.002559	lb/FU	0.023224
Isopropyl alcohol	lb/lb	0	0	0	0	lb/FU	0
MIAK	lb/lb	0.010193	0	0	0	lb/FU	0.524453
Aromatic hydrocarbons	lb/lb	0.000438	0	0	0.000084	lb/FU	0.022925
Butyl acetate	lb/lb	0.000442	0.001316	0.003828	0	lb/FU	0.135912
Naphtha	lb/lb	0.001281	0	0	0	lb/FU	0.065909
Propyl acetate	lb/lb	0	0	0	0	lb/FU	0
MPK	lb/lb	0	0	0	0	lb/FU	0
Butyl cellosolve	lb/lb	0	0	0	0	lb/FU	0
Hexyl acetate	lb/lb	0	0.00489	0	0	lb/FU	0.00546
CO2	lb/lb	3.523738	1.822771	2.08293	5.074648	lb/FU	267.9975
Hexane	lb/lb	0.000798	0.000413	0.000421	0.00115	lb/FU	0.05924
Heptane	lb/lb	0.001028	0.000532	0.000542	0.001481	lb/FU	0.076275
Octane	lb/lb	0.000687	0.000356	0.000363	0.00099	lb/FU	0.051007
C-7 cycloparaffins	lb/lb	0.000145	0.000075	0.000076	0.000209	lb/FU	0.010746
C-8 cycloparaffins	lb/lb	0.000053	0.000027	0.000028	0.000076	lb/FU	0.003929
Pentane	lb/lb	0.000499	0.000258	0.000263	0.000718	lb/FU	0.03699
Methane	lb/lb	0.003311	0.001713	0.001746	0.004769	lb/FU	0.245687
Ethane	lb/lb	0.00057	0.000295	0.0003	0.00082	lb/FU	0.042255
Propane	lb/lb	0.000893	0.000462	0.000471	0.001287	lb/FU	0.066285
n-Butane	lb/lb	0.000708	0.000366	0.000373	0.001019	lb/FU	0.052514
Iso-Butane	lb/lb	0.000035	0.000018	0.000019	0.000051	lb/FU	0.002619
Formaldehyde	lb/lb	0.000251	0.00013	0.000132	0.000362	lb/FU	0.01864
Hydrocarbons	lb/lb	0.039831	0.020604	0.021004	0.057362	lb/FU	2.955195
Aldehydes	lb/lb	0.000232	0.00012	0.000122	0.000334	lb/FU	0.017196
Organic Acids	lb/lb	0.000295	0.000153	0.000156	0.000425	lb/FU	0.021886
Kerosene						lb/FU	4.1E-09
Carbon tetrachloride	lb/lb				0.000599	lb/FU	0.002818
Chloroform	lb/lb				0.000284	lb/FU	0.001337
Ethyl chloride	lb/lb				0.000637	lb/FU	0.002999
Ethylene dichloride	lb/lb				0.001647	lb/FU	0.007745
Trichloroethane	lb/lb				0.000487	lb/FU	0.00229
Vinyl chloride	lb/lb				0.000303	lb/FU	0.001428
Hydrochloric acid	lb/lb			0.000041	0.000029	lb/FU	0.00132
Sulfuric acid	lb/lb	1.6E-06			0	lb/FU	0.000083
Propylene	lb/lb	0.000022			0	lb/FU	0.001111
1,2-butylene					0	lb/FU	0
2-nitropropane					0	lb/FU	0
Acetonitrile					0	lb/FU	0
Bromochlorodifluoromethane					0	lb/FU	0
Bromotrifluoromethane					0	lb/FU	0

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Dichlorodifluoromethane					0	lb/FU	0
Methanol					0	lb/FU	0
Naphthalene					0	lb/FU	0
Nitric acid					0	lb/FU	0
Butyl alcohol		0	0	0.001081	0.000574	lb/FU	0.03424
Nitroethane		0	0	0	0	lb/FU	0
Aliphatic hydrocarbons		0	0	0	0	lb/FU	0
Wastewater Emissions							
Wastewater	lb/lb	34.85286	17.7556	24.87046	89.14841	lb/FU	2958.256
WW Reinj'd	lb/lb	1.939361	1.003199	1.022673	2.792936	lb/FU	143.8871
WW Discharg.	lb/lb	0.857607	0.443626	0.452237	1.235067	lb/FU	63.62849
WW Injected	lb/lb	0.281159	0.145439	0.148262	0.404906	lb/FU	20.86002
Arsenic	lb/lb	3.5E-07	1.8E-07	1.9E-07	5.1E-07	lb/FU	0.000026
Benzene	lb/lb	8.6E-06	4.4E-06	4.5E-06	0.000012	lb/FU	0.000634
Boron	lb/lb	0.000182	0.000094	0.000096	0.000262	lb/FU	0.013497
Sodium	lb/lb	0.172821	0.089397	0.091133	0.248885	lb/FU	12.8221
Chloride	lb/lb	0.136437	0.070577	0.071947	0.196488	lb/FU	10.12271
Mobile Ions	lb/lb	0.418408	0.216436	0.220637	0.602563	lb/FU	31.04299
Oil and Grease	lb/lb	0.00426	0.002203	0.002246	0.006134	lb/FU	0.316038
Cadmium	lb/lb	2.9E-06	1.5E-06	0.000164	4.2E-06	lb/FU	0.004944
Chromium	lb/lb	2.6E-07	1.4E-07	0.000018	3.8E-07	lb/FU	0.000552
Mercury	lb/lb	6.6E-08	3.4E-08	5.3E-08	9.6E-08	lb/FU	5.5E-06
Thallium	lb/lb	6.3E-08	3.2E-08	3.3E-08	9.0E-08	lb/FU	4.7E-06
Sulfuric Acid						lb/FU	8.7E-08
Iron				0.000263		lb/FU	7.4E-06
Dissolved Solids						lb/FU	6.3E-07
Suspended Solids						lb/FU	2.2E-09
COD						lb/FU	4.2E-09
Phenol						lb/FU	3.5E-10
Sulfide						lb/FU	3.5E-10
Oil						lb/FU	7.0E-10
Acid						lb/FU	7.0E-10
Metals						lb/FU	3.5E-10
BOD						lb/FU	1.3E-09
Vanadium				4.5E-06		lb/FU	0.00013
Zinc				1.4E-06		lb/FU	0.000041
Copper				1.4E-06		lb/FU	0.000041
Aluminum				0.00002		lb/FU	0.000591
Titanium dioxide				0.004455		lb/FU	0.130028
Lead				0.000061		lb/FU	0.001773

Magnesium						4.1E-09			lb/FU	1.2E-07
Chlorine							0.008326		lb/FU	0.039165
Ammonia							0		lb/FU	0
Hydrogen cyanide							0		lb/FU	0
Solid Wastes										
Solid Wastes	lb/lb		0.27641	0.000476		0.593655	0.551663		lb/FU	62.13212
Hazardous Wastes	lb/lb		0.000132			0.07913	0.000264		lb/FU	80.80762
Fly Ash									lb/FU	1.9E-09
Bottom Ash									lb/FU	5.3E-10
Slag									lb/FU	2.0E-10
FGD Solids									lb/FU	7.2E-10
U238									lb/FU	5.0E-09
U236									lb/FU	3.3E-12
U235									lb/FU	4.2E-11
Pu (fissile)									lb/FU	3.4E-11
Pu (nonfissile)									lb/FU	1.3E-11
Fission Products									lb/FU	2.4E-11
2-nitropropane							0		lb/FU	0
Acetaldehyde							0		lb/FU	0
Acetone							0		lb/FU	0
Acetonitrile							0		lb/FU	0
Formaldehyde							0		lb/FU	0
Methanol							0		lb/FU	0
Naphathalene							0		lb/FU	0
Nitric acid							0		lb/FU	0
Ammonia							0		lb/FU	0
Hydrogen cyanide							0		lb/FU	0

Table C-6

Alt. Primer & Thinner CARC System Life Cycle Inventory Summary Results

Notes: = User Input

Inventory numbers for individual CARC System components do not include emissions and energy or materials consumption for electric power generation. The "Baseline CARC System" numbers do include electric power generation data.

LCI Components	Units	Thinned TC Quantity	Top Coat Quantity	Thinner Quantity	Primer Quantity	Prim. Pt. A Quantity	Prim. Pt. B Quantity	Baseline CARC System Units	Baseline CARC System Quantity
Usage Rate	ft^2/gal.	[illegible]			[illegible]				
Volumetric Mixing Ratio	CARC:thin.		[illegible]	[illegible]					
Volumetric Mixing Ratio	Pt. A:Pt. B					[illegible]	[illegible]		
Specific Gravity				[illegible]					
Unit Weight	lb/gal.		[illegible]	6.87216		14.25706	9.411273		
Usage Rate	lb/ft^2		0.05145	0.001117		0.028514	0.004706		
Functional Unit (FU)								ft^2	[illegible]
Resource and Energy Consumption									
Electricity	BTU/lb		10813.64	3020.153		4274.133	12891.53	BTU/FU	742279.6
Natural gas	BTU/lb		177054.9	48511.73		88971.35	215194.5	BTU/FU	12788675
Steam	BTU/lb		6454.894	275.1648		805.3541	3130.39	BTU/FU	498327.6
Water	lb/lb		486.9277	153.6514		386.9551	957.8537	lb/FU	40765.31
Crude oil	lb/lb		33.01711	17.0792		15.18903	39.80183	lb/FU	2338.21
Oxygen	lb/lb		0.078344	0.097628		0.214204	0.266878	lb/FU	11.50356
Refinery gases	lb/lb		1.234477	0.192075		0		lb/FU	63.72835
Cobalt oxide	lb/lb		0.0195					lb/FU	1.003275
Chrome oxide	lb/lb		0.0885					lb/FU	4.553325
Silica	lb/lb		0.26			0		lb/FU	13.377
Iron ore	lb/lb		0.023108			0.00534		lb/FU	1.341152
Magnetite	lb/lb		0.007703					lb/FU	0.396294
Magnesium ore	lb/lb		0.043719					lb/FU	2.249343
Sodium Chloride	lb/lb		0.504494			0.35447	1.573775	lb/FU	43.46975
Phosphoric acid	lb/lb		0.000926					lb/FU	0.047642
Sulfuric acid	lb/lb		0.052292			0.192562		lb/FU	8.181103
Sulfur dioxide	lb/lb		0.000044					lb/FU	0.002242
Hydrocarbons C8 to C10	lb/lb		0.00033	0		0	0	lb/FU	0.016979
Proprietary Primer Ingredients	lb/lb					0		lb/FU	0
Chlorine	lb/lb					0.332521	1.120572	lb/FU	14.75491
Coal	lb/lb					0		lb/FU	0.000015
Phosphate ore	lb/lb					0		lb/FU	0

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Zinc ore	lb/lb			0		lb/FU	0
Uranium						lb/FU	3.7E-09
Distillate Fuel Oil						lb/FU	3.8E-07
Residual Fuel Oil						lb/FU	4.3E-06
Hydropotential						m^3-m/FU	0.006128
Ilmenite	lb/lb			0.135076		lb/FU	3.851554
Rumenite	lb/lb			0.348251		lb/FU	9.930038
Air	lb/lb			4.370365		lb/FU	124.6166
Coke	lb/lb			0.061637		lb/FU	1.757529
Sodium hydroxide	lb/lb			0.018491		lb/FU	0.527259
SiAl	lb/lb			0.003082		lb/FU	0.087876
Fuel	lb/lb			2247.6		lb/FU	64088.07
Starch						lb/FU	0.209911
Soda ash						lb/FU	2.623886
Limestone						lb/FU	4.653024
Bauxite						lb/FU	83.96435
Air Emissions							
CO	lb/lb	0.011166	0.005387	0.004562	0.010987	lb/FU	0.762302
PM	lb/lb	0.108338	0.00298	0.002333	0.00206	lb/FU	5.955807
SOx	lb/lb	0.006263	0.03401	0.047844	0.113787	lb/FU	21.13969
VOC	lb/lb	0.234812	0.045559	0.027655	0.086328	lb/FU	13.32696
Benzene	lb/lb	0.001902	0.005872	0.005585	0.002362	lb/FU	0.274756
Toluene	lb/lb	0.000249	0.007122	0.005534	0.002145	lb/FU	0.188631
Ethylbenzene	lb/lb	0.000025	0	0.000011	0.000047	lb/FU	0.001828
Xylene	lb/lb	0.000889	0.000825	0.000011	0.000047	lb/FU	0.047196
Cumene	lb/lb	0.000242		0.000204	0.000904	lb/FU	0.022512
Phenol	lb/lb	0.000242		0.000138	0.000904	lb/FU	0.020629
Heavy Aromatics	lb/lb	0.003835				lb/FU	0.197299
NOx	lb/lb	0.103415	0.012404	0.011777	0.028905	lb/FU	5.806429
PM10	lb/lb	0.001298		0	0	lb/FU	0.310286
Acetaldehyde	lb/lb	0.000076	0.001967	0	0.000015	lb/FU	0.006186
Ethylene	lb/lb	3.6E-06	0.000092	0		lb/FU	0.000286
HCN	lb/lb	0.000131			0.000014	lb/FU	0.00679
Chlorine	lb/lb	0.005808		0.00581	0.025757	lb/FU	0.585698
MEK	lb/lb	0	0.004025	0	0	lb/FU	0.004495
Isobutyraldehyde	lb/lb		0			lb/FU	0
Acetone	lb/lb	0.0001	0.000052	0.000046	0.000131	lb/FU	0.007133
Ammonia	lb/lb			0	0.000189	lb/FU	0.000887
Fluorine	lb/lb			0		lb/FU	0
Lead	lb/lb			0		lb/FU	8.8E-11

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MIBK	lb/lb	0	0	0	0	lb/FU	0
Isopropyl alcohol	lb/lb	0	0	0	0	lb/FU	0
MIAK	lb/lb	0.010193	0	0	0	lb/FU	0.524453
Aromatic hydrocarbons	lb/lb	0.000438	0	0.001315	0.000121	lb/FU	0.060582
Butyl acetate	lb/lb	0.000442	0.001316	0	0	lb/FU	0.024192
Naphtha	lb/lb	0.001281	0	0	0	lb/FU	0.065909
Propyl acetate	lb/lb	0	0	0	0	lb/FU	0
MPK	lb/lb	0	0	0	0	lb/FU	0
Butyl cellosolve	lb/lb	0	0	0	0	lb/FU	0
Hexyl acetate	lb/lb	0	0.00489	0	0	lb/FU	0.00546
CO2	lb/lb	3.523738	1.822771	1.997999	4.247836	lb/FU	260.2931
Hexane	lb/lb	0.000798	0.000413	0.000367	0.000963	lb/FU	0.056546
Heptane	lb/lb	0.001028	0.000532	0.000473	0.001239	lb/FU	0.072806
Octane	lb/lb	0.000687	0.000356	0.000316	0.000829	lb/FU	0.048687
C-7 cycloparaffins	lb/lb	0.000145	0.000075	0.000067	0.000175	lb/FU	0.010257
C-8 cycloparaffins	lb/lb	0.000053	0.000027	0.000024	0.000064	lb/FU	0.00375
Pentane	lb/lb	0.000499	0.000258	0.000229	0.000601	lb/FU	0.035307
Methane	lb/lb	0.003311	0.001713	0.001523	0.003992	lb/FU	0.234511
Ethane	lb/lb	0.00057	0.000295	0.000262	0.000687	lb/FU	0.040333
Propane	lb/lb	0.000893	0.000462	0.000411	0.001077	lb/FU	0.06327
n-Butane	lb/lb	0.000708	0.000366	0.000326	0.000853	lb/FU	0.050125
Iso-Butane	lb/lb	0.000035	0.000018	0.000016	0.000043	lb/FU	0.0025
Formaldehyde	lb/lb	0.000251	0.00013	0.000116	0.000379	lb/FU	0.018151
Hydrocarbons	lb/lb	0.039831	0.020604	0.018324	0.048016	lb/FU	2.820768
Aldehydes	lb/lb	0.000232	0.00012	0.000107	0.000279	lb/FU	0.016414
Organic Acids	lb/lb	0.000295	0.000153	0.000136	0.000356	lb/FU	0.020891
Kerosene						lb/FU	3.9E-09
Carbon tetrachloride	lb/lb				0	lb/FU	0
Chloroform	lb/lb				0	lb/FU	0
Ethyl chloride	lb/lb				0	lb/FU	0
Ethylene dichloride	lb/lb				0	lb/FU	0
Trichloroethane	lb/lb				0	lb/FU	0
Vinyl chloride	lb/lb				0	lb/FU	0
Hydrochloric acid	lb/lb			0.000068	0	lb/FU	0.001937
Sulfuric acid	lb/lb	1.6E-06			0	lb/FU	0.000083
Propylene	lb/lb	0.000022			0	lb/FU	0.001111
1,2-butylene					1.5E-07	lb/FU	7.0E-07
2-nitropropane					0.000129	lb/FU	0.000608
Acetonitrile					5.1E-06	lb/FU	0.000024
Bromochlorodifluoromethane					4.7E-07	lb/FU	2.2E-06
Bromotrifluoromethane					1.8E-06	lb/FU	8.3E-06

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Dichlorodifluoromethane					0.000234	lb/FU	0.001102
Methanol					4.0E-06	lb/FU	0.000019
Naphthalene					0.000137	lb/FU	0.000643
Nitric acid					1.2E-06	lb/FU	5.5E-06
Butyl alcohol		0	0	0.001463	0	lb/FU	0.041712
Nitroethane		0	0	0	0.000822	lb/FU	0.003869
Aliphatic hydrocarbons		0	0	0	0	lb/FU	0
Wastewater Emissions							
Wastewater	lb/lb	34.85286	17.7556	29.30073	71.53912	lb/FU	2985.152
WW Reinj'd	lb/lb	1.939361	1.003199	0.892174	2.337883	lb/FU	137.3419
WW Discharg.	lb/lb	0.857607	0.443626	0.394529	1.033838	lb/FU	60.73412
WW Injected	lb/lb	0.281159	0.145439	0.129343	0.338934	lb/FU	19.91113
Arsenic	lb/lb	3.5E-07	1.8E-07	1.6E-07	4.3E-07	lb/FU	0.000025
Benzene	lb/lb	8.6E-06	4.4E-06	3.9E-06	0.00001	lb/FU	0.000606
Boron	lb/lb	0.000182	0.000094	0.000084	0.000219	lb/FU	0.012883
Sodium	lb/lb	0.172821	0.089397	0.079504	0.208334	lb/FU	12.23885
Chloride	lb/lb	0.136437	0.070577	0.062766	0.164474	lb/FU	9.662247
Mobile Ions	lb/lb	0.418408	0.216436	0.192482	0.504387	lb/FU	29.63089
Oil and Grease	lb/lb	0.00426	0.002203	0.00196	0.005135	lb/FU	0.301662
Cadmium	lb/lb	2.9E-06	1.5E-06	0.000273	3.5E-06	lb/FU	0.007953
Chromium	lb/lb	2.6E-07	1.4E-07	0.000031	3.2E-07	lb/FU	0.00089
Mercury	lb/lb	6.6E-08	3.4E-08	6.1E-08	8.0E-08	lb/FU	5.6E-06
Thallium	lb/lb	6.3E-08	3.2E-08	2.9E-08	7.6E-08	lb/FU	4.4E-06
Sulfuric Acid						lb/FU	8.4E-08
Iron				0.000441		lb/FU	7.2E-06
Dissolved Solids						lb/FU	6.1E-07
Suspended Solids						lb/FU	2.1E-09
COD						lb/FU	4.0E-09
Phenol						lb/FU	3.4E-10
Sulfide						lb/FU	3.4E-10
Oil						lb/FU	6.7E-10
Acid						lb/FU	6.7E-10
Metals						lb/FU	3.4E-10
BOD						lb/FU	1.2E-09
Vanadium				7.5E-06		lb/FU	0.000213
Zinc				2.4E-06		lb/FU	0.000068
Copper				2.4E-06		lb/FU	0.000068
Aluminum				0.000034		lb/FU	0.000968
Titanium dioxide				0.007471		lb/FU	0.213034
Lead				0.000102		lb/FU	0.002905

Magnesium						6.8E-09			lb/FU	1.9E-07
Chlorine							0.025756		lb/FU	0.12121
Ammonia							3.7E-07		lb/FU	1.7E-06
Hydrogen cyanide							2.5E-08		lb/FU	1.2E-07
Solid Wastes										
Solid Wastes	lb/lb		0.27641	0.000476		0.442834	1.513701		lb/FU	61.96051
Hazardous Wastes	lb/lb		0.000132			0.03396	0		lb/FU	79.46515
Fly Ash									lb/FU	1.8E-09
Bottom Ash									lb/FU	5.1E-10
Slag									lb/FU	1.9E-10
FGD Solids									lb/FU	7.0E-10
U238									lb/FU	4.8E-09
U236									lb/FU	3.2E-12
U235									lb/FU	4.0E-11
Pu (fissile)									lb/FU	3.3E-11
Pu (nonfissile)									lb/FU	1.3E-11
Fission Products									lb/FU	2.3E-11
2-nitropropane							0.001717		lb/FU	0.008079
Acetaldehyde							0.002214		lb/FU	0.010418
Acetone							0.001188		lb/FU	0.005591
Acetonitrile							0.000969		lb/FU	0.004561
Formaldehyde							0.000017		lb/FU	0.00008
Methanol							0.001951		lb/FU	0.009182
Naphathalene							1.4E-06		lb/FU	6.6E-06
Nitric acid							0.000137		lb/FU	0.000643
Ammonia							0.00003		lb/FU	0.000142
Hydrogen cyanide							1.4E-06		lb/FU	6.6E-06

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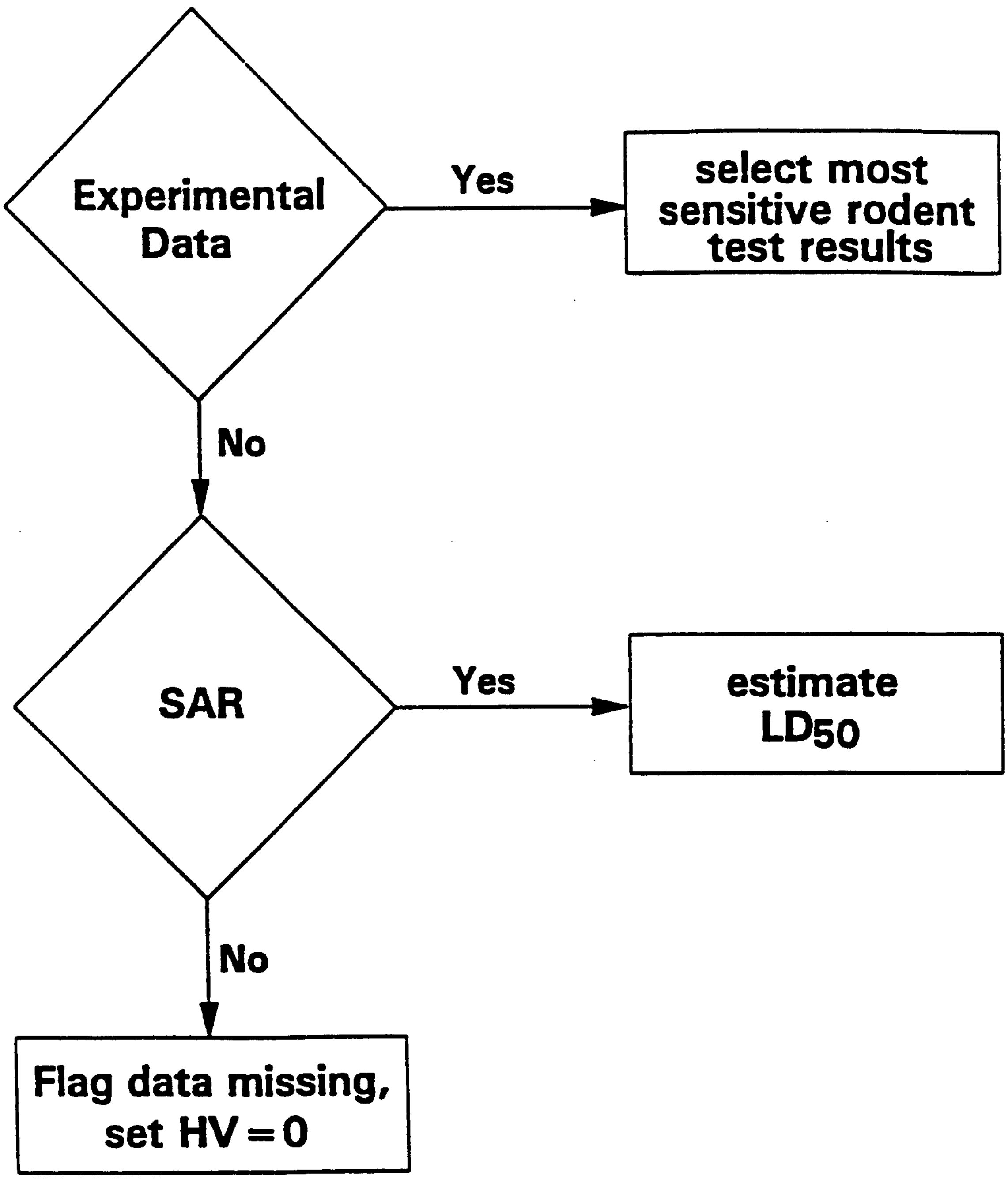


Figure D-1. Decision Tree for Oral LD_{50} Data Selection (from EPA, 1994

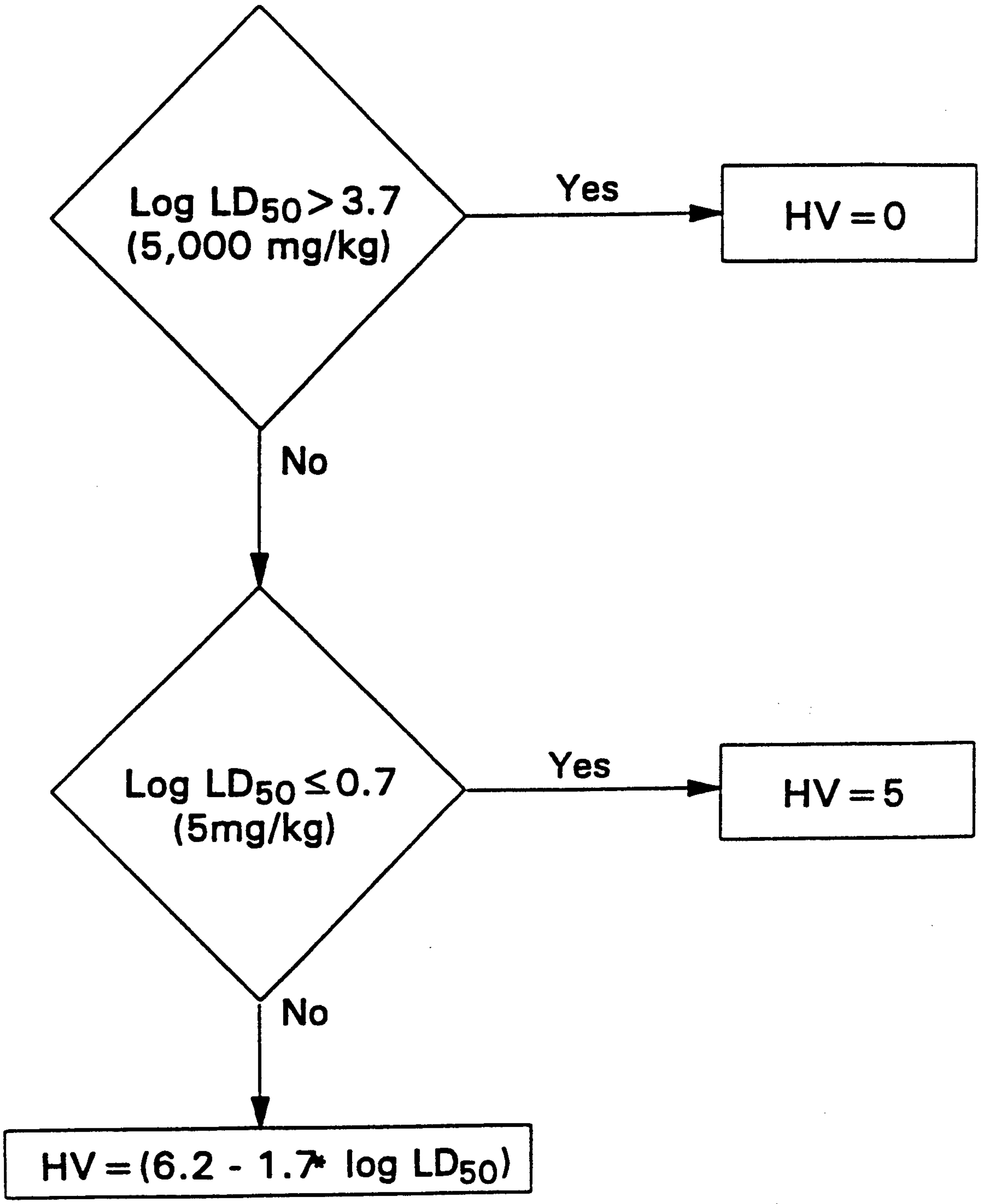


Figure D-2. Decision Tree for Oral LD_{50} Hazard Value (from EPA, 1994)

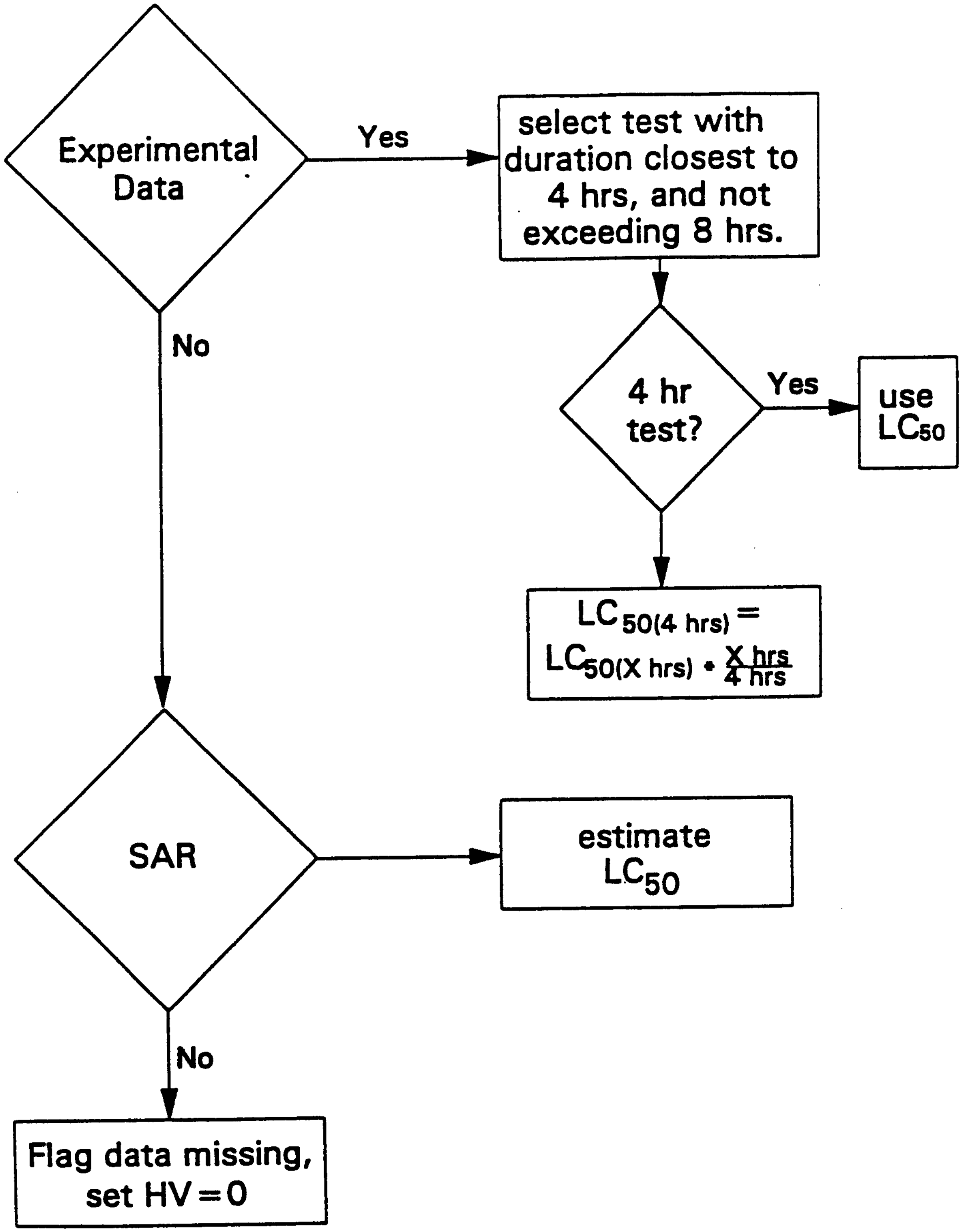


Figure D-3. Decision Tree for Inhalation LC_{50} Data Selection (from EPA, 1994)

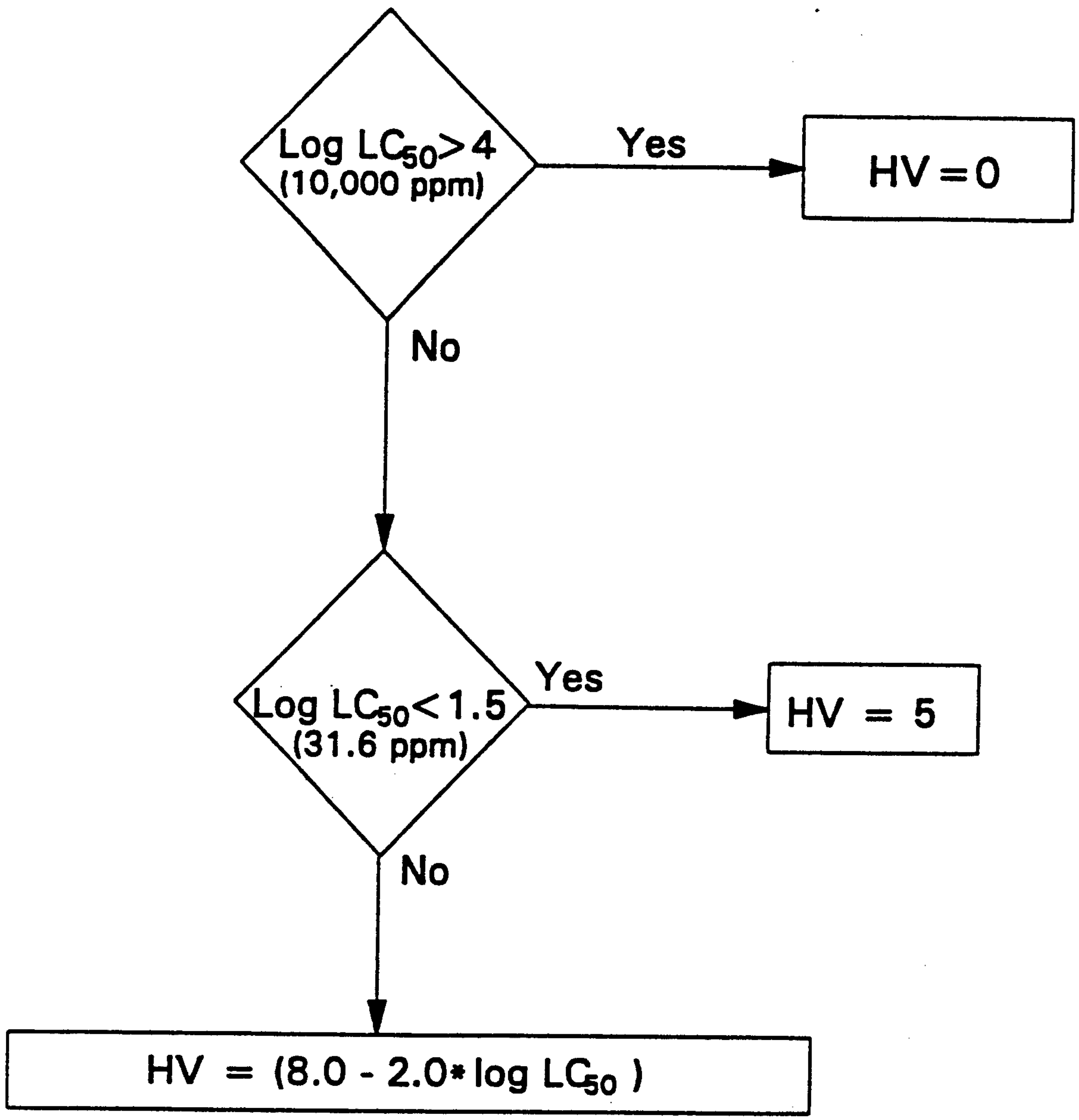
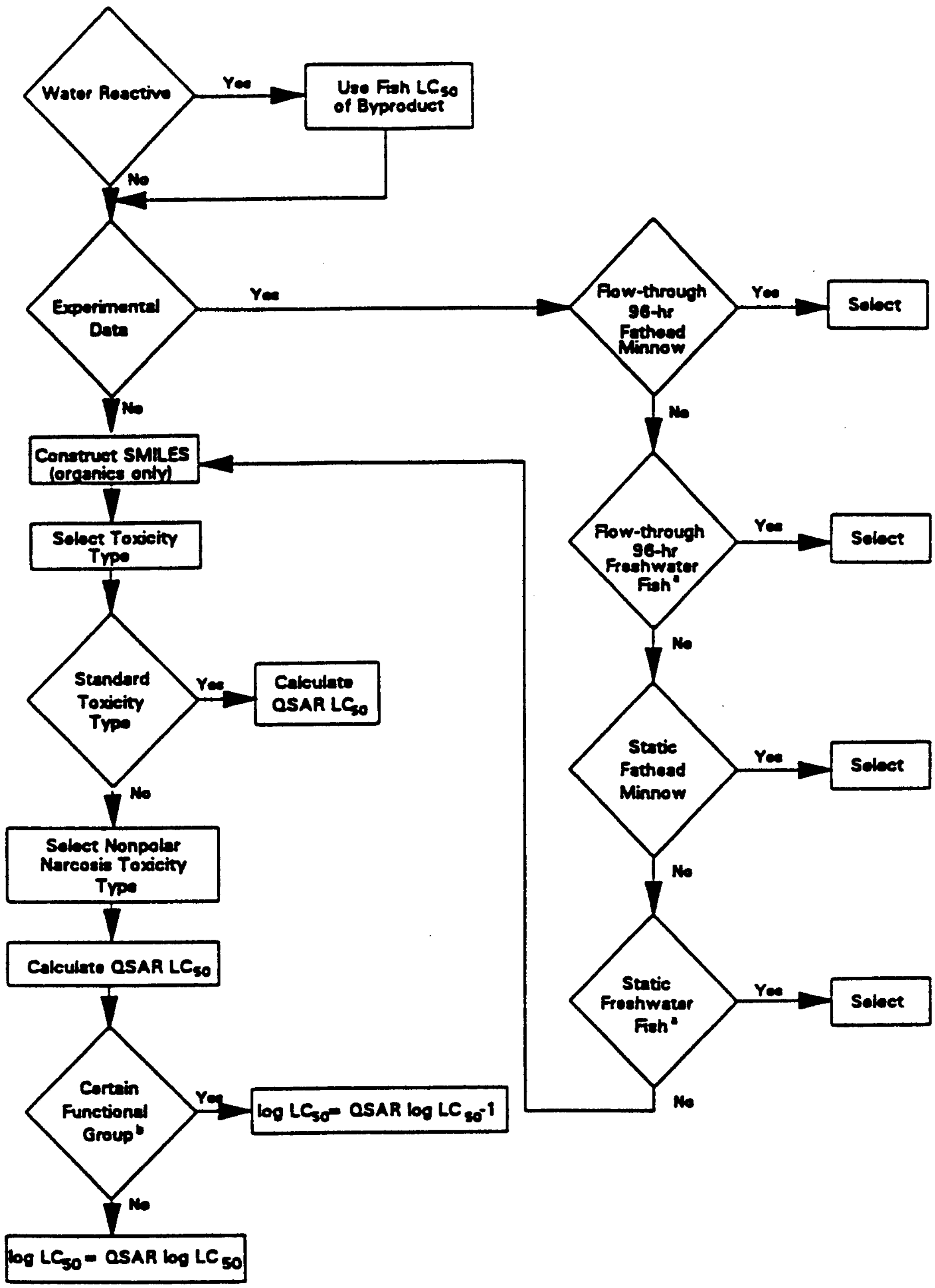


Figure D-4. Decision Tree for Inhalation LC_{50} Hazard Values (from EPA, 1994)



[a] excluding trout

[b] includes good electrophiles, good nucleophiles, strong acids, chemicals with an aromatic ring, and certain reactive groups

Figure D-5. Decision Tree for Fish LC_{50} Data Selection (from EPA, 1994)

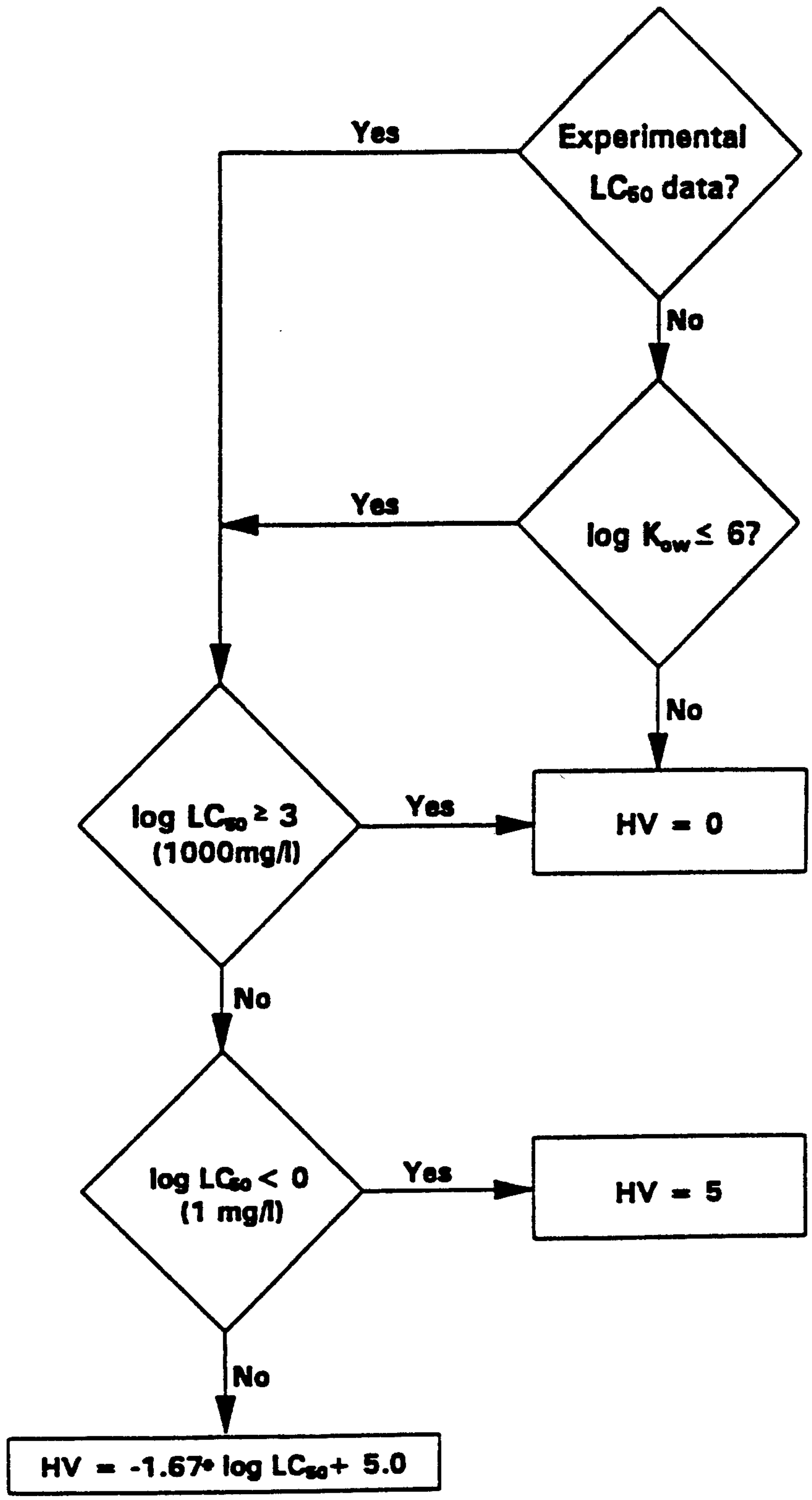


Figure D-6. Decision Tree for Aquatic LC_{50} Hazard Value (from EPA, 1994)

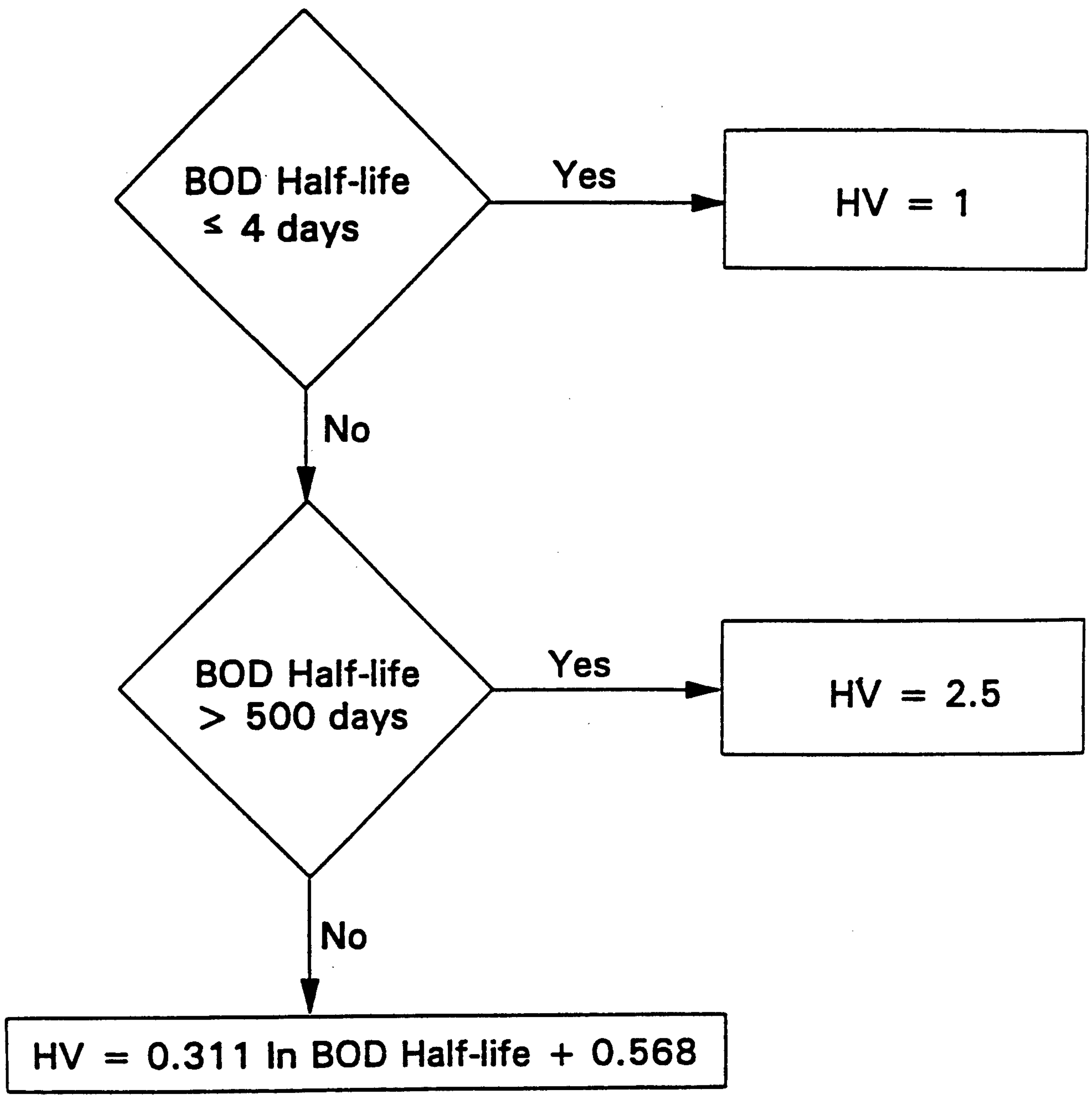


Figure D-7. Decision Tree for BOD Half-Life Hazard Value (from EPA, 1994)

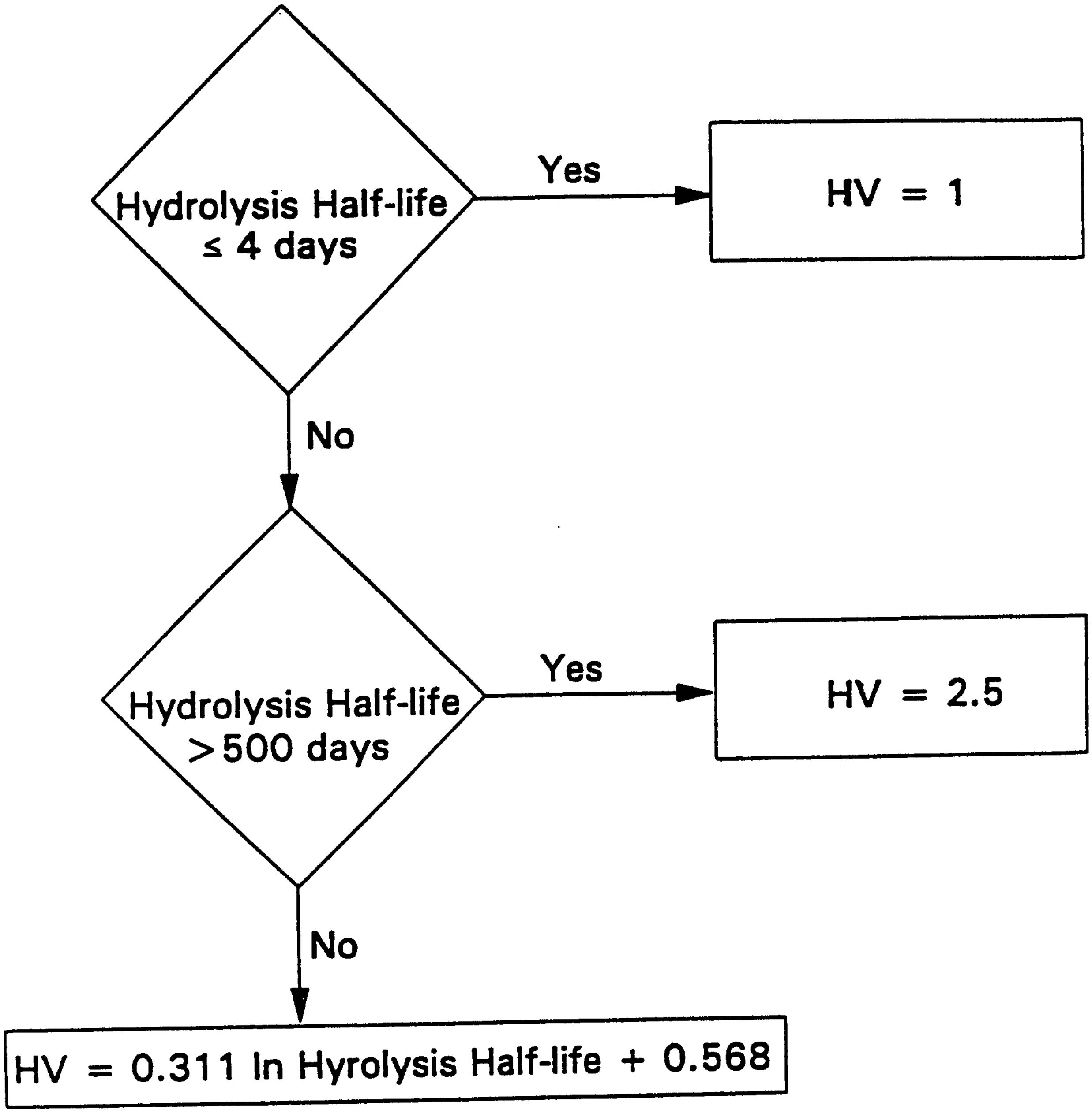


Figure D-8. Decision Tree for Hydrolysis Half-Life Hazard Value (from EPA, 1994)

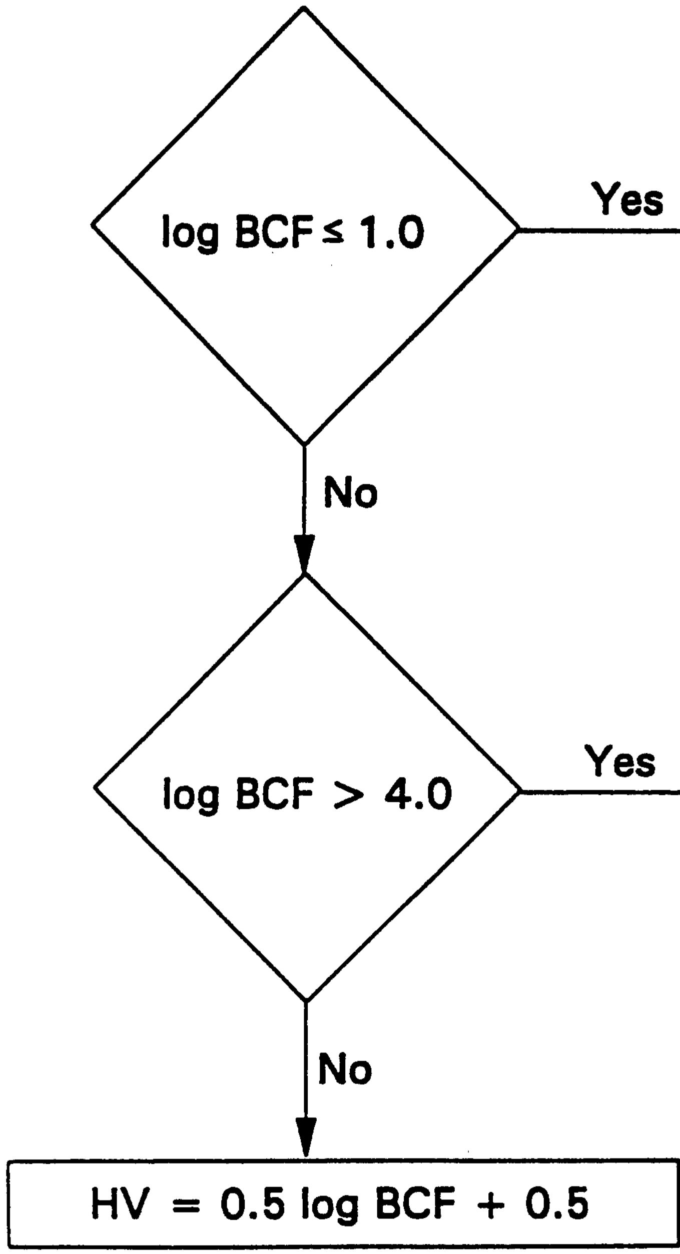


Figure D-9. Decision Tree for BCF Hazard Value (from EPA, 1994)

BASELINE SYSTEM

LIFE CYCLE IMPACT VALUATION CALCULATIONS

	Scale	Issues ------->		AHP Weighting Factor	Normalized Factored Score	Weighted Normalized Factored Score			Baseline Score
CARCOPT									0.843
	GLOBAL							0.347	
		ODP		0.17983	1.090		0.196		
		GLBLWRM		0.11328	1.013		0.115		
		FSLFUELS		0.02855	1.263		0.036		
	REGIONAL							0.220	
		ACIDDEP		0.06253	1.198		0.075		
		SMOG		0.13007	1.114		0.145		
		WTRUSE		0.01002			0.000		
	LOCAL							0.276	
		TOXICITY					0.237		
			HUMAN	0.06155	2.150	0.132			
			ENVTERR	0.02052	3.799	0.078			
			ENVAQ	0.02052	1.280	0.026			
		LANDUSE		0.02507	1.577		0.040		

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OZONE DEPLETION POTENTIAL IMPACT CALCULATIONS

CHEMICAL NAME	ODP Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total ODP Score			0.003	1.090
Normalizing Factor			0.003	
CARBON TETRACHLORIDE	1.080	0.003	0.003	1.000
DICHLORODIFLUOROMETHANE	1.000	0.000	0.000	0.000
TRICHLOROETHANE (METHYL CHLOROFORM	0.120	0.002	0.000	0.090

GLOBAL WARMING POTENTIAL IMPACT CALCULATIONS

CHEMICAL NAME	GWP Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total GWP Score			304.229	1.013
Normalizing Score			300.337	
CARBON TETRACHLORIDE	1300	0.003	3.663	0.012
CO2	1	300.337	300.337	1.000
DICHLORODIFLUOROMETHANE	7100	0.000	0.000	0.000
TRICHLOROETHANE	100	0.002	0.229	0.001

RESOURCE DEPLETION IMPACT CALCULATIONS

CHEMICAL NAME	RESOURCE DEPLETION Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Resource Depetion Score			13,906.073	1.263
Normalizing Score			11,010.628	
BAUXITE	4	83.964	335.857	0.031
CHROME OXIDE	2	4.553	9.107	0.001
COAL	3	0.292	0.875	0.000
COBALT OXIDE	3	1.003	3.010	0.000
IRON ORE	3	1.282	3.845	0.000
LIMESTONE	1	4.653	4.653	0.000
MAGNESIUM ORE	1	2.249	2.249	0.000
NATURAL GAS	4	602.895	2,411.581	0.219
PETROLEUM (CRUDE OIL)	4	2,752.657	11,010.628	1.000
PHOSPHATE ROCK	3	2.092	6.276	0.001
SALT (SODIUM CHLORIDE)	1	43.084	43.084	0.004
SILICA	1	13.657	13.657	0.001
SODA ASH	1	2.624	2.624	0.000
THALLIUM	4		0.000	0.000
TITANIUM	3	8.412	25.235	0.002
URANIUM (235, 236, 238)	3	0.000	0.000	0.000
WATER INPUT	NA	43,695.190	0.000	0.000
ZINC	4	8.347	33.390	0.003

NA = Not Available

ACIDIFICATION POTENTIAL IMPACT CALCULATIONS

CHEMICAL NAME	Acid. Pot. Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Acid. Pot. Score			25.855	1.198
Normalizing Score			21.584	
AMMONIA	1.880	0.000	0.000	0.000
HYDROCHLORIC ACID	0.880	0.001	0.001	0.000
NOX	0.700	6.099	4.270	0.198
SOX	1.000	21.584	21.584	1.000

PHOTOCHEMICAL OXIDANT POTENTIAL IMPACT CALCULATIONS

CHEMICAL NAME	POCP Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total POCP Score			6.639	1.114
Normalizing Factor			5.959	
ACETALDEHYDE	0.527	0.089	0.047	0.008
ACETONE	0.178	0.008	0.001	0.000
ALDEHYDES	0.443	0.019	0.009	0.001
AROMATIC HYDROCARBONS (C8-C10)	0.761	0.023	0.017	0.003
BENZENE	0.189	0.203	0.038	0.006
BUTANE (n-)	0.410	0.059	0.024	0.004
BUTANE (iso-)	0.315	0.003	0.001	0.000
BUTYL ACETATE (n-)	0.323	0.150	0.048	0.008
BUTYL ALCOHOL	0.196	0.034	0.007	0.001
CHLOROFORM	0.021	0.001	0.000	0.000
ETHANE	0.082	0.047	0.004	0.001
ETHYL BENZENE	0.593	0.002	0.001	0.000
ETHYLENE	1.000	0.003	0.003	0.000
HEPTANE (n-)	0.529	0.086	0.045	0.008
HEXANE (n-)	0.421	0.067	0.028	0.005
METHANE	0.007	0.276	0.002	0.000
METHANOL	0.123	0.000	0.000	0.000
METHYL ETHYL KETONE	0.473	0.059	0.028	0.005
METHYL ISOAMYL KETONE	0.326	0.524	0.171	0.029
METHYL ISOBUTYL KETONE	0.326	0.023	0.008	0.001
METHYL PROPYL KETONE	0.326	0.000	0.000	0.000
OCTANE (n-)	0.493	0.057	0.028	0.005
PENTANE (n-)	0.408	0.042	0.017	0.003
PROPANE	0.420	0.074	0.031	0.005
PROPYL ACETATE	0.218	0.000	0.000	0.000
PROPYLENE	1.030	0.000	0.000	0.000
TOLUENE	0.563	0.130	0.073	0.012
TRICHLOROETHANE	0.021	0.002	0.000	0.000
VOC	0.397	15.011	5.959	1.000
XYLENE	0.849	0.056	0.048	0.008

HUMAN HEALTH INHALATION TOXICITY IMPACT CALCULATIONS

CHEMICAL NAME	HH INHALATION TOXICITY Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total HH Inh. Tox. Factored Score			27.336	2.150
Normalizing Score			12.715	
ACETALDEHYDE	7.44	0.089	0.659	0.052
ACETONE	0	0.008	0.000	0.000
ACETONITRILE	0	0.000	0.000	0.000
AMMONIA	5.7	0.000	0.000	0.000
ALDEHYDES	NA	0.019	0.000	0.000
ALUMINUM	15.6	0.003	0.046	0.004
AROMATIC HYDROCARBONS (C8-C10)	NA	0.023	0.000	0.000
BENZENE	NA	0.203	0.000	0.000
BUTANE (n-)	17.5	0.059	1.033	0.081
BUTANE (iso-)	NA	0.003	0.000	0.000
BUTYL ACETATE (n-)	8.49	0.150	1.270	0.100
BUTANOL	0.95	0.034	0.033	0.003
BUTYL CELLOSOLVE	12.29	0.000	0.000	0.000
BUTYLENE OXIDE, 1,2-	NA	0.000	0.000	0.000
CADMIUM	2.25		0.000	0.000
CARBON TETRACHLORIDE	7.06	0.003	0.020	0.002
CHLORINE	22.05	0.577	12.715	1.000
CHLOROFORM	2.57	0.001	0.003	0.000
CO	4.47	1.386	6.195	0.487
CO2	NA	300.337	0.000	0.000
CUMENE	1.35	0.027	0.036	0.003
CYCLOPARAFFINS, C-7	NA	0.012	0.000	0.000
CYCLOPARAFFINS, C-8	NA	0.004	0.000	0.000
DICHLORODIFLUOROMETHANE (CFC	0	0.000	0.000	0.000
ETHANE	NA	0.047	0.000	0.000
ETHYL BENZENE	3.19	0.002	0.007	0.001
ETHYLENE	0	0.003.	0.000	0.000
ETHYLENE CHLORIDE	0	0.003	0.000	0.000
ETHYLENE DICHLORIDE	7.32	0.008	0.057	0.004
FLUORINE	14.64	0.028	0.410	0.032
FORMALDEHYDE	15.6	0.021	0.327	0.026
HEAVY AROMATIC	NA	0.197	0.000	0.000
HEPTANE (n-)	0	0.086	0.000	0.000
HEXYL ACETATE	NA	0.056	0.000	0.000
HEXAMETHYLENE DIISOCYANTE	10		0.000	0.000
HEXANE (n-)	0	0.067	0.000	0.000
HYDROCHLORIC ACID	14.82	0.001	0.020	0.002
HYDROGEN CYANIDE	30	0.007	0.202	0.016
ISOBUTYRALDEHYDE	1.86	0.328	0.610	0.048
ISOPROPYL ALCOHOL	0	0.000	0.000	0.000
LEAD	NA	0.001	0.000	0.000
METHANE	NA	0.276	0.000	0.000
METHANOL	0	0.000	0.000	0.000

METHYL ETHYL KETONE	1.4	0.059	0.082	0.006
METHYL ISOAMYL KETONE	4	0.524	2.098	0.165
METHYL ISOBUTYL KETONE	2.33	0.023	0.054	0.004
METHYL PROPYL KETONE	NA	0.000	0.000	0.000
NAPTHA, NM&P	NA	0.066	0.000	0.000
NAPHTHALENE	26.45		0.000	0.000
NOX	NA	6.099	0.000	0.000
NITRIC ACID	26.4	0.000	0.000	0.000
NITROETHANE	NA	0.000	0.000	0.000
NITROPROPANE	14.4	0.000	0.000	0.000
OCTANE (n-)	0	0.057	0.000	0.000
ORGANIC ACIDS	NA	0.025	0.000	0.000
PENTANE (n-)	13.34	0.042	0.554	0.044
PHENOL	22.33	0.022	0.483	0.038
PHOSGENE	12.5		0.000	0.000
PHOSPHORIC ACID	30		0.000	0.000
PM	NA	6.007	0.000	0.000
PM-10	NA	0.310	0.000	0.000
PROPANE	NA	0.074	0.000	0.000
PROPYL ACETATE	NA	0.000	0.000	0.000
TOLUENE	2.04	0.130	0.264	0.021
TRICHLOROEHTANE (METHYL CHLO	5.6	0.002	0.013	0.001
VINYL CHLORIDE	18.52	0.001	0.026	0.002
VOC	NA	15.011	0.000	0.000
XYLENE	2.1	0.056	0.118	0.009

NA = Not Available

TERRESTRIAL TOXICITY IMPACT CALCULATIONS

CHEMICAL NAME	TERRESTRIAL TOXICITY Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Terr. Tox. Factored Score			4.084	3.799
Normalizing Score			1.075	
ACETALDEHYDE	3.255	0.089	0.288	0.268
ACETONE	1.860	0.008	0.016	0.014
ACETONITRILE	0.610	0.000	0.000	0.000
ALUMINUM	0.000	0.001	0.000	0.000
AMMONIA	9.030	0.000	0.000	0.000
ARSENIC	31.730	0.000	0.001	0.001
BENZENE	0.000	0.204	0.000	0.000
BUTYL ACETATE (n-)	0.000	0.150	0.000	0.000
BUTYL ALCOHOL	6.180	0.034	0.212	0.197
BUTYL CELLOSOLVE	7.590	0.000	0.000	0.000
BUTYLENE OXIDE, 1,2-	1.610	0.000	0.000	0.000
CADMIUM	21.030	0.005	0.105	0.097
CARBON TETRACHLORIDE	1.710	0.003	0.005	0.004
CHLORINE	0.000	0.616	0.000	0.000
CHLOROFORM	6.160	0.001	0.008	0.008
CHROMIUM, TRIVALENT	19.290	0.001	0.011	0.010
COBALT COMPOUNDS	20.960		0.000	0.000
COPPER COMPOUNDS	12.000	0.000	0.000	0.000
CUMENE	2.710	0.027	0.073	0.068
DICHLORODIFLUOROMETHANE	1.330	0.000	0.000	0.000
DIETHYLAMINETRIAMINE	5.270		0.000	0.000
ETHYL BENZENE	0.000	0.002	0.000	0.000
ETHYLENE	0.000	0.003	0.000	0.000
ETHYLENE DICHLORIDE	4.890		0.000	0.000
FGD SOLIDS	0.000	0.000	0.000	0.000
FLY ASH	0.000	0.000	0.000	0.000
FORMALDEHYDE	12.600	0.021	0.264	0.245
HEPTANE (n-)	9.500	0.086	0.814	0.757
HEXANE (n-)	0.000	0.067	0.000	0.000
HEXYL ACETATE	0.000	0.056	0.000	0.000
HEXAMETYHYLENE DIISOCYANTE	2.640		0.000	0.000
HYDROCHLORIC ACID	5.740	0.001	0.008	0.007
HYDROGEN CYANIDE	30.000	0.007	0.202	0.188
IRON	0.000	0.000	0.000	0.000
ISOBUTYRALDEHYDE	1.860	0.328	0.610	0.567
ISOPROPYL ALCOHOL	0.950	0.000	0.000	0.000
KEROSENE	0.000	0.000	0.000	0.000
LEAD	5.750	0.003	0.015	0.014
METHYL ETHYL KETONE	1.860	0.059	0.109	0.102
METHYL ISOAMYL KETONE	2.050	0.524	1.075	1.000
METHYL ISOBUTYL KETONE	2.790	0.023	0.065	0.060

METHYL PROPYL KETONE	4.570	0.000	0.000	0.000
NAPHTHALENE	3.170		0.000	0.000
NITRIC ACID	10.200	0.000	0.000	0.000
NITROPROPANE, 2-	8.400		0.000	0.000
PHENOL	7.600	0.022	0.164	0.153
PHOSPHORIC ACID	5.400		0.000	0.000
PROPYL ACETATE	0.870	0.000	0.000	0.000
PLUTONIUM (FISSILE & NONFISSILE)	0.000	0.000	0.000	0.000
SLAG	0.000	0.000	0.000	0.000
SULFURIC ACID	3.600	0.000	0.000	0.000
TOLUENE	0.000	0.130	0.000	0.000
TRICHLOROETHANE (METHYL CHLOR	0.000	0.002	0.000	0.000
URANIUM (235, 236, 238)	NA	0.000	0.000	0.000
VINYL CHLORIDE	7.870	0.001	0.011	0.010
XYLENE	0.520	0.056	0.029	0.027
ZINC	0.000	0.000	0.000	0.000

NA = Not Available

AQUATIC TOXICITY IMPACT CALCULATIONS

CHEMICAL NAME	AQUATIC TOXICITY Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Aquatic Tox. Factored Score			1.128	1.280
Normalizing Score			0.881	
ACETONITRILE	0.000		0.000	0.000
AMMONIA	21.850		0.000	0.000
ALUMINUM	0.000	0.001	0.000	0.000
ARSENIC	18.750	0.000	0.001	0.001
BENZENE	14.070	0.001	0.010	0.011
BORON	0.000	0.015	0.000	0.000
BUTYL ALCOHOL	0.000	0.034	0.000	0.000
BUTYLENE OXIDE, 1,2-	NA		0.000	0.000
CADMIUM	36.250	0.005	0.180	0.204
CARBON TETRACHLORIDE	1.200		0.000	0.000
CHLORIDE	NA	11.375	0.000	0.000
CHLORINE	22.500	0.039	0.881	1.000
CHLOROFORM	9.750		0.000	0.000
CHROMIUM, TRIVALENT	16.630	0.001	0.009	0.010
COBALT COMPOUNDS	31.750		0.000	0.000
COPPER COMPOUNDS	30.000	0.000	0.001	0.001
DICHLORODIFLUOROMETHANE (CFC-1	NA		0.000	0.000
HYDROCHLORIC ACID	13.860		0.000	0.000
IRON	25.000	0.000	0.000	0.000
LEAD	25.000	0.002	0.044	0.050
MERCURY	37.500	0.000	0.000	0.000
METHYL ISOAMYL KETONE	10.200		0.000	0.000
NAPHTHALENE	19.570		0.000	0.000
NITRIC ACID	15.600		0.000	0.000
NITROPROPANE, 2-	23.400		0.000	0.000
OIL & GREASE	NA	0.355	0.000	0.000
ORGANIC ACIDS	NA		0.000	0.000
PETROLEUM (CRUDE OIL)	NA	0.000	0.000	0.000
PHENOL	11.400	0.000	0.000	0.000
PHOSPHORIC ACID	11.400		0.000	0.000
SODIUM	NA	14.408	0.000	0.000
SULFIDE	NA	0.000	0.000	0.000
SULFURIC ACID	15.000	0.000	0.000	0.000
XYLENE	16.240		0.000	0.000
ZINC	20.300	0.000	0.001	0.001

NA = Not Available

LAND USE IMPACT CALCULATIONS

CHEMICAL NAME	LAND USE Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Land Use Score			254.826	1.577
Normalizing Score			161.615	
BOTTOM ASH	2.000	0.000	0.000	0.000
FGD SOLIDS	2.000	0.000	0.000	0.000
FLY ASH	2.000	0.000	0.000	0.000
HAZARDOUS WASTE	2.000	80.808	161.615	1.000
PLUTONIUM (FISSILE & NONFISSILE)	NA	0.000	0.000	0.000
SLAG	2.000	0.000	0.000	0.000
SOLID WASTE	1.500	62.140	93.210	0.577
URANIUM (235, 236, 238)	NA	0.000	0.000	0.000

NA = Not Available

ALTERNATIVE PRIMER

LIFE CYCLE IMPACT VALUATION CALCULATIONS

	Scale	Issues ------->		AHP Weighting Factor	Normalized Factored Score	Weighted Normalized Factored Score			Baseline Score
CARCOPT									0.671
	GLOBAL							0.203	
		ODP		0.17983	0.367		0.066		
		GLBLWRM		0.11328	0.927		0.105		
		FSLFUELS		0.02855	1.121		0.032		
	REGIONAL							0.203	
		ACIDDEP		0.06253	1.173		0.073		
		SMOG		0.13007	0.993		0.129		
		WTRUSE		0.01002			0.000		
	LOCAL							0.266	
		TOXICITY					0.226		
			HUMAN	0.06155	1.612	0.099			
			ENVTERR	0.02052	2.635	0.054			
			ENVAQ	0.02052	3.537	0.073			
		LANDUSE		0.02507	1.585		0.040		

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OZONE DEPLETION POTENTIAL IMPACT CALCULATIONS

CHEMICAL NAME	ODP Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total ODP Score			0.001	0.367
Normalizing Factor			0.003	
CARBON TETRACHLORIDE	1.080	0.000	0.000	0.000
DICHLORODIFLUOROMETHANE	1.000	0.001	0.001	0.367
TRICHLOROETHANE (METHYL CHLOROFORM	0.120	0.000	0.000	0.000

GLOBAL WARMING POTENTIAL IMPACT CALCULATIONS

CHEMICAL NAME	GWP Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total GWP Score			278.555	0.927
Normalizing Score			300.337	
CARBON TETRACHLORIDE	1300	0.000	0.000	0.000
CO2	1	270.734	270.734	0.901
DICHLORODIFLUOROMETHANE	7100	0.001	7.821	0.026
TRICHLOROETHANE	100	0.000	0.000	0.000

RESOURCE DEPLETION IMPACT CALCULATIONS

CHEMICAL NAME	RESOURCE DEPLETION Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Resource Depetion Score			12,343.607	1.121
Normalizing Score			11,010.628	
BAUXITE	4	83.964	335.857	0.031
CHROME OXIDE	2	4.553	9.107	0.001
COAL	3	0.000	0.000	0.000
COBALT OXIDE	3	1.003	3.010	0.000
IRON ORE	3	1.341	4.023	0.000
LIMESTONE	1	4.653	4.653	0.000
MAGNESIUM ORE	1	2.249	2.249	0.000
NATURAL GAS	4	534.932	2,139.727	0.194
PETROLEUM (CRUDE OIL)	4	2,436.041	9,744.165	0.885
PHOSPHATE ROCK	3	0.000	0.000	0.000
SALT (SODIUM CHLORIDE)	1	43.469	43.469	0.004
SILICA	1	13.377	13.377	0.001
SODA ASH	1	2.624	2.624	0.000
THALLIUM	4		0.000	0.000
TITANIUM	3	13.782	41.345	0.004
URANIUM (235, 236, 238)	3	0.000	0.000	0.000
WATER INPUT	NA	40,210.766	0.000	0.000
ZINC	4	0.000	0.000	0.000

NA = Not Available

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ACIDIFICATION POTENTIAL IMPACT CALCULATIONS

CHEMICAL NAME	Acid. Pot. Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Acid. Pot. Score			25.324	1.173
Normalizing Score			21.584	
AMMONIA	1.880	0.001	0.002	0.000
HYDROCHLORIC ACID	0.880	0.002	0.002	0.000
NOX	0.700	5.877	4.114	0.191
SOX	1.000	21.206	21.206	0.982

PHOTOCHEMICAL OXIDANT POTENTIAL IMPACT CALCULATIONS

CHEMICAL NAME	POCP Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total POCP Score			5.918	0.993
Normalizing Factor			5.959	
ACETALDEHYDE	0.527	0.040	0.021	0.004
ACETONE	0.178	0.007	0.001	0.000
ALDEHYDES	0.443	0.017	0.008	0.001
AROMATIC HYDROCARBONS (C8-C10)	0.761	0.038	0.029	0.005
BENZENE	0.189	0.201	0.038	0.006
BUTANE (n-)	0.410	0.052	0.021	0.004
BUTANE (iso-)	0.315	0.003	0.001	0.000
BUTYL ACETATE (n-)	0.323	0.000	0.000	0.000
BUTYL ALCOHOL	0.196	0.042	0.008	0.001
CHLOROFORM	0.021	0.000	0.000	0.000
ETHANE	0.082	0.042	0.003	0.001
ETHYL BENZENE	0.593	0.004	0.003	0.000
ETHYLENE	1.000	0.001	0.001	0.000
HEPTANE (n-)	0.529	0.076	0.040	0.007
HEXANE (n-)	0.421	0.059	0.025	0.004
METHANE	0.007	0.244	0.002	0.000
METHANOL	0.123	0.000	0.000	0.000
METHYL ETHYL KETONE	0.473	0.020	0.010	0.002
METHYL ISOAMYL KETONE	0.326	0.071	0.023	0.004
METHYL ISOBUTYL KETONE	0.326	0.000	0.000	0.000
METHYL PROPYL KETONE	0.326	0.000	0.000	0.000
OCTANE (n-)	0.493	0.051	0.025	0.004
PENTANE (n-)	0.408	0.037	0.015	0.003
PROPANE	0.420	0.066	0.028	0.005
PROPYL ACETATE	0.218	0.000	0.000	0.000
PROPYLENE	1.030	0.000	0.000	0.000
TOLUENE	0.563	0.114	0.064	0.011
TRICHLOROETHANE	0.021	0.000	0.000	0.000
VOC	0.397	13.894	5.516	0.926
XYLENE	0.849	0.043	0.036	0.006

HUMAN HEALTH INHALATION TOXICITY IMPACT CALCULATIONS

CHEMICAL NAME	HH INHALATION TOXICITY Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total HH Inh. Tox. Factored Score			20.499	1.612
Normalizing Score			12.715	
ACETALDEHYDE	7.44	0.040	0.301	0.024
ACETONE	0	0.007	0.000	0.000
ACETONITRILE	0	0.000	0.000	0.000
AMMONIA	5.7	0.001	0.005	0.000
ALDEHYDES	NA	0.017	0.000	0.000
ALUMINUM	15.6	0.000	0.006	0.000
AROMATIC HYDROCARBONS (C8-C10)	NA	0.038	0.000	0.000
BENZENE	NA	0.201	0.000	0.000
BUTANE (n-)	17.5	0.052	0.914	0.072
BUTANE (iso-)	NA	0.003	0.000	0.000
BUTYL ACETATE (n-)	8.49	0.000	0.000	0.000
BUTANOL	0.95	0.042	0.040	0.003
BUTYL CELLOSOLVE	12.29	0.000	0.000	0.000
BUTYLENE OXIDE, 1,2-	NA	0.000	0.000	0.000
CADMIUM	2.25		0.000	0.000
CARBON TETRACHLORIDE	7.06	0.000	0.000	0.000
CHLORINE	22.05	0.586	12.914	1.016
CHLOROFORM	2.57	0.000	0.000	0.000
CO	4.47	0.792	3.542	0.279
CO2	NA	270.734	0.000	0.000
CUMENE	1.35	0.023	0.030	0.002
CYCLOPARAFFINS, C-7	NA	0.011	0.000	0.000
CYCLOPARAFFINS, C-8	NA	0.004	0.000	0.000
DICHLORODIFLUORMETHANE (CFC-	0	0.001	0.000	0.000
ETHANE	NA	0.042	0.000	0.000
ETHYL BENZENE	3.19	0.004	0.014	0.001
ETHYLENE	0	0.001	0.000	0.000
ETHYLENE CHLORIDE	0	0.000	0.000	0.000
ETHYLENE DICHLORIDE	7.32	0.000	0.000	0.000
FLUORINE	14.64	0.000	0.000	0.000
FORMALDEHYDE	15.6	0.019	0.295	0.023
HEAVY AROMATIC	NA	0.197	0.000	0.000
HEPTANE (n-)	0	0.076	0.000	0.000
HEXYL ACETATE	NA	0.000	0.000	0.000
HEXAMETHYLENE DIISOCYANTE	10		0.000	0.000
HEXANE (n-)	0	0.059	0.000	0.000
HYDROCHLORIC ACID	14.82	0.002	0.029	0.002
HYDROGEN CYANIDE	30	0.007	0.204	0.016
ISOBUTYRALDEHYDE	1.86	0.328	0.610	0.048
ISOPROPYL ALCOHOL	0	0.000	0.000	0.000
LEAD	NA	0.000	0.000	0.000
METHANE	NA	0.244	0.000	0.000
METHANOL	0	0.000	0.000	0.000

METHYL ETHYL KETONE	1.4	0.020	0.029	0.002
METHYL ISOAMYL KETONE	4	0.071	0.284	0.022
METHYL ISOBUTYL KETONE	2.33	0.000	0.000	0.000
METHYL PROPYL KETONE	NA	0.000	0.000	0.000
NAPTHA, NM&P	NA	0.000	0.000	0.000
NAPHTHALENE	26.45		0.000	0.000
NOX	NA	5.877	0.000	0.000
NITRIC ACID	26.4	0.000	0.000	0.000
NITROETHANE	NA	0.004	0.000	0.000
NITROPROPANE	14.4	0.001	0.009	0.001
OCTANE (n-)	0	0.051	0.000	0.000
ORGANIC ACIDS	NA	0.022	0.000	0.000
PENTANE (n-)	13.34	0.037	0.491	0.039
PHENOL	22.33	0.021	0.461	0.036
PHOSGENE	12.5		0.000	0.000
PHOSPHORIC ACID	30		0.000	0.000
PM	NA	5.958	0.000	0.000
PM-10	NA	0.310	0.000	0.000
PROPANE	NA	0.066	0.000	0.000
PROPYL ACETATE	NA	0.000	0.000	0.000
TOLUENE	2.04	0.114	0.232	0.018
TRICHLOROEHTANE (METHYL CHLO	5.6	0.000	0.000	0.000
VINYL CHLORIDE	18.52	0.000	0.000	0.000
VOC	NA	13.894	0.000	0.000
XYLENE	2.1	0.043	0.090	0.007

NA = Not Available

TERRESTRIAL TOXICITY IMPACT CALCULATIONS

CHEMICAL NAME	TERRESTRIAL TOXICITY Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Terr. Tox. Factored Score			2.832	2.635
Normalizing Score			1.075	
ACETALDEHYDE	3.255	0.040	0.132	0.123
ACETONE	1.860	0.007	0.014	0.013
ACETONITRILE	0.610	0.005	0.003	0.003
ALUMINUM	0.000	0.001	0.000	0.000
AMMONIA	9.030	0.001	0.008	0.007
ARSENIC	31.730	0.000	0.001	0.001
BENZENE	0.000	0.202	0.000	0.000
BUTYL ACETATE (n-)	0.000	0.000	0.000	0.000
BUTYL ALCOHOL	6.180	0.042	0.258	0.240
BUTYL CELLOSOLVE	7.590	0.000	0.000	0.000
BUTYLENE OXIDE, 1,2-	1.610	0.000	0.000	0.000
CADMIUM	21.030	0.008	0.167	0.156
CARBON TETRACHLORIDE	1.710	0.000	0.000	0.000
CHLORINE	0.000	0.707	0.000	0.000
CHLOROFORM	6.160	0.000	0.000	0.000
CHROMIUM, TRIVALENT	19.290	0.001	0.017	0.016
COBALT COMPOUNDS	20.960		0.000	0.000
COPPER COMPOUNDS	12.000	0.000	0.001	0.001
CUMENE	2.710	0.023	0.061	0.057
DICHLORODIFLUORMETHANE	1.330	0.001	0.001	0.001
DIETHYLAMINETRIAMINE	5.270		0.000	0.000
ETHYL BENZENE	0.000	0.004	0.000	0.000
ETHYLENE	0.000	0.001	0.000	0.000
ETHYLENE DICHLORIDE	4.890		0.000	0.000
FGD SOLIDS	0.000	0.000	0.000	0.000
FLY ASH	0.000	0.000	0.000	0.000
FORMALDEHYDE	12.600	0.019	0.238	0.221
HEPTANE (n-)	9.500	0.076	0.721	0.670
HEXANE (n-)	0.000	0.059	0.000	0.000
HEXYL ACETATE	0.000	0.000	0.000	0.000
HEXAMETYHYLENE DIISOCYANTE	2.640		0.000	0.000
HYDROCHLORIC ACID	5.740	0.002	0.011	0.010
HYDROGEN CYANIDE	30.000	0.007	0.204	0.189
IRON	0.000	0.000	0.000	0.000
ISOBUTYRALDEHYDE	1.860	0.328	0.610	0.567
ISOPROPYL ALCOHOL	0.950	0.000	0.000	0.000
KEROSENE	0.000	0.000	0.000	0.000
LEAD	5.750	0.003	0.017	0.016
METHYL ETHYL KETONE	1.860	0.020	0.038	0.035
METHYL ISOAMYL KETONE	2.050	0.071	0.146	0.135
METHYL ISOBUTYL KETONE	2.790	0.000	0.000	0.000

METHYL PROPYL KETONE	4.570	0.000	0.000	0.000
NAPHTHALENE	3.170		0.000	0.000
NITRIC ACID	10.200	0.001	0.007	0.006
NITROPROPANE, 2-	8.400		0.000	0.000
PHENOL	7.600	0.021	0.157	0.146
PHOSPHORIC ACID	5.400		0.000	0.000
PROPYL ACETATE	0.870	0.000	0.000	0.000
PLUTONIUM (FISSILE & NONFISSILE)	0.000	0.000	0.000	0.000
SLAG	0.000	0.000	0.000	0.000
SULFURIC ACID	3.600	0.000	0.000	0.000
TOLUENE	0.000	0.114	0.000	0.000
TRICHLOROETHANE (METHYL CHLOR	0.000	0.000	0.000	0.000
URANIUM (235, 236, 238)	NA	0.000	0.000	0.000
VINYL CHLORIDE	7.870	0.000	0.000	0.000
XYLENE	0.520	0.043	0.022	0.021
ZINC	0.000	0.000	0.000	0.000

NA = Not Available

AQUATIC TOXICITY IMPACT CALCULATIONS

CHEMICAL NAME	AQUATIC TOXICITY Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Aquatic Tox. Factored Score			3.116	3.537
Normalizing Score			0.881	
ACETONITRILE	0.000		0.000	0.000
AMMONIA	21.850		0.000	0.000
ALUMINUM	0.000	0.001	0.000	0.000
ARSENIC	18.750	0.000	0.000	0.001
BENZENE	14.070	0.001	0.009	0.010
BORON	0.000	0.013	0.000	0.000
BUTYL ALCOHOL	0.000	0.042	0.000	0.000
BUTYLENE OXIDE, 1,2-	NA		0.000	0.000
CADMIUM	36.250	0.008	0.289	0.328
CARBON TETRACHLORIDE	1.200		0.000	0.000
CHLORIDE	NA	10.067	0.000	0.000
CHLORINE	22.500	0.121	2.727	3.095
CHLOROFORM	9.750		0.000	0.000
CHROMIUM, TRIVALENT	16.630	0.001	0.015	0.017
COBALT COMPOUNDS	31.750		0.000	0.000
COPPER COMPOUNDS	30.000	0.000	0.002	0.002
DICHLORODIFLUOROMETHANE (CFC-1	NA		0.000	0.000
HYDROCHLORIC ACID	13.860		0.000	0.000
IRON	25.000	0.000	0.000	0.000
LEAD	25.000	0.003	0.073	0.082
MERCURY	37.500	0.000	0.000	0.000
METHYL ISOAMYL KETONE	10.200		0.000	0.000
NAPHTHALENE	19.570		0.000	0.000
NITRIC ACID	15.600		0.000	0.000
NITROPROPANE, 2-	23.400		0.000	0.000
OIL & GREASE	NA	0.314	0.000	0.000
ORGANIC ACIDS	NA		0.000	0.000
PETROLEUM (CRUDE OIL)	NA	0.000	0.000	0.000
PHENOL	11.400	0.000	0.000	0.000
PHOSPHORIC ACID	11.400		0.000	0.000
SODIUM	NA	12.751	0.000	0.000
SULFIDE	NA	0.000	0.000	0.000
SULFURIC ACID	15.000	0.000	0.000	0.000
XYLENE	16.240		0.000	0.000
ZINC	20.300	0.000	0.001	0.002

NA = Not Available

LAND USE IMPACT CALCULATIONS

CHEMICAL NAME	LAND USE Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Land Use Score			251.882	1.585
Normalizing Score			161.615	
BOTTOM ASH	2.000	0.000	0.000	0.000
FGD SOLIDS	2.000	0.000	0.000	0.000
FLY ASH	2.000	0.000	0.000	0.000
HAZARDOUS WASTE	2.000	79.465	158.930	1.000
PLUTONIUM (FISSILE & NONFISSILE)	NA	0.000	0.000	0.000
SLAG	2.000	0.000	0.000	0.000
SOLID WASTE	1.500	61.968	92.951	0.585
URANIUM (235, 236, 238)	NA	0.000	0.000	0.000

NA = Not Available

ALTERNATIVE GUN

LIFE CYCLE IMPACT VALUATION CALCULATIONS

	Scale	Issues ------->		AHP Weighting Factor	Normalized Factored Score	Weighted Normalized Factored Score			Baseline Score
CARCOPT									0.630
	GLOBAL							0.254	
		ODP		0.17983	0.799		0.144		
		GLBLWRM		0.11328	0.739		0.084		
		FSLFUELS		0.02855	0.929		0.027		
	REGIONAL							0.174	
		ACIDDEP		0.06253	1.116		0.070		
		SMOG		0.13007	0.800		0.104		
		WTRUSE		0.01002			0.000		
	LOCAL							0.202	
		TOXICITY					0.165		
			HUMAN	0.06155	1.510	0.093			
			ENVTERR	0.02052	2.565	0.053			
			ENVAQ	0.02052	0.925	0.019			
		LANDUSE		0.02507	1.493		0.037		

BCBPBTAG.WK4

OZONE DEPLETION POTENTIAL IMPACT CALCULATIONS

CHEMICAL NAME	ODP Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total ODP Score			0.002	0.799
Normalizing Factor			0.003	
CARBON TETRACHLORIDE	1.080	0.002	0.002	0.732
DICHLORODIFLUOROMETHANE	1.000	0.000	0.000	0.000
TRICHLOROETHANE (METHYL CHLOROFORM	0.120	0.002	0.000	0.066

GLOBAL WARMING POTENTIAL IMPACT CALCULATIONS

CHEMICAL NAME	GWP Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total GWP Score			221.802	0.739
Normalizing Score			300.337	
CARBON TETRACHLORIDE	1300	0.002	2.645	0.009
CO2	1	218.992	218.992	0.729
DICHLORODIFLUOROMETHANE	7100	0.000	0.000	0.000
TRICHLOROETHANE	100	0.002	0.165	0.001

BCBPBTAG.WK4

RESOURCE DEPLETION IMPACT CALCULATIONS

CHEMICAL NAME	RESOURCE DEPLETION Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Resource Depetion Score			10,233.632	0.929
Normalizing Score			11,010.628	
BAUXITE	4	83.964	335.857	0.031
CHROME OXIDE	2	3.288	6.575	0.001
COAL	3	0.211	0.632	0.000
COBALT OXIDE	3	0.724	2.173	0.000
IRON ORE	3	0.925	2.776	0.000
LIMESTONE	1	4.653	4.653	0.000
MAGNESIUM ORE	1	1.624	1.624	0.000
NATURAL GAS	4	439.669	1,758.676	0.160
PETROLEUM (CRUDE OIL)	4	2,007.554	8,030.216	0.729
PHOSPHATE ROCK	3	1.511	4.532	0.000
SALT (SODIUM CHLORIDE)	1	31.106	31.106	0.003
SILICA	1	9.861	9.861	0.001
SODA ASH	1	2.624	2.624	0.000
THALLIUM	4		0.000	0.000
TITANIUM	3	6.073	18.220	0.002
URANIUM (235, 236, 238)	3	0.000	0.000	0.000
WATER INPUT	NA	31,785.094	0.000	0.000
ZINC	4	6.027	24.108	0.002

NA = Not Available

ACIDIFICATION POTENTIAL IMPACT CALCULATIONS

CHEMICAL NAME	Acid. Pot. Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Acid. Pot. Score			24.080	1.116
Normalizing Score			21.584	
AMMONIA	1.880	0.000	0.000	0.000
HYDROCHLORIC ACID	0.880	0.001	0.001	0.000
NOX	0.700	4.418	3.093	0.143
SOX	1.000	20.986	20.986	0.972

PHOTOCHEMICAL OXIDANT POTENTIAL IMPACT CALCULATIONS

CHEMICAL NAME	POCP Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total POCP Score			4.768	0.800
Normalizing Factor			5.959	
ACETALDEHYDE	0.527	0.066	0.035	0.006
ACETONE	0.178	0.006	0.001	0.000
ALDEHYDES	0.443	0.014	0.006	0.001
AROMATIC HYDROCARBONS (C8-C10)	0.761	0.012	0.009	0.002
BENZENE	0.189	0.153	0.029	0.005
BUTANE (n-)	0.410	0.043	0.018	0.003
BUTANE (iso-)	0.315	0.002	0.001	0.000
BUTYL ACETATE (n-)	0.323	0.079	0.026	0.004
BUTYL ALCOHOL	0.196	0.018	0.003	0.001
CHLOROFORM	0.021	0.001	0.000	0.000
ETHANE	0.082	0.035	0.003	0.000
ETHYL BENZENE	0.593	0.002	0.001	0.000
ETHYLENE	1.000	0.002	0.002	0.000
HEPTANE (n-)	0.529	0.063	0.033	0.006
HEXANE (n-)	0.421	0.049	0.020	0.003
METHANE	0.007	0.201	0.001	0.000
METHANOL	0.123	0.000	0.000	0.000
METHYL ETHYL KETONE	0.473	0.040	0.019	0.003
METHYL ISOAMYL KETONE	0.326	0.288	0.094	0.016
METHYL ISOBUTYL KETONE	0.326	0.014	0.005	0.001
METHYL PROPYL KETONE	0.326	0.000	0.000	0.000
OCTANE (n-)	0.493	0.042	0.021	0.003
PENTANE (n-)	0.408	0.030	0.012	0.002
PROPANE	0.420	0.054	0.023	0.004
PROPYL ACETATE	0.218	0.000	0.000	0.000
PROPYLENE	1.030	0.000	0.000	0.000
TOLUENE	0.563	0.098	0.055	0.009
TRICHLOROETHANE	0.021	0.002	0.000	0.000
VOC	0.397	10.892	4.324	0.726
XYLENE	0.849	0.032	0.027	0.005

HUMAN HEALTH INHALATION TOXICITY IMPACT CALCULATIONS

CHEMICAL NAME	HH INHALATION TOXICITY Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total HH Inh. Tox. Factored Score			19.203	1.510
Normalizing Score			12.715	
ACETALDEHYDE	7.44	0.066	0.493	0.039
ACETONE	0	0.006	0.000	0.000
ACETONITRILE	0	0.000	0.000	0.000
AMMONIA	5.7	0.000	0.000	0.000
ALDEHYDES	NA	0.014	0.000	0.000
ALUMINUM	15.6	0.002	0.033	0.003
AROMATIC HYDROCARBONS (C8-C10)	NA	0.012	0.000	0.000
BENZENE	NA	0.153	0.000	0.000
BUTANE (n-)	17.5	0.043	0.753	0.059
BUTANE (iso-)	NA	0.002	0.000	0.000
BUTYL ACETATE (n-)	8.49	0.079	0.674	0.053
BUTANOL	0.95	0.018	0.017	0.001
BUTYL CELLOSOLVE	12.29	0.000	0.000	0.000
BUTYLENE OXIDE, 1,2-	NA	0.000	0.000	0.000
CADMIUM	2.25		0.000	0.000
CARBON TETRACHLORIDE	7.06	0.002	0.014	0.001
CHLORINE	22.05	0.416	9.180	0.722
CHLOROFORM	2.57	0.001	0.002	0.000
CO	4.47	1.007	4.502	0.354
CO2	NA	218.992	0.000	0.000
CUMENE	1.35	0.019	0.026	0.002
CYCLOPARAFFINS, C-7	NA	0.009	0.000	0.000
CYCLOPARAFFINS, C-8	NA	0.003	0.000	0.000
DICHLORODIFLUOROMETHANE (CFC	0	0.000	0.000	0.000
ETHANE	NA	0.035	0.000	0.000
ETHYL BENZENE	3.19	0.002	0.005	0.000
ETHYLENE	0	0.002	0.000	0.000
ETHYLENE CHLORIDE	0	0.002	0.000	0.000
ETHYLENE DICHLORIDE	7.32	0.006	0.041	0.003
FLUORINE	14.64	0.020	0.296	0.023
FORMALDEHYDE	15.6	0.015	0.238	0.019
HEAVY AROMATIC	NA	0.142	0.000	0.000
HEPTANE (n-)	0	0.063	0.000	0.000
HEXYL ACETATE	NA	0.035	0.000	0.000
HEXAMETHYLENE DIISOCYANTE	10		0.000	0.000
HEXANE (n-)	0	0.049	0.000	0.000
HYDROCHLORIC ACID	14.82	0.001	0.014	0.001
HYDROGEN CYANIDE	30	0.005	0.146	0.011
ISOBUTYRALDEHYDE	1.86	0.257	0.478	0.038
ISOPROPYL ALCOHOL	0	0.000	0.000	0.000
LEAD	NA	0.001	0.000	0.000
METHANE	NA	0.201	0.000	0.000
METHANOL	0	0.000	0.000	0.000

METHYL ETHYL KETONE	1.4	0.040	0.055	0.004
METHYL ISOAMYL KETONE	4	0.288	1.151	0.090
METHYL ISOBUTYL KETONE	2.33	0.014	0.033	0.003
METHYL PROPYL KETONE	NA	0.000	0.000	0.000
NAPTHA, NM&P	NA	0.034	0.000	0.000
NAPHTHALENE	26.45		0.000	0.000
NOX	NA	4.418	0.000	0.000
NITRIC ACID	26.4	0.000	0.000	0.000
NITROETHANE	NA	0.000	0.000	0.000
NITROPROPANE	14.4	0.000	0.000	0.000
OCTANE (n-)	0	0.042	0.000	0.000
ORGANIC ACIDS	NA	0.018	0.000	0.000
PENTANE (n-)	13.34	0.030	0.404	0.032
PHENOL	22.33	0.016	0.349	0.027
PHOSGENE	12.5		0.000	0.000
PHOSPHORIC ACID	30		0.000	0.000
PM	NA	4.425	0.000	0.000
PM-10	NA	0.292	0.000	0.000
PROPANE	NA	0.054	0.000	0.000
PROPYL ACETATE	NA	0.000	0.000	0.000
TOLUENE	2.04	0.098	0.201	0.016
TRICHLOROEHTANE (METHYL CHLO	5.6	0.002	0.009	0.001
VINYL CHLORIDE	18.52	0.001	0.019	0.002
VOC	NA	10.892	0.000	0.000
XYLENE	2.1	0.032	0.067	0.005

NA = Not Available

TERRESTRIAL TOXICITY IMPACT CALCULATIONS

CHEMICAL NAME	TERRESTRIAL TOXICITY Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Terr. Tox. Factored Score			2.757	2.565
Normalizing Score			1.075	
ACETALDEHYDE	3.255	0.066	0.216	0.200
ACETONE	1.860	0.006	0.011	0.011
ACETONITRILE	0.610	0.000	0.000	0.000
ALUMINUM	0.000	0.000	0.000	0.000
AMMONIA	9.030	0.000	0.000	0.000
ARSENIC	31.730	0.000	0.001	0.001
BENZENE	0.000	0.154	0.000	0.000
BUTYL ACETATE (n-)	0.000	0.079	0.000	0.000
BUTYL ALCOHOL	6.180	0.018	0.110	0.103
BUTYL CELLOSOLVE	7.590	0.000	0.000	0.000
BUTYLENE OXIDE, 1,2-	1.610	0.000	0.000	0.000
CADMIUM	21.030	0.004	0.076	0.070
CARBON TETRACHLORIDE	1.710	0.002	0.003	0.003
CHLORINE	0.000	0.445	0.000	0.000
CHLOROFORM	6.160	0.001	0.006	0.006
CHROMIUM, TRIVALENT	19.290	0.000	0.008	0.007
COBALT COMPOUNDS	20.960		0.000	0.000
COPPER COMPOUNDS	12.000	0.000	0.000	0.000
CUMENE	2.710	0.019	0.052	0.049
DICHLORODIFLUOROMETHANE	1.330	0.000	0.000	0.000
DIETHYLAMINETRIAMINE	5.270		0.000	0.000
ETHYL BENZENE	0.000	0.002	0.000	0.000
ETHYLENE	0.000	0.002	0.000	0.000
ETHYLENE DICHLORIDE	4.890		0.000	0.000
FGD SOLIDS	0.000	0.000	0.000	0.000
FLY ASH	0.000	0.000	0.000	0.000
FORMALDEHYDE	12.600	0.015	0.192	0.179
HEPTANE (n-)	9.500	0.063	0.594	0.552
HEXANE (n-)	0.000	0.049	0.000	0.000
HEXYL ACETATE	0.000	0.035	0.000	0.000
HEXAMETYHYLENE DIISOCYANTE	2.640		0.000	0.000
HYDROCHLORIC ACID	5.740	0.001	0.005	0.005
HYDROGEN CYANIDE	30.000	0.005	0.146	0.136
IRON	0.000	0.000	0.000	0.000
ISOBUTYRALDEHYDE	1.860	0.257	0.478	0.445
ISOPROPYL ALCOHOL	0.950	0.000	0.000	0.000
KEROSENE	0.000	0.000	0.000	0.000
LEAD	5.750	0.002	0.011	0.010
METHYL ETHYL KETONE	1.860	0.040	0.074	0.069
METHYL ISOAMYL KETONE	2.050	0.288	0.590	0.549
METHYL ISOBUTYL KETONE	2.790	0.014	0.040	0.037

METHYL PROPYL KETONE	4.570	0.000	0.000	0.000
NAPHTHALENE	3.170		0.000	0.000
NITRIC ACID	10.200	0.000	0.000	0.000
NITROPROPANE, 2-	8.400		0.000	0.000
PHENOL	7.600	0.016	0.119	0.110
PHOSPHORIC ACID	5.400		0.000	0.000
PROPYL ACETATE	0.870	0.000	0.000	0.000
PLUTONIUM (FISSILE & NONFISSILE)	0.000	0.000	0.000	0.000
SLAG	0.000	0.000	0.000	0.000
SULFURIC ACID	3.600	0.000	0.000	0.000
TOLUENE	0.000	0.098	0.000	0.000
TRICHLOROETHANE (METHYL CHLOR	0.000	0.002	0.000	0.000
URANIUM (235, 236, 238)	NA	0.000	0.000	0.000
VINYL CHLORIDE	7.870	0.001	0.008	0.008
XYLENE	0.520	0.032	0.017	0.016
ZINC	0.000	0.000	0.000	0.000

NA = Not Available

AQUATIC TOXICITY IMPACT CALCULATIONS

CHEMICAL NAME	AQUATIC TOXICITY Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Aquatic Tox. Factored Score			0.815	0.925
Normalizing Score			0.881	
ACETONITRILE	0.000		0.000	0.000
AMMONIA	21.850		0.000	0.000
ALUMINUM	0.000	0.000	0.000	0.000
ARSENIC	18.750	0.000	0.000	0.000
BENZENE	14.070	0.001	0.007	0.008
BORON	0.000	0.011	0.000	0.000
BUTYL ALCOHOL	0.000	0.018	0.000	0.000
BUTYLENE OXIDE, 1,2-	NA		0.000	0.000
CADMIUM	36.250	0.004	0.130	0.148
CARBON TETRACHLORIDE	1.200		0.000	0.000
CHLORIDE	NA	8.296	0.000	0.000
CHLORINE	22.500	0.028	0.636	0.722
CHLOROFORM	9.750		0.000	0.000
CHROMIUM, TRIVALENT	16.630	0.000	0.007	0.008
COBALT COMPOUNDS	31.750		0.000	0.000
COPPER COMPOUNDS	30.000	0.000	0.001	0.001
DICHLORODIFLUOROMETHANE (CFC-1	NA		0.000	0.000
HYDROCHLORIC ACID	13.860		0.000	0.000
IRON	25.000	0.000	0.000	0.000
LEAD	25.000	0.001	0.032	0.036
MERCURY	37.500	0.000	0.000	0.000
METHYL ISOAMYL KETONE	10.200		0.000	0.000
NAPHTHALENE	19.570		0.000	0.000
NITRIC ACID	15.600		0.000	0.000
NITROPROPANE, 2-	23.400		0.000	0.000
OIL & GREASE	NA	0.259	0.000	0.000
ORGANIC ACIDS	NA		0.000	0.000
PETROLEUM (CRUDE OIL)	NA	0.000	0.000	0.000
PHENOL	11.400	0.000	0.000	0.000
PHOSPHORIC ACID	11.400		0.000	0.000
SODIUM	NA	10.508	0.000	0.000
SULFIDE	NA	0.000	0.000	0.000
SULFURIC ACID	15.000	0.000	0.000	0.000
XYLENE	16.240		0.000	0.000
ZINC	20.300	0.000	0.001	0.001

NA = Not Available

LAND USE IMPACT CALCULATIONS

CHEMICAL NAME	LAND USE Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Land Use Score			239.296	1.493
Normalizing Score			161.615	
BOTTOM ASH	2.000	0.000	0 000	0.000
FGD SOLIDS	2.000	0.000	0.000	0.000
FLY ASH	2.000	0.000	0.000	0.000
HAZARDOUS WASTE	2.000	80.163	160.327	1.000
PLUTONIUM (FISSILE & NONFISSILE)	NA	0.000	0.000	0.000
SLAG	2.000	0.000	0.000	0.000
SOLID WASTE	1.500	52.646	78.970	0.493
URANIUM (235, 236, 238)	NA	0.000	0.000	0.000

NA = Not Available

ALTERNATIVE PRIMER AND GUN

LIFE CYCLE IMPACT VALUATION CALCULATIONS

Scale	Issues ------->		AHP Weighting Factor	Normalized Factored Score	Weighted Normalized Factored Score			Baseline Score
CARCOPT								0.511
GLOBAL							0.148	
	ODP		0.17983	0.265		0.048		
	GLBLWRM		0.11328	0.677		0.077		
	FSLFUELS		0.02855	0.827		0.024		
REGIONAL							0.162	
	ACIDDEP		0.06253	1.098		0.069		
	SMOG		0.13007	0.721		0.094		
	WTRUSE		0.01002			0.000		
LOCAL							0.201	
	TOXICITY					0.164		
		HUMAN	0.06155	1.172	0.072			
		ENVTERR	0.02052	1.906	0.039			
		ENVAQ	0.02052	2.554	0.052			
	LANDUSE		0.02507	1.497		0.038		

BCAPBTAG.WK4

OZONE DEPLETION POTENTIAL IMPACT CALCULATIONS

CHEMICAL NAME	ODP Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total ODP Score			0.001	0.265
Normalizing Factor			0.003	
CARBON TETRACHLORIDE	1.080	0.000	0.000	0.000
DICHLORODIFLUOROMETHANE	1.000	0.001	0.001	0.265
TRICHLOROETHANE (METHYL CHLOROFORM	0.120	0.000	0.000	0.000

GLOBAL WARMING POTENTIAL IMPACT CALCULATIONS

CHEMICAL NAME	GWP Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total GWP Score			203.264	0.677
Normalizing Score			300.337	
CARBON TETRACHLORIDE	1300	0.000	0.000	0.000
CO2	1	197.618	197.618	0.658
DICHLORODIFLUOROMETHANE	7100	0.001	5.646	0.019
TRICHLOROETHANE	100	0.000	0.000	0.000

BCAPBTAG.WK4

RESOURCE DEPLETION IMPACT CALCULATIONS

CHEMICAL NAME	RESOURCE DEPLETION Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Resource Depetion Score			9,105.511	0.827
Normalizing Score			11,010.628	
BAUXITE	4	83.964	335.857	0.031
CHROME OXIDE	2	3.288	6.575	0.001
COAL	3	0.000	0.000	0.000
COBALT OXIDE	3	0.724	2.173	0.000
IRON ORE	3	0.968	2.905	0.000
LIMESTONE	1	4.653	4.653	0.000
MAGNESIUM ORE	1	1.624	1.624	0.000
NATURAL GAS	4	390.599	1,562.395	0.142
PETROLEUM (CRUDE OIL)	4	1,778.953	7,115.812	0.646
PHOSPHATE ROCK	3	0.000	0.000	0.000
SALT (SODIUM CHLORIDE)	1	31.384	31.384	0.003
SILICA	1	9.658	9.658	0.001
SODA ASH	1	2.624	2.624	0.000
THALLIUM	4		0.000	0.000
TITANIUM	3	9.950	29.851	0.003
URANIUM (235, 236, 238)	3	0.000	0.000	0.000
WATER INPUT	NA	29,269.170	0.000	0.000
ZINC	4	0.000	0.000	0.000

NA = Not Available

ACIDIFICATION POTENTIAL IMPACT CALCULATIONS

CHEMICAL NAME	Acid. Pot. Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Acid. Pot. Score			23.696	1.098
Normalizing Score			21.584	
AMMONIA	1.880	0.001	0.001	0.000
HYDROCHLORIC ACID	0.880	0.001	0.001	0.000
NOX	0.700	4.258	2.981	0.138
SOX	1.000	20.713	20.713	0.960

PHOTOCHEMICAL OXIDANT POTENTIAL IMPACT CALCULATIONS

CHEMICAL NAME	POCP Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total POCP Score			4.294	0.721
Normalizing Factor			5.959	
ACETALDEHYDE	0.527	0.031	0.017	0.003
ACETONE	0.178	0.005	0.001	0.000
ALDEHYDES	0.443	0.012	0.006	0.001
AROMATIC HYDROCARBONS (C8-C10)	0.761	0.020	0.015	0.003
BENZENE	0.189	0.151	0.029	0.005
BUTANE (n-)	0.410	0.038	0.016	0.003
BUTANE (iso-)	0.315	0.002	0.001	0.000
BUTYL ACETATE (n-)	0.323	0.000	0.000	0.000
BUTYL ALCOHOL	0.196	0.022	0.004	0.001
CHLOROFORM	0.021	0.000	0.000	0.000
ETHANE	0.082	0.031	0.003	0.000
ETHYL BENZENE	0.593	0.003	0.002	0.000
ETHYLENE	1.000	0.000	0.000	0.000
HEPTANE (n-)	0.529	0.055	0.029	0.005
HEXANE (n-)	0.421	0.043	0.018	0.003
METHANE	0.007	0.178	0.001	0.000
METHANOL	0.123	0.000	0.000	0.000
METHYL ETHYL KETONE	0.473	0.016	0.008	0.001
METHYL ISOAMYL KETONE	0.326	0.051	0.017	0.003
METHYL ISOBUTYL KETONE	0.326	0.000	0.000	0.000
METHYL PROPYL KETONE	0.326	0.000	0.000	0.000
OCTANE (n-)	0.493	0.037	0.018	0.003
PENTANE (n-)	0.408	0.027	0.011	0.002
PROPANE	0.420	0.048	0.020	0.003
PROPYL ACETATE	0.218	0.000	0.000	0.000
PROPYLENE	1.030	0.000	0.000	0.000
TOLUENE	0.563	0.088	0.050	0.008
TRICHLOROETHANE	0.021	0.000	0.000	0.000
VOC	0.397	10.085	4.004	0.672
XYLENE	0.849	0.031	0.026	0.004

HUMAN HEALTH INHALATION TOXICITY IMPACT CALCULATIONS

CHEMICAL NAME	HH INHALATION TOXICITY Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total HH Inh. Tox. Factored Score			14.900	1.172
Normalizing Score			12.715	
ACETALDEHYDE	7.44	0.031	0.234	0.018
ACETONE	0	0.005	0.000	0.000
ACETONITRILE	0	0.000	0.000	0.000
AMMONIA	5.7	0.001	0.004	0.000
ALDEHYDES	NA	0.012	0.000	0.000
ALUMINUM	15.6	0.000	0.000	0.000
AROMATIC HYDROCARBONS (C8-C10)	NA	0.020	0.000	0.000
BENZENE	NA	0.151	0.000	0.000
BUTANE (n-)	17.5	0.038	0.667	0.052
BUTANE (iso-)	NA	0.002	0.000	0.000
BUTYL ACETATE (n-)	8.49	0.000	0.000	0.000
BUTANOL	0.95	0.022	0.021	0.002
BUTYL CELLOSOLVE	12.29	0.000	0.000	0.000
BUTYLENE OXIDE, 1,2-	NA	0.000	0.000	0.000
CADMIUM	2.25		0.000	0.000
CARBON TETRACHLORIDE	7.06	0.000	0.000	0.000
CHLORINE	22.05	0.423	9.324	0.733
CHLOROFORM	2.57	0.000	0.000	0.000
CO	4.47	0.579	2.586	0.203
CO2	NA	197.618	0.000	0.000
CUMENE	1.35	0.016	0.022	0.002
CYCLOPARAFFINS, C-7	NA	0.008	0.000	0.000
CYCLOPARAFFINS, C-8	NA	0.003	0.000	0.000
DICHLORODIFLUORMETHANE (CFC-	0	0.001	0.000	0.000
ETHANE	NA	0.031	0.000	0.000
ETHYL BENZENE	3.19	0.003	0.010	0.001
ETHYLENE	0	0.000	0.000	0.000
ETHYLENE CHLORIDE	0	0.000	0.000	0.000
ETHYLENE DICHLORIDE	7.32	0.000	0.000	0.000
FLUORINE	14.64	0.000	0.000	0.000
FORMALDEHYDE	15.6	0.014	0.215	0.017
HEAVY AROMATIC	NA	0.142	0.000	0.000
HEPTANE (n-)	0	0.055	0.000	0.000
HEXYL ACETATE	NA	0.000	0.000	0.000
HEXAMETHYLENE DIISOCYANTE	10		0.000	0.000
HEXANE (n-)	0	0.043	0.000	0.000
HYDROCHLORIC ACID	14.82	0.001	0.021	0.002
HYDROGEN CYANIDE	30	0.005	0.147	0.012
ISOBUTYRALDEHYDE	1.86	0.257	0.478	0.038
ISOPROPYL ALCOHOL	0	0.000	0.000	0.000
LEAD	NA	0.000	0.000	0.000
METHANE	NA	0.178	0.000	0.000
METHANOL	0	0.000	0.000	0.000

METHYL ETHYL KETONE	1.4	0.016	0.022	0.002
METHYL ISOAMYL KETONE	4	0.051	0.205	0.016
METHYL ISOBUTYL KETONE	2.33	0.000	0.000	0.000
METHYL PROPYL KETONE	NA	0.000	0.000	0.000
NAPTHA, NM&P	NA	0.000	0.000	0.000
NAPHTHALENE	26.45		0.000	0.000
NOX	NA	4.258	0.000	0.000
NITRIC ACID	26.4	0.000	0.000	0.000
NITROETHANE	NA	0.002	0.000	0.000
NITROPROPANE	14.4	0.000	0.006	0.000
OCTANE (n-)	0	0.037	0.000	0.000
ORGANIC ACIDS	NA	0.016	0.000	0.000
PENTANE (n-)	13.34	0.027	0.358	0.028
PHENOL	22.33	0.015	0.333	0.026
PHOSGENE	12.5		0.000	0.000
PHOSPHORIC ACID	30		0.000	0.000
PM	NA	4.390	0.000	0.000
PM-10	NA	0.292	0.000	0.000
PROPANE	NA	0.048	0.000	0.000
PROPYL ACETATE	NA	0.000	0.000	0.000
TOLUENE	2.04	0.088	0.180	0.014
TRICHLOROEHTANE (METHYL CHLO	5.6	0.000	0.000	0.000
VINYL CHLORIDE	18.52	0.000	0.000	0.000
VOC	NA	10.085	0.000	0.000
XYLENE	2.1	0.031	0.065	0.005

NA = Not Available

TERRESTRIAL TOXICITY IMPACT CALCULATIONS

CHEMICAL NAME	TERRESTRIAL TOXICITY Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Terr. Tox. Factored Score			2.049	1.906
Normalizing Score			1.075	
ACETALDEHYDE	3.255	0.031	0.103	0.095
ACETONE	1.860	0.005	0.010	0.009
ACETONITRILE	0.610	0.003	0.002	0.002
ALUMINUM	0.000	0.001	0.000	0.000
AMMONIA	9.030	0.001	0.006	0.005
ARSENIC	31.730	0.000	0.001	0.001
BENZENE	0.000	0.152	0.000	0.000
BUTYL ACETATE (n-)	0.000	0.000	0.000	0.000
BUTYL ALCOHOL	6.180	0.022	0.134	0.125
BUTYL CELLOSOLVE	7.590	0.000	0.000	0.000
BUTYLENE OXIDE, 1,2-	1.610	0.000	0.000	0.000
CADMIUM	21.030	0.006	0.121	0.112
CARBON TETRACHLORIDE	1.710	0.000	0.000	0.000
CHLORINE	0.000	0.510	0.000	0.000
CHLOROFORM	6.160	0.000	0.000	0.000
CHROMIUM, TRIVALENT	19.290	0.001	0.012	0.012
COBALT COMPOUNDS	20.960		0.000	0.000
COPPER COMPOUNDS	12.000	0.000	0.001	0.001
CUMENE	2.710	0.016	0.044	0.041
DICHLORODIFLUORMETHANE	1.330	0.001	0.001	0.001
DIETHYLAMINETRIAMINE	5.270		0.000	0.000
ETHYL BENZENE	0.000	0.003	0.000	0.000
ETHYLENE	0.000	0.000	0.000	0.000
ETHYLENE DICHLORIDE	4.890		0.000	0.000
FGD SOLIDS	0.000	0.000	0.000	0.000
FLY ASH	0.000	0.000	0.000	0.000
FORMALDEHYDE	12.600	0.014	0.174	0.162
HEPTANE (n-)	9.500	0.055	0.526	0.490
HEXANE (n-)	0.000	0.043	0.000	0.000
HEXYL ACETATE	0.000	0.000	0.000	0.000
HEXAMETYHYLENE DIISOCYANTE	2.640		0.000	0.000
HYDROCHLORIC ACID	5.740	0.001	0.008	0.007
HYDROGEN CYANIDE	30.000	0.005	0.147	0.137
IRON	0.000	0.000	0.000	0.000
ISOBUTYRALDEHYDE	1.860	0.257	0.478	0.445
ISOPROPYL ALCOHOL	0.950	0.000	0.000	0.000
KEROSENE	0.000	0.000	0.000	0.000
LEAD	5.750	0.002	0.012	0.011
METHYL ETHYL KETONE	1.860	0.016	0.030	0.028
METHYL ISOAMYL KETONE	2.050	0.051	0.105	0.098
METHYL ISOBUTYL KETONE	2.790	0.000	0.000	0.000

METHYL PROPYL KETONE	4.570	0.000	0.000	0.000
NAPHTHALENE	3.170		0.000	0.000
NITRIC ACID	10.200	0.000	0.005	0.004
NITROPROPANE, 2-	8.400		0.000	0.000
PHENOL	7.600	0.015	0.113	0.105
PHOSPHORIC ACID	5.400		0.000	0.000
PROPYL ACETATE	0.870	0.000	0.000	0.000
PLUTONIUM (FISSILE & NONFISSILE)	0.000	0.000	0.000	0.000
SLAG	0.000	0.000	0.000	0.000
SULFURIC ACID	3.600	0.000	0.000	0.000
TOLUENE	0.000	0.088	0.000	0.000
TRICHLOROETHANE (METHYL CHLOR	0.000	0.000	0.000	0.000
URANIUM (235, 236, 238)	NA	0.000	0.000	0.000
VINYL CHLORIDE	7.870	0.000	0.000	0.000
XYLENE	0.520	0.031	0.016	0.015
ZINC	0.000	0.000	0.000	0.000

NA = Not Available

AQUATIC TOXICITY IMPACT CALCULATIONS

CHEMICAL NAME	AQUATIC TOXICITY Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Aquatic Tox. Factored Score			2.250	2.554
Normalizing Score			0.881	
ACETONITRILE	0.000		0.000	0.000
AMMONIA	21.850		0.000	0.000
ALUMINUM	0.000	0.001	0.000	0.000
ARSENIC	18.750	0.000	0.000	0.000
BENZENE	14.070	0.000	0.006	0.007
BORON	0.000	0.010	0.000	0.000
BUTYL ALCOHOL	0.000	0.022	0.000	0.000
BUTYLENE OXIDE, 1,2-	NA		0.000	0.000
CADMIUM	36.250	0.006	0.208	0.237
CARBON TETRACHLORIDE	1.200		0.000	0.000
CHLORIDE	NA	7.351	0.000	0.000
CHLORINE	22.500	0.087	1.969	2.235
CHLOROFORM	9.750		0.000	0.000
CHROMIUM, TRIVALENT	16.630	0.001	0.011	0.012
COBALT COMPOUNDS	31.750		0.000	0.000
COPPER COMPOUNDS	30.000	0.000	0.001	0.002
DICHLORODIFLUOROMETHANE (CFC-1	NA		0.000	0.000
HYDROCHLORIC ACID	13.860		0.000	0.000
IRON	25.000	0.000	0.000	0.000
LEAD	25.000	0.002	0.052	0.060
MERCURY	37.500	0.000	0.000	0.000
METHYL ISOAMYL KETONE	10.200		0.000	0.000
NAPHTHALENE	19.570		0.000	0.000
NITRIC ACID	15.600		0.000	0.000
NITROPROPANE, 2-	23.400		0.000	0.000
OIL & GREASE	NA	0.230	0.000	0.000
ORGANIC ACIDS	NA		0.000	0.000
PETROLEUM (CRUDE OIL)	NA	0.000	0.000	0.000
PHENOL	11.400	0.000	0.000	0.000
PHOSPHORIC ACID	11.400		0.000	0.000
SODIUM	NA	9.312	0.000	0.000
SULFIDE	NA	0.000	0.000	0.000
SULFURIC ACID	15.000	0.000	0.000	0.000
XYLENE	16.240		0.000	0.000
ZINC	20.300	0.000	0.001	0.001

NA = Not Available

LAND USE IMPACT CALCULATIONS

CHEMICAL NAME	LAND USE Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Land Use Score			237.170	1.497
Normalizing Score			161.615	
BOTTOM ASH	2.000	0.000	0.000	0.000
FGD SOLIDS	2.000	0.000	0.000	0.000
FLY ASH	2.000	0.000	0.000	0.000
HAZARDOUS WASTE	2.000	79.194	158.388	1.000
PLUTONIUM (FISSILE & NONFISSILE)	NA	0.000	0.000	0.000
SLAG	2.000	0.000	0.000	0.000
SOLID WASTE	1.500	52.521	78.782	0.497
URANIUM (235, 236, 238)	NA	0.000	0.000	0.000

NA = Not Available

ALTERNATIVE THINNER

LIFE CYCLE IMPACT VALUATION CALCULATIONS

	Scale	Issues ------->		AHP Weighting Factor	Normalized Factored Score	Weighted Normalized Factored Score			Baseline Score
CARCOPT									0.791
	GLOBAL							0.334	
		ODP		0.17983	1.106		0.199		
		GLBLWRM		0.11328	0.905		0.103		
		FSLFUELS		0.02855	1.133		0.032		
	REGIONAL							0.209	
		ACIDDEP		0.06253	1.187		0.074		
		SMOG		0.13007	1.035		0.135		
		WTRUSE		0.01002			0.000		
	LOCAL							0.249	
		TOXICITY					0.209		
			HUMAN	0.06155	1.999	0.123			
			ENVTERR	0.02052	2.923	0.060			
			ENVAQ	0.02052	1.279	0.026			
		LANDUSE		0.02507	1.577		0.040		

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OZONE DEPLETION POTENTIAL IMPACT CALCULATIONS

CHEMICAL NAME	ODP Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total ODP Score			0.003	1.090
Normalizing Factor			0.003	
CARBON TETRACHLORIDE	1.080	0.003	0.003	1.000
DICHLORODIFLUOROMETHANE	1.000	0.000	0.000	0.000
TRICHLOROETHANE (METHYL CHLOROFORM	0.120	0.002	0.000	0.090

BCBPATBG.WK4

GLOBAL WARMING POTENTIAL IMPACT CALCULATIONS

CHEMICAL NAME	GWP Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total GWP Score			271.890	0.905
Normalizing Score			300.337	
CARBON TETRACHLORIDE	1300	0.003	3.663	0.012
CO2	1	267.997	267.997	0.892
DICHLORODIFLUOROMETHANE	7100	0.000	0.000	0.000
TRICHLOROETHANE	100	0.002	0.229	0.001

RESOURCE DEPLETION IMPACT CALCULATIONS

CHEMICAL NAME	RESOURCE DEPLETION Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Resource Depetion Score			12,479.242	1.133
Normalizing Score			11,010.628	
BAUXITE	4	83.964	335.857	0.031
CHROME OXIDE	2	4.553	9.107	0.001
COAL	3	0.292	0.875	0.000
COBALT OXIDE	3	1.003	3.010	0.000
IRON ORE	3	1.282	3.845	0.000
LIMESTONE	1	4.653	4.653	0.000
MAGNESIUM ORE	1	2.249	2.249	0.000
NATURAL GAS	4	549.204	2,196.817	0.200
PETROLEUM (CRUDE OIL)	4	2,449.640	9,798.561	0.890
PHOSPHATE ROCK	3	2.092	6.276	0.001
SALT (SODIUM CHLORIDE)	1	43.084	43.084	0.004
SILICA	1	13.657	13.657	0.001
SODA ASH	1	2.624	2.624	0.000
THALLIUM	4		0.000	0.000
TITANIUM	3	8.412	25.235	0.002
URANIUM (235, 236, 238)	3	0.000	0.000	0.000
WATER INPUT	NA	40,071.312	0.000	0.000
ZINC	4	8.347	33.390	0.003

NA = Not Available

ACIDIFICATION POTENTIAL IMPACT CALCULATIONS

CHEMICAL NAME	Acid. Pot. Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Acid. Pot. Score			25.615	1.187
Normalizing Score			21.584	
AMMONIA	1.880	0.000	0.000	0.000
HYDROCHLORIC ACID	0.880	0.001	0.001	0.000
NOX	0.700	5.879	4.115	0.191
SOX	1.000	21.498	21.498	0.996

PHOTOCHEMICAL OXIDANT POTENTIAL IMPACT CALCULATIONS

CHEMICAL NAME	POCP Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total POCP Score			6.168	1.035
Normalizing Factor			5.959	
ACETALDEHYDE	0.527	0.054	0.029	0.005
ACETONE	0.178	0.007	0.001	0.000
ALDEHYDES	0.443	0.017	0.008	0.001
AROMATIC HYDROCARBONS (C8-C10)	0.761	0.023	0.017	0.003
BENZENE	0.189	0.110	0.021	0.003
BUTANE (n-)	0.410	0.053	0.022	0.004
BUTANE (iso-)	0.315	0.003	0.001	0.000
BUTYL ACETATE (n-)	0.323	0.139	0.045	0.008
BUTYL ALCOHOL	0.196	0.036	0.007	0.001
CHLOROFORM	0.021	0.001	0.000	0.000
ETHANE	0.082	0.042	0.003	0.001
ETHYL BENZENE	0.593	0.002	0.001	0.000
ETHYLENE	1.000	0.003	0.003	0.000
HEPTANE (n-)	0.529	0.076	0.040	0.007
HEXANE (n-)	0.421	0.059	0.025	0.004
METHANE	0.007	0.246	0.002	0.000
METHANOL	0.123	0.000	0.000	0.000
METHYL ETHYL KETONE	0.473	0.002	0.001	0.000
METHYL ISOAMYL KETONE	0.326	0.524	0.171	0.029
METHYL ISOBUTYL KETONE	0.326	0.023	0.008	0.001
METHYL PROPYL KETONE	0.326	0.000	0.000	0.000
OCTANE (n-)	0.493	0.051	0.025	0.004
PENTANE (n-)	0.408	0.037	0.015	0.003
PROPANE	0.420	0.066	0.028	0.005
PROPYL ACETATE	0.218	0.000	0.000	0.000
PROPYLENE	1.030	0.001	0.001	0.000
TOLUENE	0.563	0.024	0.014	0.002
TRICHLOROETHANE	0.021	0.002	0.000	0.000
VOC	0.397	14.210	5.641	0.947
XYLENE	0.849	0.047	0.040	0.007

HUMAN HEALTH INHALATION TOXICITY IMPACT CALCULATIONS

CHEMICAL NAME	HH INHALATION TOXICITY Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total HH Inh. Tox. Factored Score			25.416	1.999
Normalizing Score			12.715	
ACETALDEHYDE	7.44	0.054	0.404	0.032
ACETONE	0	0.007	0.000	0.000
ACETONITRILE	0	0.000	0.000	0.000
AMMONIA	5.7	0.000	0.000	0.000
ALDEHYDES	NA	0.017	0.000	0.000
ALUMINUM	15.6	0.003	0.041	0.003
AROMATIC HYDROCARBONS (C8-C10)	NA	0.023	0.000	0.000
BENZENE	NA	0.110	0.000	0.000
BUTANE (n-)	17.5	0.053	0.919	0.072
BUTANE (iso-)	NA	0.003	0.000	0.000
BUTYL ACETATE (n-)	8.49	0.139	1.177	0.093
BUTANOL	0.95	0.036	0.034	0.003
BUTYL CELLOSOLVE	12.29	0.000	0.000	0.000
BUTYLENE OXIDE, 1,2-	NA	0.000	0.000	0.000
CADMIUM	2.25		0.000	0.000
CARBON TETRACHLORIDE	7.06	0.003	0.020	0.002
CHLORINE	22.05	0.577	12.715	1.000
CHLOROFORM	2.57	0.001	0.003	0.000
CO	4.47	1.289	5.763	0.453
CO2	NA	267.997	0.000	0.000
CUMENE	1.35	0.027	0.036	0.003
CYCLOPARAFFINS, C-7	NA	0.011	0.000	0.000
CYCLOPARAFFINS, C-8	NA	0.004	0.000	0.000
DICHLORODIFLUOROMETHANE (CFC	0	0.000	0.000	0.000
ETHANE	NA	0.042	0.000	0.000
ETHYL BENZENE	3.19	0.002	0.007	0.001
ETHYLENE	0	0.003	0.000	0.000
ETHYLENE CHLORIDE	0	0.003	0.000	0.000
ETHYLENE DICHLORIDE	7.32	0.008	0.057	0.004
FLUORINE	14.64	0.028	0.410	0.032
FORMALDEHYDE	15.6	0.019	0.291	0.023
HEAVY AROMATIC	NA	0.197	0.000	0.000
HEPTANE (n-)	0	0.076	0.000	0.000
HEXYL ACETATE	NA	0.000	0.000	0.000
HEXAMETHYLENE DIISOCYANTE	10		0.000	0.000
HEXANE (n-)	0	0.059	0.000	0.000
HYDROCHLORIC ACID	14.82	0.001	0.020	0.002
HYDROGEN CYANIDE	30	0.007	0.202	0.016
ISOBUTYRALDEHYDE	1.86	0.000	0.000	0.000
ISOPROPYL ALCOHOL	0	0.002	0.000	0.000
LEAD	NA	0.001	0.000	0.000
METHANE	NA	0.246	0.000	0.000
METHANOL	0	0.000	0.000	0.000

METHYL ETHYL KETONE	1.4	0.002	0.003	0.000
METHYL ISOAMYL KETONE	4	0.524	2.098	0 165
METHYL ISOBUTYL KETONE	2.33	0.023	0.054	0.004
METHYL PROPYL KETONE	NA	0.000	0.000	0.000
NAPTHA, NM&P	NA	0.066	0.000	0.000
NAPHTHALENE	26.45		0.000	0.000
NOX	NA	5.879	0.000	0.000
NITRIC ACID	26.4	0.000	0.000	0.000
NITROETHANE	NA	0.000	0.000	0.000
NITROPROPANE	14.4	0.000	0.000	0.000
OCTANE (n-)	0	0.051	0.000	0.000
ORGANIC ACIDS	NA	0.022	0.000	0.000
PENTANE (n-)	13.34	0.037	0.493	0.039
PHENOL	22.33	0.022	0.483	0.038
PHOSGENE	12.5		0.000	0.000
PHOSPHORIC ACID	30		0.000	0.000
PM	NA	5.948	0.000	0.000
PM-10	NA	0.310	0.000	0.000
PROPANE	NA	0.066	0.000	0.000
PROPYL ACETATE	NA	0.000	0.000	0.000
TOLUENE	2.04	0.024	0.049	0.004
TRICHLOROEHTANE (METHYL CHLO	5.6	0.002	0.013	0.001
VINYL CHLORIDE	18.52	0.001	0.026	0.002
VOC	NA	14.210	0.000	0.000
XYLENE	2.1	0.047	0.098	0.008

NA = Not Available

TERRESTRIAL TOXICITY IMPACT CALCULATIONS

CHEMICAL NAME	TERRESTRIAL TOXICITY Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Terr. Tox. Factored Score			3.142	2.923
Normalizing Score			1.075	
ACETALDEHYDE	3.255	0.054	0.177	0.164
ACETONE	1.860	0.007	0.014	0.013
ACETONITRILE	0.610	0.000	0.000	0.000
ALUMINUM	0.000	0.001	0.000	0.000
AMMONIA	9.030	0.000	0.000	0.000
ARSENIC	31.730	0.000	0.001	0.001
BENZENE	0.000	0.111	0.000	0.000
BUTYL ACETATE (n-)	0.000	0.139	0.000	0.000
BUTYL ALCOHOL	6.180	0.036	0.220	0.205
BUTYL CELLOSOLVE	7.590	0.000	0.000	0.000
BUTYLENE OXIDE, 1,2-	1.610	0.000	0.000	0.000
CADMIUM	21.030	0.005	0.104	0.097
CARBON TETRACHLORIDE	1.710	0.003	0.005	0.004
CHLORINE	0.000	0.616	0.000	0.000
CHLOROFORM	6.160	0.001	0.008	0.008
CHROMIUM, TRIVALENT	19.290	0.001	0.011	0.010
COBALT COMPOUNDS	20.960		0.000	0.000
COPPER COMPOUNDS	12.000	0.000	0.000	0.000
CUMENE	2.710	0.027	0.073	0.068
DICHLORODIFLUOROMETHANE	1.330	0.000	0.000	0.000
DIETHYLAMINETRIAMINE	5.270		0.000	0.000
ETHYL BENZENE	0.000	0.002	0.000	0.000
ETHYLENE	0.000	0.003	0.000	0.000
ETHYLENE DICHLORIDE	4.890		0.000	0.000
FGD SOLIDS	0.000	0.000	0.000	0.000
FLY ASH	0.000	0.000	0.000	0.000
FORMALDEHYDE	12.600	0.019	0.235	0.218
HEPTANE (n-)	9.500	0.076	0.725	0.674
HEXANE (n-)	0.000	0.059	0.000	0.000
HEXYL ACETATE	0.000	0.000	0.000	0.000
HEXAMETYHYLENE DIISOCYANTE	2.640		0.000	0.000
HYDROCHLORIC ACID	5.740	0.001	0.008	0.007
HYDROGEN CYANIDE	30.000	0.007	0.202	0.188
IRON	0.000	0.000	0.000	0.000
ISOBUTYRALDEHYDE	1.860	0.000	0.000	0.000
ISOPROPYL ALCOHOL	0.950	0.002	0.002	0.002
KEROSENE	0.000	0.000	0.000	0.000
LEAD	5.750	0.003	0.015	0.014
METHYL ETHYL KETONE	1.860	0.002	0.004	0.004
METHYL ISOAMYL KETONE	2.050	0.524	1.075	1.000
METHYL ISOBUTYL KETONE	2.790	0.023	0.065	0.060

METHYL PROPYL KETONE	4.570	0.000	0.000	0.000
NAPHTHALENE	3.170		0.000	0.000
NITRIC ACID	10.200	0.000	0.000	0.000
NITROPROPANE, 2-	8.400		0.000	0.000
PHENOL	7.600	0.022	0.164	0.153
PHOSPHORIC ACID	5.400		0.000	0.000
PROPYL ACETATE	0.870	0.000	0.000	0.000
PLUTONIUM (FISSILE & NONFISSILE)	0.000	0.000	0.000	0.000
SLAG	0.000	0.000	0.000	0.000
SULFURIC ACID	3.600	0.000	0.000	0.000
TOLUENE	0.000	0.024	0.000	0.000
TRICHLOROETHANE (METHYL CHLOR	0.000	0.002	0.000	0.000
URANIUM (235, 236, 238)	NA	0.000	0.000	0.000
VINYL CHLORIDE	7.870	0.001	0.011	0.010
XYLENE	0.520	0.047	0.024	0.023
ZINC	0.000	0.000	0.000	0.000

NA = Not Available

AQUATIC TOXICITY IMPACT CALCULATIONS

CHEMICAL NAME	AQUATIC TOXICITY Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Aquatic Tox. Factored Score			1.127	1.279
Normalizing Score			0.881	
ACETONITRILE	0.000		0.000	0.000
AMMONIA	21.850		0.000	0.000
ALUMINUM	0.000	0.001	0.000	0.000
ARSENIC	18.750	0.000	0.000	0.001
BENZENE	14.070	0.001	0.009	0.010
BORON	0.000	0.013	0.000	0.000
BUTYL ALCOHOL	0.000	0.036	0.000	0.000
BUTYLENE OXIDE, 1,2-	NA		0.000	0.000
CADMIUM	36.250	0.005	0.179	0.203
CARBON TETRACHLORIDE	1.200		0.000	0.000
CHLORIDE	NA	10.123	0.000	0.000
CHLORINE	22.500	0.039	0.881	1.000
CHLOROFORM	9.750		0.000	0.000
CHROMIUM, TRIVALENT	16.630	0.001	0.009	0.010
COBALT COMPOUNDS	31.750		0.000	0.000
COPPER COMPOUNDS	30.000	0.000	0.001	0.001
DICHLORODIFLUOROMETHANE (CFC-1	NA		0.000	0.000
HYDROCHLORIC ACID	13.860		0.000	0.000
IRON	25.000	0.000	0.000	0.000
LEAD	25.000	0.002	0.044	0.050
MERCURY	37.500	0.000	0.000	0.000
METHYL ISOAMYL KETONE	10.200		0.000	0.000
NAPHTHALENE	19.570		0.000	0.000
NITRIC ACID	15.600		0.000	0.000
NITROPROPANE, 2-	23.400		0.000	0.000
OIL & GREASE	NA	0.316	0.000	0.000
ORGANIC ACIDS	NA		0.000	0.000
PETROLEUM (CRUDE OIL)	NA	0.000	0.000	0.000
PHENOL	11.400	0.000	0.000	0.000
PHOSPHORIC ACID	11.400		0.000	0.000
SODIUM	NA	12.822	0.000	0.000
SULFIDE	NA	0.000	0.000	0.000
SULFURIC ACID	15.000	0.000	0.001	0.001
XYLENE	16.240		0.000	0.000
ZINC	20.300	0.000	0.001	0.001

NA = Not Available

LAND USE IMPACT CALCULATIONS

CHEMICAL NAME	LAND USE Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Land Use Score			254.813	1.577
Normalizing Score			161.615	
BOTTOM ASH	2.000	0.000	0.000	0.000
FGD SOLIDS	2.000	0.000	0.000	0.000
FLY ASH	2.000	0.000	0.000	0.000
HAZARDOUS WASTE	2.000	80.808	161.615	1.000
PLUTONIUM (FISSILE & NONFISSILE)	NA	0.000	0.000	0.000
SLAG	2.000	0.000	0.000	0.000
SOLID WASTE	1.500	62.132	93.198	0.577
URANIUM (235, 236, 238)	NA	0.000	0.000	0.000

NA = Not Available

ALTERNATIVE PRIMER AND THINNER

LIFE CYCLE IMPACT VALUATION CALCULATIONS

	Scale	Issues ------->		AHP Weighting Factor	Normalized Factored Score	Weighted Normalized Factored Score			Baseline Score
CARCOPT									0.692
	GLOBAL							0.211	
		ODP		0.17983	0.367		0.066		
		GLBLWRM		0.11328	0.984		0.111		
		FSLFUELS		0.02855	1.180		0.034		
	REGIONAL							0.203	
		ACIDDEP		0.06253	1.175		0.074		
		SMOG		0.13007	0.992		0.129		
		WTRUSE		0.01002			0.000		
	LOCAL							0.278	
		TOXICITY					0.238		
			HUMAN	0.06155	1.739	0.107			
			ENVTERR	0.02052	2.862	0.059			
			ENVAQ	0.02052	3.540	0.073			
		LANDUSE		0.02507	1.585		0.040		

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OZONE DEPLETION POTENTIAL IMPACT CALCULATIONS

CHEMICAL NAME	ODP Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total ODP Score			0.001	0.367
Normalizing Factor			0.003	
CARBON TETRACHLORIDE	1.080	0.000	0.000	0.000
DICHLORODIFLUOROMETHANE	1.000	0.001	0.001	0.367
TRICHLOROETHANE (METHYL CHLOROFORM	0.120	0.000	0.000	0.000

GLOBAL WARMING POTENTIAL IMPACT CALCULATIONS

CHEMICAL NAME	GWP Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total GWP Score			295.468	0.984
Normalizing Score			300.337	
CARBON TETRACHLORIDE	1300	0.000	0.000	0.000
CO2	1	287.647	287.647	0.958
DICHLORODIFLUOROMETHANE	7100	0.001	7.821	0.026
TRICHLOROETHANE	100	0.000	0.000	0.000

RESOURCE DEPLETION IMPACT CALCULATIONS

CHEMICAL NAME	RESOURCE DEPLETION Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Resource Depetion Score			12,987.118	1.180
Normalizing Score			11,010.628	
BAUXITE	4	83.964	335.857	0.031
CHROME OXIDE	2	4.553	9.107	0.001
COAL	3	0.000	0.000	0.000
COBALT OXIDE	3	1.003	3.010	0.000
IRON ORE	3	1.341	4.023	0.000
LIMESTONE	1	4.653	4.653	0.000
MAGNESIUM ORE	1	2.249	2.249	0.000
NATURAL GAS	4	537.339	2,149.357	0.195
PETROLEUM (CRUDE OIL)	4	2,594.511	10,378.045	0.943
PHOSPHATE ROCK	3	0.000	0.000	0.000
SALT (SODIUM CHLORIDE)	1	43.470	43.470	0.004
SILICA	1	13.377	13.377	0.001
SODA ASH	1	2.624	2.624	0.000
THALLIUM	4		0.000	0.000
TITANIUM	3	13.782	41.345	0.004
URANIUM (235, 236, 238)	3	0.000	0.000	0.000
WATER INPUT	NA	40,765.310	0.000	0.000
ZINC	4	0.000	0.000	0.000

NA = Not Available

ACIDIFICATION POTENTIAL IMPACT CALCULATIONS

CHEMICAL NAME	Acid. Pot. Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Acid. Pot. Score			25.370	1.175
Normalizing Score			21.584	
AMMONIA	1.880	0.001	0.002	0.000
HYDROCHLORIC ACID	0.880	0.002	0.002	0.000
NOX	0.700	5.993	4.195	0.194
SOX	1.000	21.172	21.172	0.981

PHOTOCHEMICAL OXIDANT POTENTIAL IMPACT CALCULATIONS

CHEMICAL NAME	POCP Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total POCP Score			5.910	0.992
Normalizing Factor			5.959	
ACETALDEHYDE	0.527	0.006	0.003	0.001
ACETONE	0.178	0.008	0.001	0.000
ALDEHYDES	0.443	0.018	0.008	0.001
AROMATIC HYDROCARBONS (C8-C10)	0.761	0.061	0.046	0.008
BENZENE	0.189	0.275	0.052	0.009
BUTANE (n-)	0.410	0.056	0.023	0.004
BUTANE (iso-)	0.315	0.003	0.001	0.000
BUTYL ACETATE (n-)	0.323	0.024	0.008	0.001
BUTYL ALCOHOL	0.196	0.042	0.008	0.001
CHLOROFORM	0.021	0.000	0.000	0.000
ETHANE	0.082	0.045	0.004	0.001
ETHYL BENZENE	0.593	0.002	0.001	0.000
ETHYLENE	1.000	0.000	0.000	0.000
HEPTANE (n-)	0.529	0.081	0.043	0.007
HEXANE (n-)	0.421	0.063	0.026	0.004
METHANE	0.007	0.260	0.002	0.000
METHANOL	0.123	0.000	0.000	0.000
METHYL ETHYL KETONE	0.473	0.004	0.002	0.000
METHYL ISOAMYL KETONE	0.326	0.524	0.171	0.029
METHYL ISOBUTYL KETONE	0.326	0.000	0.000	0.000
METHYL PROPYL KETONE	0.326	0.000	0.000	0.000
OCTANE (n-)	0.493	0.054	0.027	0.004
PENTANE (n-)	0.408	0.039	0.016	0.003
PROPANE	0.420	0.070	0.029	0.005
PROPYL ACETATE	0.218	0.000	0.000	0.000
PROPYLENE	1.030	0.001	0.001	0.000
TOLUENE	0.563	0.189	0.106	0.018
TRICHLOROETHANE	0.021	0.000	0.000	0.000
VOC	0.397	13.327	5.291	0.888
XYLENE	0.849	0.047	0.040	0.007

HUMAN HEALTH INHALATION TOXICITY IMPACT CALCULATIONS

CHEMICAL NAME	HH INHALATION TOXICITY Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total HH Inh. Tox. Factored Score			22.109	1.739
Normalizing Score			12.715	
ACETALDEHYDE	7.44	0.006	0.046	0.004
ACETONE	0	0.008	0.000	0.000
ACETONITRILE	0	0.000	0.000	0.000
AMMONIA	5.7	0.001	0.005	0.000
ALDEHYDES	NA	0.018	0.000	0.000
ALUMINUM	15.6	0.003	0.043	0.003
AROMATIC HYDROCARBONS (C8-C10)	NA	0.061	0.000	0.000
BENZENE	NA	0.275	0.000	0.000
BUTANE (n-)	17.5	0.056	0.973	0.077
BUTANE (iso-)	NA	0.003	0.000	0.000
BUTYL ACETATE (n-)	8.49	0.024	0.205	0.016
BUTANOL	0.95	0.042	0.040	0.003
BUTYL CELLOSOLVE	12.29	0.000	0.000	0.000
BUTYLENE OXIDE, 1,2-	NA	0.000	0.000	0.000
CADMIUM	2.25		0.000	0.000
CARBON TETRACHLORIDE	7.06	0.000	0.000	0.000
CHLORINE	22.05	0.586	12.915	1.016
CHLOROFORM	2.57	0.000	0.000	0.000
CO	4.47	0.832	3.719	0.293
CO2	NA	287.647	0.000	0.000
CUMENE	1.35	0.023	0.030	0.002
CYCLOPARAFFINS, C-7	NA	0.011	0.000	0.000
CYCLOPARAFFINS, C-8	NA	0.004	0.000	0.000
DICHLORODIFLUOROMETHANE (CFC	0	0.001	0.000	0.000
ETHANE	NA	0.045	0.000	0.000
ETHYL BENZENE	3.19	0.002	0.006	0.000
ETHYLENE	0	0.000	0.000	0.000
ETHYLENE CHLORIDE	0	0.000	0.000	0.000
ETHYLENE DICHLORIDE	7.32	0.000	0.000	0.000
FLUORINE	14.64	0.000	0.000	0.000
FORMALDEHYDE	15.6	0.020	0.314	0.025
HEAVY AROMATIC	NA	0.197	0.000	0.000
HEPTANE (n-)	0	0.081	0.000	0.000
HEXYL ACETATE	NA	0.005	0.000	0.000
HEXAMETHYLENE DIISOCYANTE	10		0.000	0.000
HEXANE (n-)	0	0.063	0.000	0.000
HYDROCHLORIC ACID	14.82	0.002	0.029	0.002
HYDROGEN CYANIDE	30	0.007	0.204	0.016
ISOBUTYRALDEHYDE	1.86	0.000	0.000	0.000
ISOPROPYL ALCOHOL	0	0.000	0.000	0.000
LEAD	NA	0.000	0.000	0.000
METHANE	NA	0.260	0.000	0.000
METHANOL	0	0.000	0.000	0.000

METHYL ETHYL KETONE	1.4	0.004	0.006	0.000
METHYL ISOAMYL KETONE	4	0.524	2.098	0.165
METHYL ISOBUTYL KETONE	2.33	0.000	0.000	0.000
METHYL PROPYL KETONE	NA	0.000	0.000	0.000
NAPTHA, NM&P	NA	0.066	0.000	0.000
NAPHTHALENE	26.45		0.000	0.000
NOX	NA	5.993	0.000	0.000
NITRIC ACID	26.4	0.000	0.000	0.000
NITROETHANE	NA	0.004	0.000	0.000
NITROPROPANE	14.4	0.001	0.009	0.001
OCTANE (n-)	0	0.054	0.000	0.000
ORGANIC ACIDS	NA	0.023	0.000	0.000
PENTANE (n-)	13.34	0.039	0.523	0.041
PHENOL	22.33	0.021	0.461	0.036
PHOSGENE	12.5		0.000	0.000
PHOSPHORIC ACID	30		0.000	0.000
PM	NA	5.956	0.000	0.000
PM-10	NA	0.310	0.000	0.000
PROPANE	NA	0.070	0.000	0.000
PROPYL ACETATE	NA	0.000	0.000	0.000
TOLUENE	2.04	0.189	0.385	0.030
TRICHLOROEHTANE (METHYL CHLO	5.6	0.000	0.000	0.000
VINYL CHLORIDE	18.52	0.000	0.000	0.000
VOC	NA	13.327	0.000	0.000
XYLENE	2.1	0.047	0.099	0.008

NA = Not Available

TERRESTRIAL TOXICITY IMPACT CALCULATIONS

CHEMICAL NAME	TERRESTRIAL TOXICITY Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Terr. Tox. Factored Score			3.077	2.862
Normalizing Score			1.075	
ACETALDEHYDE	3.255	0.006	0.020	0.019
ACETONE	1.860	0.008	0.015	0.014
ACETONITRILE	0.610	0.005	0.003	0.003
ALUMINUM	0.000	0.001	0.000	0.000
AMMONIA	9.030	0.001	0.008	0.007
ARSENIC	31.730	0.000	0.001	0.001
BENZENE	0.000	0.275	0.000	0.000
BUTYL ACETATE (n-)	0.000	0.024	0.000	0.000
BUTYL ALCOHOL	6.180	0.042	0.258	0.240
BUTYL CELLOSOLVE	7.590	0.000	0.000	0.000
BUTYLENE OXIDE, 1,2-	1.610	0.000	0.000	0.000
CADMIUM	21.030	0.008	0.168	0.156
CARBON TETRACHLORIDE	1.710	0.000	0.000	0.000
CHLORINE	0.000	0.707	0.000	0.000
CHLOROFORM	6.160	0.000	0.000	0.000
CHROMIUM, TRIVALENT	19.290	0.001	0.017	0.016
COBALT COMPOUNDS	20.960		0.000	0.000
COPPER COMPOUNDS	12.000	0.000	0.001	0.001
CUMENE	2.710	0.023	0.061	0.057
DICHLORODIFLUOROMETHANE	1.330	0.001	0.001	0.001
DIETHYLAMINETRIAMINE	5.270		0.000	0.000
ETHYL BENZENE	0.000	0.002	0.000	0.000
ETHYLENE	0.000	0.000	0.000	0.000
ETHYLENE DICHLORIDE	4.890		0.000	0.000
FGD SOLIDS	0.000	0.000	0.000	0.000
FLY ASH	0.000	0.000	0.000	0.000
FORMALDEHYDE	12.600	0.020	0.253	0.236
HEPTANE (n-)	9.500	0.081	0.767	0.714
HEXANE (n-)	0.000	0.063	0.000	0.000
HEXYL ACETATE	0.000	0.005	0.000	0.000
HEXAMETYHYLENE DIISOCYANTE	2.640		0.000	0.000
HYDROCHLORIC ACID	5.740	0.002	0.011	0.010
HYDROGEN CYANIDE	30.000	0.007	0.204	0.189
IRON	0.000	0.000	0.000	0.000
ISOBUTYRALDEHYDE	1.860	0.000	0.000	0.000
ISOPROPYL ALCOHOL	0.950	0.000	0.000	0.000
KEROSENE	0.000	0.000	0.000	0.000
LEAD	5.750	0.003	0.017	0.016
METHYL ETHYL KETONE	1.860	0.004	0.008	0.008
METHYL ISOAMYL KETONE	2.050	0.524	1.075	1.000
METHYL ISOBUTYL KETONE	2.790	0.000	0.000	0.000

METHYL PROPYL KETONE	4.570	0.000	0.000	0.000
NAPHTHALENE	3.170		0.000	0.000
NITRIC ACID	10.200	0.001	0.007	0.006
NITROPROPANE, 2-	8.400		0.000	0.000
PHENOL	7.600	0.021	0.157	0.146
PHOSPHORIC ACID	5.400		0.000	0.000
PROPYL ACETATE	0.870	0.000	0.000	0.000
PLUTONIUM (FISSILE & NONFISSILE)	0.000	0.000	0.000	0.000
SLAG	0.000	0.000	0.000	0.000
SULFURIC ACID	3.600	0.000	0.000	0.000
TOLUENE	0.000	0.189	0.000	0.000
TRICHLOROETHANE (METHYL CHLOR	0.000	0.000	0.000	0.000
URANIUM (235, 236, 238)	NA	0.000	0.000	0.000
VINYL CHLORIDE	7.870	0.000	0.000	0.000
XYLENE	0.520	0.047	0.025	0.023
ZINC	0.000	0.000	0.000	0.000

NA = Not Available

AQUATIC TOXICITY IMPACT CALCULATIONS

CHEMICAL NAME	AQUATIC TOXICITY Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Aquatic Tox. Factored Score			3.119	3.540
Normalizing Score			0.881	
ACETONITRILE	0.000		0.000	0.000
AMMONIA	21.850		0.000	0.000
ALUMINUM	0.000	0.001	0.000	0.000
ARSENIC	18.750	0.000	0.001	0.001
BENZENE	14.070	0.001	0.009	0.011
BORON	0.000	0.014	0.000	0.000
BUTYL ALCOHOL	0.000	0.042	0.000	0.000
BUTYLENE OXIDE, 1,2-	NA		0.000	0.000
CADMIUM	36.250	0.008	0.289	0.328
CARBON TETRACHLORIDE	1.200		0.000	0.000
CHLORIDE	NA	10.721	0.000	0.000
CHLORINE	22.500	0.121	2.727	3.096
CHLOROFORM	9.750		0.000	0.000
CHROMIUM, TRIVALENT	16.630	0.001	0.015	0.017
COBALT COMPOUNDS	31.750		0.000	0.000
COPPER COMPOUNDS	30.000	0.000	0.002	0.002
DICHLORODIFLUOROMETHANE (CFC-1	NA		0.000	0.000
HYDROCHLORIC ACID	13.860		0.000	0.000
IRON	25.000	0.000	0.000	0.000
LEAD	25.000	0.003	0.073	0.082
MERCURY	37.500	0.000	0.000	0.000
METHYL ISOAMYL KETONE	10.200		0.000	0.000
NAPHTHALENE	19.570		0.000	0.000
NITRIC ACID	15.600		0.000	0.000
NITROPROPANE, 2-	23.400		0.000	0.000
OIL & GREASE	NA	0.335	0.000	0.000
ORGANIC ACIDS	NA		0.000	0.000
PETROLEUM (CRUDE OIL)	NA	0.000	0.000	0.000
PHENOL	11.400	0.000	0.000	0.000
PHOSPHORIC ACID	11.400		0.000	0.000
SODIUM	NA	13.580	0.000	0.000
SULFIDE	NA	0.000	0.000	0.000
SULFURIC ACID	15.000	0.000	0.001	0.001
XYLENE	16.240		0.000	0.000
ZINC	20.300	0.000	0.001	0.002

NA = Not Available

LAND USE IMPACT CALCULATIONS

CHEMICAL NAME	LAND USE Equiv. Factor	Inventory Value lb/FU	Factored Score	Normalized Factored Score
Total Land Use Score			251.871	1.585
Normalizing Score			161.615	
BOTTOM ASH	2.000	0.000	0.000	0.000
FGD SOLIDS	2.000	0.000	0.000	0.000
FLY ASH	2.000	0.000	0.000	0.000
HAZARDOUS WASTE	2.000	79.465	158.930	1.000
PLUTONIUM (FISSILE & NONFISSILE)	NA	0.000	0.000	0.000
SLAG	2.000	0.000	0.000	0.000
SOLID WASTE	1.500	61.961	92.941	0.585
URANIUM (235, 236, 238)	NA	0.000	0.000	0.000

NA = Not Available

APPENDIX E
SENSITIVITY ANALYSIS

Table E-1

Compound	Environmental Compartment	Current Equivalency Factors POCP	ODP	AP	GWP	HHIT	Terr	Aqua	Land	Res
VOC	Air	0.397				NA				
Heavy aromatics	Air					NA				
Aromatic hydrocarbons	Air	0.761				NA				
C7 cycloparaffins	Air					NA				
C8 cycloparaffins	Air					NA				
Hydrocarbons	Air									
Organic acids	Air					NA				
Aliphatic hydrocarbons	Air									
Mobile ions	Water									
Dissolved solids	Water									
Metals	Water									

Compound	Environmental Compartment	Worst Case Equivalency Factors Derived from Tabulated Equivalency Factors POCP	ODP	AP	GWP	HHIT	Terr	Aqua	Land	Res
VOC	Air	1.03				26.45	12 6			4
Heavy aromatics	Air					26.45	12.6			4
Aromatic hydrocarbons	Air	1.03				26.45	12.6			4
C7 cycloparaffins	Air					26.45	12.6			4
C8 cycloparaffins	Air					26.45	12.6			4
Hydrocarbons	Air	1.03				26.45	12.6			4
Organic acids	Air									4
Aliphatic hydrocarbons	Air	0.493				26.45	12.6			4
Mobile ions	Water							21.85		
Dissolved solids	Water							15.6		
Metals	Water							37.5		4

	POCP	ODP	AP	GWP	HHIT	Terr	Aqua	Land	Res	Total	% Change
Normalizing Factors	5.959	0.003	21 584	300.337	12.715	1 075	0.881	161.615	11010 63		
AHP Weighting Factors	0.13007	0.17983	0.06253	0.11328	0.06155	0 02052	0.02052	0.02507	0.02855		
Total Normalized Fact. Sc. - Scenario 1	1.114	1.09	1.198	1.013	2.15	3.799	1.28	1.577	1 263	0.842724	
Revised Total Norm. Fact. Sc - Scen 1	1 652084	1.09	1 198	1.013	1.305836	1.258577	1.00148	1.577	1.269755	0.803102	4 701608
Total Normalized Fact. Sc. - Scenario 2	0.993	0.367	1.173	0.927	1.612	2 635	3.537	1.585	1 121	0.671124	
Revised Normalized Fact. Sc. - Scen 2	1.506585	0.367	1.173	0.927	1.189616	1.15297	0.889067	1.585	1.127214	0.627359	6 521181
Total Normalized Fact. Sc. - Scenario 3	0.8	0.799	1.116	0.739	1.51	2.565	0.925	1.493	0 929	0 629745	
Revised Normalized Fact. Sc. - Scen. 3	1.196015	0.799	1.116	0.739	0 946338	0 912561	0 730384	1.493	0 933904	0 6088	3 325989
Total Normalized Fact. Sc. - Scenario 4	0.721	0.265	1.098	0.677	1 172	1.906	2 554	1.497	0 827	0 51158	
Revised Normalized Fact. Sc. - Scen. 4	1 093978	0.265	1.098	0.677	0.863833	0 837134	0 64922	1.497	0.831512	0 480236	6.127058
Total Normalized Fact. Sc. - Scenario 5	1.035	1.09	1 187	0.905	1.999	2.923	1.279	1.577	1 133	0.788525	
Revised Normalized Fact. Sc. - Scen 5	1.54396	1.09	1.187	0.905	1.223262	1.175859	0 891411	1.577	1.13933	0.763355	3 19206
Total Normalized Fact. Sc. - Scenario 6	0 992	0.367	1.175	0.984	1 739	2.862	3.54	1.585	1. 18	0.691797	
Revised Normalized Fact. Sc. - Scen. 6	1.482657	0.367	1.175	0.984	1 170204	1 130781	0.94664	1.585	1 186086	0.632041	8 637826

Compound	Environmental Compartment	Current Factored Score - Scenario 1 POCP	ODP	AP	GWP	HHIT	Terr	Aqua	Land	Res
VOC	Air	5 959				0				
Heavy aromatics	Air					0				

Aromatic hydrocarbons	Air	0.017	0
C7 cycloparaffins	Air		0
C8 cycloparaffins	Air		0
Hydrocarbons	Air		
Organic acids	Air		0
Aliphatic hydrocarbons	Air		
Mobile ions	Water		
Dissolved solids	Water		
Metals	Water		

Compound	Environmental Compartment	Current Emissions Rates - Scenario 1
VOC	Air	15.01133
Heavy aromatics	Air	0.197299
Aromatic hydrocarbons	Air	0.022925
C7 cycloparaffins	Air	0.012075
C8 cycloparaffins	Air	0.004414
Hydrocarbons	Air	3.320748
Organic acids	Air	0.024594
Aliphatic hydrocarbons	Air	0
Mobile ions	Water	34.88296
Dissolved solids	Water	6.8E-07
Metals	Water	3.8E-10

	Environmental	Revised Factored Score - Scenario 1								
Compound	Compartment	POCP	ODP	AP	GWP	HHIT	Terr	Aqua	Land	Res
VOC	Air	15.46167	0	0	0	397.0497	189.1428	0	0	60 04532
Heavy aromatics	Air	0	0	0	0	5.218559	2.485967	0	0	0.789196
Aromatic hydrocarbons	Air	0.023613	0	0	0	0.606366	0 288855	0	0	0.0917
C7 cycloparaffins	Air	0	0	0	0	0.319384	0.152145	0	0	0 0483
C8 cycloparaffins	Air	0	0	0	0	0.11675	0 055616	0	0	0 017656
Hydrocarbons	Air	3.42037	0	0	0	87.83378	41 84142	0	0	13 28299
Organic acids	Air	0	0	0	0	0	0	0	0	0.098376
Aliphatic hydrocarbons	Air	0	0	0	0	0	0	0	0	0
Mobile ions	Water	0	0	0	0	0	0	762.1927	0	0
Dissolved solids	Water	0	0	0	0	0	0	0.000011	0	0
Metals	Water	0	0	0	0	0	0	1.4E-08	0	1 5E-09

	Environmental	Revised Normalized Factored Score - Scenario 1								
Compound	Compartment	POCP	ODP	AP	GWP	HHIT	Terr	Aqua	Land	Res
VOC	Air	1	0	0	0	1	1	0	0	0.005453
Heavy aromatics	Air	0	0	0	0	0.013143	0 013143	0	0	0.000072
Aromatic hydrocarbons	Air	0.001527	0	0	0	0.001527	0 001527	0	0	8 3E-06
C7 cycloparaffins	Air	0	0	0	0	0.000804	0 000804	0	0	4 4E-06
C8 cycloparaffins	Air	0	0	0	0	0.000294	0 000294	0	0	1 6E-06
Hydrocarbons	Air	0.221216	0	0	0	0.221216	0 221216	0	0	0.001206
Organic acids	Air	0	0	0	0	0	0	0	0	8 9E-06
Aliphatic hydrocarbons	Air	0	0	0	0	0	0	0	0	0
Mobile ions	Water	0	0	0	0	0	0	1	0	0
Dissolved solids	Water	0	0	0	0	0	0	1.4E-08	0	0

Metals	Water	0	0	0	0	0	0	1.9E-11	0	1.4E-13

Compound	Environmental Compartment	Current Factored Score - Scenario 2 POCP	ODP	AP	GWP	HHIT	Terr	Aqua	Land	Res
VOC	Air	5.516				0				
Heavy aromatics	Air					0				
Aromatic hydrocarbons	Air	0.029				0				
C7 cycloparaffins	Air					0				
C8 cycloparaffins	Air					0				
Hydrocarbons	Air									
Organic acids	Air					0				
Aliphatic hydrocarbons	Air									
Mobile ions	Water									
Dissolved solids	Water									
Metals	Water									

Compound	Environmental Compartment	Current Emissions Rates - Scenario 2
VOC	Air	13.89406
Heavy aromatics	Air	0.197299
Aromatic hydrocarbons	Air	0.038055
C7 cycloparaffins	Air	0.010686
C8 cycloparaffins	Air	0.003907
Hydrocarbons	Air	2.93879
Organic acids	Air	0.021765
Aliphatic hydrocarbons	Air	0
Mobile ions	Water	30.87066
Dissolved solids	Water	6.3E-07
Metals	Water	3.5E-10

Compound	Environmental Compartment	Revised Factored Score - Scenario 2 POCP	ODP	AP	GWP	HHIT	Terr	Aqua	Land	Res
VOC	Air	14.31088	0	0	0	367.4979	175.0652	0	0	55.57624
Heavy aromatics	Air	0	0	0	0	5.218559	2.485967	0	0	0.789196
Aromatic hydrocarbons	Air	0.039197	0	0	0	1.006555	0.479493	0	0	0.15222
C7 cycloparaffins	Air	0	0	0	0	0.282645	0.134644	0	0	0.042744
C8 cycloparaffins	Air	0	0	0	0	0.10334	0.049228	0	0	0.015628
Hydrocarbons	Air	3.026954	0	0	0	77.731	37.02875	0	0	11.75516
Organic acids	Air	0	0	0	0	0	0	0	0	0.08706
Aliphatic hydrocarbons	Air	0	0	0	0	0	0	0	0	0
Mobile ions	Water	0	0	0	0	0	0	674.5239	0	0
Dissolved solids	Water	0	0	0	0	0	0	9.8E-06	0	0
Metals	Water	0	0	0	0	0	0	1.3E-08	0	1.4E-09

Compound	Environmental Compartment	Revised Normalized Factored Score - Scenario 2 POCP	ODP	AP	GWP	HHIT	Terr	Aqua	Land	Res
VOC	Air	0.925572	0	0	0	0.925572	0.925572	0	0	0.005048
Heavy aromatics	Air	0	0	0	0	0.013143	0.013143	0	0	0.000072
Aromatic hydrocarbons	Air	0.002535	0	0	0	0.002535	0.002535	0	0	0.000014

C7 cycloparaffins	Air	0	0	0	0	0.000712	0.000712	0	0	3.9E-06
C8 cycloparaffins	Air	0	0	0	0	0.00026	0.00026	0	0	1.4E-06
Hydrocarbons	Air	0.195771	0	0	0	0.195771	0.195771	0	0	0.001068
Organic acids	Air	0	0	0	0	0	0	0	0	7.9E-06
Aliphatic hydrocarbons	Air	0	0	0	0	0	0	0	0	0
Mobile ions	Water	0	0	0	0	0	0	0.884978	0	0
Dissolved solids	Water	0	0	0	0	0	0	1.3E-08	0	0
Metals	Water	0	0	0	0	0	0	1.7E-11	0	1.3E-13

Current Factored Score - Scenario 3

Compound	Environmental Compartment	POCP	ODP	AP	GWP	HHIT	Terr	Aqua	Land	Res
VOC	Air	4.324				0				
Heavy aromatics	Air					0				
Aromatic hydrocarbons	Air	0.009				0				
C7 cycloparaffins	Air					0				
C8 cycloparaffins	Air					0				
Hydrocarbons	Air									
Organic acids	Air					0				
Aliphatic hydrocarbons	Air									
Mobile ions	Water									
Dissolved solids	Water									
Metals	Water									

Current Emissions Rates - Scenario 3

Compound	Environmental Compartment	
VOC	Air	10.89153
Heavy aromatics	Air	0.14245
Aromatic hydrocarbons	Air	0.01203
C7 cycloparaffins	Air	0.008807
C8 cycloparaffins	Air	0.00322
Hydrocarbons	Air	2.421871
Organic acids	Air	0.017937
Aliphatic hydrocarbons	Air	0
Mobile ions	Water	25.44066
Dissolved solids	Water	5.0E-07
Metals	Water	2.7E-10

Revised Factored Score - Scenario 3

Compound	Environmental Compartment	POCP	ODP	AP	GWP	HHIT	Terr	Aqua	Land	Res
VOC	Air	11.21828	0	0	0	288 081	137.2333	0	0	43.56612
Heavy aromatics	Air	0	0	0	0	3 767803	1.79487	0	0	0.5698
Aromatic hydrocarbons	Air	0.012391	0	0	0	0 318194	0.151578	0	0	0.04812
C7 cycloparaffins	Air	0	0	0	0	0.232945	0 110968	0	0	0.035228
C8 cycloparaffins	Air	0	0	0	0	0.085169	0 040572	0	0	0 01288
Hydrocarbons	Air	2.494527	0	0	0	64.05849	30 51557	0	0	9.687484
Organic acids	Air	0	0	0	0	0	0	0	0	0.071748
Aliphatic hydrocarbons	Air	0	0	0	0	0	0	0	0	0
Mobile ions	Water	0	0	0	0	0	0	555.8784	0	0
Dissolved solids	Water	0	0	0	0	0	0	7 8E-06	0	0

Compound	Environmental Compartment									
Metals	Water	0	0	0	0	0	0	1.0E-08	0	1.1E-09

Compound	Environmental Compartment	Revised Normalized Factored Score - Scenario 3 POCP	ODP	AP	GWP	HHIT	Terr	Aqua	Land	Res
VOC	Air	0.725554	0	0	0	0.725554	0.725554	0	0	0.003957
Heavy aromatics	Air	0	0	0	0	0.009489	0.009489	0	0	0.000052
Aromatic hydrocarbons	Air	0.000801	0	0	0	0.000801	0.000801	0	0	4.4E-06
C7 cycloparaffins	Air	0	0	0	0	0.000587	0.000587	0	0	3.2E-06
C8 cycloparaffins	Air	0	0	0	0	0.000215	0.000215	0	0	1.2E-06
Hydrocarbons	Air	0.161336	0	0	0	0.161336	0.161336	0	0	0.00088
Organic acids	Air	0	0	0	0	0	0	0	0	6.5E-06
Aliphatic hydrocarbons	Air	0	0	0	0	0	0	0	0	0
Mobile ions	Water	0	0	0	0	0	0	0.729315	0	0
Dissolved solids	Water	0	0	0	0	0	0	1.0E-08	0	0
Metals	Water	0	0	0	0	0	0	1.3E-11	0	9.8E-14

Compound	Environmental Compartment	Current Factored Score - Scenario 4 POCP	ODP	AP	GWP	HHIT	Terr	Aqua	Land	Res
VOC	Air	4.324				0				
Heavy aromatics	Air					0				
Aromatic hydrocarbons	Air	0.015				0				
C7 cycloparaffins	Air					0				
C8 cycloparaffins	Air					0				
Hydrocarbons	Air									
Organic acids	Air					0				
Aliphatic hydrocarbons	Air									
Mobile ions	Water									
Dissolved solids	Water									
Metals	Water									

Compound	Environmental Compartment	Current Emissions Rates - Scenario 4
VOC	Air	10.08484
Heavy aromatics	Air	0.14245
Aromatic hydrocarbons	Air	0.019837
C7 cycloparaffins	Air	0.007804
C8 cycloparaffins	Air	0.002853
Hydrocarbons	Air	2.146092
Organic acids	Air	0.015894
Aliphatic hydrocarbons	Air	0
Mobile ions	Water	22.54372
Dissolved solids	Water	4.6E-07
Metals	Water	5.0E-10

Compound	Environmental Compartment	Revised Factored Score - Scenario 4 POCP	ODP	AP	GWP	HHIT	Terr	Aqua	Land	Res
VOC	Air	10.38739	0	0	0	266 744	127.069	0	0	40.33936
Heavy aromatics	Air	0	0	0	0	3.767803	1 79487	0	0	0.5698
Aromatic hydrocarbons	Air	0.020432	0	0	0	0 524689	0 249946	0	0	0 079348

C7 cycloparaffins	Air	0	0	0	0	0.206416	0.09833	0	0	0.031216
C8 cycloparaffins	Air	0	0	0	0	0.075462	0.035948	0	0	0.011412
Hydrocarbons	Air	2.210475	0	0	0	56.76413	27.04076	0	0	8.584368
Organic acids	Air	0	0	0	0	0	0	0	0	0.063576
Aliphatic hydrocarbons	Air	0	0	0	0	0	0	0	0	0
Mobile ions	Water	0	0	0	0	0	0	492.5803	0	0
Dissolved solids	Water	0	0	0	0	0	0	7.2E-06	0	0
Metals	Water	0	0	0	0	0	0	1.9E-08	0	2.0E-09

	Environmental	Revised Normalized Factored Score - Scenario 4								
Compound	Compartment	POCP	ODP	AP	GWP	HHIT	Terr	Aqua	Land	Res
VOC	Air	0.671815	0	0	0	0.671815	0.671815	0	0	0.003664
Heavy aromatics	Air	0	0	0	0	0.009489	0.009489	0	0	0.000052
Aromatic hydrocarbons	Air	0.001321	0	0	0	0.001321	0.001321	0	0	7.2E-06
C7 cycloparaffins	Air	0	0	0	0	0.00052	0.00052	0	0	2.8E-06
C8 cycloparaffins	Air	0	0	0	0	0.00019	0.00019	0	0	1.0E-06
Hydrocarbons	Air	0.142965	0	0	0	0.142965	0.142965	0	0	0.00078
Organic acids	Air	0	0	0	0	0	0	0	0	5.8E-06
Aliphatic hydrocarbons	Air	0	0	0	0	0	0	0	0	0
Mobile ions	Water	0	0	0	0	0	0	0.646267	0	0
Dissolved solids	Water	0	0	0	0	0	0	9.4E-09	0	0
Metals	Water	0	0	0	0	0	0	2.5E-11	0	1.8E-13

	Environmental	Current Factored Score - Scenario 5								
Compound	Compartment	POCP	ODP	AP	GWP	HHIT	Terr	Aqua	Land	Res
VOC	Air	5.641				0				
Heavy aromatics	Air					0				
Aromatic hydrocarbons	Air	0.017				0				
C7 cycloparaffins	Air					0				
C8 cycloparaffins	Air					0				
Hydrocarbons	Air									
Organic acids	Air					0				
Aliphatic hydrocarbons	Air									
Mobile ions	Water									
Dissolved solids	Water									
Metals	Water									

	Environmental	Current Emissions Rates - Scenario 5
Compound	Compartment	
VOC	Air	14.20999
Heavy aromatics	Air	0.197299
Aromatic hydrocarbons	Air	0.022925
C7 cycloparaffins	Air	0.010746
C8 cycloparaffins	Air	0 003929
Hydrocarbons	Air	2 955243
Organic acids	Air	0.021887
Aliphatic hydrocarbons	Air	0.001695
Mobile ions	Water	31.04349
Dissolved solids	Water	6 3E-07

Metals	Water	3.5E-10

Compound	Environmental Compartment	Revised Factored Score - Scenario 5 POCP	ODP	AP	GWP	HHIT	Terr	Aqua	Land	Res
VOC	Air	14.63629	0	0	0	375.8542	179.0459	0	0	56.83996
Heavy aromatics	Air	0	0	0	0	5.218559	2.485967	0	0	0.789196
Aromatic hydrocarbons	Air	0.023613	0	0	0	0.606366	0.288855	0	0	0.0917
C7 cycloparaffins	Air	0	0	0	0	0.284232	0.1354	0	0	0.042984
C8 cycloparaffins	Air	0	0	0	0	0.103922	0.049505	0	0	0.015716
Hydrocarbons	Air	3.0439	0	0	0	78.16618	37.23606	0	0	11.82097
Organic acids	Air	0	0	0	0	0	0	0	0	0.087548
Aliphatic hydrocarbons	Air	0.000836	0	0	0	0.044833	0.021357	0	0	0.00678
Mobile ions	Water	0	0	0	0	0	0	678.3003	0	0
Dissolved solids	Water	0	0	0	0	0	0	9.8E-06	0	0
Metals	Water	0	0	0	0	0	0	1.3E-08	0	1.4E-09

Compound	Environmental Compartment	Revised Normalized Factored Score - Scenario 5 POCP	ODP	AP	GWP	HHIT	Terr	Aqua	Land	Res
VOC	Air	0.946618	0	0	0	0.946618	0.946618	0	0	0.005162
Heavy aromatics	Air	0	0	0	0	0.013143	0.013143	0	0	0.000072
Aromatic hydrocarbons	Air	0.001527	0	0	0	0.001527	0.001527	0	0	8.3E-06
C7 cycloparaffins	Air	0	0	0	0	0.000716	0.000716	0	0	3.9E-06
C8 cycloparaffins	Air	0	0	0	0	0.000262	0.000262	0	0	1.4E-06
Hydrocarbons	Air	0.196867	0	0	0	0.196867	0.196867	0	0	0.001074
Organic acids	Air	0	0	0	0	0	0	0	0	8.0E-06
Aliphatic hydrocarbons	Air	0.000054	0	0	0	0.000113	0.000113	0	0	6.2E-07
Mobile ions	Water	0	0	0	0	0	0	0.889933	0	0
Dissolved solids	Water	0	0	0	0	0	0	1.3E-08	0	0
Metals	Water	0	0	0	0	0	0	1.7E-11	0	1.3E-13

Compound	Environmental Compartment	Current Factored Score - Scenario 6 POCP	ODP	AP	GWP	HHIT	Terr	Aqua	Land	Res
VOC	Air	5.291				0				
Heavy aromatics	Air					0				
Aromatic hydrocarbons	Air	0.046				0				
C7 cycloparaffins	Air					0				
C8 cycloparaffins	Air					0				
Hydrocarbons	Air									
Organic acids	Air					0				
Aliphatic hydrocarbons	Air									
Mobile ions	Water									
Dissolved solids	Water									
Metals	Water									

Compound	Environmental Compartment	Current Emissions Rates - Scenario 6
VOC	Air	13 32696
Heavy aromatics	Air	0.197299
Aromatic hydrocarbons	Air	0 060582

C7 cycloparaffins	Air	0.011381
C8 cycloparaffins	Air	0.004161
Hydrocarbons	Air	3.129964
Organic acids	Air	0.023181
Aliphatic hydrocarbons	Air	0
Mobile ions	Water	32.87886
Dissolved solids	Water	6.3E-07
Metals	Water	3.5E-10

Compound	Environmental Compartment	Revised Factored Score - Scenario 6 POCP	ODP	AP	GWP	HHIT	Terr	Aqua	Land	Res
VOC	Air	13.72677	0	0	0	352.4981	167.9197	0	0	53.30784
Heavy aromatics	Air	0	0	0	0	5.218559	2.485967	0	0	0.789196
Aromatic hydrocarbons	Air	0.062399	0	0	0	1.602394	0.763333	0	0	0.242328
C7 cycloparaffins	Air	0	0	0	0	0.301027	0.143401	0	0	0.045524
C8 cycloparaffins	Air	0	0	0	0	0.110058	0.052429	0	0	0.016644
Hydrocarbons	Air	3.223863	0	0	0	82.78755	39.43755	0	0	12.51986
Organic acids	Air	0	0	0	0	0	0	0	0	0.092724
Aliphatic hydrocarbons	Air	0	0	0	0	0	0	0	0	0
Mobile ions	Water	0	0	0	0	0	0	718.4031	0	0
Dissolved solids	Water	0	0	0	0	0	0	9.8E-06	0	0
Metals	Water	0	0	0	0	0	0	1.3E-08	0	1.4E-09

Compound	Environmental Compartment	Revised Normalized Factored Score - Scenario 6 POCP	ODP	AP	GWP	HHIT	Terr	Aqua	Land	Res
VOC	Air	0.887793	0	0	0	0.887793	0.887793	0	0	0.004841
Heavy aromatics	Air	0	0	0	0	0.013143	0.013143	0	0	0.000072
Aromatic hydrocarbons	Air	0.004036	0	0	0	0.004036	0.004036	0	0	0.000022
C7 cycloparaffins	Air	0	0	0	0	0.000758	0.000758	0	0	4.1E-06
C8 cycloparaffins	Air	0	0	0	0	0.000277	0.000277	0	0	1.5E-06
Hydrocarbons	Air	0.208507	0	0	0	0.208507	0.208507	0	0	0.001137
Organic acids	Air	0	0	0	0	0	0	0	0	8.4E-06
Aliphatic hydrocarbons	Air	0	0	0	0	0	0	0	0	0
Mobile ions	Water	0	0	0	0	0	0	0.942548	0	0
Dissolved solids	Water	0	0	0	0	0	0	1.3E-08	0	0
Metals	Water	0	0	0	0	0	0	1.7E-11	0	1.3E-13

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