

APPENDIX C:

**METHODOLOGY FOR ASSESSING IMPACTS ON HUMAN HEALTH
FROM AIR EMISSIONS DURING ROUTINE OPERATIONS**

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Air emissions from operating the neutralization/biotreatment (Neut/Bio), neutralization/supercritical water oxidation (Neut/SCWO), neutralization/gas-phase chemical reduction/transpiring wall SCWO (Neut/GPCR/TW-SCWO), and electrochemical oxidation (Elchem Ox) pilot facilities were estimated on the basis of demonstration test data (Mitretek 2001a–d). These estimates were used to model air concentrations of contaminants that might occur at potential off-post (general public) and on-post (worker) receptor locations (Section C.1). Estimated inhalation exposures of receptors to these contaminants in air were then combined with chemical-specific toxicity data to estimate the potential for adverse health impacts (Section C.2). The potential impacts of chemicals for which no quantitative toxicity estimates were available are also discussed (Section C.3).

C.1 ESTIMATED TOXIC AIR POLLUTANT EMISSIONS AND CONCENTRATIONS

For each of the technology systems evaluated, emissions from diesel generators and boilers were estimated on the basis of standard algorithms that used estimated fuel consumption as input (Kimmell et al. 2001). For the destruction facility stacks (i.e., filter farm stack, SCWO vent, biotreatment vent, product gas burner vent, catalytic oxidation [CatOx] unit/filter farm stack vent), emission estimates were based on post-specific munitions inventories and demonstration test data compiled by Mitretek Corp. (2001a–d). However, demonstration testing was not conducted for each system component (e.g., for baseline reverse assembly). Furthermore, in some instances, demonstration configurations differed significantly from the likely configuration of a full-scale unit, so certain demonstration test data were not considered useful in predicting emissions for specific process components (e.g., fluid abrasive cutting, fluid mining, and energetics hydrolysis processes for Neut/Bio [Mitretek 2001a]; projectile rotary hydrolyzer and dunnage shredder/hydropulper system for Neut/SCWO [Mitretek 2001b]). Therefore, the estimated emissions for each technology should be considered only indicative of potential emissions from the complete system. Estimates may be revised as facility designs are finalized and more system testing is conducted.

Estimated daily emission rates of toxic air pollutants for each technology system are provided in the Technology Resource Document (TRD; Kimmell et al. 2001). The emissions were estimated by dividing the maximum concentration of each substance detected during demonstration testing by the estimated total air flow for the stack (Mitretek 2001a–d). For organic emissions, these before-treatment estimates were then multiplied by a reduction factor to account for passing the effluent through a series of six carbon filters, each with a removal efficiency of 95%. For inorganic substances (e.g., metals, dioxins, furans), it was assumed that

two high-efficiency particulate air (HEPA) filters with removal efficiencies of 99.97% would be used for treatment.

For a Neut/Bio facility, it is not known whether the emissions from the biotreatment vent would require further treatment. The provider of the equipment used during the technology demonstrations for Neut/Bio has stated that further treatment would not be necessary. In this assessment, both treatment and no treatment of biotreatment vent stack emissions were assessed. For a Neut/GPCR/TW-SCWO facility, it was assumed that emissions from the product gas burner vent would not be further treated after release from the facility's scrubber system.

Polychlorinated biphenyls (PCBs) have been identified as a constituent in the firing tubes of M55 rockets. However, PCBs were not tested as part of the ACWA demonstration project, because doing so would have triggered regulatory requirements under the *Toxic Substances Control Act* (TSCA). Meeting those requirements would have added considerably to the cost and difficulty of the demonstration (PMACWA 1999). Instead, demonstration tests were conducted with wood spiked with pentachlorophenol (PCP, a chlorinated substance similar to PCBs). Results showed degradation of the PCP in the test systems, indicating that PCBs would also likely be destroyed. Pilot testing of M55 rocket destruction systems would be conducted to comply with appropriate TSCA regulations on PCB monitoring and control. For the purposes of this assessment, it was assumed that the technology systems evaluated would achieve a PCB destruction efficiency of 99.9999%. For filtered stacks (i.e., CatOx/filter farm stack, SCWO stack, but not the product gas burner vent), further removal by carbon filtration was also assumed. These assumptions were not applicable for the Neut/Bio technology system, which only addresses ACW containing mustard (M55 rockets do not contain mustard).

For each emission source for each installation, the maximum on-post and off-post concentration locations were identified through air modeling. At each of the four stockpile locations, the proposed location for the ACWA facility that would result in the largest off-post concentrations was selected as the source location for modeling. This location was Area A for Anniston Army Depot (ANAD), Pine Bluff Arsenal (PBA), and Pueblo Chemical Depot (PCD) and Area B for Blue Grass Army Depot (BGAD). The Industrial Source Complex Short-Term 3 (ISCST3) model (U.S. Environmental Protection Agency [EPA] 1995) was used in conjunction with location-specific meteorological and topographical data and facility footprint information to generate on-post and off-post multipliers for each ACWA facility emission source (e.g., diesel generators, filter farm stack). The installation- and inventory-specific emission estimates were then multiplied by these factors to generate estimates of on-post and off-post maximum annual average concentrations attributable to each emission source for each ACWA technology system.

As a simplification useful for generating exposure estimates, it was assumed that the chemical-specific on-post and off-post air concentration estimates from each source (i.e., generators, boilers, and destruction facility stacks) could be added together to yield one maximum annual average on-post or off-post concentration. This procedure is equivalent to assuming that the stacks for each of these sources would be in the same location. This assumption would result in somewhat overestimated air concentration estimates. In actuality, the

concentrations would be lower than estimated, because the fact that emissions would be from sources that are close together, but not at exactly the same location, would result in some dilution.

To account for possible fluctuating conditions that could occur during operations, it was assumed that for 5% of the time the levels of organic compounds would be 10 times higher than the estimated annual average, and that for 20% of the time the levels of inorganic compounds would be 10 times higher than the estimated annual average. These assumptions were based on EPA guidance (EPA 1994, as cited in National Research Council 1997). The maximum annual average levels, increased to take fluctuating operations into account, were used as the input levels for exposure and risk assessment (see Section C.2).

No estimates of potential emission levels of the agents GB, VX, and mustard were available from demonstration testing. To assess potential impacts from low-level agent emissions during routine operations, it was assumed that an agent could hypothetically be continuously emitted from the stacks at the detection limits ($0.06 \mu\text{g}/\text{m}^3$ for GB and VX and $6 \mu\text{g}/\text{m}^3$ for mustard; Kimmell et al. 2001). In practice, the facility stacks would be equipped with continuous agent-monitoring devices that would sound if any agent were detected. The source would then be identified and eliminated. If agent were released from pilot facility processes, it is highly unlikely that it would be present continuously at a level just below the detection limit. A more likely scenario would be the occurrence of a short-term release at a level above the detection limit that could be detected and corrected.

A complete compilation of the estimated maximum annual average on-post and off-post concentrations of the various detected compounds associated with pilot testing of the four ACWA technology systems is provided in backup documentation for this environmental impact statement (Hartmann and Nieves 2001).

C.2 EXPOSURE AND RISK ESTIMATION

The estimated maximum annual average on-post and off-post contaminant air concentrations (Section C.1) were used to estimate exposures (intakes) by inhalation for hypothetical “maximum exposed individuals” (MEIs). Estimates for on-post exposures assumed the receptor would be a worker. The rationale for this assumption was that even though some residences are located on-post at the ACW storage locations, the maximum on-post airborne contaminant concentrations would occur quite close to the proposed pilot facility sites, where no residences are located. MEI worker exposure parameters assumed that the receptor was present at the location of maximum on-post air concentration for 8 hours per day, 250 days per year. For off-post general public exposures, the MEI receptor was assumed to be a resident present at the off-post location of maximum air concentration for 24 hours per day, 365 days per year. For cancer risk calculations, the number of years of exposure is used in estimating the total excess cancer risk. Since the length of pilot testing operations is unknown for each of the storage locations and technology systems evaluated, a worst-case assumption was made that the

exposure could occur for the length of time required to process the entire inventory. Specifically, the exposure duration assumptions were 9.1 years for ANAD, 1.8 years for PBA, 1.6 years for BGAD, and 2.7 years for PCD. These assumptions resulted in overestimates of cancer risk from the inhalation pathway for each technology at each site, since pilot testing would certainly occur over a shorter length of time.

This assessment was limited to the estimation of risks associated with inhalation of emitted substances. For some of the emitted substances (e.g., dioxins and furans, PCBs), exposure through other pathways, such as food-chain pathways or incidental soil ingestion, could be as large or larger than exposure through inhalation. Estimates of exposure through these other pathways can be highly uncertain and are beyond the scope of this evaluation. However, for all the technologies, the estimated emission rates for these substances are quite low (less than 0.00001 lb/yr for all forms of dioxins and furans and about 0.005 lb/yr or less for PCBs). For the purposes of this assessment (i.e., to compare the risks associated with pilot testing of the alternate ACWA technology systems), estimation of the risk associated with inhalation should be indicative of risk from all pathways.

The equation used to estimate inhalation intakes is as follows:

$$\text{Intake (mg/kg/d)} = (\text{CA} \times \text{IR} \times \text{ET} \times \text{EF} \times \text{ED}) / (\text{BW} \times \text{AT}),$$

where

CA = contaminant concentration in air (mg/m³),

IR = inhalation rate (m³/hr),

ET = exposure time (h/d),

EF = exposure frequency (d/yr),

ED = exposure duration (yr),

BW = body weight (70 kg), and

AT = averaging time (ED × 365 d/yr for noncarcinogenic effects; 70 × 365 d/yr for carcinogenic effects).

Exposure (intake) estimates were compared with cancer and noncancer toxicity values to generate estimates of increased cancer risk and of the potential for noncancer health impacts to the receptors. Cancer toxicity values (termed slope factors, in units of [mg/kg/d]⁻¹) and

noncancer toxicity values (termed reference doses, in units of mg/kg/d) used in this assessment were obtained from the EPA's Integrated Risk Information System (IRIS) (EPA 2000) for those chemicals included in that system. However, no slope factor or reference dose was available from IRIS for many of the chemicals detected during demonstration testing. For those substances, other sources of quantitative toxicity data (Smith et al. 1999; EPA 1997) were used in an effort to thoroughly estimate the risk associated with ACWA facility emissions. Still, many substances did not have quantitative toxicity data available from any of these sources (see Section C.3).

Toxicity values are specific to either inhalation exposure or oral exposure, but significantly fewer values are available for inhalation than for oral exposure. Again, in an effort to thoroughly estimate risks, when inhalation toxicity values were not available for a given chemical, oral slope factors or reference doses were used.

Table C.1 gives the complete list of substances detected during ACWA demonstration testing for the four technology systems and lists toxicity values used for risk estimation. The sources of those values are also provided. The complete compilation of substance- and technology-specific intake and risk estimates for on-post and off-post MEI receptors for each of the four storage locations is provided in backup documentation for this EIS (Hartmann and Nieves 2001).

Mustard is the only chemical agent present in ACW that is considered to be a carcinogen; GB and VX are not. Mustard has been classified as a known carcinogen (Agency for Toxic Substances and Disease Registry [ATSDR] 1992). Evidence of its carcinogenicity is indicated by (1) increased cancer incidence among factory workers who made mustard gas and other chemical agents; (2) a slight, but statistically significant, increased incidence of lung cancer deaths among World War I veterans exposed to mustard during combat (those studies did not control for cigarette smoking); and (3) two animal studies showing increased incidence of pulmonary tumors (ATSDR 1992). None of those studies was sufficiently extensive to establish a dose/response relationship for mustard-induced cancers.

The available data have generally been considered inadequate to estimate the carcinogenic potency (i.e., carcinogenic risk) of mustard (CDC 1988; ATSDR 1992). Nonetheless, because of a need to estimate potential risks to populations residing near military sulfur mustard stockpile locations, the EPA did use the available (although inadequate) data to estimate a carcinogenic unit risk for mustard inhalation of $0.085 (\mu\text{g}/\text{m}^3)^{-1}$ (EPA 1991). However, risk estimates generated from this value must be considered highly uncertain.

The typical benchmark indicator for a significant noncarcinogenic health risk is a hazard index (HI) greater than 1. The benchmark indicator for a significant increased lifetime carcinogenic risk is in the range of 1×10^{-6} and 1×10^{-4} (one in 1 million to one in 10,000), which is the target used by the EPA to determine whether cleanup of hazardous waste sites is warranted (EPA 1990). Any increased carcinogenic risk of less than 1×10^{-6} is generally

TABLE C.1 Toxicity Values for All Detected Substances for the Four Technology Systems

Chemical	Inhalation Unit Risk ($\mu\text{g}/\text{m}^3$) ⁻¹	Inhalation Slope Factor ($\text{mg}/\text{kg}/\text{d}$) ⁻¹	Notes ^a	Inhalation Reference Concentration (mg/m^3)	Inhalation Reference Dose ($\text{mg}/\text{kg}/\text{d}$)	Notes ^a	Technology System ^b
(R)-(-)-2,2-Dimethyl-1,3-dioxolane-4-methanol	- ^c	-	-	-	-	-	3
1,1,1-Trichloroethane	-	-	-	1	2.9×10^{-1}	J; CA	1, 3
1,1-Dichloroethene	-	-	-	2.0×10^{-2}	5.7×10^{-3}	J; CA	4
1,2,3,4,6,7,8,9-OCDD	3.3×10^{-2}	1.2×10^2	B	-	1.0×10^{-6}	B	1
1,2,3,4,6,7,8,9-OCDF	3.3×10^{-2}	1.2×10^2	B	-	1.0×10^{-6}	B	1
1,2,3,4,6,7,8-HpCDD	3.3×10^{-1}	1.2×10^3	B	-	1.0×10^{-7}	B	1, 3
1,2,3,4,6,7,8-HpCDF	3.3×10^{-1}	1.2×10^3	B	-	1.0×10^{-7}	B	1, 3
1,2,3,4,7,8,9-HpCDD	3.3×10^{-1}	1.2×10^3	B	-	1.0×10^{-7}	B	1
1,2,3,4,7,8-HxCDD	3.3	1.2×10^4	B	-	1.0×10^{-8}	B	1
1,2,3,4,7,8-HxCDF	3.3	1.2×10^4	B	-	1.0×10^{-8}	B	1, 3
1,2,3,6,7,8-HxCDD	3.3	1.2×10^4	B	-	1.0×10^{-8}	B	1, 3
1,2,3,6,7,8-HxCDF	3.3	1.2×10^4	B	-	1.0×10^{-8}	B	1, 3
1,2,3,7,8,9-HxCDD	3.3	1.2×10^4	B	-	1.0×10^{-8}	B	1, 3
1,2,3,7,8,9-HxCDF	3.3	1.2×10^4	B	-	1.0×10^{-8}	B	1
1,2,3,7,8-PeCDD	1.7×10^1	5.8×10^4	B	-	2.0×10^{-9}	B	1, 3
1,2,3,7,8-PeCDF	1.7	5.8×10^3	B	-	2.0×10^{-8}	B	1
1,2,4-Trimethylbenzene	-	-	B	-	-	-	3
1,2-Dichloroethane	2.6×10^{-5}	9.1×10^{-2}	-	8.1×10^{-1}	2.3×10^{-1}	J; AT	1
1,2-Dichloropropane	4.0×10^{-3}	14	-	4.0×10^{-3}	1.2×10^{-3}	-	1
1,3-Butadiene	2.8×10^{-4}	9.8×10^{-1}	-	8.0×10^{-3}	2.3×10^{-3}	J; CA	1, 2, 3, 4
1,4-Dichlorobenzene	-	-	-	8.0E-01	2.3×10^{-1}	-	1, 3
1,5-Pentenediol, dinitrate	-	-	-	-	-	-	4
1-Butanol, 3-methyl-, nitrate	-	-	-	-	-	-	4
1-Ethyl-2,2,6-trimethylcyclohexane	-	-	-	-	-	-	3
1-Hexanol, 2-ethyl-	-	-	-	-	-	-	3
1H-Indene	-	-	-	-	-	-	3
1H-Indene, 2,3-dihydro-	-	-	-	-	-	-	3
1-Propene, 3,3,3-trichloro-	-	-	-	-	-	-	3
2-(2-Butoxyethoxy) ethanol	-	-	-	-	-	-	3
2,3,4,6,7,8-HxCDF	3.3	1.2×10^4	B	-	1.0×10^{-8}	B	1
2,3,4,7,8-PeCDF	1.7×10^{-1}	5.8×10^4	B	-	2.0×10^{-9}	B	1, 3
2,3,7,8-TCDD	33	1.2×10^5	J; HE	-	1.0×10^{-9}	A	1
2,3,7,8-TCDF	3.3	1.2×10^4	B	-	1.0×10^{-8}	B	1, 3
2,4-Dimethylphenol	-	-	-	-	-	-	3
2-Butanone	-	-	-	1	2.9×10^{-1}	J	3
2-Heptanone	-	-	-	-	-	-	4
2-Hexanone	-	-	-	-	-	-	4
2-Methylnaphthalene	-	-	-	-	-	-	1, 2, 3, 4
2-Nitrophenol	-	-	-	-	-	-	3
2-Octanone	-	-	-	-	-	-	4
2-Pentanol, nitrate	-	-	-	-	-	-	4
3/4-Methyl phenol	-	-	-	-	5.0×10^{-2}	A	1
3-Methylchloranthrene	2.1×10^{-3}	7.4	J; CA	-	-	-	1, 2, 3, 4
4-Methyl-2-pentanone	-	-	-	-	-	-	4

TABLE C.1 (Cont.)

Chemical	Inhalation Unit Risk ($\mu\text{g}/\text{m}^3$) ⁻¹	Inhalation Slope Factor ($\text{mg}/\text{kg}/\text{d}$) ⁻¹	Notes ^a	Inhalation Reference Concentration (mg/m^3)	Inhalation Reference Dose ($\text{mg}/\text{kg}/\text{d}$)	Notes ^a	Technology System ^b
4-Octene, (E)-	-	-	-	-	-	-	4
9H-Fluoren-9-one	-	-	-	-	-	-	3
Acenaphthene	-	-	-	-	6.0×10^{-2}	A; J	1, 2, 3, 4
Acenaphthylene	-	-	-	-	-	-	1, 2, 3, 4
Acetaldehyde	2.2×10^{-6}	7.7×10^{-3}	-	9.0×10^{-3}	2.6×10^{-3}	-	1, 2, 3, 4
Acetamide, N,N-dimethyl-	-	-	-	-	-	-	4
Acetic acid	-	-	-	-	-	-	3, 4
Acetone	-	-	-	-	1.0×10^{-1}	A; J	3, 4
Acrolein	-	-	-	2.0×10^{-5}	5.7×10^{-6}	-	1, 2, 3, 4
Aldehydes	-	-	-	-	-	-	1, 2, 3, 4
Aluminum	-	-	-	-	-	-	3
Anthracene	-	-	-	-	3.0×10^{-1}	A	1, 2, 3, 4
Antimony	-	-	-	2.0×10^{-4}	5.7×10^{-5}	-	2, 3
Arsenic	4.3×10^{-3}	1.5×10^1	-	3.0×10^{-5}	8.6×10^{-6}	J; CA	1, 2, 3, 4
Barium	-	-	-	-	7.0×10^{-2}	A	1, 2, 3, 4
Benz(a)anthracene	1.1×10^{-4}	4.0×10^{-1}	J; CA	-	-	-	1, 2, 3, 4
Benzaldehyde	-	-	-	-	1.0×10^{-1}	A; J	3
Benzaldehyde, 4-ethyl-	-	-	-	-	-	-	3
Benzaldehyde, ethyl-	-	-	-	-	-	-	3
Benzaldehyde, ethyl- benzenemethanol, 4-(1-methylethyl)	-	-	-	-	-	-	3
Benzene	7.8×10^{-6}	2.7×10^{-2}	-	6.0×10^{-2}	1.7×10^{-2}	-	1, 2, 3, 4
Benzene, 1,2,3-trimethyl-	-	-	-	-	-	-	3
Benzene, 1,2,4,5-tetramethyl-	-	-	-	-	-	-	3
Benzene, 1-methyl-2-propyl-	-	-	-	-	-	-	3
Benzene, 1-methyl-3-propyl-	-	-	-	-	-	-	3
Benzo(a)pyrene	1.1×10^{-3}	3.9	J; CA	-	-	-	1, 2, 3, 4
Benzo(b)fluoranthene	1.1×10^{-4}	4.0×10^{-1}	J; CA	-	-	-	1, 2, 3, 4
Benzo(g,h,i)perylene	-	-	-	-	-	-	1, 2, 3, 4
Benzo(k)fluoranthene	1.1×10^{-4}	4.0×10^{-1}	J; CA	-	-	-	1, 2, 3, 4
Benzyl alcohol	-	-	-	-	-	-	3
Beryllium	2.4×10^{-3}	8.4	-	2.0×10^{-5}	5.7×10^{-6}	-	1, 2, 3, 4
Bis (2-chloroethyl) ether	3.3×10^{-4}	1.2	-	NA ^c	-	-	1
Bis (2-ethylhexyl) phthalate	2.4×10^{-6}	8.4×10^{-3}	J; CA	1.0×10^{-2}	2.9×10^{-3}	J; CA	1, 3, 4
Bromomethane	-	-	-	5.0×10^{-3}	1.4×10^{-3}	-	1
Butanal	-	-	-	-	-	-	3
Butane	-	-	-	-	-	-	1, 2, 3, 4
C3-Alkyl benzenes	-	-	-	-	-	-	3
Cadmium	1.8×10^{-3}	6.3	-	1.0×10^{-5}	2.9×10^{-6}	J; CA	1, 2, 3, 4
Calcium	-	-	-	-	-	-	3
Carbon disulfide	-	-	-	7.0×10^{-1}	2.0×10^{-1}	-	1, 3, 4
Carbon tetrachloride	1.5×10^{-5}	5.3×10^{-2}	-	4.0×10^{-2}	1.1×10^{-2}	J; CA	1
Chlorobenzene	-	-	-	2.0×10^{-2}	5.7×10^{-3}	J; HE	1
Chloroethane	-	-	-	10	2.9	J	1, 4
Chloroform	2.3×10^{-5}	8.1×10^{-3}	J	1.0×10^{-1}	2.8×10^{-2}	J; AT	1, 3, 4

TABLE C.1 (Cont.)

Chemical	Inhalation Unit Risk ($\mu\text{g}/\text{m}^3$) ⁻¹	Inhalation Slope Factor ($\text{mg}/\text{kg}/\text{d}$) ⁻¹	Notes ^a	Inhalation Reference Concentration (mg/m^3)	Inhalation Reference Dose ($\text{mg}/\text{kg}/\text{d}$)	Notes ^a	Technology System ^b
Chloromethane	1.8×10^{-6}	6.3×10^{-3}	HE	1.0×10^{-1}	2.9×10^{-2}	J; AT	1, 4
Chromium	1.2×10^{-2}	4.2×10^1	-	1.0×10^{-4}	2.9×10^{-5}	-	1, 2, 3, 4
Chrysene	1.1×10^{-5}	3.9×10^{-2}	J; CA	-	-	-	1, 2, 3, 4
Cobalt	-	-	-	-	-	-	1, 2, 3, 4
Copper	-	-	-	-	-	-	1, 2, 3, 4
Cyclododecane	-	-	-	-	-	-	3
Cyclohexane, 1,2,3-trimethyl-	-	-	-	-	-	-	4
Cyclohexane, 2-butyl-1,1,3-trimethyl-	-	-	-	-	-	-	3
Cyclohexane, butyl-	-	-	-	-	-	-	3
Cyclohexane, hexyl-	-	-	-	-	-	-	3
Cyclohexane, propyl-	-	-	-	-	-	-	3
Cyclohexanol	-	-	-	-	-	-	3
Cyclohexanone	-	-	-	-	5.0	A; J	3
Cyclohexasiloxane, dodecamethyl-	-	-	-	-	-	-	3
Cyclotetrasiloxane, octamethyl-	-	-	-	-	-	-	3, 4
Decane	-	-	-	-	-	-	3, 4
Decane, 2,6,7-trimethyl-	-	-	-	-	-	-	3
Decane, 2-methyl-	-	-	-	-	-	-	3
Decane, 3-methyl-	-	-	-	-	-	-	3
Decane, 4-methyl-	-	-	-	-	-	-	3
Decane, 5-methyl-	-	-	-	-	-	-	3
Decanenitrile	-	-	-	-	-	-	4
Dibenz(a,h)anthracene	3.9×10^{-4}	1.4	J; CA	-	-	-	1, 2, 3, 4
Dibenzofuran	-	-	-	-	-	-	1, 3
Dichlorobenzene	-	-	-	8.0×10^{-1}	2.3×10^{-1}	-	1, 2, 3, 4
Diethylene glycol	-	-	-	-	-	-	3
Diethylphthalate	-	-	-	-	8.0×10^{-1}	A	1, 3
Dimethylbenz(a)anthracene	2.4×10^{-2}	8.4×10^1	J; CA	-	8.0×10^{-1}	A; J	1, 2, 3, 4
Dimethylphthalate	-	-	-	-	-	-	1
Di-n-butylphthalate	-	-	-	-	1.0×10^{-1}	A; J	3
Diphenylmethane	-	-	-	-	-	-	3
Dodecane	-	-	-	-	-	-	3, 4
Dodecane, 2,6,10-trimethyl-	-	-	-	-	-	-	3
Dodecane, 4-methyl-	-	-	-	-	-	-	3
Dodecane, 6-methyl-	-	-	-	-	-	-	3
Ethane	-	-	-	-	-	-	1, 2, 3, 4
Ethanol, 2-(2-butoxyethoxy)-, acetate	-	-	-	-	-	-	3
Ethanone, 1-(3-methylphenyl)-	-	-	-	-	-	-	3
Ethanone, 1-phenyl-	-	-	-	-	-	-	3
Ether	-	-	-	-	-	-	3
Ethyl benzene	-	-	-	1.0	2.9×10^{-1}	J	1, 2, 3, 4
Ethylene glycol	-	-	-	4.0×10^{-1}	1.1×10^{-1}	J; CA	3
Fluoranthene	-	-	-	-	4.0×10^{-2}	A	1, 2, 3, 4
Fluorene	-	-	-	-	4.0×10^{-2}	A	2, 3, 4
Formaldehyde	1.3×10^{-5}	5.0×10^{-3}	-	4.0×10^{-3}	1.1×10^{-3}	J; AT	1, 2, 3, 4

TABLE C.1 (Cont.)

Chemical	Inhalation Unit Risk ($\mu\text{g}/\text{m}^3$) ⁻¹	Inhalation Slope Factor ($\text{mg}/\text{kg}/\text{d}$) ⁻¹	Notes ^a	Inhalation Reference Concentration (mg/m^3)	Inhalation Reference Dose ($\text{mg}/\text{kg}/\text{d}$)	Notes ^a	Technology System ^b
GB	-	-	-	3.0×10^{-6}	8.6×10^{-7}	I	2, 3, 4
Glycol ethers (2-butoxy ethanol)	-	-	-	2.0×10^{-2}	5.7×10^{-3}	C	1
HCl	-	-	-	2.0×10^{-2}	5.7×10^{-3}	J	3
Heptadecane	-	-	-	-	-	-	3
Heptanal	-	-	-	-	-	-	3, 4
Heptane, 3-ethyl-2-methyl-	-	-	-	-	-	-	3
Heptanenitrile	-	-	-	-	-	-	4
Hexadecane	-	-	-	-	-	-	4
Hexadecane, 2,6,10,14-tetramethyl-	-	-	-	-	-	-	3
Hexanal	-	-	-	-	-	-	3
Hexane(n)	-	-	-	2.0×10^{-1}	5.7×10^{-2}	-	1, 2, 3, 4
Hexanenitrile	-	-	-	-	-	-	4
HF	-	-	-	3.0×10^{-2}	8.6×10^{-3}	J; CA	3
Hydrogen cyanide	-	-	-	3.0×10^{-3}	8.6×10^{-4}	J	3
Hydrogen sulfide	-	-	-	1.0×10^{-3}	2.9×10^{-4}	J	3
Indeno(1,2,3-cd)pyrene	1.1×10^{-4}	4.0×10^{-1}	J; CA	-	-	-	1, 2, 3, 4
Iron	-	-	-	-	-	-	3
Isobutyl alcohol	-	-	-	-	3.0×10^{-1}	A; J	3
Isopropyl nitrate	-	-	-	-	-	-	4
Lead	1.2×10^{-5}	4.2×10^{-2}	J; CA	1.5×10^{-3}	4.3×10^{-4}	D	1, 2, 3, 4
Magnesium	-	-	-	-	-	-	3
Malonic acid	-	-	-	-	-	-	3
Manganese	-	-	-	5.0×10^{-5}	1.4×10^{-5}	-	1, 2, 3, 4
Mercury	-	-	-	3.0×10^{-4}	8.6×10^{-5}	-	1, 2, 3, 4
Methyl ethyl ketone/butyraldehydes	-	-	-	1.0	2.9×10^{-1}	-	1, 2
Methylene chloride	4.7×10^{-7}	1.6×10^{-3}	-	3.0	8.6×10^{-1}	J; HE	1, 3, 4
Molybdenum	-	-	-	-	5.0×10^{-3}	A	1, 2, 3, 4
MPA	-	-	-	-	-	-	4
m-Tolualdehyde	-	-	-	-	-	-	3
Mustard	8.5×10^{-2}	3.0×10^2	G	1.0×10^{-4}	2.9×10^{-5}	I	1, 2, 3, 4
Naphthalene	-	-	-	3.0×10^{-3}	8.6×10^{-4}	-	1, 2, 3, 4
Naphthalene, 1,2,3,4-tetrahydro-	-	-	-	-	-	-	3
Naphthalene, 1,2,3,4-tetrahydro- 6-methyl-	-	-	-	-	-	-	3
Naphthalene, 1,7-dimethyl-	-	-	-	-	-	-	3
Naphthalene, 1-methyl	-	-	-	-	-	-	3
Nickel	4.8×10^{-4}	1.7	H	2.0×10^{-4}	5.7×10^{-5}	J; AT	1, 2, 3, 4
Nitric acid esters	-	-	-	-	-	-	4
Nitric acid, butyl ester	-	-	-	-	-	-	4
Nitric acid, decyl ester	-	-	-	-	-	-	4
Nitric acid, ethyl ester	-	-	-	-	-	-	4
Nitric acid, hexyl ester	-	-	-	-	-	-	4
Nitric acid, nonyl ester	-	-	-	-	-	-	4
Nitric acid, pentyl ester	-	-	-	-	-	-	4
Nitric acid, propyl ester	-	-	-	-	-	-	4

TABLE C.1 (Cont.)

Chemical	Inhalation Unit Risk ($\mu\text{g}/\text{m}^3$) ⁻¹	Inhalation Slope Factor ($\text{mg}/\text{kg}/\text{d}$) ⁻¹	Notes ^a	Inhalation Reference Concentration (mg/m^3)	Inhalation Reference Dose ($\text{mg}/\text{kg}/\text{d}$)	Notes ^a	Technology System ^b
Nitrobenzene	-	-	-	-	5.7×10^{-4}	J; HE	3
Nonanal	-	-	-	-	-	-	4
Nonane, 2,6-dimethyl-	-	-	-	-	-	-	3
Nonane, 3,7-dimethyl-	-	-	-	-	-	-	3
Nonane, 3-methyl-	-	-	-	-	-	-	3
Nonanenitrile	-	-	-	-	-	-	4
n-Propylbenzene	-	-	-	-	-	-	3
OCDD	3.3×10^{-2}	1.2×10^2	B	-	1.0×10^{-6}	B	1
OCDF	3.3×10^{-2}	1.2×10^2	B	-	1.0×10^{-6}	B	1
Octanal	-	-	-	-	-	-	4
Octane, 2,6-dimethyl-	-	-	-	-	-	-	3
Octane, 3,6-dimethyl-	-	-	-	-	-	-	3
Octane, 3-methyl-	-	-	-	-	-	-	3
Octanenitrile	-	-	-	-	-	-	4
Particulates	-	-	-	1.5×10^{-2}	4.3×10^{-3}	E	1, 2
p-Creosol (4-methylphenol)	-	-	-	-	-	-	2
Pentadecane	-	-	-	-	-	-	3, 4
Pentanal	-	-	-	-	-	-	3
Pentane(n)	-	-	-	-	-	-	1, 2, 3, 4
Phenanthrene	-	-	-	-	-	-	1, 2, 3, 4
Phenol	-	-	-	6.0×10^{-1}	1.7×10^{-1}	J; CA	1, 3
Phosphorus	-	-	-	-	-	-	1, 2, 3
Polychlorinated biphenyls	1.0×10^{-4}	3.5×10^{-1}	-	-	-	-	2, 3, 4
Polycyclic aromatic hydrocarbons (PAHs)	1.1×10^{-3}	3.9	C	-	-	-	1, 2, 3, 4
Polycyclic organic matter (fluorene)	-	-	-	-	-	-	1
Potassium	-	-	-	-	-	-	3
Propanal (propionaldehyde)	-	-	-	-	-	-	1, 3
Propane	-	-	-	-	-	-	1, 2, 3, 4
Propylene	-	-	-	-	-	-	1, 2, 3, 4
Pyrene	-	-	-	-	3.0×10^{-2}	A	1, 2, 3, 4
Selenium	-	-	-	-	5.0×10^{-3}	A	1, 2, 3, 4
Silver	-	-	-	-	5.0×10^{-3}	A; J	3
Sodium	-	-	-	-	-	-	3
Styrene	-	-	-	1.0	2.9×10^{-1}	J	1, 3
Sulfur, mol. (S8)	-	-	J; CA	-	-	-	3
Tetrachloroethene	5.9×10^{-6}	2.1×10^{-2}	J; CA	3.0×10^{-1}	7.7×10^{-2}	J; AT	1, 3
Tetradecane	-	-	-	-	-	-	3, 4
Thallium	-	-	-	-	8.0×10^{-5}	A; J	3
Tin	-	-	-	-	-	-	3
Toluene	-	-	-	4.0×10^{-1}	1.1×10^{-1}	-	1, 2, 3, 4
Total HpCDD	3.3×10^{-2}	1.2×10^2	B	-	1.0×10^{-6}	A; B	1, 3
Total HpCDF	3.3×10^{-1}	1.2×10^2	B	-	1.0×10^{-7}	A; B	1, 2, 3
Total HxCDD	3.3	1.2×10^5	B	-	1.0×10^{-8}	A; B	1, 3
Total HxCDF	3.3	1.2×10^5	B	-	1.0×10^{-8}	A; B	1, 3

TABLE C.1 (Cont.)

Chemical	Inhalation Unit Risk ($\mu\text{g}/\text{m}^3$) ⁻¹	Inhalation Slope Factor ($\text{mg}/\text{kg}/\text{d}$) ⁻¹	Notes ^a	Inhalation Reference Concentration (mg/m^3)	Inhalation Reference Dose ($\text{mg}/\text{kg}/\text{d}$)	Notes ^a	Technology System ^b
Total PeCDD	1.7×10^1	5.8×10^5	B	-	2.0×10^{-9}	A; B	1, 3
Total PeCDF	1.7×10^1	5.8×10^5	B	-	2.0×10^{-9}	A; B	1, 3
Total TCDD	3.3×10^1	1.2×10^6	B	-	1.0×10^{-9}	A; B	1, 2, 3
Total TCDF	3.3	1.2×10^5	J; CA	-	1.0×10^{-8}	A; B	1, 3
Trichloroethene	2.0×10^{-6}	7.0×10^{-3}	J; CA	6.0×10^{-1}	1.7×10^{-1}	J; CA	3, 4
Tridecane	-	-	-	-	-	-	3, 4
Tridecane, 2-methyl-	-	-	-	-	-	-	3
Tridecane, 4-methyl-	-	-	-	-	-	-	3
Tridecane, 6-propyl-	-	-	-	-	-	-	3
Undecane	-	-	-	-	-	-	3, 4
Undecane, 2,10-dimethyl-	-	-	-	-	-	-	3
Undecane, 2,6-dimethyl-	-	-	-	-	-	-	3
Undecane, 2-methyl-	-	-	-	-	-	-	3
Undecane, 3,6-dimethyl-	-	-	-	-	-	-	3
Undecane, 4-methyl-	-	-	-	-	-	-	3
Vanadium	-	-	-	-	9.0×10^{-3}	A; F	1, 2, 3, 4
Vinyl chloride	8.6×10^{-5}	0.3	J; HE	5.0×10^{-3}	1.4×10^{-3}	J; CA	4
VX	-	-	-	3.0×10^{-6}	8.6×10^{-7}	I	2, 3, 4
Xylenes	-	-	-	-	2.0	A; J	3, 4
m-Xylene	-	-	-	4.3×10^{-1}	1.2×10^{-1}	-	2
m,p-Xylene	-	-	-	4.3×10^{-1}	1.2×10^{-1}	J; AT	1, 2, 3, 4
o-Xylene	-	-	-	-	2.0	A	1
p-Xylene	-	-	-	-	2.0	A; J	3
Zinc	-	-	-	-	3.0×10^{-1}	A	1, 2
Total = 245							

^a Notes:

A = Oral RfD used as a surrogate for the inhalation RfD.

B = Toxicity equivalence factors for dioxins and furans obtained from EPA (2001).

C = Value for B[a]P assigned.

D = The quarterly average NAAQS for lead is used as the RfC.

E = RfD value for particulates is the NAAQS for PM_{2.5}.

F = IRIS value for vanadium pentoxide.

G = Unit risk for mustard given in EPA (1991).

H = IRIS value for nickel subsulfide is used.

I = Allowable 72-hour concentration for general public (CDC 1988).

J = As given in Smith et al. (1999).

AT = ATSDR minimum risk level.

CA = California EPA.

HE = Health Effects Summary Tables (EPA 1997).

^b Indicates the technology system for which this substance was detected during demonstration testing: 1 = Neut/Bio; 2 = Neut/SCWO; 3 = Neut/GPCR/TW-SCWO; 4 = Elchem Ox.

^c A hyphen means the substance was not detected.

Source: where not otherwise noted, values are from IRIS (EPA 2000).

considered negligible; even larger risks up to about 1×10^{-4} are often considered to be tolerable. The noncarcinogenic and carcinogenic risk estimates for ACWA facility emissions at the four storage locations are summarized in Table C.2. The risk estimates are all well below the benchmark indicators for significant risk (i.e., HIs considerably less than one and carcinogenic risks considerably less than 1×10^{-6}). Note that exposures and risks are slightly higher for the off-post MEIs than for the on-post MEIs because the annual exposure duration for the off-post MEI is assumed to be longer.

Much of the estimated noncarcinogenic and carcinogenic risk shown in Table C.2 is associated with boiler and diesel generator emissions rather than with destruction facility processes. For example, 90% of the HI of 0.002 calculated for the Neut/SCWO technology system at ANAD was contributed by five substances (acrolein, cadmium, chromium, formaldehyde, and nickel) that would be emitted primarily from the boilers and generators. Similarly, of the excess cancer risk of 3×10^{-8} reported, about 90% would be contributed by four substances primarily emitted from boilers (arsenic, cadmium, chromium, and nickel).

Some uncertainties in the demonstration test data used to estimate emissions of toxic air pollutants should be considered in interpreting the results. For example, some unit operations were not characterized in demonstration testing, so trace effluents were not estimated for all unit operations that would make up the complete systems. Generally, data were available for unit operations that would be expected to generate the most gaseous emissions during actual operations (Mitretek 2000a–d). However, the emission levels and health risk estimates provided here should be considered only indicative of likely levels. They may need to be revised as technology designs near completion and as estimates of process efficiencies become more reliable (Kimmell et al. 2001). Nevertheless, the values used for the risks from operations presented in this EIS were designed to be very conservative (i.e., potentially resulting in overestimates of risk) and to bound minor variations in the way that the ACWA destruction systems would be engineered.

C.3 SUBSTANCES FOR WHICH QUANTITATIVE TOXICITY DATA WERE UNAVAILABLE

Many of the substances detected in demonstration testing do not have established (i.e., peer-reviewed) toxicity benchmark levels available to allow quantitative risk of exposures (see Table C.3). For Neut/Bio operations, 17 of the 107 detected chemicals (16%) did not have established noncarcinogenic or carcinogenic toxicity benchmark levels. For Neut/SCWO operations, 14 of the 63 detected chemicals (22%) did not have established toxicity benchmark levels. For Neut/GPCR/TW-SCWO operations, 99 of the 188 detected chemicals (53%) did not have established toxicity benchmark levels. For Elchem Ox operations, 50 of the 103 detected chemicals (49%) did not have established toxicity benchmark levels. For most of the substances for which toxicity could not be quantitatively evaluated, emission levels would be very low (e.g., less than 10 g/d). These low emissions would be associated with very low overall ambient

TABLE C.2 Summary of Noncarcinogenic and Carcinogenic Risk Estimates for the Four Technologies at the Four Storage Sites^a

Human Health Impacts ^c	Neut/Bio ^b				Neut/SCWO			
	ANAD	PBA	PCD	BGAD	ANAD	PBA	PCD	BGAD
<i>Hazard Index (HI of <1 means adverse health impacts are unlikely)</i>								
MEI ^d in off-post general public, nerve agent	NA ^d	NA	NA	NA	2×10^{-3}	7×10^{-3}	NA	4×10^{-4}
MEI in off-post general public, mustard agent	3×10^{-3}	NA	1×10^{-3}	9×10^{-5}	2×10^{-3}	NA	7×10^{-4}	2×10^{-5}
MEI in on-post population, nerve agent	NA	NA	NA	NA	2×10^{-4}	6×10^{-4}	NA	8×10^{-5}
MEI in on-post population, mustard agent	3×10^{-4}	NA	3×10^{-4}	2×10^{-5}	2×10^{-4}	NA	1×10^{-4}	6×10^{-6}
<i>Increased lifetime carcinogenic risk (risk of 10^{-6} is generally considered negligible)</i>								
MEI in off-post general public, nerve agent	NA	NA	NA	NA	3×10^{-8}	2×10^{-8}	NA	9×10^{-10}
MEI in off-post general public, mustard agent	8×10^{-9}	NA	5×10^{-9}	1×10^{-10}	7×10^{-9}	NA	3×10^{-9}	3×10^{-11}
MEI in on-post population, nerve agent	NA	NA	NA	NA	2×10^{-9}	2×10^{-9}	NA	2×10^{-10}
MEI in on-post population, mustard agent	2×10^{-9}	NA	3×10^{-9}	3×10^{-11}	5×10^{-10}	NA	6×10^{-10}	1×10^{-11}
<i>Increased lifetime carcinogenic risk to population due to worst-case mustard emissions^e</i>								
Off-post	2×10^{-7}	NA	2×10^{-7}	2×10^{-9}	2×10^{-7}	NA	2×10^{-7}	2×10^{-9}
On-post	1×10^{-8}	NA	7×10^{-9}	4×10^{-10}	1×10^{-8}	NA	1×10^{-8}	4×10^{-10}

TABLE C.2 (Cont.)

Human Health Impacts ^c	Neut/GPCR/TW-SCWO				Elchem Ox			
	ANAD	PBA	PCD	BGAD	ANAD	PBA	PCD	BGAD
Hazard Index (HI of <1 means adverse health impacts are unlikely)								
MEI ^c in off-post general public, nerve agent	3×10^{-3}	5×10^{-3}	NA	2×10^{-3}	5×10^{-3}	7×10^{-4}	NA	3×10^{-4}
MEI in off-post general public, mustard agent	5×10^{-4}	NA	NA	4×10^{-5}	2×10^{-3}	NA	NA	2×10^{-5}
MEI in on-post population, nerve agent	2×10^{-3}	6×10^{-4}	NA	1×10^{-3}	4×10^{-4}	5×10^{-5}	NA	9×10^{-5}
MEI in on-post population, mustard agent	3×10^{-4}	NA	NA	1×10^{-5}	2×10^{-4}	NA	NA	7×10^{-6}
Increased lifetime carcinogenic risk (risk of 10^{-6} is generally considered negligible)								
MEI in off-post general public, nerve agent	2×10^{-9}	4×10^{-9}	NA	1×10^{-9}	5×10^{-8}	2×10^{-9}	NA	1×10^{-9}
MEI in off-post general public, mustard agent	7×10^{-10}	NA	NA	6×10^{-11}	6×10^{-9}	NA	NA	4×10^{-11}
MEI in on-post population, nerve agent	3×10^{-9}	2×10^{-10}	NA	3×10^{-10}	5×10^{-9}	2×10^{-10}	NA	3×10^{-10}
MEI in on-post population, mustard agent	7×10^{-10}	NA	NA	2×10^{-11}	5×10^{-10}	NA	NA	1×10^{-11}
Increased lifetime carcinogenic risk to population due to worst-case mustard emissions^e								
Off-post	2×10^{-7}	NA	NA	2×10^{-9}	2×10^{-7}	NA	NA	2×10^{-9}
On-post	1×10^{-8}	NA	NA	4×10^{-10}	1×10^{-8}	NA	NA	4×10^{-10}

^a Based on emission estimates from demonstration testing (Kimmell et al. 2001) and model estimates of maximum on-post and off-post concentrations and adjusted to account for fluctuating operations. ISCST3 model was used. Estimates for general public assumed 24-h/d exposures for the duration of operations. Estimates for the on-post population assumed 8-h/d exposures and 250-d/yr for the duration of operations. Potential noncarcinogenic impacts from some detected chemicals could not be evaluated quantitatively because toxicity data were not available. For Neut/Bio, Neut/SCWO, Neut/GPCR/TW-SCWO, and Elchem Ox, 17 of 107, 14 of 63, 99 of 188, and 50 of 103 chemicals, respectively, could not be quantitatively evaluated for either noncarcinogenic or carcinogenic effects.

^b For Neut/Bio, the value shown assumes no further treatment of emissions from the biotreatment vent after they have been processed in the immobilized cell bioreactor (ICB) unit. This risk is only slightly higher (generally less than a factor of 10) than the risk when treatment of biovent emissions is assumed.

^c From all technologies, carcinogenic risks are less than 10^{-6} and hazard indexes are less than 0.01, all in the negligible range. Although calculated cancer risks range from approximately 10^{-10} to 10^{-7} , and calculated hazard indexes range from 10^{-4} to 10^{-2} , there is no significant difference in risk among the technologies. In other words, for all the technologies, increased cancer and noncancer risks from inhalation of emissions are in the range considered to be negligible.

^d MEI = maximum exposed individual; NA = not applicable.

^e Although the facilities would be designed to operate without mustard releases, these values were estimated as a worst case by assuming continuous emission at the detection limit (Kimmell et al. 2001). The estimated concentrations are all 1% or less of the allowable concentrations for general population exposures.

TABLE C.3 List of Substances with No Toxicity Values and Associated Maximum Concentrations^a

Chemical	Highest Concentration ($\mu\text{g}/\text{m}^3$)			Technology ^b for Maximum Concentration	Technology Systems ^b in Which Detected
	Mustard Processing	GB Processing	VX Processing		
(R)-(-)-2,2-Dimethyl-1,3-dioxolane-4-methanol	2.9×10^{-14}	-	-	3	3
1,2,4-Trimethylbenzene	-	7.7×10^{-15}	2.7×10^{-12}	3	3
1,5-Pentanediol, dinitrate	-	3.2×10^{-12}	2.1×10^{-12}	4	4
1-Butanol, 3-methyl-, nitrate	-	1.4×10^{-11}	9.1×10^{-12}	4	4
1-Ethyl-2,2,6-trimethylcyclohexane	-	-	2.0×10^{-12}	3	3
1-Hexanol, 2-ethyl-	4.6×10^{-4}	2.8×10^{-4}	1.3×10^{-10}	3	3
1H-Indene	1.1×10^{-4}	7.0×10^{-5}	9.8×10^{-10}	3	3
1H-Indene, 2,3-dihydro-	-	4.6×10^{-14}	-	3	3
1-Propene, 3,3,3-trichloro-	4.9×10^{-15}	-	-	3	3
2-(2-Butoxyethoxy)ethanol	-	-	2.3×10^{-12}	3	3
2,4-Dimethylphenol	4.5×10^{-5}	2.8×10^{-5}	3.6×10^{-10}	3	3
2-Heptanone	-	3.3×10^{-13}	2.1×10^{-13}	4	4
2-Hexanone	4.8×10^{-14}	3.3×10^{-12}	2.3×10^{-12}	4	4
2-Methylnaphthalene	8.1×10^{-7}	8.1×10^{-7}	8.1×10^{-7}	3	1, 2, 3, 4
2-Nitrophenol	-	5.1×10^{-15}	-	3	3
2-Octanone	1.1×10^{-14}	6.0×10^{-13}	4.2×10^{-13}	4	4
2-Pentanol, nitrate	-	2.0×10^{-11}	1.3×10^{-11}	4	4
4-Methyl-2-pentanone	3.5×10^{-14}	3.0×10^{-13}	3.4×10^{-13}	4	4
4-Octene, (E)-	1.6×10^{-14}	1.3×10^{-13}	1.5×10^{-13}	4	4
9H-Fluoren-9-one	-	2.7×10^{-12}	-	3	3
Acenaphthylene	9.5×10^{-7}	9.5×10^{-7}	9.5×10^{-7}	3	1, 2, 3, 4
Acetamide, N,N-dimethyl-	-	1.1×10^{-12}	6.9×10^{-13}	4	4
Acetic acid	-	-	7.5×10^{-13}	3	3, 4
Aldehydes	1.2×10^{-2}	1.2×10^{-2}	1.2×10^{-2}	3	1, 2, 3, 4
Aluminum	3.0×10^{-4}	1.8×10^{-4}	1.1×10^{-9}	3	3
Benzaldehyde, 4-ethyl-	3.6×10^{-5}	2.2×10^{-5}	2.8×10^{-7}	3	3
Benzaldehyde, ethyl-	2.2×10^{-5}	1.4×10^{-5}	3.9×10^{-6}	3	3
Benzaldehyde, ethyl-	2.1×10^{-5}	1.3×10^{-5}	3.7×10^{-6}	3	3
Benzene, 1,2,3-trimethyl-	-	-	5.2×10^{-13}	3	3
Benzene, 1,2,4,5-tetramethyl-	-	-	2.5×10^{-12}	3	3
Benzene, 1-methyl-2-propyl-	-	-	2.4×10^{-12}	3	3
Benzene, 1-methyl-3-propyl-	-	-	5.9×10^{-13}	3	3
Benzo(g,h,i)perylene	1.3×10^{-7}	1.3×10^{-7}	1.3×10^{-7}	3	1, 2, 3, 4
Benzyl alcohol	2.1×10^{-5}	1.7×10^{-5}	1.2×10^{-5}	3	3
Butanal	4.7×10^{-14}	7.8×10^{-15}	3.9×10^{-14}	3	3
Butane	7.1×10^{-2}	7.1×10^{-2}	7.1×10^{-2}	3	1, 2, 3, 4
C3-Alkyl benzenes	2.4×10^{-12}	4.8×10^{-13}	-	3	3
Calcium	5.9×10^{-4}	4.1×10^{-4}	3.0×10^{-5}	3	3
Cobalt	6.6×10^{-6}	6.2×10^{-6}	3.7×10^{-4}	3	1, 2, 3, 4
Copper	8.0×10^{-5}	9.6×10^{-5}	6.0×10^{-5}	3	1, 2, 3, 4
Cyclododecane	-	3.0×10^{-5}	3.7×10^{-5}	3	3
Cyclohexane, 1,2,3-trimethyl-	5.5×10^{-14}	4.6×10^{-13}	5.2×10^{-13}	4	4

TABLE C.3 (Cont.)

Chemical	Highest Concentration ($\mu\text{g}/\text{m}^3$)			Technology ^b for Maximum Concentration	Technology Systems ^b in Which Detected
	Mustard Processing	GB Processing	VX Processing		
Cyclohexane, 2-butyl-1,1,3-trimethyl-	-	-	4.7×10^{-13}	3	3
Cyclohexane, butyl-	2.1×10^{-13}	5.7×10^{-15}	3.7×10^{-12}	3	3
Cyclohexane, hexyl-	-	-	5.3×10^{-13}	3	3
Cyclohexane, propyl-	2.4×10^{-13}	-	-	3	3
Cyclohexanol	-	-	1.2×10^{-12}	3	3
Cyclohexasiloxane, dodecamethyl-	9.4×10^{-15}	-	-	3	3
Cyclotetrasiloxane, octamethyl-	4.9×10^{-5}	3.0×10^{-5}	1.0×10^{-5}	3	3, 4
Decane	1.0×10^{-12}	6.2×10^{-14}	1.5×10^{-11}	3	3, 4
Decane, 2,6,7-trimethyl-	-	5.1×10^{-15}	-	3	3
Decane, 2-methyl-	-	-	3.4×10^{-12}	3	3
Decane, 3-methyl-	2.5×10^{-13}	-	2.6×10^{-12}	3	3
Decane, 4-methyl-	3.4×10^{-15}	6.7×10^{-15}	1.9×10^{-12}	3	3
Decane, 5-methyl-	-	2.4×10^{-14}	-	3	3
Decanenitrile	1.3×10^{-14}	5.6×10^{-13}	4.1×10^{-13}	4	4
Dibenzofuran	-	1.1×10^{-5}	4.2×10^{-12}	3	1, 3
Diethylene glycol	-	-	7.0×10^{-12}	3	3
Dimethylphthalate	3.0×10^{-5}	1.8×10^{-5}	3.3×10^{-7}	3	1
Diphenylmethane	-	5.0×10^{-15}	-	3	3
Dodecane	2.0×10^{-5}	1.2×10^{-5}	2.7×10^{-5}	3	3, 4
Dodecane, 2,6,10-trimethyl-	-	7.1×10^{-15}	-	3	3
Dodecane, 4-methyl-	-	2.1×10^{-14}	-	3	3
Dodecane, 6-methyl-	3.8×10^{-15}	1.3×10^{-14}	1.8×10^{-12}	3	3
Ethane	1.0×10^{-1}	1.0×10^{-1}	1.0×10^{-1}	3	1, 2, 3, 4
Ethanol, 2-(2-butoxyethoxy)-, acetate	1.6×10^{-14}	2.4×10^{-14}	-	3	3
Ethanone, 1-(3-methylphenyl)-	-	7.6×10^{-15}	-	3	3
Ethanone, 1-phenyl-	-	5.5×10^{-14}	-	3	3
Ether	-	2.1×10^{-3}	2.7×10^{-5}	3	3
Heptadecane	-	1.7×10^{-14}	-	3	3
Heptanal	1.2×10^{-13}	2.8×10^{-13}	-	3	3, 4
Heptane, 3-ethyl-2-methyl-	-	1.7×10^{-14}	1.1×10^{-12}	3	3
Heptanenitrile	-	4.3×10^{-13}	2.7×10^{-13}	4	4
Hexadecane	1.3×10^{-8}	7.6×10^{-13}	5.2×10^{-13}	4	4
Hexadecane, 2,6,10,14-tetramethyl-	-	3.2×10^{-14}	-	3	3
Hexanal	3.0×10^{-14}	1.0×10^{-13}	1.4×10^{-13}	3	3
Hexanenitrile	-	3.9×10^{-13}	2.4×10^{-13}	4	4
Iron	4.4×10^{-4}	2.7×10^{-4}	1.4×10^{-3}	3	3
Isopropyl nitrate	3.8×10^{-7}	9.2×10^{-11}	5.9×10^{-11}	4	4
Magnesium	8.3×10^{-5}	6.2×10^{-5}	2.4×10^{-5}	3	3
Malonic acid	7.2×10^{-12}	2.1×10^{-11}	-	3	3
MPA	-	-	1.1×10^{-17}	4	4

TABLE C.3 (Cont.)

Chemical	Highest Concentration ($\mu\text{g}/\text{m}^3$)			Technology ^b for Maximum Concentration	Technology Systems ^b in Which Detected
	Mustard Processing	GB Processing	VX Processing		
m-Tolualdehyde	-	7.0×10^{-14}	6.7×10^{-14}	3	3
Naphthalene, 1,2,3,4-tetrahydro-	-	-	1.3×10^{-12}	3	3
Naphthalene, 1,2,3,4-tetrahydro-6-methyl-	-	-	6.9×10^{-13}	3	3
Naphthalene, 1,7-dimethyl-	-	-	7.4×10^{-13}	3	3
Naphthalene, 1-methyl	-	1.9×10^{-14}	-	3	3
Nitric acid esters	-	3.4×10^{-12}	2.2×10^{-12}	4	4
Nitric acid, butyl ester	-	1.6×10^{-11}	1.0×10^{-11}	4	4
Nitric acid, decyl ester	1.8×10^{-14}	1.4×10^{-12}	9.9×10^{-13}	4	4
Nitric acid, ethyl ester	-	9.0×10^{-12}	5.7×10^{-12}	4	4
Nitric acid, hexyl ester	-	8.9×10^{-12}	5.6×10^{-12}	4	4
Nitric acid, nonyl ester	5.8×10^{-14}	3.3×10^{-12}	2.3×10^{-12}	4	4
Nitric acid, pentyl ester	-	9.3×10^{-12}	5.9×10^{-12}	4	4
Nitric acid, propyl ester	-	9.6×10^{-12}	6.1×10^{-12}	4	4
Nonanal	1.5×10^{-13}	1.2×10^{-12}	1.4×10^{-12}	4	4
Nonane, 2,6-dimethyl-	-	1.9×10^{-14}	6.3×10^{-12}	3	3
Nonane, 3,7-dimethyl-	-	-	9.3×10^{-13}	3	3
Nonane, 3-methyl-	-	-	4.8×10^{-13}	3	3
Nonanenitrile	1.6×10^{-14}	9.1×10^{-13}	6.5×10^{-13}	4	4
n-Propylbenzene	1.5×10^{-13}	-	-	3	3
Octanal	1.0×10^{-13}	1.4×10^{-12}	1.3×10^{-12}	4	4
Octane, 2,6-dimethyl-	3.8×10^{-13}	-	-	3	3
Octane, 3,6-dimethyl-	-	-	2.2×10^{-12}	3	3
Octane, 3-methyl-	1.4×10^{-13}	-	-	3	3
Octanenitrile	-	9.6×10^{-13}	6.1×10^{-13}	4	4
p-Creosol (4-Methylphenol)	5.5×10^{-13}	5.5×10^{-14}	5.5×10^{-14}	2	2
Pentadecane	3.8×10^{-15}	1.0×10^{-14}	1.6×10^{-12}	3	3, 4
Pentanal	9.3×10^{-14}	1.3×10^{-13}	-	3	3
Pentane(n)	8.7×10^{-2}	8.7×10^{-2}	8.7×10^{-2}	3	1, 2, 3, 4
Phenanthrene	5.7×10^{-6}	5.7×10^{-6}	5.7×10^{-6}	3	1, 2, 3, 4
Phosphorus	1.6×10^{-4}	1.2×10^{-4}	$1.5\text{E} \times 10^{-3}$	3	1, 2, 3
Polycyclic organic matter (fluorene)	4.8×10^{-14}	NA ^c	NA	1	1
Potassium	1.4×10^{-12}	-	2.4×10^{-10}	3	3
Propanal (propionaldehyde)	-	9.4×10^{-14}	1.2×10^{-13}	3	1, 3
Propane	5.4×10^{-2}	5.4×10^{-2}	5.4×10^{-2}	3	1, 2, 3, 4
Propylene	4.5×10^{-4}	4.5×10^{-4}	4.5×10^{-4}	3	1, 2, 3, 4
Sodium	8.0×10^{-3}	5.3×10^{-3}	8.1×10^{-6}	3	3
Sulfur, mol. (S8)	1.2×10^{-13}	-	-	3	3
Tetradecane	2.2×10^{-13}	7.0×10^{-14}	7.2×10^{-12}	3	3, 4
Tin	5.2×10^{-5}	3.1×10^{-5}	1.9×10^{-6}	3	3
Tridecane	2.7×10^{-13}	1.1×10^{-13}	3.3×10^{-12}	3	3, 4
Tridecane, 2-methyl-	-	-	2.0×10^{-12}	3	3
Tridecane, 4-methyl-	-	-	9.3×10^{-13}	3	3
Tridecane, 6-propyl-	-	-	7.1×10^{-13}	3	3

TABLE C.3 (Cont.)

Chemical	Highest Concentration ($\mu\text{g}/\text{m}^3$)			Technology ^b for Maximum Concentration	Technology Systems ^b in Which Detected
	Mustard Processing	GB Processing	VX Processing		
Undecane	6.8×10^{-13}	1.0×10^{-13}	9.6×10^{-12}	3	3, 4
Undecane, 2,10-dimethyl-	-	3.2×10^{-14}	4.2×10^{-13}	3	3
Undecane, 2,6-dimethyl-	-	3.9×10^{-14}	-	3	3
Undecane, 2-methyl-	-	2.5×10^{-14}	-	3	3
Undecane, 3,6-dimethyl-	-	-	1.5×10^{-12}	3	3
Undecane, 4-methyl-	-	-	9.8×10^{-13}	3	3
Total = 130					

^a ANAD was the installation with maximum modeled concentrations; used on-post values. A hyphen means the substance was not detected.

^b Indicates the technology system for which this substance was detected during demonstration testing: 1 = Neut/Bio; 2 = Neut/SCWO; 3 = Neut/GPCR/TW-SCWO; 4 = Elchem Ox.

^c NA = not applicable.

on-post and off-post concentrations (Table C.3). Although not quantitatively assessed, toxic effects would be highly unlikely in association with these very low ambient concentrations. For several substances emitted from boilers and diesel generators (aldehydes, propane, butane, pentane, and ethane), emission levels were somewhat higher (up to about 1 kg/d). Although potential health effects from inhalation of these substances could not be quantitatively evaluated because of the lack of toxicity benchmark levels, such data would not distinguish among risks associated with the alternate technologies because each of the technologies evaluated uses boilers and diesel generators.

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