Responses to

TERMS OF REFERENCE FOR THE PREPARATION OF A FOCUS REPORT

Regarding the Canso Spaceport Facility Proposed by Maritime Launch Service Ltd.

March 2019

AECOM

MLS
Maritime Launch Services Ltd

Stantec

LIST OF ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
ADEC	Alaska Department of Environmental Conservation
ADR	Agreement concerning the Carriage of Dangerous Goods by Road
AFI	USAF Instruction
AFTOX	US Air Force Toxic Chemical Dispersion Model
AST	Office of Commercial Space Transportation
BMP	best management practice
BRRC	Blue Ridge Research and Consulting, LLC
CAA	Clean Air Act
CAP	Collection Accumulation Point
CCAFS	Cape Canaveral Air Force Station
CCEMP	Consolidated Comprehensive Emergency Management Plan
CCME	Canadian Council of Ministers of the Environment
CCOHS	Canadian Centre of Occupational Health and Safety
CCR	California Code of Regulations
CEPA	Canadian Environmental Protection Act
CERCLA	Comprehensive Environmental Response, and Liability Act
CFR	Code of Federal Regulations
CO	carbon monoxide
CO2	carbon dioxide
CWA	Clean Water Act
dBA	A-weighted decibels
DEQ	Department of Environmental Quality
dm^3	cubic decimeter
DNL	day-night average sound level
DoD	US Department of Defense
DOT	Department of Transportation
DSL	Domestic Substances List
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	US Environmental Protection Agency
EPC	Emergency Preparedness Canada
EPP	Environmental Protection Plan
EQS	Environmental Quality Standard
ESA	European Space Agency
FAA	Federal Aviation Administration
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
ft	feet
g	grams
GCIFA	Guysborough County Inshore Fisherman’s Association
GSFC	Goddard Space Flight Center
ha.	Hectares
HNO_3	nitric acid
ICAO	International Civil Aviation Organization
ICP	Integrated Contingency Plan
IMDG	International Maritime Dangerous Goods

LIST OF ACRONYMS AND ABBREVIATIONS (continued)

ISO	International Organization for Standardization
kg	kilograms
KLC	Kodiak Island Launch Complex
km	kilometers
kN	kilonewton
kPa	kilopascal
KSC	Kennedy Space Centre
l	litre
LOX	liquid oxygen
m	metres
m^3	cubic metres
MARS	Mid-Atlantic Regional Spaceport
mg	milligrams
MLS	Maritime Launch Services, Ltd
mm	millimetres
MMH	monomethylhydrazine
MPC	maximum permissible concentration
MSDS	Material Safety Data Sheet
N_2O	nitrogen oxide
N2O4	nitrogen tetroxide
NAAQS	National Ambient Air Quality Standards
NaGISA	National Geography In-Shore Areas
NASA	National Aeronautics and Space Administration
NDMA	Nitrosodimethylamine
NDSL	Non-Domestic Substances List
NEF	Noise Exposure Forecast
NO	nitric oxide
NO_2	nitrogen dioxide
NOx	nitrogen oxides
NPDES	National Pollution Discharge Elimination System permits
NPR	NASA Procedural Requirement
NPS	non-point source
NSE	Nova Scotia Environment
NTO	Dinitrogen Textroxide
OPlan	Operation Plan
PEIS	Programmatic Environmental Impact Statement
PM_{10}	particulate matter 10 micrometers or less in diameter
$PM_{2.5}$	particulate matter 2.5 micrometers or less in diameter
ppm	parts per million
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RID	Agreement concerning the Carriage of Dangerous Goods by Rail
RP-1	Refined petroleum-1
RTS	Reagan Test Site
RWQCB	Regional Water Quality Control Board

LIST OF ACRONYMS AND ABBREVIATIONS (continued)

SAU	single-action unit
SBCAPCD	Santa Barbara County Air Pollution Control District
SDO	State Design Office
SO_2	sulfur dioxide
TLV	threshold limit value
TNSC	Tanegashima Space Center
TSCA	Toxic Substances Control Act
UDMH	unsymmetrical dimethyl hydrazine
UES	USAKA Environmental Standards
UIC	Union of Railways
UPC	United PARADYNE Corporation
US	United States
USAF	US Air Force
USAKA	US Army Kwajalein Atoll
VAC	Commonwealth of Virginia Administrative Code
VAFB	Vandenberg Air Force Base
VPDES	Virginia Pollution Discharge Elimination System permits
WFF	Wallops Island Flight Facility

LIST OF APPENDICES

1.0 PROJECT DESCRIPTION

1.1 Provide an updated description of the Project, including clarification of the following:

- ***It is understood the site operator will be Maritime Launch Services Ltd. Provide further information on responsibility for managing the launches;***

The implementation of the Cyclone-4M program will be carried out by Maritime Launch Services Ltd. (MLS), Halifax, Nova Scotia, Canada, together with leading Ukrainian space enterprises Yuzhnoye State Design Office (SDO), PA Yuzhmash Machine-Building Plant and American United PARADYNE Corporation (UPC). Table 1.1 lists the responsibilities for each organization. Figure 1.1 shows a launch team organizational chart.

Table 1.1 Cyclone-4M Program Management and Responsibilities

Organization	Responsibilities
MLS	Responsible for overall management of the Cyclone-4M program for all phases of Space Launch System development and its operation, including: • Obtaining necessary licenses, permits, etc. • Ensuring safety of operations at the launch complex • Organization and coordinating work on preparation and conduct of the launch vehicle launches • Development of design and construction documentation for launch site • Construction of the launch site and support GSE
Yuzhnoye SDO	• Design and construction of the launch vehicle • Design of SLS ground infrastructure including ground support equipment • Spacecraft integration with Cyclone-4M space launch system and preparation of necessary launch information; • Participation in prelaunch processing and launch of the launch vehicle
PA Yuzhmash Machine-Building Plant	• Production of Cyclone-4M space launch system components • Assembly and preparation of the launch vehicle for launch • Participation in launch
UPC	• Maintenance supply of propellant, compressed and liquefied gases • Operation and maintenance of propellant facilities, their engineering systems and equipment

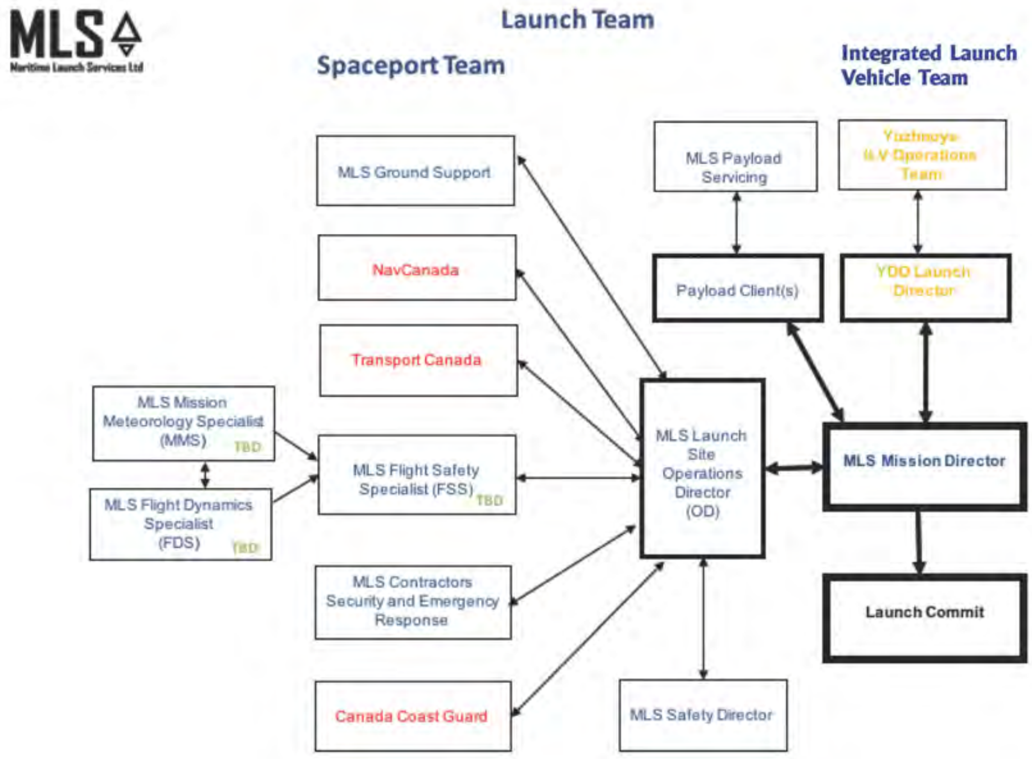


Figure 1.1 Cyclone-4M Launch Team Organizational Chart

1.1 Provide an updated description of the Project, including clarification of the following:

- ***Clarify how many launches are expected annually. There is inconsistency in the EA Registration Document in this regard.***

The Cyclone-4M will ramp up to a maximum of eight (8) launches per year over the first five (5) of operation. It is anticipated there would be one launch in the first year (2021) and an increasing number of launches each year up to a maximum of eight (8) by approximately 2026. The total number of launches under this project (2021-2030) is estimated to be 159.

1.2 Given the highly toxic properties of hydrazine related chemicals (e.g., unsymmetrical dimethyl hydrazine, hydrazine and monomethylhydrazine), the following information requests are required as part of the Focus Report:

- ***A jurisdictional review on where hydrazine related chemicals are used for similar spaceport facilities in developed countries, and a list of spaceports in developed countries where hydrazine related chemicals are used currently;***

Historically, the primary use of hydrazine was as a rocket propellant. In the United States (US), 73% of hydrazine consumed in 1964 was used for this purpose. By 1982, the use profile for hydrazine had diversified: 40% of hydrazine was used in the manufacture of agricultural chemicals, 33% for chemical blowing agents, 15% in boiler water treatment as a corrosion inhibitor, 5% as rocket propellant and 7% for other purposes.

Hydrazine was not manufactured in Canada in 2006 (the data collection year for the Canadian Environmental Protection Act [CEPA] Domestic Substances List [DSL] Assessment) above the reporting threshold of 100 kg. The quantity of hydrazine imported into Canada in 2006 was in the range of 10000–100000 kg. Most of these imports were as aqueous solutions of hydrazine, the form of the product commonly found on the market. In 2006, 123 kg and 1,865 kg of hydrazine were reported to have been released to the atmosphere and hydrosphere, respectively. In addition to environmental releases of hydrazine, 1,076 kg were transferred to hazardous waste facilities for disposal in 2006 (EC/HC 2011a).

In addition to use as fuel for many rockets and spacecraft, including the space shuttle, Northrop Grumman's (Formerly Orbital ATK) Cygnus capsule, SpaceX's Dragon Capsule, and the MAC-200 satellite bus manufactured by Magellan Aerospace for the RADARSAT Constellation, hydrazine is used to treat boiler water to reduce corrosion, to reduce other chemicals, and to bring about or speed up chemical reactions. In the US, it is also used as a medicine and to make other medicines, farm chemicals, and plastic foams. 1,1-Dimethylhydrazine has been used as a rocket propellant and to make other chemicals (ASTDR 1997).

There are no spaceport facilities in Canada; however there are dozens of launch facilities worldwide which support launch vehicles (rockets) using a range of propellants including hydrazine compounds as propellants and/or propellants for spacecraft maneuvering in orbit. Countries with spaceport facilities that have recently used hydrazine related chemicals include the US, Russia, China, Japan, Kazakhstan, South Korea, French Guiana, Brazil, Australia, and Israel.

Table 1.2.1 lists the countries with spaceport facilities that are currently storing and using hydrazine related chemicals.

Table 1.2.1. Spaceport Facilities using Hydrazine Related Chemicals

Launch Pad and Location
Baikonur Site 1/5, Kazakhstan
Baikonur Site 175/59, Kazakhstan
Baikonur Site 200/39, Kazakhstan
Baikonur Site 31/6, Kazakhstan

Table 1.2.1. Spaceport Facilities using Hydrazine Related Chemicals

Launch Pad and Location
Baikonur Site 45/1, Kazakhstan
Baikonur Site 81/24, Kazakhstan
Cape Canaveral SLC-37B, Cape Canaveral, Florida, US
Cape Canaveral SLC-40, Cape Canaveral, Florida, US
Cape Canaveral SLC-41, Cape Canaveral, Florida, US
Dombarovsky Site 13, Dombarovsky, Russia
Jiuquan LA-4/SLS-2, Ejin Banner, China
Jiuquan LC-43/94, Ejin Banner, China
Jiuquan SLS-2, Ejin Banner, China
Jiuquan SLS-E2, Ejin Banner, China
Jiuquan, Ejin Banner, China
Kennedy LC-39A, Merritt Island, Florida, US
Kourou ELA-3, Guiana Space Center, French Guiana
Kourou ELS, Guiana Space Center, French Guiana
Kourou ELV, Guiana Space Center, French Guiana
MARS LP-0A, Wallops Island, Virginia, US
Odyssey (launch platform), Registered in Monrovia, Liberia
Palmachim Airbase, Central District, Israel
Plesetsk Site 133/3, Mimy, Arkhangelsk Oblast, Russia
Plesetsk Site 35/1, Mimy, Arkhangelsk Oblast, Russia
Plesetsk Site 43/4, Mimy, Arkhangelsk Oblast, Russia
Plesetsk, Mimy, Arkhangelsk Oblast, Russia
Satish Dhawan FLP, Sriharikota, Andhra Pradesh, India
Satish Dhawan SLP, Sriharikota, Andhra Pradesh, India
Semnan, Iranian Space Center, Iran
Sohae, North Pyongan Province, North Korea
Taiyuan LA-16, Xinzhou, Shanzi Province, China
Taiyuan LA-9, Xinzhou, Shanzi Province, China
Taiyuan LC-9, Xinzhou, Shanzi Province, China
Tanegashima LA-Y2, Tanegashima, Japan
Uchinoura, Kagoshima Prefecture, Japan
Vandenberg SLC-2W, Lompoc, California, US
Vandenberg SLC-3E, Lompoc, California, US
Vandenberg SLC-4E, Lompoc, California, US

Table 1.2.1. Spaceport Facilities using Hydrazine Related Chemicals

Launch Pad and Location
Vandenberg SLC-6, Lompoc, California, US
Vostochny Site 1S, Amur Oblast, Russia
Vostochny Site 1S, Amur Oblast, Russia
Wenchang LC-1, Hainan, China
Xichang LA-2, Liangshan, Sichuan, China
Xichang LA-3, Liangshan, Sichuan, China
Xichang LC-2, Liangshan, Sichuan, China
Xichang LC-3, Liangshan, Sichuan, China

The following list provides a summary of some of the larger government and commercial rocket design and launch service organizations and facilities.

- SpaceX designs, manufactures and launches advanced rockets and spacecraft. Founded in 2002, it has developed three launch vehicles, and employs over 6,000 people. As one of the world’s fastest growing providers of launch services, SpaceX has secured over 100 missions including commercial satellite launches as well as US government missions. SpaceX’s Dragon spacecraft is flying numerous cargo resupply missions to the space station under a series of Commercial Resupply Services contracts. https://www.spacex.com/

- Blue Origin is an American privately funded aerospace manufacturer and spaceflight services company headquartered in Kent, Washington. Founded in 2000 by Jeff Bezos, Blue Origin manufactures rocket engines, launch vehicles, and space capsules and has an operational launch facility in West Texas, where they also test rocket engines. https://www.blueorigin.com/

- Rocket Lab operates the world’s only private commercial orbital launch site, located on the Mahia Peninsula, New Zealand. https://www.rocketlabusa.com/

- Virginia space/Mid-Atlantic Regional Spaceport (MARS) is licensed by the Federal Aviation Administration Office of Commercial Space Transportation (FAA/AST) for launches to orbital trajectories. MARS is only one of four spaceports in the U.S. that is currently licensed to launch to orbit and is only one of two on the east coast. Over 16,000 rockets have been launched from NASA Wallops Flight Facility. MARS provides a competitive alternative for responsive, cost effective, reliable, and mission capable Space Access. https://www.vaspace.org/

- The Oklahoma Air & Space Port is a public-use airport and industrial airpark that has facilities in place for aerospace testing, research and development, flights and launches. It is one of the ten spaceports in the nation, and is home to one of the country’s longest and the widest runways (13,503-foot by 300-foot concrete runway) available for both civilian and military use. https://airspaceportok.com/

- Space Florida’s Launch Complex 46 business strategy is to provide launch capabilities at the lowest cost possible. To help reach this goal, the Mobile Access Structure was carefully planned and designed to accommodate a variety of types and sizes of launch vehicles. Space Florida is actively seeking launch and payload customers for this multi-use vertical launch facility (Cape Canaveral Spaceport) https://www.spaceflorida.gov/

- The Cecil Spaceport, co-located with Cecil Airport in Jacksonville, Florida, will utilize its existing 12,500-foot-long Runway 18L-36R to launch and recover space vehicles that take off and land horizontally. The Cecil Spaceport was granted a Commercial Launch Site Operator License by the FAA/AST in January 2010. Initially, Cecil Spaceport intends to conduct horizontal space launch operations using existing facilities to the extent possible, with long-term plans to develop dedicated facilities as warranted by the number of space flight operations conducted at Cecil Spaceport. https://www.spaceflorida.gov/wp-content/uploads/2018/12/spaceport-mp.pdf
- Spaceport America is the first facility designed and constructed for the sole purpose of commercial and private public-access spaceflight. https://spaceportamerica.com/
- Virgin Galactic is a part of Sir Richard Branson's Virgin Group, and with their sister companies – The Spaceship Company and Virgin Orbit – are developing and operating a new generation of space vehicles to open space for everyone. https://www.virgingalactic.com/
- Arianespace is the world's leading satellite launch company, operating a full family of launchers. The Spaceport in French Guiana – also known as the Guiana Space Center – is a strategically-located facility that provides optimum operating conditions for Arianespace's commercial launches and for the European Space Agency http://www.arianespace.com/spaceport-facility/
- The Baikonur Cosmodrome in Kazakhstan is the chief launch center for both piloted and unpiloted space vehicles. It supports the Soyuz and Proton launch vehicles and plays an essential role in the deployment and operation of the international space station. https://www.nasa.gov/mission_pages/station/structure/elements/baikonur.html
- Japan - Tanegashima Space Center (TNSC) is the largest rocket-launch complex in Japan with a total area of about 9,700,000 square metres (m). On-site facilities include the Yoshinobu Launch Complex, a launch site for large-size rockets, Spacecraft Test and Assembly Buildings, and the Spacecraft and Fairing Assembly Building. The TNSC plays a pivotal role for satellite launches among Japan's space development activities. http://global.jaxa.jp/about/centers/tnsc/index.html

Additional lists of spaceport and rocket launch facilities worldwide are provided at the following websites:

- Commercial Spaceport Facilities in the US: http://www.photostospace.com/spaceports/
- Wikipedia – Spaceports: https://en.wikipedia.org/wiki/Spaceport
- Wikipedia – List of Rocket Launch Sites: https://en.wikipedia.org/wiki/List_of_rocket_launch_sites

A detailed regulatory review discussing the requirements and standards where hydrazine related chemicals are used for spaceports in developed countries is provided in Section 1.2.

1.2 Given the highly toxic properties of hydrazine related chemicals (e.g., unsymmetrical dimethyl hydrazine, hydrazine and monomethylhydrazine), the following information requests are required as part of the Focus Report:

- ***Information on precisely how, and for what purpose, hydrazine related chemicals are used by facilities highlighted above;***

The Yuzhnoye Cyclone-4M is a two-stage medium-lift class launch vehicle with a gross lift-off weight of approximately 272,000 kg and an approximate length of 40 m. The Cyclone-4M uses liquid oxygen (LOX) and highly refined kerosene, also known as rocket propellant-1 or refined petroleum-1 (RP-1), as propellants for its first stage. The Cyclone-4M uses nitrogen tetroxide (N2O4) and unsymmetrical dimethyl hydrazine (UDMH) as propellants for its upper stage to carry payloads into orbit. Many payloads will also require some additional propellants on board, either for orbit maintenance or attitude control. Payload propellants may include hypergolic fuels such as hydrazine and nitrogen tetroxide (NTO) (Strum 2018).

Hypergolic-fueled rocket engines are usually simple and reliable because they need no ignition system. The two propellant components usually consist of a fuel and an oxidizer. Although commonly used hypergolic propellants require careful handling because of their toxicity and/or corrosiveness, they can be stored as liquids at room temperature and hypergolic engines are easy to ignite reliably and repeatedly (Quitney 2016). Because hypergolic-fueled engines do not need an ignition system, they can fire any number of times by simply opening and closing the propellant valves until the propellants are exhausted and are therefore uniquely suited for spacecraft maneuvering and well suited as upper stages of launch vehicles such at the Cyclone-4M, Antares Cygnus capsule, and ESA Vega launch vehicles which must perform more than one burn to reach or change orbit.

1.2 Given the highly toxic properties of hydrazine related chemicals (e.g., unsymmetrical dimethyl hydrazine, hydrazine and monomethylhydrazine), the following information requests are required as part of the Focus Report:

- ***A discussion of current regulatory requirements and standards where hydrazine related chemicals are used for spaceports in developed countries;***

The Ministers of Environment Canada and Health Canada completed a screening assessment of hydrazine (based on data collected in 2006), Chemical Abstracts Service Registry Number 302-01-2 in 2011. Hydrazine was identified in the categorization of the DSL as a high priority for action under the Chemicals Management Plan because it was considered to present an intermediate potential for exposure and had been classified by other agencies on the basis of carcinogenicity (EC/HC 2011a).

In Canada, hydrazine is used for industrial purposes only and no consumer products containing hydrazine as an ingredient were identified. When used as a raw material or an intermediate in the formulation of consumer products, hydrazine may be found in final products as a residual. The major use of hydrazine in Canada in 2006 was as an oxygen scavenger/corrosion inhibitor in the boiler water used mainly at power generating plants, which accounted for 87% of reported uses (Environment Canada 2009). In Canada and elsewhere, hydrazine may be used as a raw material or an intermediate in the production of pesticides and other agricultural chemicals (EC/HC 2011a).

Releases of hydrazine to the environment from these sources do occur. However, exposure of the general population of Canada to hydrazine is expected to be low (EC/HC 2011a). Given its use particularly in power generating plants, this substance can be dispersed widely in the Canadian environment.

Based on DSL assessment (EC/HC 2011a), it was concluded that hydrazine is entering the environment in a quantity or concentration or under conditions that have or may have an immediate or long-term harmful effect on the environment or its biological diversity. The Ministers proposed to recommend the addition of hydrazine to the List of Toxic Substances in Schedule 1. Hydrazine is not subject to virtual elimination but is to be managed using a lifecycle approach, to prevent or minimize its release into the environment. As a result, the Ministers have developed instruments respecting preventive and control actions to protect the health of Canadians and the environment from the potential effects of exposure to hydrazine (EC/HC 2011b).

In Canada, the following controls are currently in place to address hydrazine. Hydrazine is listed (EC/HC 2011b):

- Under Schedule 3 of the Transportation of Dangerous Goods Regulations under the Transportation of Dangerous Goods Act;
- In the Environmental Emergency Regulations under Part 8 of CEPA 1999 (EC 2003). Facilities with the equivalent of at least 6.8 tonnes of pure hydrazine on site, that is in a concentration of 10% or greater, and with a hydrazine container size of at least 6.8 tonnes are required to prepare and implement an environmental emergency plan;
- As a pure form, on Schedule 7, Part 2, of the Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations under CEPA 1999;
- On the Cosmetic Ingredient Hotlist; and
- On Schedule 1 as a pollutant on the Regulations for the Prevention of Pollution from Ships and for Dangerous Chemicals under the Canada Shipping Act (Canada 2001).

The proposed human health objective for hydrazine under Canada Risk Management (EC/HC 2011b) is to minimize human exposure to the greatest extent practicable. The proposed environmental objective is to prevent or minimize releases of hydrazine to water.

To meet the environmental objectives, the Government of Canada issued a notice requiring the preparation and implementation of pollution prevention plans with respect to thermal and nuclear power generating facilities using hydrazine in 2018. Details on the pollution prevention notice can be found at the following web link:

> https://www.canada.ca/en/environment-climate-change/services/pollution-prevention/planning-notices/performance-results/hydrazine-electricity-sector-overview.html

Releases, disposals and transfers for recycling for hydrazine are also reportable to the National Pollutant Release Inventory.

JURISDICTIONAL REVIEW OF HYDRAZINE USE AT SPACEPORTS

Hydrazines which are used as rocket propellants are one group of many hazardous materials that are regulated at Spaceports in various jurisdictions through a variety of codes, statutes and regulations, permits, technical guidance, standards and policy.

Where the specific scope of the Jurisdictional Review was not defined in the Terms of Reference for the Focus Report, the following regulatory topics have been identified for discussion in this report. These topics are based on the issues/concerns related to hydrazines identified in the Stakeholder comments on the MLS EA submission. Topics for discussion in the jurisdictional review include the following:

- General Regulation of Spaceports
- Transportation of Hazardous Materials (Dangerous Goods)
- Worker and Public Health and Safety
- Hazardous Materials (Dangerous Goods) Management
- Hazardous Waste (Waste Dangerous Goods) Management
- Air Quality
- Water Quality
- Spills and Contingency Planning
- Cleanup Guidelines

Based on the large number of launch facilities worldwide reportedly using hydrazines as propellants, and the potential issues related to language and translation of regulatory requirements and technical guidance, it was determined that the current jurisdictional review be limited to a review of Spaceports currently operated in the US by NASA and/or the FAA Office of Commercial Space Transportation.

The review consisted of a desktop literature review of documents and internet searches relating to spaceports that use, or have used, hydrazine compounds in a similar manner to that proposed for the Canso Spaceport.

A review of the American environmental regulatory framework is presented in the following sections, followed by a summary of Canadian and Nova Scotian regulations as they may be applicable to the proposed Canso Spaceport facility. The discussion here is focused on the environmental framework in place as it may relate to the use of hydrazines at specific spaceports. The discussion does not consider the many other regulated activities required to operate a spaceport and relevant regulatory framework that would apply.

Based on review, it is noted that hydrazines may be used at many of the identified spaceports in the US and is handled, transported, stored and used following applicable American government regulations and industry best practices. It is further noted that the agency guidance provided by NASA is considered the “gold standard” for technical guidance and best practices to support regulatory compliance related to the use of hydrazines in developed countries. It is anticipated that the proposed MLS Canso Spaceport facility would operate following similar federal, provincial and local requirements and best practices in relation to its proposed handling of hydrazines.

UNITED STATES OF AMERICA (US)

National Aeronautics and Space Administration (NASA) Launch Facilities

The following five locations are currently used by NASA for the launch of expendable launch vehicles to support routine payload delivery into earth orbit.

- Cape Canaveral Air Force Station/ Kennedy Space Centre (CCAFS/KSC) - Florida
- Vandenberg Air Force Base (VAFB) - California
- Wallops Island Flight Facility (WFF) - Virginia
- US Army Kwajalein Atoll - Reagan Test Site (USAKA/RTS) –- Marshall Islands (North Pacific)
- Kodiak Island Launch Complex (KLC) – Alaska

NASA Launch Vehicles Using Hydrazine

Of the five NASA launch facilities listed above, all but the USAKA/RTS are known to support launch vehicles that use hydrazines either as main propellants, or in Hydrazine Auxiliary Propulsion Systems(NASA 2011). The various launch vehicles used at these sites and the respective amounts of hydrazine propellants used in each are listed below:

- Athena I, II, III: 435 kg of hydrazine
- Delta II: 2,064 kg of A-50
- Minotaur I, II, III, IV, V: 59 kg liquid hydrazine
- Taurus II: 358 kg MMH
- Titan II: 41 kg hydrazine

General Regulatory Framework

Spaceport Launch Licenses and Permits

The FAA/AST is the federal department that issues launch operator licenses and experimental permits. (NASA 2011). The following are FAA currently licensed launch sites:

- California Spaceport, CA
- Cape Canaveral Air Force Station, FL
- Cape Canaveral Spaceport/Shuttle Landing Facility, FL
- Cecil Field, FL
- Colorado Air & Space Port, CO
- Ellington Airport, TX
- Midland International Airport, TX
- Mojave Air and Space Port, CA
- Oklahoma Air and Space Ports, OK
- Spaceport America, NM
- Wallops Flight Facility, VA

Details related to operator licenses and permits can be found at the following web link: https://www.faa.gov/about/office_org/headquarters_offices/ast/licenses_permits/

A general fact sheet on FAA oversight activities and other requirements can be found at the following web link: https://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=19074

Public Safety

The FAA has the authority to issue a safety approval for one or more of the following safety elements: a launch vehicle, a reentry vehicle, a safety system, process, service, or any identified component thereof, and qualified and trained personnel performing a process or function related to licensed launch activities. Information on FAA Safety Approvals can be found at the following web link: https://www.faa.gov/about/office_org/headquarters_offices/ast/licenses_permits/safety_approvals/

Agency or site-specific guidance has been developed to distill the applicable regulatory framework into actionable or digestible documents. The Air Force Space Command Manual provides range safety regulations for both CCAFS and VAFB. The aim of these regulations is to ensure that operations are conducted in an acceptably safe manner and that all operations adhere to public laws. WFF operates under the Goddard Space Flight Center (GSFC) and WFF Range Safety Manual, and the KLC operates under the KLC Range Safety Manual. A directory of NASA Range Safety documents for CCAFS/KSC and WFF can be found at the following web links:

https://kscsma.ksc.nasa.gov/RangeSafety/reqDocs/DoDlinks

https://www.nasa.gov/sites/default/files/atoms/files/rsm2002revc.pdf)

Worker Health and Safety

Processing of NASA Routine Payloads spacecraft would involve the handling of propellants, including hydrazine. Hydrazine is a strong irritant and may damage eyes and cause respiratory tract damage. Exposure to high vapor concentrations can cause convulsions and possibly death. Repeated exposures to lower concentrations may cause toxic damage to liver and kidneys as well as anemia (NASA 2011).

The US Environmental Protection Agency (EPA) classifies hydrazine and monomethylhydrazine (MMH) as probable human carcinogens. Both are flammable and could spontaneously ignite when exposed to an oxidizer. NTO is a corrosive oxidizing agent. Contact with the skin and eyes can result in severe burns. Inhalation of vapors can damage the respiratory system, potentially leading to death. NTO would ignite when combined with fuels and may promote ignition of other combustible materials. Fires involving NTO burn vigorously and produce toxic fumes (NASA 2011).

Health and safety impacts to personnel involved in the propellant loading operations are minimized by adherence to U.S. Occupational Safety and Health Administration, NASA, U.S. Army, FAA, and U.S. Air Force Occupational Safety and Health regulations. These regulations require use of appropriate protective clothing and breathing protection. Toxic vapor detectors are used in the facilities to monitor for leaks and unsafe atmospheres (NASA 2011). Worker Safety and other related public safety and health assessment information related to hydrazines can be found at the following web links:

https://www.osha.gov/dts/sltc/methods/organic/org108/org108.html

https://www.cdc.gov/niosh/topics/hydrazine/default.html

Transportation of Hazardous Materials

Transportation of hazardous materials must be done in accordance with the US Department of Transportation (DOT) regulations for interstate shipment of hazardous substances (Title 49 Code of Federal Regulations [CFR] 100-199). These outline that liquid rocket propellent be transported in containers that minimize the risk of a leak in the event of an accident (NASA 2011). A copy of these Regulations can be found at the following web links:

https://www.phmsa.dot.gov/regulations/title49/b/2/1
https://www.govinfo.gov/content/pkg/CFR-2012-title49-vol2/pdf/CFR-2012-title49-vol2.pdf

Storage of UDMH

UDMH may be stored in the DOT-approved container in which it is shipped. UDMH should be stored away from heat, sparks open flame and oxidants, only in well-ventilated areas. Since UDMH is stable, it can be stored without loss of purity (ARCH 2018).

Information related to the safety and handling of hydrazines and other hazardous chemicals can be found at the following web links:

https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19650018358.pdf
https://apps.dtic.mil/dtic/tr/fulltext/u2/p005339.pdf

ENVIRONMENTAL CODES AND REGULATIONS

The use of hydrazine and other hazardous materials at NASA spaceports is governed by a collection of federal and state departments, regulations, and agency guidance. The overarching structure is that federal and state departments provide regulatory tools for broad based activities (e.g., handling hazardous materials) and NASA has developed protocols or directives for spaceport-specific activities including aspects related to hydrazine. An overview of this relationship and references to the specific departments and guidance is provided in the following sections.

NASA – Environmental Assessment for Launch of NASA Routine Payloads (2011).

In 2011, NASA's Science Mission Directorate completed an Environmental Assessment (EA) for the launch of NASA routine payloads (NASA 2011). Based on this EA the agency published a Finding of No Significant Impact in the Federal Register. Through this comprehensive EA completed on the launch of routine payloads from the above noted NASA launch sites, the use of hydrazine was determined to not contribute substantial environmental impacts, even in the case of a launch accident (NASA 2011).

This document was also used as a significant source of information related to the regulation of environmental aspects at NASA’s launch facilities and was a major contributor to the information provided within this document. In many cases, excerpts are taken directly from the EA document with appropriate referencing.

MANAGEMENT OF HAZARDOUS MATERIALS

Federal Requirements and Agency Standards

In the United States, management of **hazardous materials** is regulated by the Comprehensive Environmental Response, and Liability Act (CERCLA), and the Toxic Substances Control Act (TSCA). Hazardous materials are defined in these acts and are substances that may present a public health or environmental danger if released. To ensure compliance with these acts, NASA and the US Air Force (USAF) use both agency and site specific standards and protocols. NASA has issued and implemented a plan to manage hazardous materials in compliance with the Resource Conservation and Recovery Act (RCRA). The NASA General Safety Program Requirements assures that any accumulated hazardous materials are properly handled and characterized, and that appropriate methods and means for spill control are in place. The USAF Instruction (AFI) 32-7086, Hazardous Materials Management establishes procedures and standards for hazardous materials at both CCAFS and VAFB. At KLC and WFF spaceports the applicable NASA standards apply, which include NASA Procedural Requirement (NPR) 8715.5 and NPR 8715.7 (NASA 2011).

An overview of CERCLA and TSCA can be found at the following web links:

https://www.epa.gov/superfund/superfund-cercla-overview
https://www.epa.gov/chemicals-under-tsca

Copies of the agency standards referenced above can be found at the following web links:

https://static.e-publishing.af.mil/production/1/af_a4/publication/afi32-7086/afi32-7086.pdf
https://nodis3.gsfc.nasa.gov/npg_img/N_PR_8715_007A_/N_PR_8715_007A_.pdf

State and Facility Specific Guidance

Cape Canaveral Air Force Station/Kennedy Space Centre (CCAFS/KSC)

Numerous types of hazardous materials including hydrazines are used to support the missions and general operations at CCAFS and KSC. Management of hazardous materials, excluding hazardous fuels, is the responsibility of each individual or organization. Each organization has a supply organization and uses a “pharmacy” control approach to track hazardous materials and to minimize hazardous waste generation by minimizing the use of hazardous materials. The Joint Propellants Contractor controls the purchase, transport, and temporary storage of hazardous propellants. Response to spills of hazardous materials is covered under JHB-2000, the Consolidated Comprehensive Emergency Management Plan (CCEMP). CCEMP establishes uniform policy guidelines for the effective mitigation of, preparation for, response to, and recovery from a variety of emergency situations.

The CCEMP is applicable to all NASA, USAF, and NASA/USAF Contractor organizations and to all other Government agencies located at KSC, CCAFS, and Florida Annexes. To ensure continuity of operations, the application of the provisions of the CCEMP is executed as required by responding organizations through the Incident Management System. RCRA requirements are accomplished by the directives listed in the respective permits issued to KSC/CCAFS (as per 45 SW Operation Plan (OPlan) 32-3 and Kennedy NPR (KNPR) 8500.1) (NASA 2011). Copies of the CCEMP and KNPR 8500.1 can be found at the following web links, respectively.

https://prod.nais.nasa.gov/eps/eps_data/128659-SOL-001-011.pdf
https://tdglobal.ksc.nasa.gov/servlet/sm.web.Fetch/KNPR_8500.1__Rev_D_FINAL.pdf?rhid=1000&did=7250&type=released

Vandenberg Air Force Base (VAFB)

VAFB requires all contractors using hazardous materials to submit a hazardous materials contingency plan prior to working on base. Distribution of hazardous materials at VAFB is coordinated from a single-issue point. Management of hazardous materials obtained directly from off-base suppliers by contractors is the responsibility of the individual contractor.

Hazardous propellants are controlled by the base propellant contractor, which handles the purchase, transport, temporary storage, and loading of hypergolic fuels and oxidizers. They are stored at a designated Hypergolic Storage Facility. Spills of hazardous materials are covered under the Hazardous Materials Emergency Response Plan, 30 SW Plan 32-4002, which ensures that adequate and appropriate guidance, policies, and protocols regarding hazardous material incidents and associated emergency response are available to all installation personnel. (NASA 2011). Copies of the Hazardous Materials Emergency Response Plan can be found at the following web link:

> https://webapp1.dlib.indiana.edu/virtual_disk_library/index.cgi/821003/FID577/pubs/af/32/afi32-4002/afi32-4002.pdf

US Army Kwajalein Atoll / Reagan Test Site (USAKA/RTS)

The use of hazardous materials at USAKA/RTS, is limited primarily to materials used in facility infrastructure support and flight operations, with some additional quantities of hazardous materials used by various test operations. A hazardous materials management plan is prepared for all hazardous materials or petroleum products shipped to USAKA/RTS. The plan outlines the procedures for storage, use, transportation, and disposal of the hazardous materials or petroleum products.

These substances may be shipped to USAKA/RTS by ship or by air. Upon arrival at USAKA/RTS, hazardous materials are distributed, as needed, to various satellite supply facilities, from which they are distributed to the individual users.

An activity-specific Hazardous Materials Procedure must be submitted to the Commander, USAKA/RTS for approval within 15 days of receipt of any hazardous material or before use, whichever comes first. Hazardous materials to be used by organizations on the test range and its facilities are under the direct control of the user organization, which is responsible for ensuring that these materials are stored and used in accordance with all USAKA Environmental Standards and Procedures (UES) requirements. The use of all hazardous materials is subject to ongoing inspection by USAKA/RTS environmental compliance and safety offices to ensure the safe use of all materials (NASA 2011). Copies of these agency standards can be found at the following web link:

> http://usagkacleanup.info/wp-content/uploads/2017/01/UES-14Ed-FNL-Nov-2014-15-16Sep2016-rd.pdf

Wallops Island Flight Facility (WFF)

The Virginia Department of Environmental Quality (DEQ) has issued a formal approval of WFF's Integrated Contingency Plan (ICP). The ICP, developed by the Environmental Office in accordance with CFR 1910, Subpart H (Hazardous Materials), includes the following procedures:

- The Environmental Office provides annual ICP to all Civil Service and Contractor employees who handle hazardous materials and petroleum as part of their job;
- WFF labels each container of hazardous material in English with the following minimal description: name of the chemical and all appropriate hazard warnings;
- WFF has on file in each work area Material Safety Data Sheets (MSDS) for each hazardous material used onsite. WFF utilizes an online electronic chemical inventory (MSDS-Pro) that contains links to appropriate MSDSs and is accessible to all WFF personnel through the GSFC intranet;
- Individual WFF support contractor offices train their personnel in the applicable hazardous communication pertinent to the requirements for each employee; and
- WFF prepares and implements spill contingency and response procedures.

A listing of WFF Environmental Codes and manuals can be found at the following web link:

> https://sites.wff.nasa.gov/code250/documents.html#cat9

Note: The ICP is an internal NASA document.

MANAGEMENT OF HAZARDOUS WASTE

Federal Requirements and Agency Standards

Management of hazardous waste is regulated by RCRA which dictates that wastes must be disposed of to minimize potential environmental and human threats. The USAF Instruction AFI-32-7042 provides the framework for handling and disposing of hazardous wastes at both CCAFS and VAFB. Hazardous and solid waste management activities at all NASA facilities comply with all applicable federal, state, and local regulations.

An overview of RCRA can be found at the following web link:

https://www.epa.gov/laws-regulations/summary-resource-conservation-and-recovery-act

AFI 32-7042 can be found online at the following web address: https://static.e-publishing.af.mil/production/1/af_a4/publication/afi32-7042/afi32-7042.pdf

State and Facility Specific Guidance

Cape Canaveral Air Force Station/Kennedy Space Centre (CCAFS/KSC)

Hazardous waste management at CCAFS is regulated under RCRA and the Florida Administrative Code (FAC) 62-730. These regulations are implemented by 45th SW OPlan 32-3, which addresses the proper identification, management, and disposition of hazardous waste at CCAFS. A copy of the FAC requirements can be found at the following web link:

https://www.flrules.org/gateway/ChapterHome.asp?Chapter=62-730

Individual contractors and organizations maintain hazardous waste satellite accumulation points and 90-day hazardous waste accumulation areas in accordance with 45th SW OPlan 19-14. The organizational and procedural requirements of the KSC hazardous waste management program are contained in KNPR 8500.1 “Hazardous Waste Management”. KSC has an operating permit from the Florida Department of Environmental Protection (FDEP) for the storage, treatment, and disposal of hazardous waste.

KSC Environmental Requirements can be found at the following web address:

https://tdglobal.ksc.nasa.gov/servlet/sm.web.Fetch/KNPR_8500.1__Rev_D_FINAL.pdf?rhid=1000&did=7250&type=released

Vandenberg Air Force Base (VAFB)

RCRA and the California Environmental Protection Agency’s Department of Toxic Substances Control (under the California Health and Safety Code and the California Administrative Code) regulate hazardous wastes at VAFB. These regulations require that hazardous waste be handled, stored, transported, disposed, or recycled according to defined procedures. The VAFB Hazardous Waste Management Plan, 30 SW Plan 32-7043-A, implements the above regulations and outlines the procedures for disposing of hazardous waste.

All hazardous waste generated is labeled with the EPA identification number for VAFB, under which it is transported, treated, and disposed. Individual contractors and organizations at VAFB are responsible for administering all applicable regulations and plans regarding hazardous waste.

Typical hazardous wastes include various solvents, paints and primers, sealants, photograph developing solutions, adhesives, alcohol, oils, fuels, and various process chemicals. Hazardous waste is stored at its point of origin until the waste container is full, or until 60 days following the day the container first received waste (whichever is first). The waste is then transported to the permitted consolidated Collection Accumulation Point (CAP) for temporary storage for no longer than 30 days. Waste hypergolic fuel is stored at a separate consolidated Hypergolic Storage Facility CAP. Hazardous waste can be stored at the permitted storage facility (Building 3300) for up to 1 year from the date of accumulation. Waste not listed in the Part B permit must be shipped to an off-base treatment, storage, or disposal facility within the allowable 90-day storage period. Copies of the VAFB Hazardous Waste Management Plan can be accessed at the following web links:

https://static.e-publishing.af.mil/production/1/af_a4/publication/afi32-7042/afi32-7042.pdf

https://webapp1.dlib.indiana.edu/virtual_disk_library/index.cgi/821003/FID577/pubs/af/32/afpam32-7043/afpam32-7043.pdf

US Army Kwajalein Atoll / Reagan Test Site (USAKA/RTS)

Hazardous waste management at USAKA/RTS is performed in accordance with the UES, which requires shipment of hazardous waste back to the Continental US for treatment and/or disposal. Personnel trained in the appropriate procedures to handle potentially hazardous waste, including spill containment and cleanup, would be on standby should a mishap occur. Such personnel involved in these operations would wear appropriate protective clothing, as necessary. A copy of the UES Activities in the Republic of the Marshall Islands can be found at the following web address:

http://usagkacleanup.info/wp-content/uploads/2017/01/UES-14Ed-FNL-Nov-2014-15-16Sep2016-rd.pdf

Wallops Island Flight Facility (WFF)

The regulations which govern hazardous waste management at WFF are 40 CFR 260-270 (Federal) and 9VAC20-60 (Commonwealth of Virginia Administrative Code [VAC]). The Environmental Office manages hazardous waste generated at WFF. They are responsible for tracking manifests and certificates of disposal for hazardous wastes, which leave the facility. The Environmental Office also provides annual Hazardous Waste training to all Civil Service and Contractor employees who handle hazardous waste as part of their job. The generators at each operation or activity are responsible for:

- Properly containing waste.
- Properly completing and transferring of a disposal inventory sheet to the Environmental office.
- Properly labeling waste containers with information pertaining to the contents and with the words: “Hazardous Waste.”

The Hazardous Waste Technicians at each operation or activity are responsible for inspecting the material and transporting the waste to a satellite accumulation area.

Hazardous waste may be stored on-site at an accumulation area for up to 90 days from the date of initial accumulation. WFF uses a licensed hazardous waste transporter to transport hazardous waste to a licensed treatment, storage, and disposal Facility.

A RCRA Part B permitted treatment storage and disposal facility is maintained on the southern end of Wallops Island. Rocket motors are treated at the facility by open burning until the casings are certified to be free of contamination.

A copy of the Virginia Hazardous Waste Management Regulations can be found at the following web link:

https://leg1.state.va.us/cgi-bin/legp504.exe?000+reg+9VAC20-60

AIR QUALITY (FEDERAL)

Air quality at four of the NASA launch sites (except RTS) is regulated by the National Ambient Air Quality Standards (NAAQS) (Title 40 CFR 50), Implementation Plans (Title 40 CFR 51), National Emission Standards for Hazardous Air Pollutants (Title 40 CFR 61 and 63), and Operating Permits (Title 40 CFR 70).

Air quality for the RTS is regulated under the UES Activities in the Republic of the Marshall Islands. Air quality tested for and meeting NAAQS is considered to be in attainment. NAAQS exist for ozone, carbon monoxide, oxides of nitrogen, sulfur dioxide, particulate <10 microns, particulate <2.5 microns, and lead(NASA 2011). Air quality is also regulated under the Clean Air Act (CAA) and any approved State Implementation Plan falling under the CAA. All major emitters are required to obtain an operating permit under the CAA. Protection of Stratospheric Ozone (Title 40 CFR 82) must also be adhered to operations at launch facilities. Information on NAAQS, Implementation Plans, Emission Standards and Operating Permits can be found at the following web links:

https://www.govinfo.gov/content/pkg/CFR-2018-title40-vol2/xml/CFR-2018-title40-vol2-part50.xml

https://www.govinfo.gov/content/pkg/CFR-2018-title40-vol2/xml/CFR-2018-title40-vol2-part51.xml

https://www.epa.gov/stationary-sources-air-pollution/national-emission-standards-hazardous-air-pollutants-neshap-9

https://www.govinfo.gov/content/pkg/CFR-2018-title40-vol17/xml/CFR-2018-title40-vol17-part70.xml

State and Facility Specific Guidance

Cape Canaveral Air Force Station/Kennedy Space Centre (CCAFS/KSC)

Air quality for the CCAFS and KSC area is regulated under FAC 62-200. The Florida Ambient Air Quality Standards are not significantly different from the NAAQS. FAC 62-210 establishes general requirements for stationary sources of air pollutant emissions and provides criteria for determining the need to obtain an air construction or air operation permit. FAC 62-213 implements Federal Rule Title 40 CFR 70, which provides a comprehensive operation permit system for permitting major sources of air pollution (Title V sources). CCAFS and KSC are classified as major sources because emissions are above major source thresholds. KSC and CCAFS have Title V permits.

FC 62-213 – Operation Permits for Major Sources of Air Pollution can be found at the following web link:

https://www.flrules.org/gateway/ChapterHome.asp?Chapter=62-213

Vandenberg Air Force Base (VAFB)

Air quality for the VAFB area is regulated under the California Code of Regulations (CCR), Title 17. Under CCR 17-Section 70200, the California Air Resources Board has developed ambient air quality standards, which represent the maximum allowable atmospheric concentrations that may occur and still ensure protection of public health.

Subchapter 7 of CCR 17-93000 defines toxic air pollutants as well as hazardous air pollutants. Subchapter 7.5 contains requirements for air-toxics control measures for specific industries. Subchapter 7.6 incorporates the requirements of the Air Toxics “Hot Spots” Information and Assessment Act of 1987.

Section 44340 of the Air Toxics “Hot Spots” Information and Assessment regulations requires preparation and submission of a comprehensive emissions inventory plan.

The Santa Barbara County Air Pollution Control District (SBCAPCD) also regulates VAFB. SBCAPCD Regulation XIII incorporates the Federal regulation for Operating Permits under Title 40 CFR Part 70 (NASA 2011).

CCR 17-Section 70200 can be found at the following web link:

https://www.arb.ca.gov/regs/title17old/toc17.htm

Wallops Island Flight Facility (WFF)

Air quality for the WFF area is regulated under the Virginia DEQ, by the State Air Pollution Control Board. WFF is in an attainment area for the Ambient Air Quality Standards, therefore, is not required to complete the CAA conformity process.

The Virginia DEQ does not currently perform ambient air quality monitoring in the vicinity of WFF. The Virginia DEQ considers the Eastern Shore of Virginia to be an attainment area for ozone, indicating compliance with primary and secondary standards. Accomack County is not designated as an Air Quality Maintenance Area. An Air Quality Maintenance Area is defined as “any area which, due to current air quality or projected growth rate or both, may have the potential for exceeding any ambient air quality standard (for criteria pollutants) within a subsequent 10-year period. WFF has an air permit from the Virginia DEQ that allows it to maintain emissions for criteria pollutants and hazardous air pollutants below major source thresholds (NASA 2011).

Kodiak Island Launch Complex (KLC)

Air quality for Kodiak Island is regulated under the Alaska Department of Environmental Conservation (ADEC). The air quality at Narrow Cape can be generally classified as unimpaired. Ranching, occasional vehicular traffic, and the occasional operation of two standby generators at the US Coast Guard Loran Station are the only human activities within the vicinity of Narrow Cape that would affect background air quality. Wind-blown volcanic dust is the primary air contaminant on the Island.

The ADEC Division of Air and Water Quality does not maintain air monitoring activities on the island due to minimal industrial activity and overall good air quality in the area (NASA 2011).

US Army Kwajalein Atoll / Reagan Test Site (USAKA/RTS)

Air quality for the Kwajalein area is regulated under the UES. These standards are based upon the U.S. CAA and its promulgated regulations, but do not include many of the procedural and technology-based requirements. The standards are designed to maintain the current air quality at USAKA/RTS. Pollutant ambient air concentrations may not increase above the baseline level by more than an increment of 25 percent of the applicable Ambient Air Quality Standards (NASA 2011).

A copy of the UES Activities in the Republic of the Marshall Islands can be found at the following web address: http://usagkacleanup.info/wp-content/uploads/2017/01/UES-14Ed-FNL-Nov-2014-15-16Sep2016-rd.pdf

WATER QUALITY (FEDERAL)

The Federal Clean Water Act (CWA) establishes a comprehensive approach to cleaning up and maintaining the quality of the nation’s surface waters. This approach is most commonly known by the National Pollution Discharge Elimination System (NPDES),permits which control point source pollution, and by Section 319 area-wide non-point source (NPS) pollution control management planning and associated best management practices (BMPs).

The CWA authorizes delegation of the NPDES permitting program to qualified states and federally recognized tribes and transfer of Federal funds for water quality management to states and federally recognized tribes that agree to adopt NPS plans and develop BMPs. Florida, California, Virginia, and Alaska have been delegated NPDES permitting authority and have adopted section 319 NPS plans and BMPs (NASA 2011). A summary of the CWA can be found at the following web link:

https://www.epa.gov/laws-regulations/summary-clean-water-act

State and Facility Specific Guidance

Cape Canaveral Air Force Station/Kennedy Space Centre (CCAFS/KSC)

NASA manages the monitoring of surface water quality on and near CCAFS and KSC at 11 long-term monitoring stations. The FDEP has classified water quality in the Florida Middle East Coast Basin as poor to good based on the physical and chemical characteristics of the water.

Vandenberg Air Force Base (VAFB)

The State Water Resources Control Board and the Regional Water Quality Control Board (RWQCB) administer the CWA and State water regulations in California. The Central Coast Region RWQCB is the local agency responsible for the VAFB area. The RWQCB is responsible for management of the NPDES permits process for California. State regulations require a Waste Discharge Requirement for permitting discharge. A Report of Waste Discharge is required for actions that would involve discharge of waste to surface and/or groundwater. The California Porter-Cologne Water Quality Act implements the NPDES program for the State.

Wallops Island Flight Facility (WFF)

The CWA is administered for WFF by the Virginia DEQ. The Commonwealth of Virginia, in a federally approved program, has the authority to issue a Virginia Pollution Discharge Elimination System (VPDES) permit. A VPDES permit, issued by the DEQ, authorizes potential or actual discharge of pollutants from a point source to surface waters under prescribed conditions and limitations.

WFF currently holds a VPDES Permit for 28 outfalls; 15 are on the Main Base and 13 are on Wallops Island. One of its Main Base outfalls is the discharge from its 0.3 million gallon per day wastewater treatment plant. As a result of this process discharge, a portion of Little Mosquito Creek is closed for shellfish harvesting by the Virginia Department of Health.

The closure serves as a buffer zone to ensure protection of human health. Buffer zone closures in the vicinity of point source discharges are a standard practice to provide protection of public health.

HAZARDOUS MATERIAL SPILLS AND CONTINGENCY PLANNING

Spills, fires, and explosions are possible outcomes from accidents during payload processing of expendable launch vehicles and could produce severe injuries or even death. A catastrophic accident of this type during payload processing would be extremely unlikely. Most propellant spills would be contained within the payload processing facility with no health impacts on personnel. The most likely consequences of a severe accident during processing would be some level of damage to the spacecraft and the immediate liquid propellant transfer area. Facility design would limit damage to the spacecraft and the transfer area. Injuries would not be anticipated if facility personnel follow emergency procedures (NASA 2011).

Extremely small quantities of toxic propellant vapors would be emitted from the payload processing facility during propellant-loading operations. These small emissions would not impact the health of the public or on-site personnel. The Toxic Hazard Assessment for the facility would provide additional protection by identifying the safety areas to be cleared of unprotected personnel during propellant operations (NASA 2011).

Details on the safe handling for a range of hydrazine propellants can be found at the following web link:

https://www.hydrazine.com/safety-handling/hydratesehs

Inadvertent releases of toxic air contaminants are possible as a result of accidents during payload processing, transportation, and launch. The largest releases would result from the spillage of the entire quantity of liquid propellants. Lesser releases could result from fires or explosions that would consume significant amounts of the propellants. Safety procedures in place at all of the proposed launch sites ensure that these events are unlikely to occur. In addition, spill response planning procedures are in place to minimize spill size and duration, as well as possible exposures to harmful air contaminants. The magnitude of air releases from payload accidents would be relatively small compared to possible releases from accidents involving launch vehicles.

Chapter 4 of the 2011 Environmental Assessment for NASA Routine Payloads (NASA 2011) provides an assessment of the effects for potential propellant spills at all NASA launch facilities. Appendix B contains documents for the mean hazard distance predictions at CCAFS, KSC, and VAFB for release of 1,000 kg (2,200 lb) total propellant load of hydrazine, 1,000 kg (2,200 lb) of MMH, and 1,200 kg (2,640 lb) of NTO.

Air dispersion modelling results for propellant spills are also provided. This documents the areas and distances that would temporarily have hazardous levels of the propellants in the event of a spill. These results indicate that the chemicals are diluted to non-hazardous levels in reasonably short distances.

A summary of historical spills at NASA facilities including lessons learned can be found at the following web link:

https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20100042352.pdf

State and Facility Specific Guidance

Cape Canaveral Air Force Station/Kennedy Space Centre (CCAFS/KSC)

Response to spills of hazardous materials JHB-2000 revision D, CCEMP establishes uniform policy guidelines for the effective mitigation of, preparation for, response to, and recovery from a variety of emergency situations. The CCEMP is applicable to all NASA, USAF, and NASA/USAF Contractor organizations and to all other Government agencies located at KSC, CCAFS, and Florida Annexes.

KNPR 8500.1 Rev. D Kennedy NASA Procedural Requirements - Kennedy Space Center Environmental Requirements can be found at the following web link:

https://prod.nais.nasa.gov/eps/eps_data/128659-SOL-001-011.pdf

https://tdglobal.ksc.nasa.gov/servlet/sm.web.Fetch/KNPR_8500.1__Rev_D_FINAL.pdf?rhid=1000&did=7250&type=released

CANADA

General Regulatory Framework for Future Spaceports

Launch Licenses and Public Safety

Transport Canada is responsible for the requirements of launching orbital and sub-orbital vehicles, through the Aeronautics Act which can be found at the following web link:

https://www.tc.gc.ca/eng/civilaviation/opssvs/sitemap-550.htm

Requirements for launching high power rockets in Canada can be found at the following web link:

http://www.canadianrocketry.org/files/tc_hpr_reqs_jan00.pdf

Applications for authorization to launch high power and advances high power rockets can be found at the following web link:

https://www.tc.gc.ca/media/documents/ca-standards/26-0660.pdf

Transportation of Dangerous Goods Act and Regulations

Transportation of hydrazines within Canada is regulated by the Transportation of Dangerous Goods Act which outlines requirements for handling, storing, and labelling substances such as UDMH. Transportation of dangerous goods classification and related subclasses for UDMH can be summarized as follows:

UDMH – UN 1163; Emergency Guide No. 131; Class 6.1; Special Provisions 4, 15, 17, 19, 44, 73

Storage of UDMH

UDMH may be stored in the DOT-approved container in which it is shipped. UDMH should be stored away from heat, sparks open flame and oxidants, only in well-ventilated areas. Since UDMH is stable, it can be stored without loss of purity. (ARCH 2019)

ENVIRONMENTAL STATUTES AND REGULATIONS

Canadian Environmental Assessment Act

The Canso Spaceport project did not trigger the need for an assessment under the Canadian Environmental Assessment Act, as it was not located on federal land and it did not constitute a designated project as listed in the Regulations Designating Physical Activities under the Act(Government of Canada 2019).

Canadian Environmental Protection Act (CEPA)

Domestic Substances List

Hydrazine is listed on the DSL while 1, 1-dimethylhydrazine (CAS RN 57-14-7) is listed on the Non-Domestic Substance List (NDSL) and any import of more than 1000 kg/year would require notification to the new substances program for review.

- DSL – hydrazine is listed without conditions, can be imported, manufactured, and used.
- NDSL – UDMH is listed and requires notification to the new substances program if more than 1,000 km/year is imported or manufactured in Canada.

Details of the DSL Review and status of hydrazines can be found at the following web link:

https://www.canada.ca/en/environment-climate-change/services/management-toxic-substances/list-canadian-environmental-protection-act/hydrazine.html

National Pollutant Release Inventory

National Pollutant Release Inventory – hydrazine is listed, and is reportable if manufactured, processed, or otherwise used at quantities greater than 1,000 kg.

Details on the National Pollutant Release Inventory Reporting requirements can be found at the following link:

https://www.canada.ca/en/environment-climate-change/services/national-pollutant-release-inventory/public-consultations/proposed-changes-response-substance-review.html

Environmental Emergency Regulations

Environmental Emergency Plans are required for:

- 1-dimethylhydrazine at concentrations equal to or greater than 10% by weight (Minimum Quantity threshold of 6.80 tonnes)
- Hydrazine at concentrations equal to or greater than 10% by weight (Minimum Quantity threshold of 6.80 tonnes (-6730 litres assuming a density of 1.011 g/cm^3)

Information and Environment and Climate Change Canada requirements for Environmental Emergency Plans can be found at the following web link:

https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/plans-policies/emergency.html

National Pollutant Release Inventory

A release or spill of hydrazine requires reporting under the National Pollutant Release Inventory as it is a listed substance.

Federal Environmental Quality Guidelines

Federal Environmental Quality Guidelines have been established for hydrazine and are considered voluntary limits, unless prescribed in specific approval documentation. Hydrazine was found to not meet the criteria for persistence and bioaccumulation and is considered to biodegrade quickly (EC, 2013).

Environment Canada has developed federal water quality guidelines for hydrazine which are protective of Freshwater Aquatic Life: 2.6 µg/L and Marine Aquatic Life: 0.2 µg/L.

A copy for the supporting document for the development of the Federal Environmental Quality Guidelines s can be found at the following web link:

http://www.ec.gc.ca/ese-ees/default.asp?lang=En&n=D66353C2-1

NOVA SCOTIA

Regulatory Framework

While there are currently no operating spaceports within Canada, it is anticipated that the use of hydrazine at a Canadian spaceport would follow the American model of regulation implementation whereby the applicable regulations are addressed in site or agency specific standards and manuals.

Nova Scotia Environmental Assessment Regulations

The current Spaceport project is subject to a Class 1 EA as defined by the Environmental Assessment Regulations under the Nova Scotia Environment Act due to the potential impact to greater than 2.0 hectares of a wetland.

Nova Scotia Activity Designation Regulations

The Nova Scotia Activity Designation Regulations outline the various activities that require approval from Nova Scotia Environment (NSE) to either be constructed or operated. There are no specific requirements for an approval to construct or operate a Spaceport. Section 10 of the Regulations outlines the requirements for a ‘dangerous goods facility’, a ‘waste dangerous goods facility’, and ‘a site with a chemical storage tank system with capacity exceeding 2000L’. Section 5 of the Regulations outlines requirements for watercourse and wetland alteration.

Nova Scotia Dangerous Goods Management Regulations

The Nova Scotia Dangerous Goods Management Regulations would also apply to the handling and use of hydrazines through specific storage requirements including the following:

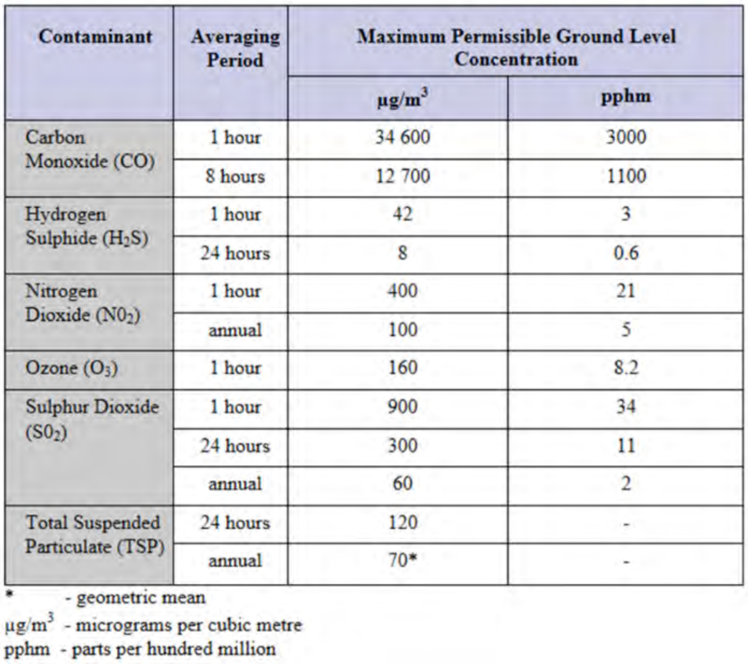
- Section 2 – Definitions – Linked to Transportation of Dangerous Goods Hazard Classes
- Section 5 – No applicable exemptions
- Section 7 – Specific storage requirements
- Section 8 – General storage requirements
- Section 10 – Contingency Plans
- Section 11 – Inventory Controls
- Section 12 – Prohibition regarding disposal

A copy of Nova Scotia’s Contingency Planning Guidelines can be found at the following web link:

https://novascotia.ca/nse/dept/docs.policy/Guidelines-Contingency.Plan.pdf

Nova Scotia Air Quality Regulations

Nova Scotia has established ambient air quality objectives for the province. Objectives are expressed as Maximum permissible ground level concentrations as outlined in the following Table from Schedule A of the Regulations.



Contaminant	Averaging Period	Maximum Permissible Ground Level Concentration	
		µg/m³	pphm
Carbon Monoxide (CO)	1 hour	34 600	3000
	8 hours	12 700	1100
Hydrogen Sulphide (H_2S)	1 hour	42	3
	24 hours	8	0.6
Nitrogen Dioxide ($N0_2$)	1 hour	400	21
	annual	100	5
Ozone (O_3)	1 hour	160	8.2
Sulphur Dioxide ($S0_2$)	1 hour	900	34
	24 hours	300	11
	annual	60	2
Total Suspended Particulate (TSP)	24 hours	120	-
	annual	70*	-

* - geometric mean
µg/m³ - micrograms per cubic metre
pphm - parts per hundred million

Ambient Air Monitoring Program

Ambient air monitoring stations measure the quality of outdoor air and air pollution emissions from many sources, such as industrial facilities (electrical power plants, pulp and paper mills), vehicles, natural sources (such as forest fires and trees), and emissions generated in Nova Scotia, neighboring provinces and states, and globally.

This information is compared against Maximum Permissible Ground Level Concentrations in the Nova Scotia Air Quality Regulations, and the Canadian Ambient Air Quality Standards which replaced the Canada-wide Standards for Particulate and Ozone in 2015.

The application gives the latest real-time hourly measurements for pollutants measured at all the Government of Nova Scotia's ambient air quality monitoring stations in the Province. Pollutants measured at the monitoring stations can include:

- ground-level ozone (O_3)
- fine particulate matter ($PM_{2.5}$)
- carbon monoxide (CO)
- sulphur dioxide (SO_2)
- Total reduced sulphur (TRS)
- nitrogen oxides (NOx), nitric oxide (NO) and nitrogen dioxide (NO_2)

Provincial ambient air quality monitoring stations are located in these communities:

- Aylesford Mountain
- Kentville
- Halifax
- Lake Major

- Pictou
- Port Hawkesbury
- Sydney

Nova Scotia Contaminated Sites Regulation

Hydrazine is not currently listed as Chemical of Concern and has not been assigned with an Environmental Quality Standard (EQS) under the Nova Scotia Contaminated Sites Regulation for any media. However, Federal Water Quality Guidelines have been developed by Environment and Climate Change Canada and could be adopted as Tier1 EQS.

EPA Regional Screening Levels are available and could be adopted as Tier 1 EQS, however these values would need to be adjusted for use in Nova Scotia to account for differences in the Target Risk = $1x10^{-05}$ Incremental Lifetime Cancer Risk (ILCR) and 0.2 of the product Reference Dose (RfD) in accordance with Canadian Council of Ministers of the Environment (CCME) procedures.

1.2 Given the highly toxic properties of hydrazine related chemicals (e.g., unsymmetrical dimethyl hydrazine, hydrazine and monomethylhydrazine), the following information requests are required as part of the Focus Report:

- ***A discussion to justify why hydrazine related chemicals are needed for the Project;***

Hydrazine gives the best performance as a rocket fuel because it ignites spontaneously on contact with an oxidizer and does not require an ignition source (Quitney 2016). Hydrazine is an easily storable fuel that can be managed for extensive periods of time because it remains liquid at normal temperatures and does not pose the storage problems of cryogenic propellants (Quitney 2016). The easy start and restart capability of hypergols make them ideal for spacecraft maneuvering systems. They can fire any number of times by simply opening and closing the propellant valves until the propellants are exhausted. Therefore, hydrazine is uniquely suited for the Cyclone-4M launch vehicle which must perform more than one burn to reach, maintain and change orbit.

In 2016, the Ukrainian space agency gave formal permission to KB Yuzhnoye to proceed with the development of a joint venture for a new designed Cyclone-4 rocket in North America. The second stage for Cyclone-4M will be borrowed from the third stage of the Cyclone-4M rocket. It will use a hypergolic (or storable) propellant. Although both of its components are toxic, they remove all time limitations of easily evaporating cryogenic propellants (KB Yuzhnoye 2019). As a result, the upper stage can be restarted multiple times and operate in space almost indefinitely, performing elaborate maneuvers.

1.2 Given the highly toxic properties of hydrazine related chemicals (e.g., unsymmetrical dimethyl hydrazine, hydrazine and monomethylhydrazine), the following information requests are required as part of the Focus Report:

- ***A discussion regarding options to replace or reduce the use of hydrazine related chemicals;***

Experience with hydrazine and other conventional propellants is flight proven since before the Gemini program (E.W. Schmidt and E.J. Wucherer 2004). There are efforts being made by both NASA and the European Space Agency (ESA) to identifying a “green propellant” to replace hydrazine. These studies are ongoing and currently have not been proven to outperform or reduce costs associated with hydrazine.

The European Commission’s Registration, Evaluation, Authorization, and Restriction of Chemical Substances program has identified hydrazine as a substance of high concern (ESA, 2013). This distinction means that hydrazine may be limited or restricted for industrial use in the future but exemptions for specific uses (e.g., spacecraft) are possible if no alternative is available. The ESA has begun to engage industry to seek alternative fuel sources, such as ammonium dinitramide (Negri, 2015). NASA is also currently engaged in finding a “green” alternative to the use of hydrazine through the Green Propellant Infusion Mission Project. This project is currently assessing the use of hydroxyl ammonium nitrate fuel-oxidizer blend (AF-M315E) as an alternative to hydrazine (NASA 2019). While both the ESA and NASA identify the advantages of developing a green alternative to hydrazine, both agencies still rely on and use it for current and planned future launches.

In time, these alternate fuels could potentially be used in place of hydrazine but will require significant testing and flight certification and are not suitable for use with the proposed launch vehicle. Currently there are no hydrazine replacement options for restart of propulsion systems while in orbit.

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2.0 EXPERTISE

2.1 Expertise in the assessment of valued environmental components related to spaceports is required for this EA, and the resumes of these experts are required as part of the Focus Report.

Resumes are provided as Appendix A of this report.

3.0 DANGEROUS GOODS MANAGEMENT

3.1 Provide details regarding the management of dangerous goods:

- ***Provide a list of chemicals and associated quantity to be used for the Project (e.g., rocket propellants, other fuel types, oxidizer, additives, etc.). The Chemical Abstracts Service registry number (CASRN) of these chemicals should also be provided;***

Chemicals	Purpose	CASRN	Amount (tonnes)	Application*
Unsymmetrical dimethylhydrazine (UDMH)	Second stage fuel	57-14-7	Up to 14	Storage and fuel for second stage
Hydrazine	Spacecraft fuel	302-01-02	Up to 0.2	Storage and fuel for spacecraft
Dinitrogen tetroxide (NTO)	Second stage oxidizer	10544-72-6	Up to 23	Storage and filling second stage
RP-1 (highly pure kerosene)	First stage fuel	8008-20-6	Up to 90	Storage and fuel for first stage
Liquid oxygen (LOX)	First stage oxidizer	7782-44-7	Up to 285	Filling first stage
Antifrogen N	Antifreeze, cooling brine	107-21-1	Up to 2	Constantly in ground support equipment

Notes:
* The Cyclone-4M launch vehicle would contain the following propellant components:
First stage – Fuel: RP-1 (62.3 tonnes); Oxidizer: LOX (166.0 tonnes)
Second stage - Fuel: UDMH (3.2 tonnes); Oxidizer: NTO (7.7 tonnes)

3.1 Provide details regarding the management of dangerous goods:

- ***Clarify which hydrazine chemical(s) including associated CASRN and quantity will be used for the Project if hydrazine chemicals cannot be replaced with non-toxic or less toxic propellants;***

Hydrazines are chemical compounds that contain two nitrogen atoms joined by a single covalent bond. Three examples of common hydrazine compounds include:

- hydrazine - also known as diamine, diamide, anhydrous hydrazine, and hydrazine base
- 1,1-dimethylhydrazine - also known as unsymmetrical dimethylhydrazine, dimazine and others
- 1,2-dimethylhydrazine - also known as symmetrical dimethylhydrazine, hydrazomethane, and others

The following hydrazine chemical compounds will be used in association with this project.

Compound	CASRN	Application	Mass (kg)
UDMH	57-14-7	Storage Tanks	up to 14000
		Integrate Launch Vehicle Stage 2	up to 3230
		Total	up to 14000
Hydrazine	302-01-02	Storage Containers	up to 100
		Spacecraft	from 2 to 50
		Total	up to 100

3.1 Provide details regarding the management of dangerous goods:

- ***Clarify whether perchlorate related chemicals will be used for the Project;***

No solid propellants containing perchlorate related chemicals will be used for the project.

3.1 Provide details regarding the management of dangerous goods:

- ***Provide detailed information on the environmental properties of hydrazine related substances and other uncommon chemicals to be used in the launches (including degradation products and rates, environmental persistence, fate and transport parameters, toxicity to aquatic and terrestrial organisms in water, soil and air).***

The hydrazine related compound used in greatest quantities, UDMH, is a transparent, colorless, highly volatile, highly toxic liquid with ammonia odor. It has a strong irritant and pronounced resorptive toxic effect. Hazard classes for UDMH and its main decomposition products are shown in Table 3.1.1. Decomposition of UDMH is dependent on temperature, light, pH, medium, and the presence of other substances.

Table 3.1.1. Hydrazine Related Components and Hazard Classes

Component	Hazard class	
UDMH	1	Explosive
UDMH decomposition products		
Dimethylamine	2	Gas
Tetramethyltetrazene	3	Flammable and Combustible Liquid
Nitrosodimethylamine	1	Explosive

Reaction products of UDMH with air and water also include trimethylamine, tetramethylhydrazine, acetaldehyde dimethylhydrazone, formaldehyde dimethylhydrazone, trimethylhydrazine, and 1-formyl 2,2-dimethylhydrazine.

It should be noted that maximum permissible concentration (MPC) for UDMH in water does not fully reflect the effect of this product on marine organisms. Table 3.1.2 shows the persistence and selected toxicity values (LC50 and EC50). LC50 is the concentration lethal to 50 percent of the test organism population, while EC50 is the concentration resulting in growth reduction of 50 percent of the test organism population.

Table 3.1.2. Persistence and Ecotoxicity of UDMH

Component	CASRN	Fast Anaerobic Biodegradation	Persistent	LC50 Fish (mg/L)	LC50 Daphnid (mg/L)	EC50 Algae (mg/L)
UDMH	57-14-7	Yes	Yes	7.89	4.7	8.0
Trimethylamine	75-50-3	No	No	1000	—	—
Dimethylamine	124-40-3	Yes	No	118	50	6.2
Nitrosodimethylamine (NDMA)	62-75-9	Yes	No	940	330	4.0

mg/L – milligrams per liter; Sources: U.S. National Library of Medicine 2004, 2008, 2012, 2018

To put these values into perspective, for a typical-size swimming pool (375,000 L), it would take 2.9 kg of UDMH or about 1 gallon to reach a concentration at which 50 percent of the fish in the pool would be expected to die from exposure. For the invertebrate daphnia, it would take 1.8 kg of UDMH or about 0.5 gallon to reach a concentration at which 50 percent of the daphnids would be expected to die from exposure. For algae, it would take about 2.9 kg or 1 gallon of UDMH to reach the concentration at which the growth of half of the population would be affected. UDMH degradation products are less toxic than UDMH to fish and daphnids, so these organisms could survive exposure to higher concentrations than for UDMH before half of the organisms would be affected. NDMA is more toxic to algae than UDMH or dimethylamine. Exposure to 1.5 kg or 0.5 gallons of NDMA in the typical-sized swimming pool could affect the growth of half of the algal population. In the ocean, because of the rapid dilution and mixing process, the potential harm to aquatic plants and animals from exposure to UDMH or its degradation products would be *de minimis* under the worst case scenario of a full upper stage tank impacting the ocean. The concentration of UDMH is expected to be reduced by half within 1-2 hours in sea water (Table 3.1.3).

NDMA is a nitrosamine contaminant found in a number of foods and beverages including beers, cheeses, sausages and smoked and pickled foods. They are formed during frying, smoking and pickling processes. These compounds can also be produced in man and other mammals under the acidic conditions in the stomach. In a study conducted to determine the level of NDMA in 13 meat products, the level of NDMA varied from 0.049 mg/kg to 16.47 mg/kg, with the highest concentration of NDMA found in smoked sausage (Rocz 2006).

Biodegradation of UDMH occurs in both water and soil. In the screening assessment for hydrazine, Environment Canada (2011) determined that:

- If released to air, hydrazine will not partition to alkaline hardwater, but will partition to slightly acid softwater;
- If released to surface water, hydrazine will not readily partition to other environmental media;
- If released to soil, hydrazine will not readily partition to other environmental media in alkaline hardwater areas and will partition significantly in slightly acidic softwater.

Bioconcentration of UDMH does occur, but biomagnification through the food chain is unlikely due to rapid degradation. Hydrazine does not meet the criteria for persistence or bioaccumulation potential as set out in the Persistence and Bioaccumulation Regulating (Canada 2000). In small quantities UDMH does not inhibit, but stimulates the growth of algae.

Evaluations of the half-life of UDMH in natural environments are contradictory since its elimination (decomposition) is a multifactorial process and depends on temperature, illumination, and the presence of other substances in the medium. For example, the oxidation of UDMH in sea water differs from the oxidation process of UDMH in fresh water. Various elements in sea water, including transition metal ions (Cu^{2+}, Fe^{2+}, Ni^{2+}, CO^{2+}), serve as catalysts for the oxidation of UDMH. The main product of UDMH oxidation in sea water is tetramethyltetrazene, which has a MPC of 0.1 mg/l in water.

Table 3.1.3 shows half-lives of UDMH estimated theoretically for air and determined during laboratory studies for sea water (oxidation to tetramethyltetrazene).

Table 3.1.3. Approximate Half-lives of UDMH in Natural Environments

Air, h	Sea water, h
100	1 – 2

The stability of UDMH in soil depends on multiple factors:

- Quantity of the component entering the soil: the higher the concentration, the higher the stability;
- Aeration conditions: the better the aeration, the lower the stability;
- Weather conditions: in the summer period (high illumination, average air temperature is higher than 20 degrees Celsius [°C]), the stability is lower than in winter (low light level, average air temperature is lower than 5°C);
- Type of soil: the more organic matter and humus in the soil, the higher the stability; and
- Presence of other substances.

Toxicity of hydrazine

Hydrazine fluid is corrosive and can cause dermatitis to humans and animals when in contact with skin. Effects in the lungs, liver, spleen, thyroid gland were observed for animals after chronic (prolonged) inhalation exposure to hydrazine. Rodents exposed to hydrazine experienced damage to the lungs, nasal cavity and liver, as well as developing tumors.

Tests on rats, mice, rabbits and guinea pigs showed high acute toxicity from inhalation and ingestion.

An increase in the incidence of lung and liver tumors was observed in mice exposed to hydrazine through inhalation, drinking water and injections. Tumors in the nasal cavity were observed in rats and hamsters after inhalation exposure to hydrazine (NCBI 2019a).

Toxicity of 1,1-dimethylhydrazine

Carcinogenic effects were observed in mice and rats exposed to 1,1-dimethylhydrazine through inhalation; however, because of the presence of impurities in the study, the results were inconclusive. 1,1-dimethylhydrazine is a carcinogen for mice and hamsters exposed orally. Birth defects were not observed in offspring of animals exposed to 1,1-dimethylhydrazine on the abdominal cavity (NCBI 2019b).

Effects of acute poisoning in rats, mice, hamsters, rabbits, and guinea pigs has shown that 1,1-dimethylhydrazine vapors are highly toxic.

For a single 4-hour exposure to 1,1-dimethylhydrazine, lethal concentrations for 50% of animals are as follows:

1) for mice – 0.42 milligrams per cubic decimeter (mg/dm^3);
2) for rats – 0.62 mg/dm^3; and
3) for guinea pigs – 0.10 mg/dm^3.

At repeated 6-hour exposures of 5 parts per million (ppm) hydrazine for 6 months, 2 of 2 dogs survived; 2 of 4 dogs lived after 194 6-hour exposures to 14 ppm while 2 died during the third and fifteenth weeks in a debilitated condition. The dog that died during the fifteenth week had a severe convulsive seizure prior to death. Prior to death, both dogs showed signs of anorexia and general fatigue. Changing diets and forced feedings resulted in the survival of the remaining two dogs (MacEwen and Vernot 1981)

Effect of hydrazine fuel on soil

The MPC of 1,1-dimethylhydrazine in soil is 0.1 mg/m^3. Hydrazine fuel has a low degree of persistence in soil. The estimated half-life of hydrazine in doses of 1.0-10.0 mg/kg is about 1.5 days, and total decomposition takes about 8.5 days. Low concentrations of hydrazine in the soil (from 0.1-10 mg/kg) decompose almost completely within 10 days. High concentrations (more than 100 mg/kg) are more resistant to decomposition (60 days). The effect of various concentrations of hydrazine on the biological activity of soil exposed to hydrazine at concentrations of 0.1, 1.0, 10 mg/kg and 100 mg/kg in 1, 2, 3, 6 and 12 hours after treatment and 10, 20, 30 days after exposure showed that hydrazine changes the quantity and qualitative composition of soil microorganisms.

When exposed to hydrazine in the above mentioned doses, the total number of microorganisms in the soil decreased by 22.7, 50, 50 and 1000 times, respectively, after 1 hour. Greater change (decreases of 500-1000 times) occurred in the group of microorganisms assimilating inorganic forms of nitrogen. Microscopic fungi were the most sensitive to hydrazine. The number of microscopic fungi in soil containing 0.1 mg/kg hydrazine decreased by 400 times and were absent in soils with a higher concentration of hydrazine. The decrease in the number of microorganisms continued for up to 30 days. Significant changes in the quantitative and qualitative composition of soil microorganisms were observed at a concentration of equal to 0.1 mg/kg. The number of spore microorganisms in the experimental soils decreased, but had increased 20 days after the soil treatment (Kozlovskiy and Alubrekov *no date*).

To put these values into perspective, if the microorganisms in the soil of a 10 ft. x 10 ft. x 2 ft.(200 ft^3) garden plot were exposed for up to 30 days to 100 mg/kg of hydrazine (686 grams) (the equivalent of 2.5 cups of hydrazine mixed into this volume of soil), a change in soil microorganism quality and quantity would be expected. Complete decomposition of hydrazine would be expected in about 60 days. At lower concentrations of exposure the quality and number of soil microorganisms would return to normal more quickly.

Additional toxicological-related properties of hydrazines are provided in Table 3.1.4.

Table 3.1.4 – Toxicological-Related Properties of Hydrazines

Property	Hours / pH	1/days		LC50 (inhalation)	LD50 (food)	
		Summer	Winter		Rats	Mice
Half-life of UDMH in water	630 / 5 66 / 6 10 / 7 4.5 / 8					
UDMH transformation rate constants (1-10 mg/dm^3)		0.115	0.007			
Acute inhalation toxicity (mg/m^3)						
Hydrazine				740		
UDMH				330		
Acute non-inhalation toxicity (mg/kg)						
Hydrazine					60	122
UDMH					60	265

3.2 Provide detailed procedures for the management of dangerous goods (e.g., transportation, handling, storage, etc.), including: transportation to and from the Project site, minimum separation distance between energetic liquids in a storage facility (intraline setback), secondary containment and monitoring, etc.

TRANSPORT AND HANDLING OF PROPELLANT AND COMPRESSED GASES FOR THE FIRST STAGE

Liquid nitrogen (LOX), RP-1 (highly pure kerosene), and compressed helium are required for the first stage launch process. Material Safety Data Sheets (MSDS) for each of these chemicals are provided in Appendix B. Transportation and handling requirements are detailed in the individual MSDSs. The chemicals used in the first stage of the launch process are common industrial chemicals commonly transported by tank semitrailers or tank containers in compliance with all local, provincial, federal, and international regulations, standards, and laws. Helium is expected to be delivered in rented high pressure American Society of Mechanical Engineers (ASME)-certified bottles from FIBA Technologies, Inc. via semitrailer.

LOX, RP-1, and liquid nitrogen will be delivered in transport tanks at the launch complex and will be subjected to a physical-chemical quality control analysis. If the quality control analyses are acceptable, the propellant and helium are pumped into the filling system tanks for temporary storage before launch vehicle filling.

TRANSPORT AND HANDLING OF PROPELLANT AND COMPRESSED GASES FOR THE SECOND STAGE

The following propellant components and compressed gases would be delivered in approved transport containers to the fueling/neutralization station at the spacecraft and payload unit processing complex:

- Dinitrogen tetroxide (NTO) (oxidizer);
- UDMH (fuel); and
- Compressed helium.

MSDSs for each of these chemicals are provided in Appendix B. NTO will be transported and handled in UNT50 tank containers. The tank containers are provided with a heat exchange system intended for heating or cooling NTO. The tank containers would be loaded onto the transport vehicle and secured in place. The tank container will be certified by Maritime Register for sea deployment.

UDMH will be transported and handled in UNT20 tank containers. The tank containers would be loaded onto the transport vehicle and secured in place. The tank container will be certified by Maritime Register for sea deployment. The oxidizer tank container is similar to the fuel tank container except for the thermostating system of the oxidizer tank container.

NTO and UDMH will never be shipped or transported at the same time.

Oxidizer and fuel tank containers are designed to provide safety and security during transport and temporary storage. They will meet the standards of:

- International Convention for Safe Containers;
- International Customs Convention;
- International Maritime Dangerous Goods Code (IMDG Code);
- International Agreement concerning the Carriage of Dangerous Goods by Road (ADR);
- International Agreement concerning the Carriage of Dangerous Goods by Rail (RID);
- International Union of Railways (UIC);
- International Organization for Standardization (ISO) 668:2013, ISO 1161:2016, ISO 1496-3:1995, ISO 6346:1995 International Standards;
- United Nations Recommendations on the Transport of Dangerous Goods; and
- Rules for the Manufacture of Containers by the Maritime Register of Shipping.

Roll-on/roll-off type vessels designed to carry wheeled cargo are recommended for delivery of tank containers from the propellant manufacturer to Canada. Propellant tank containers would be loaded onto semitrailers by cranes and transported by trucks to the launch complex where they would be transported to the spacecraft and payload unit processing complex and fueling/neutralization station. There the propellant components will be tested to verify quality and pumped into oxidizer and fuel filling systems tanks for temporary storage and further second stage propulsion system filling.

The launch services Customer provides hydrazine in tanks with a capacity of no more than 200 kg for spacecraft filling. Unused residuals at the end of the mission are removed by the Customer.

Other Materials

The following dangerous goods are used with the Cyclone-4M launch vehicle (list subject to update):

- Pyrocartridges EVM-4-2;
- Explosive bolts 15X569 (BR-11); and
- Consumables (flammable liquids, lubrications, lithium-ion batteries).

Pyrocartridges and explosive bolts can be transported by numerous transportation methods, all in accordance with international rules on the carriage of dangerous goods (IMDG Code, SMGS, ADR, RID, IATA Regulations or International Civil Aviation Organization (ICAO) Technical Instructions).

In addition, a variety of consumables are transported and handled in association with the project. These consumables include:

Consumable Type	UN Number	Hazard Class*	Packaging Type
Nitro adhesive AK-20	1133	3	Packed in sealed aluminum can placed in a wooden box
Ethylacetate	1173	3	Packed in sealed aluminum can placed in a wooden box
Adhesive Leuconat	1133	3	Packed in sealed aluminum can placed in a wooden box
Primer AK-070	1139	3	Packed in sealed aluminum can placed in a wooden box
Naphtha C2-80/120	1263	3	Packed in 15 standard sealed aluminum cans (1 kg each) and placed in a wooden box

Consumable Type	UN Number	Hazard Class*	Packaging Type
Enamel EP-51	1263	3	Packed in separate 1 kg standard sealed aluminum cans and placed in a wooden box.
Perchlorovinyl enamel	1263	3	Packed in 15 standard sealed aluminum cans (1 kg each) and placed in a wooden box
Lithium-ion batteries	3090	9	Battery is placed in sealed polyethylene film cover and fixed with four bolts to two intermediate transport laths. Two blocks are attached as spare parts, tools and accessories.
Adhesive 88	1133	3	Packed in 15 standard sealed aluminum cans (1 kg each) and placed in a wooden box
Primer	1139	3	Packed in sealed aluminum can placed in a wooden box

***** Hazard class: 3 – flammable liquid; 9 – miscellaneous dangerous substances

These consumables are transported by numerous methods, all in accordance with international rules on the carriage of dangerous goods (IMDG Code, SMGS, ADR, RID, IATA Regulations or ICAO Technical Instructions).

MINIMUM DISTANCE FOR ENERGETIC LIQUIDS STORAGE

The minimum distances between energetic liquids was calculated using United States (US) 14 Code of Federal Regulations (CFR) Appendix E to Part 420, Tables for Explosive Site Plan and will meet or exceed the requirements as defined by international standards and are presented in Table 3.2.1.

Table 3.2.1. Minimum Distances Between Energetic Liquids

Chemical/ Item	Use	Location	Volume litre (gal)	Mass kg (lb)	Net Explosive Weight kg (lb)	Nearest Public Receptor m (ft)	Nearest Public Traffic Roadway m (ft)	Intraline Distance m (feet)
LOX	First Stage	Vertical Launch Area	302,833 (80,000)	345,229 (761,100)	103,568 (228,330)	15.24 (50)*	15.24 (50)*	335 (1100)
RP-1	First Stage	Vertical Launch Area	113,562 (30,000)	92,533 (204,000)	18,506 (40,800)	420 (1,377)	252 (826)	189 (620)
NTO	Second Stage	Horizontal Integration Facility	18,927 (5,000)	27,255 (60,087)	2,725 (6,009)	381 (1,250)	229 (750)	100 (327)
UDMH	Second Stage	Horizontal Integration Facility	18,927 (5,000)	15,009 (33,090)	1,501 (3,309)	366 (1,200)	219 (720)	34 (110)

Notes: gal – gallons; lb – pounds; m – metres; ft – feet
* From NFPA 55, Table 9.3.2 (Public assembly/Combustible liquids)

The actual distances, based on current site-layout, are presented in Table 3.2-2.

Table 3.2-2. Proposed Minimum Distances of Storage Areas (metres)

Object	Fuel Tank Container Storage Site (UDMH)	Oxidizer Tank Container Reception and Storage Site (NTO)	RP-1 Filling System Site	Oxygen Filling System Site	Liquid Nitrogen Supply System Site
Fuel Tank Containers Storage Site (UDMH)	X	345	815	890	875
Oxidizer Tank Containers Reception And Storage Site (NTO)	345	X	1100	1150	1136
RP-1 Filling System Site	815	1100	X	110	100
Oxygen Filling System Site	890	1150	110	X	14
Liquid Nitrogen Supply System Site	875	1136	100	14	X

3.3 Provide a detailed spill contingency plan(s). Given the hazardous properties of the substances potentially stored and used at the Project site and the various regulatory instruments that could be applicable, spill contingency plans specific to each fuel, oxidizer, etc. might be required.

United PARADYNE Corp (UPC), has been purchasing, transporting, storing and loading hypergolic fuels and oxidizers for over 25 years and have existing procedures for spill contingency planning.

A UPC Emergency Response Plan is included in Appendix C and includes an example spill contingency plan. The plan will be modified to address local, provincial, and federal requirements, including:

- Notification Procedures
- Roles and Responsibilities
- Containment and Clean-Up Procedures
- Restoration
- Disposal
- Reporting Requirements

In addition, detailed procedures and emergency plans for fueling and defueling of launch vehicles will be provided to all operational staff once final launch vehicle and site development plans are complete. These procedures will adhere to all regulatory requirements. Fueling and filling procedures will make it possible to terminate the process at any time in case of deviations from monitored parameters, adverse external factors, or other reasons.

3.4 Provide detailed procedures for fueling and de-fueling of rockets (e.g., due to unexpected circumstances such as bad weather), including purging and decontamination.

Standard operational fueling activities include the following actions:

- Fueling of the first stage,
- Fueling of the second stage,
- Fueling of payloads, and
- Purging supply lines at completion of fueling.

First Stage Fueling

Layout of the filling system is shown on Figure 3.4.1.

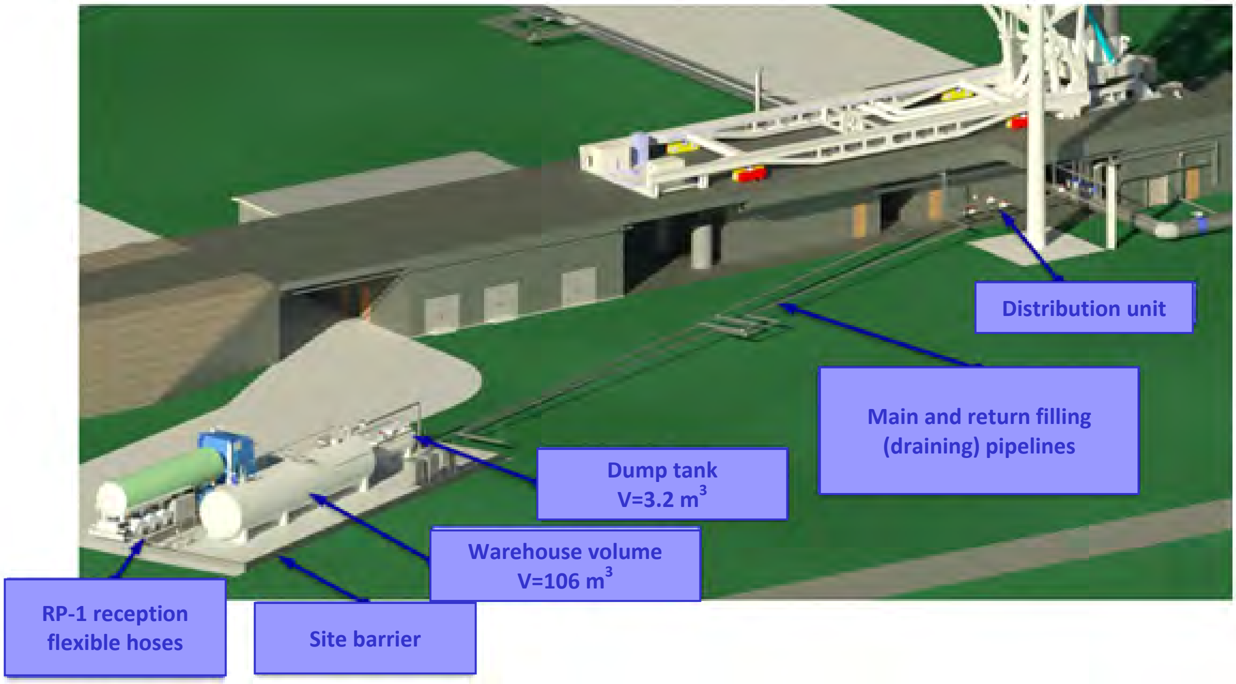


Figure 3.4.1. Layout of RP-1 Filling System Equipment at Launch Complex

Initial status of RP-1 filling system prior to the integrate launch vehicle filling is as follows:

- Function of the fueling/neutralization station equipment is tested;
- Sufficient volume of RP-1 at required temperature is in a RP-1 warehouse tank; and
- Main filling pipeline and distribution unit are not filled.

After installation of the launch vehicle at the launch pad, personnel manually connect the launch vehicle fill line with the RP-1 fill line by means of flexible metal pipelines with flanges. A leak test of flange interfaces is carried out. Further operations on the launch vehicle filling are performed without maintenance personnel at the launch complex according to approved control procedures. The following sequence of operations is performed:

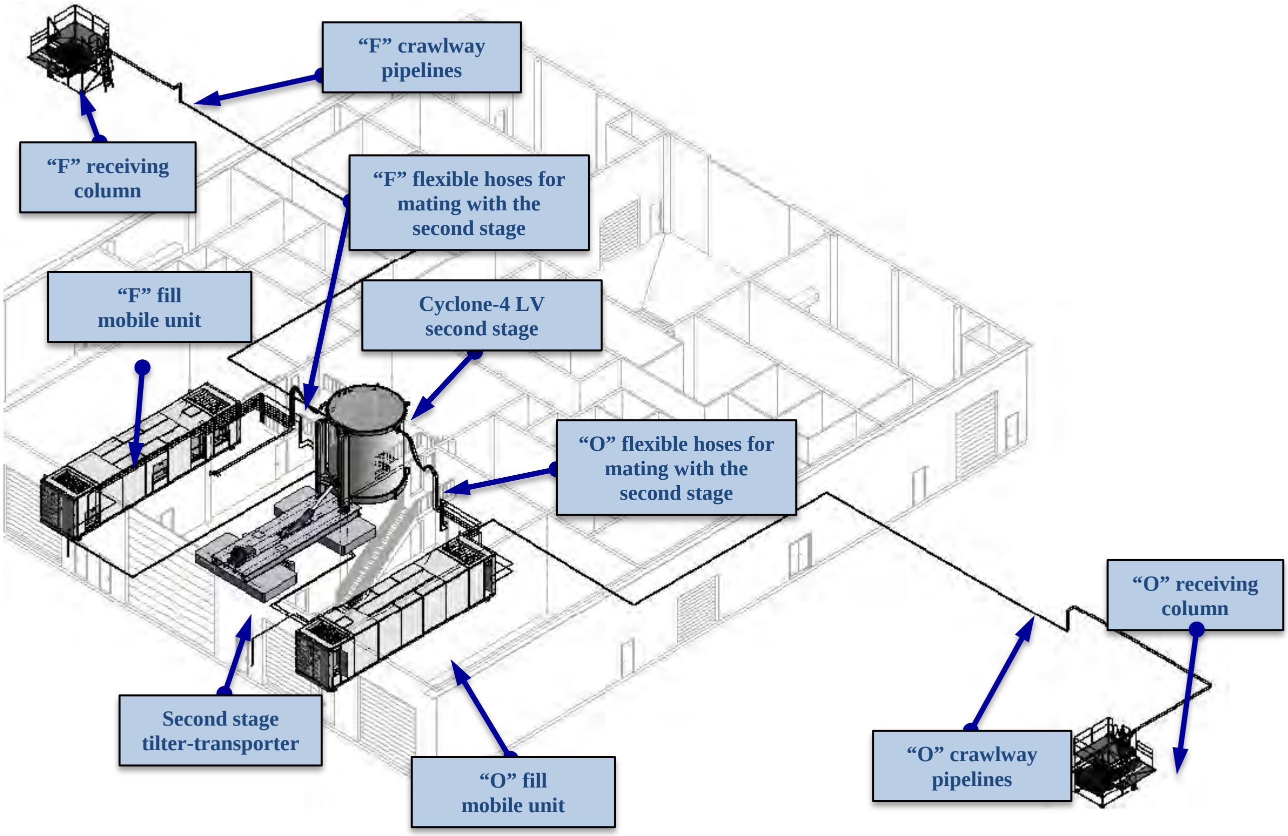
- Filling RP-1 system line, including main pipeline and distribution unit;
- Filling the launch vehicle fuel tank by expelling RP-1 from the warehouse tank under gas pressure after opening of the launch vehicle fill valve with a low flow rate to avoid pressure jumps when filling the launch vehicle pipelines;
- After the specified time period of low flow rate, filling is carried out with a high flow rate in order to minimize RP-1 heating the launch vehicle fuel tank;
- When the specified level of RP-1 in the launch vehicle tank is reached, the filling is again carried out with low flow rate to ensure the accuracy of filling and to avoid overflow; and
- After the specified volume is indicated, the launch vehicle fill valve closes and the fuel is drained from the launch vehicle main line and RP-1 filling line end section into a dump tank by feeding compressed nitrogen to the main line.

Flow rate of RP-1, pressure in the RP-1 tanks and in the launch vehicle tank, the level of RP-1 in the RP-1 filling system tanks and launch vehicle, and pressure difference between filter inlet and outlet are monitored during filling.

At the completion of fueling, all valves will be closed and fuel will be drained from the filling lines to storage tanks or separate vehicles. Defueling operations will include pressure relief (as needed), draining of launch vehicle fuel and oxidizer; release of drainage gases; and purging, decontaminating, and dismantling of the fueling system.

Second Stage Fueling

A schematic of operations during dinitrogen tetroxide and dimethylhydrazine second stage filling (draining) at a fueling/neutralization station is shown in Figure 3.4.2.



(Cyclone-4M launch vehicle second stage and its tilter-transporter are not included in the filling system; "F" designates fuel; "O" designates oxidizer)

Figure 3.4.2. Layout of Second Stage Filling System Equipment at Fueling/Neutralization Station

The Cyclone-4M launch vehicle second stage is delivered to the fueling/neutralization station filling hall and locked on the tilter-transporter in vertical position for fill/drain operations. After successful pneumatic leak testing at the launch vehicle, oxidizer and fuel cavities are pressurized with helium to the storage and transportation pressure. Next, second stage drain and fill valves are closed and caps are installed on drain and fill necks. Then maintenance personnel manually remove the caps from the drain and fill necks and connect them to fill and drain system interfaces with flexible hoses. The interface joints are then tested for leaks.

In advance of filling, the required volume of propellant is transmitted through the oxidizer ("O") and fuel ("F") receiving columns and crawlway pipelines into warehouse tanks located in mobile units (see Figure 3.4.2). Propellant is ready for filling when proper temperature and gas saturation is reached and the quality of oxidizer and fuel is checked. Propellant residuals are drained from crawlway pipelines, supply lines, and receiving columns.

Second stage filling is performed according to the specified procedures below:

- Oxidizer filling of pipelines, mobile unit, and then second stage;
- Manifold filling of second stage propellant compartment oxidizer;
- Fuel filling of pipelines, mobile unit, and second stage;
- Manifold filling of second stage propellant compartment fuel;

- After filling is complete and the fill valves are closed, oxidizer and fuel is drained from mobile units and supply lines to dump tanks located in the mobile units**;**
- After oxidizer and fuel is drained from the supply lines, the lines are purged with nitrogen gas after which personnel manually disconnect supply lines of the filling system from the fill and drain necks of the second stage "O" and "F" valves; and
- After disconnecting supply lines, the pressure sealing caps are installed by personnel on the second stage "O" and "F" fill and drain valves and leak testing of interfaces is carried out.

The flow rate of oxidizer and fuel, pressure and level in tanks located inside the mobile units, pressure in the second stage oxidizer and fuel cavities, and the pressure difference between filters inlet and outlets located inside the mobile units are monitored during filling**.**

During all operations, starting from propellant draining in warehouse tanks of the fill mobile units until the end of second stage filling operations, any generated drain gases enter the fueling/neutralization station neutralization system tanks.

After filling operations are completed, the second stage is locked on the tilter-transporter in a horizontal position and transported to the launch vehicle for subsequent Cyclone-4M launch vehicle assembly.

Filling procedures make it possible to terminate the filling process at any time. The reason for termination of filling and resulting defueling may be unacceptable deviation of monitored parameters from specified values, as well as other reasons related to prelaunch processing.

Post-Launch

After the launch, the following operations are performed:

- Draining fuel from filling units and system supply lines to a dump tank;
- Expelling fuel from the dump tank to the warehouse by compressed nitrogen;
- Pressurizing kerosene tanks with nitrogen gas to the pressure of 0.01 mPa to ensure an optimal storage environment of RP-1 residues; and
- Dismantling the flexible metal pipeline which is expendable and disposed after launch.

Launch Cancellation

In a case of launch cancellation, if the launch vehicle was fully or partially filled, the following operations are performed:

- Pressure relief by means of drainage of gas-vapor mixture from fuel filling system warehouse volume;
- Fuel transfer from the launch vehicle tank, fill and drain line, and RP-1 filling system filling line end section to the warehouse tank; and
- Releasing drainage gases from the launch vehicle fill and drain line, the end section of the filling line of the RP-1 filling system and drainage lines of the launch vehicle and RP-1 filling system to the atmosphere.

Then, depending on the reasons for the cancellation of launch and the plan for subsequent work, the following operations may be performed:

- Dismantling of a flexible metal pipeline;

- Fuel draining from units and system supply lines to dump tank;
- Transmitting fuel from dump tank to warehouse volume;
- RP-1 removal from the fueling/neutralization station warehouse volume to delivery vehicle (if necessary); and
- RP-1 filling system tanks pressurization by gaseous nitrogen to the pressure of 0.01 mPa.

In all of the above mentioned cases of the gas-vapor mixture drainage, the concentration of RP-1 vapor in the air of the working area will not exceed the threshold limit value of 28.3 ppm (200 mg/m^3).

Dangerous Goods Management References

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4.0 WASTE MANAGEMENT

4.1 Identify potential contaminants in waste water from the deluge water retention basin (e.g., metals, acids, dioxin and furans, etc.), as well as management measures of the contaminated waste water (e.g., how will the retention basin prevent the release of wastewater from entering the environment? Where will the waste water be stored and sent for treatment/disposal?).

Launch vehicles using liquid propellant have shown little to no contaminants exceeding regulatory requirements. During launch the water tower will discharge up to 375,000 gallons (1,419,529 liters) of deluge water, half of which will vaporize. The principle contaminants potentially present in deluge water are:

- Carbonic acid;
- RP-1; and
- Particulate matter.

Carbonic acid is derived from liquid oxygen (LOX) combustion and the reaction of carbon monoxide (CO) and carbon dioxide (CO_2) with water in the atmosphere that produces a weak acid. RP-1 would be present in deluge water as a result of any kerosene not consumed at launch. Particulate matter could result from ablation of the launch pad or launch vehicle and could contain metals. Antifrogen N is a compound used in the ground launch support system. It is essentially antifreeze used for cooling. Antifrogen N is contained in a closed loop system and should not be a contaminant in standard operational deluge water.

Because the launch vehicle will use only LOX and RP-1, the exhaust cloud would consist of steam only and would not contain significant concentrations of dangerous goods. The volume of water expected to condense from the exhaust cloud is expected to be minimal and result in insignificant adverse effects on environmental media.

The vehicle launch area will have a retention basin of sufficient size to contain deluge water under the launch pad. Deluge water that did not evaporate would remain in the retention basin. Water not vaporized will be analyzed to determine if it contains any contaminants at concentrations exceeding water quality standards. Testing will be conducted in accordance with the Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment, Volume 4 Analytical Methods, PN 1557 (CCME 2016) or by otherwise local, provincial or federal approved laboratory methods, if necessary. Waste dangerous goods will be managed in compliance with local, provincial, and federal regulations. It is anticipated that the launch deluge waste water would be characterized as non-hazardous (NASA 2011). If the deluge water meets regulatory standards, it could be discharged to grade if permitted.

Any contaminated water will be transported from the launch pad to approved waste collection tanks or containers outside the vehicle launch area. Contaminants will be treated in neutralization units that are situated within the launch complex. Storage and management of waste dangerous goods will comply with the Nova Scotia Dangerous Goods Management Regulations. Waste dangerous goods would be stored securely on an interim basis as needed, and then shipped off-site for disposal at an approved facility (in province or out of province) in accordance with local, provincial and federal regulations.

4.2 Provide detailed procedures for testing fuels and oxidants and procedures for managing contaminated or off-spec materials in case of launch delays and/or accidental contamination of water during fueling.

Quality Control Testing

Quality control of propellant, compressed gases (nitrogen, air, helium), and liquid nitrogen will be performed by the launch complex physical-chemical laboratory. Quality parameters, including gas saturation standards, for the testing fuels and oxidants are presented in Tables 4.2.1 and 4.2.2.

Table 4.2.1. Physicochemical Parameters

Controlled parameter	Standard
Dinitrogen Tetroxide	
Dinitrogen tetroxide mass fraction, %, no less than	99.5
Mass fraction of technological impurities in terms of nitric acid (HNO_3), %, no more than	From 0.5 to 1.5 incl.
Mass fraction of mechanical impurities, %, no more than	0.002
Density at plus 20°C, g/cm^3	1.4462
Color	Orange-brown liquid
LOX	
Cleanliness, percent by volume	99.6 min
Impurities, parts per million in volume	4000
Total hydrocarbons like methane	50
Water	3
Particulates, mg/l	1.0 max
Unsymmetrical dimethyl hydrazine (UDMH)	
Mass fraction of dimethylhydrazine, %	From 98.0 to 99.0 incl.
Mass fraction of dimethylamine, %, no more than	0.6
Mass fraction of methyl alcohol, %, no more than	0.04
Mass fraction of water, %, no more than	0.25
Mass fraction of mechanical impurities, %, no more than	0.001(10 mg/l)
Specific weight at plus 20°C, g/cm3	0.791 ± 0.0004
Form	Transparent colorless or yellow liquid without impurities

Table 4.2.1. Physicochemical Parameters

Controlled parameter	Standard
Hydrazine	
Mass fraction, %, no less than	99.5
Mass fraction of ammonia, %, no more than	0.1
Mass fraction of water, %, no more than	0.4
Mass fraction of fixed residue, %, no more than	0.003
Temperature stability	
at plus 20°C, dm3/t.·per year, no more than	3.0
Mass fraction of iron, %	Specified by user's standards
RP-1	
Specific weight, 60/60 °F	From 0.799 to 0.815 incl.
Gum presence, mg/100 ml	1 max
Sulfur, total, mg/kg	30 max
Mercaptocarbon sulfur, mg/kg	3 max
Freezing point, °F	Minus 60 max
Fuel efficiency: calorific value, BTU / lb	18500 min
Viscosity at – 30 °F, cSt	16.5 max
Aromatizers, % by volume	5.0 max
Olefins , % by volume	2.0 max
Hydrogen content, % by mass	13.8 min
Corrosion flat copper	1 max
Burning point, °F	140 min
Particulates, mg/l	1.0 max

Table 4.2.2. Gas Saturation Control

Controlled parameter	Standard
Dinitrogen Tetroxide	
Concentration of dissolved nitrogen in tank container, g/l, no more than	0.25
Concentration of dissolved nitrogen in warehouse tank, g/l, no more than	0.007
Concentration of dissolved helium in warehouse tank, g/l	From 0.019 to 0.024 incl.
UDMH	
Concentration of dissolved nitrogen in tank container, g/dm3	0.25
Concentration of dissolved nitrogen in warehouse tank, g/l	0.007
Concentration of dissolved helium in warehouse tank, g/l, no more than	From 0.005 to 0.007 incl.

Controlled parameter	Standard
RP-1	
Concentration of dissolved nitrogen in delivery systems, g/dm3	To be defined after obtaining data from RP-1 manufacturer
Concentration of dissolved nitrogen in warehouse tank, g/dm3, no more than	0.18

Propellant quality control will be performed by the following analyses (see Table 4.2.3):

- Complete analysis for identification of physicochemical parameters stated in Table 4.2.1;
- Check analysis for identification of those physicochemical parameters that are most inclined to change during transportation, storage and transmission (see Table 4.2.4); and
- Gas saturation analysis (if required) for parameters stated in Table 4.2.2.

Table 4.2.3. Propellant Quality Control Procedures

Operations and Activities	Sampling points and frequencies	Analysis scope
Second stage oxidizer and fuel filling system		
Reception of new shipment of NTO/UDMH from tank container to the empty warehouse tank filling system	From tank container	Complete analysis, gas content analysis
	From warehouse tank, within a day after transmission	Complete analysis
Storage of NTO/UDMH in warehouse tank filling system	From warehouse tank according to the plan of quality check once in 6 months	Check analysis
	From warehouse tank according to the plan of quality check once in 12 months	Complete analysis
Transmission of NTO/UDMH from tank container to warehouse tank filling system with residue of propellant component	From warehouse tank with residue of propellant component before transmission	Check analysis
	From warehouse tank within a day after transmission	Complete analysis
Transmission of NTO/UDMH from warehouse tank to the empty tank container	From warehouse tank before transmission	Check analysis, gas content analysis
	From tank container with propellant component, within a day after transmission	Complete analysis

Table 4.2.3. Propellant Quality Control Procedures

Operations and Activities	Sampling points and frequencies	Analysis scope
Transmission of NTO/UDMH from warehouse tank to the tank container with residue	From warehouse tank before transmission	Check analysis, gas content analysis
	From tank container before transmission	Complete analysis
	From tank container with propellant component, within a day after transmission	Complete analysis
Reduction of nitrogen content in NTO/UDMH in filling system warehouse tank during propellant preparation for launch vehicle launch	From warehouse tank before, during and after reduction operation	Gas content analysis
NTO/UDMH helium saturation in filling system warehouse tank	From warehouse tank before and during saturation operation	Gas content analysis
Feeding NTO/UDMH from filling system warehouse tank for filling launch vehicle second stage (analysis is performed if propellant thermostating is required)	From warehouse tank before filling launch vehicle second stage (after thermostating operation)	Check analysis, gas content analysis
Draining NTO/UDMH from launch vehicle second stage into filling system warehouse tank (for refilling)	From warehouse tank before and during helium saturation	Gas content analysis
	From warehouse tank before filling launch vehicle second stage (after thermostating operation)	Check analysis, gas content analysis
RP-1 Filling System		
Reception of new fuel shipment	From each delivery vehicle, but no later than three days after arrival	Complete analysis
Draining fuel from delivery vehicles into warehouse tank	From warehouse tank within a day after warehouse tank filling	Check analysis, gas content analysis, analysis on content of dissolved water mass fraction

Table 4.2.3. Propellant Quality Control Procedures

Operations and Activities	Sampling points and frequencies	Analysis scope
Fuel storage in warehouse tank	From warehouse tank according to the plan of quality check once in 6 months	Check analysis
	From warehouse tank according to the plan of quality check once in 12 months	Complete analysis
Fuel transmitting from dump tank into warehouse tank	From warehouse tank	Complete analysis
Fuel drying in warehouse tank	From warehouse tank within a day after drying	Content of dissolved water mass fraction
Preparations for fuel cooling in warehouse tank (if more than a day has passed after drying)	From warehouse tank	Content of dissolved water mass fraction
Fuel cooling in warehouse tank	From warehouse tank within a day after cooling	Complete analysis
Fuel saturation in warehouse tank	From warehouse tank	Gas content analysis
Fuel feeding from warehouse tank to integrated launch vehicle tank	From warehouse tank	Complete analysis
Fuel draining from integrated launch vehicle tank into warehouse tank	From warehouse tank	Complete analysis
LOX Filling System		
Reception of new shipment of oxidizer. LOX draining from delivery vehicles into warehouse tank	From each delivery vehicle, but no later than three days after arrival	Complete analysis
	From warehouse tank. The sample is taken within a day after filling the warehouse tank	Complete analysis
LOX storage	From warehouse tank with LOX according to the plan of quality check once in a month	Check analysis
	From warehouse tank with LOX according to the plan of quality check once in 6 months	Complete analysis

Table 4.2.3. Propellant Quality Control Procedures

Operations and Activities	Sampling points and frequencies	Analysis scope
LOX draining from warehouse tank into delivery vehicles	From warehouse tank	Complete analysis
LOX feeding from warehouse tank into integrated launch vehicle tank	From warehouse tank	Complete analysis
LOX draining from integrated launch vehicle tank into warehouse tank	From warehouse tank	Complete analysis

Table 4.2.4. Propellant Check Analysis

Propellants	Scope of check analysis
Oxidizer (NTO)	Content of technological impurities in terms of HNO_3
	Density at plus 20°C
Fuel (UDMH)	Water content
	Density at plus 20°C
	Appearance (color)
	Presence of mechanical impurities (visually)
Oxidizer (LOX)	Oxygen volume fraction, %
	Volume of carbon dioxide in one l of LOX at plus 20°C and 760 mm Hg, ml
Fuel (RP-1)	Density at plus 20°C and 760 mm Hg, kg/m^3
	Content of mechanical impurities and free water
	Mass fraction of dissolved water

Support equipment is made of materials resistant to the effects of NTO, nitric acid solution, nitrogen oxides (along the oxidizer line), UDMH, hydrazine, UDMH solution in water, UDMH vapor and hydrazine (along the fuel line). Totally enclosed equipment will prevent discharge of waste dangerous goods into the environment including ground water. Propellant entry into the open water is unlikely due to the considerable distance from launch site.

Management of Contaminated or Off-spec Materials

A primary complete check of propellant quality is performed when the tank containers are received. If the supplied propellant does not comply with quality indicators, it is returned to the manufacturer (supplier). If propellant is non-compliant with the quality indicators at subsequent stages of work, depending on the reasons and the amount of rejected propellant components, the following measures may be taken:

- Return the propellant to the supplier;

- Dispose of small amounts of NTO and UDMH by neutralization using waste dangerous goods neutralization technologies;
- Transport substandard propellant to an approved off-site contractor;
- If RP-1 enters into a gas duct when integrated launch vehicle is on the launch pad (see also response to Item 3.3), it is burned down in a high temperature jet from the first stage;
- If there is a launch cancellation and RP-1 collects on the surface of the water, depending on the amount of RP-1 and the results of rapid analysis of water samples, qualified persons will determine subsequent cleanup activities, such as RP-1 collection (pumping, using sorbents) with subsequent for disposal or discharge.

4.3 Provide details for the management of waste dangerous goods and contaminated materials, including storage (types and maximum capacities) and transportation of these wastes.

Activities at the launch site and facilities will result in waste dangerous goods and domestic wastes. Waste will be accumulated, stored, transported, and disposed in compliance with local, provincial, and federal regulatory requirements. For collection and temporary storage of dangerous goods waste, and domestic waste, containers (tanks) will be placed in specified locations that will permit handling and transport without polluting the environment. Removal and disposal of waste will be handled by contractors using specialized containers and vehicles in accordance with governing regulations.

Dangerous Goods Contaminated Materials

Waste and related materials associated with a single launch (designated single-action units or SAU) are shown in Table 4.3.1).

Table 4.3.1 SAU Waste Per Single Mission (Preliminary Data)

No	System	SAU name	Amount of SAU in system	SAU material (-s)	Weight (kg)
1	Launch site	Hold-down bay	1	Steel	4120
2	Kerosene filling system	Heat-insulated pipeline	1	Stainless steel	33
				Heat insulation	3
		Flexible hose	1	Stainless steel	24
3	LOX filling system	Heat-insulated pipeline	1	Stainless steel	60
				Heat insulation	4.5
		Flexible hose	1	Stainless steel	30
4	Launch site compressed gas generation and supply system	Flexible hose	3	Armor from steel wire Material of fixing elements - steel Rubber	13.8

Table 4.3.1 SAU Waste Per Single Mission (Preliminary Data)

No	System	SAU name	Amount of SAU in system	SAU material (-s)	Weight (kg)
5	Temperature monitoring system, filling monitoring system	Cable	1	Twist, copper wire	8.8
6	Launch vehicle and payload unit thermostating system	Nozzle	5	Steel	34.5
		Heat-shielding material	140	Siliceous fabric	532.0
		Fixing items		Steel	11.93
		Mating assembly with payload unit: Hose EOLO hose Adapter Clamp	 5 5 5 20	 Rubber Polyurethane Aluminum Galvanized steel	 10.4 85.3 6.05 0.132
		Valve	5	Steel	24.6
		Temperature sensor	5	Steel	4.0
		Pressure sensor	5	Aluminum	6.0
		Consumables		Fabric Adhesive Enamel Primer Wire	3.87
7	Measurement system, ground equipment	MS cable	1	Wire SPEC 55A Raychem Insulation: ethylene tetrafluoroethylene (ETFE) Conductor: silver plated cooper alloy	6
				Twist Silver plated cooper wire	0.65
				Pipe Polyvinyl chloride plastic	1.6
				Glue tape Polypropylene	0.65
				Siliceous tape Glass twisted yarn	0.4
				Connector	1.65
Total:					5026.832

Single-action units and systems after launch of integrated launch vehicle are manually put together by personnel, stored in special containers and, prior to the next mission, removed for processing to qualified waste disposal contractors. Dismantled hold-down bays may temporarily be placed on designated areas of launch complex. These materials include:

- Equipment and devices resulting from repair, restoration, annual maintenance, or rejected components. After dismantling, the accessories, structural components and devices which were in a contact with propellant will undergo neutralization procedures at the fueling/neutralization station to reduce concentration of hazardous substances.
- Mineral oils, process liquids, up to 250 kg per year;
- Packaging materials (wood, cardboard, paper, plastic);
- Oils, rags, lamps of lighting equipment; and
- Used specialized technological clothes.

Domestic Waste

The domestic waste includes:

- Household waste;
- Food waste; and
- Glass, plastic, paper.

Domestic waste collection will be temporarily stored in containers (tanks) placed in specified locations that will permit handling and transport without polluting the environment. Removal and disposal of waste will be handled by contractors using specialized containers and vehicles in accordance with governing regulations will be removed as required in accordance with the agreements concluded.

During the each launch operation up to 6000 kg of non-hazardous waste (“Greenwastelist”) from launch site systems and equipment, including 4120 kg of hold-down bay, is expected to be generated.

4.4 Provide detailed assessment and clean-up procedures for spills and other accident and malfunction scenarios including launch failures related to the use of hydrazine related substances, which may impact surface water, groundwater and/or other applicable environmental media:

- ***Research and provide the appropriate notification and clean-up levels for chemicals (e.g., hydrazine related substances), as well as byproducts and daughter products of the chemicals which on release have the potential to contaminate various media (e.g. soil, surface water and groundwater) at the Project site;***

- ***Identify sampling procedures and laboratories with reportable detection limits acceptable for the clean-up criteria identified for the impacted media;***

- ***Provide a list of facilities approved to accept and treat the potential contaminated media.***

A site-specific emergency response plan, including a spill contingency plan will be developed to address accident and malfunction scenarios including launch failures. The emergency response plan will also address hydrazine related issues. A United PARADYNE Corporation Emergency Response Plan is included in Appendix C and will modified to include a site specific issues such as:

- Description of the site's Emergency Response Organization;
- Emergency Communication Procedures;
- Hazard Awareness and Recognition including a list of the hazardous chemicals and their locations on the facility;
- Training Requirements; and
- Hazard specific procedures for emergency assessment, notification, action, post-emergency action, and post-emergency evaluation including, but not limited to:
    - Fire (internal and external to the site facilities),
    - Power Failure,
    - Hypergolic Liquid Releases,
    - Hypergolic Vapor Releases/Low Level Alarms,
    - Hazardous Chemical Spill, Containment, and Control,
    - Launch and Aircraft Failure,
    - In-Flight Emergency,
    - Emergency Protective Actions to Declare Hazardous Materials Incidents, and
    - Emergency Response related to Tanking/Filling Operations (as applicable).

The US has developed Regional Screening Levels and recommended clean-up levels for Hydrazine and UDMH. In addition, since nitrosodimethylamine (NDMA) (one of the degradation products of UDMH) was found at high concentrations in groundwater and down gradient drinking wells at a rocket testing facility in California. There are several state water standards that are included in Appendix D. It should be noted that this level of groundwater contamination is unique to the rocket testing facility and activities not associated with the MLS project. The MLS launch vehicle upper stage ignition occurs at an altitude of over 100 km and is downrange over 300 km. Regional Screening Levels are provided in Table 4.4.1 and could be adjusted for use in Canada/Nova Scotia based on 10^{-05} Increased Lifetime Cancer Risk (ILCR) and 20% of the Reference Dose (RfD). There are no drinking water guidelines or other regulatory standards for the other decomposition products of UDMH.

As noted in Section 3, the primary degradation products of UDMH are dimethylamine, tetramethyltetrazene and NDMA. There are no drinking water guidelines for these decomposition products.

Table 4.4.1. Regional Screening Level Summary Table – November 2018

Analyte	Screening Levels					Protection of Groundwater Soil Screening Levels
	Resident Soil (mg/kg)	Industrial Soil (mg/kg)	Resident Air (µg/m^3)	Industrial Air (µg/m3)	Tapwater (µg/L)	Risk-based SSL (mg/kg)
Hydrazine	$3.2\text{x}10^{-02}$	$1.4\text{x}10^{-01}$	$5.7\text{x}10^{-04}$	$2.5\text{x}10^{-03}$	$1.1\text{x}10^{-03}$	$2.2\text{x}10^{-07}$
UDMH	$5.7\text{x}10^{-02}$	$2.4\text{x}10^{-01}$	$2.1\text{x}10^{-03}$	$8.8\text{x}10^{-03}$	$4.2\text{x}10^{-03}$	$9.3\text{x}10^{-07}$
NDMA	$2.0\text{x}10^{-03}$	$3.4\text{x}10^{-02}$	$7.2\text{x}10^{-05}$	$8.8\text{x}10^{-04}$	$1.1\text{x}10^{-04}$	$2.7\text{x}10^{-08}$

It should be noted that limited analytical laboratories have the capabilities to analyze trace levels of hydrazine, methylhydrazine and 1,1-dimethylhydrazine in water and soil. However, there are a few laboratories that offer trace level analysis of these compounds. Eurofins Lancaster Laboratories Environment, LLC has developed procedures based on modifications to EPA 8315 (LC/MS/MS), to obtain trace detection levels. Descriptions of these procedures are provided in Appendix E.

NDMA can be analyzed via Method 1625, Revision B:Semivolatile Organic Compounds by Isotope Dilution GC/MS. This procedure is included in Appendix F.

The treatment and/or disposal of contaminated media associated with this project can be handled by firms within Canada. Terrapure Environmental, with five locations in Nova Scotia, has indicated that they have the capacity to manage the waste materials. Any contaminated media containing hydrazine (liquid or contaminated solids) would need to be transported to Ontario for incineration at an approved facility and an Emergency Response Assistance Plan would likely be required. Other waste streams would be managed in the same manner as other industrial hazardous wastes under existing Canadian Transportation of Dangerous Goods Act and Regulations and processed at approved recovery/disposal facilities.

Waste Management References

CCME (Canadian Council of Ministers of the Environment). 2016. Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment, Volume 4, Analytical Methods, PN 1557.

NASA (National Aeronautics and Space Administration). 2011. Final Environmental Assessment, Falcon 9 and Falcon 9 Heavy Launch Vehicle Programs from Space Launch Complex 4 East. March 1, 2011.

5.0 WATER AND SOIL RESOURCES

5.1 Conduct baseline studies to determine background conditions of relevant environmental media (e.g., surface water, groundwater, marine water, soil, etc.) that may be impacted by Project related activities including potential impacts from various chemicals to be used (e.g., hydrazine related chemicals).

Maritime Launch Services, Ltd. conducted baseline studies as part of the environmental registration process for the facility. Other baseline studies such as the National Geography In-Shore Areas (NaGISA) project (Miller 2010) have been conducted in the project area. If additional baseline studies are required to characterize existing site conditions, they would be completed before commencement of launch operations.

The objective of baselining characterization is to collect appropriate baseline data either from existing sources or environmental monitoring to characterize pre-operational environmental media quality. A baseline monitoring plan will be developed to describe the rationale for baseline study design including rationale for incorporation of data from previous studies, collection methods, parameters analyzed, sampling frequency and period, site locations, statistical considerations and quality assurance/quality control (QA/QC) protocols. Methods and QA/QC procedures will comply with the latest edition of the Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment, Volume 4, Analytical Methods, PN 1557 (CCME 2016) or other applicable and approved methods. Results will be compared to provincial water quality guidelines as appropriate. Key environmental indicators and action thresholds (such as existing national, provincial or regional standards) for adaptive management will be described.

- **Surface Water** - Deposition of emission particulates or metals could occur immediately outside of the launch pad, and in the case of a launch failure on the pad or accidental spill, petroleum products from RP-1 (highly pure kerosene)fuel could be deposited in surface water. Post-construction water quality monitoring and testing for metals and petroleum products in Watercourse 1 and nearby waterbodies/wetlands, including Publicover Lake, will be conducted. Representative samples of surface water will be obtained and water quality parameters and selected analyte concentrations will be compared to provincial water quality guidelines.

  As indicated in the Environmental Assessment, two watercourses have been identified within the Project footprint. Watercourse 1 consists of an intermittent channel, flowing from Publicover Lake into the ocean. Within the Project footprint it is a confined channel, becoming less confined as it approaches its outflow. Water depths were approximately 0.3 m with a channel width of 1.77 m. The banks were entirely vegetated with good stability and little evidence of streambank erosion. Watercourse 2 drains into Spinney Gully and consists of an intermittent channel flowing through a Black spruce grove. Water depths were 0.05 – 0.15 m and it has a channel width of 0.5 m (AMEC 2006).

  In addition, the original registration document indicated that a fish habitat assessment was completed on Watercourse 1 to determine its propensity to provide fish habitat. The stream provides fish habitat in the form of abundant overhanging vegetation and instream woody debris, with moderate levels of undercut banks and instream vegetation. The substrate was 100 percent fines and the banks were entirely vegetated. Due to the soft substrate, the watercourse does not provide spawning habitat, nor does the shallow water provide good overwintering habitat. Water quality data was not assessed, however, assessments completed on nearby Winter Creek and tributary to Winter Creek identified a pH of 4.5 and dissolved oxygen levels between 5.4 and 7.1 mg/L (AMEC 2006). As the watercourse flows from and through bogs, it is expected that the pH will also be acidic. As most fish species have tolerances higher than this (Lacoul et al. 2011), it is unlikely that Watercourse 1 is conducive to fish presence. A fish habitat assessment has not yet been completed on Watercourse 2.

MLS is coordinating with the Guysborough County Inshore Fisherman's Association (GCIFA) to supplement their in place water monitoring program. The GCIFA has been conducting water sampling in the project area for years to monitor the health of the water as it relates to their industry. MLS has committed to increasing the water sampling program frequency in the waters around the project area and to include additional analysis for any potential project related concerns. This will be run independently by the GCIFA and baseline work is already in place.

- **Soil** - Deposition of emission particulates or metals could occur immediately outside of the launch pad, and in the case of a launch failure on the pad or accidental spill, petroleum products from RP-1 fuel could occur within the upper meter of soil. Testing of soils for metals and petroleum products surrounding the launch pad will be conducted. Representative samples of soil will be obtained and selected analyte concentrations will be compared to provincial soil guidelines.
- **Marine Water** - Because of the tidal mixing and vastness of marine waters that would provide rapid dilution of pollutants, baseline studies of marine water quality are not proposed. Existing data will be used to evaluate pre-construction marine water quality. In the unlikely event of an accident, studies of potential contaminants would be implemented in accordance with the project Environmental Protection Plan (EPP).
- **Groundwater** - The majority of the site consists of shallow soils and granitic bedrock. Bedrock containing sulfide materials can generate acid rock drainage if exposed to oxygen and water resulting in lowered groundwater pH. Based upon the review of local surficial and bedrock geology, the likelihood of encountering bedrock mineralogy that would be harmful to the environment is low. Therefore, existing data will be used to evaluate pre-construction groundwater quality. In the event of a launch failure on the pad or a spill of petroleum products or other toxic materials outside containment, studies of potential contaminants in groundwater would be implemented in accordance with the project EPP.

Although adverse effects on environmental media are possible, no significant impacts on environmental media are anticipated during construction or nominal operation of the Canso Launch Complex. The first stage exhaust plume consists mainly of steam and carbon dioxide (CO_2) including small amounts of carbonic acid (a weak acid) that breaks down into bicarbonate and hydrogen ions when mixed with water. The most significant adverse effect on water or soil resources would be associated with accidental release of toxic materials or failure on the launch pad (leak, fire, or explosion). Emission of gaseous pollutants resulting from a launch vehicle explosion on the launch pad are carbon monoxide (CO) and nitrogen oxide (N_2O).

Prior to the initiation of launch activities, an environmental monitoring plan will be developed to measure and ensure the collection, processing, analysis and storage of information on the status of ecosystems in the area of the launch station. The environmental monitoring plan will include procedures for system operation and interaction with the launch facilities and infrastructure of the system operation area and instrumental means and methods of monitoring and processing environmental indicator data.

The main objectives of the environmental monitoring plan will be to monitor the state of the environment and any changes due to the launch system construction and operation and verification of implementation of the plans and measures for environmental protection, compliance with the requirements of environmental legislation and environmental quality standards applied in the area of launch site operation.

5.2 Provide predictive and conceptual modelling for each credible worst-case accident and malfunction scenario, and assess potential Project related impacts on water (surface water including wetlands, groundwater and marine water) and soil (including concentrations and distribution) resulting from:

o *Launch failure at ground zero;*

The following effects could occur in association with an explosion of the launch vehicle either on the pad or early in the flight:

- The primary impact would be damage to vegetation, soil, and water in the immediate vicinity due to thermal heat flow and excessive pressure. Vegetation in the immediate vicinity of the launch pad would burn. Soils in the immediate vicinity of the launch pad may burn and scorch. Vegetation and soil at further distances would experience the effects of overpressure as shown in Table 5.2-1.

- CO, CO_2 and nitrogen oxide (N_2O) are the primary gaseous emissions during explosion. Applying the Gaussian model for the instantaneous source, ambient concentrations of combustion products generated by an explosion on the launch pad could exceed the threshold limit values for CO (25 parts per million [ppm]) and nitrogen oxides (NOx) (3 ppm) covering an area 3-10 kilometer (km) long by 1.5 km wide, lasting 5 to 20 minutes depending on meteorological conditions. Carbonic oxide may form from the combustion products. Sulfur dioxide (SOx), NOx, volatile organic compounds, and other substances that can cause the secondary formation of pollutants are absent in the composition of the combustion products. The resultant plume from an explosion could affect some individual fauna in the immediate vicinity of the launch pad. The effects would be temporary, minor based on the composition, and would not be anticipated to affect entire populations of species. Furthermore, launch day go-no go criteria takes the meteorological conditions into account to ensure that gaseous emissions if it occurred would be away from populated areas.

- The nearest lake is about 700 metres (m) from the launch pad. No adverse impact is expected on water, aquatic fauna and flora in the case of a launch vehicle explosion at the launch pad.

The possible effects of damage caused by excessive pressure to soil and vegetation in the case of a launch vehicle explosion at the launch pad are presented in Table 5.2.1. In this example, the vegetation analyzed is forest. The result of pressure on grasses would be a temporary flattening followed by recovery. Standing brush or bushes could experience a range of effects depending on the nature of the pressure and the characteristics of the vegetation. For the specific citing for the Cyclone 4M launch pad, the area is mostly granite covered with scrub and/or peat with virtually no trees.

Table 5.2.1. Estimated Effects of Damage Caused by Excessive Pressure to Soil and Vegetation Outside the Launch Complex

Excessive Pressure (kPa)	Impact radius (m)	% of Forest Area Damage	Soil Damage
more than 100	up to 130	from 70% to 100%	Local damage
from 99 to 70	up to 150		
from 69 to 28	up to 255	from 30% to 50%	
from 27 to 14	up to 400	up to 15%	
from 13 to 2	up to 2070	not expected	

kPa - kilopascal

Damage to soil and vegetation outside of the launch complex would not be expected.

5.2 Provide predictive and conceptual modelling for each credible worst-case accident and malfunction scenario, and assess potential Project related impacts on water (surface water including wetlands, groundwater and marine water) and soil (including concentrations and distribution) resulting from:

- ***Launch failure in flight;***

In the case of an in-flight emergency of the launch vehicle, the control system would initiate emergency engine termination to prevent unpredictable developments. Therefore, a launch failure in flight could result in the failed launch vehicle impacting the ground surface without fragmentation or explosion at a certain altitude:

- If an emergency engine shutdown occurs prior to the 70th second after liftoff, the launch vehicle would impact the Earth's surface as a single unit.
- If an emergency engine shutdown occurs between 70 and 140 seconds after liftoff, the first and second stages would separate at altitudes ranging from 7 to 35 km. As a result, the unbroken first and second stage (including the payload fairing) would impact the Earth's surface individually.
- If an emergency engine shutdown occurs between 140 and 250 seconds after liftoff, the primary destruction of the launch vehicle would occur at altitudes above 95 km. The most probable types of failed launch vehicle destruction are as follows:
    - Destruction (explosion) of the first stage fuel tank caused by internal pressure due to a decrease in the mechanical properties of the tank material because of aerodynamic heating; and
    - Destruction of the interstage bay and (or) upper skirt of the first stage oxidizer tank as a result of reaching the melting point for the structural materials of these compartments.

- If an emergency engine shutdown occurs during the second stage flight, the primary destruction of the launch vehicle would occur at altitudes from 95 to 53 km. Destruction of the second stage leads to the formation of separate fragments of varying sizes that can reach the surface of the Earth individually.

The emergency flight path and impact areas of a failed launch vehicle as a function of an emergency engine shutdown time are shown in Figure 5.2.1. The contaminants that would be released as a result of an in-flight launch failure would be the same as those released as a result of a launch pad failure.

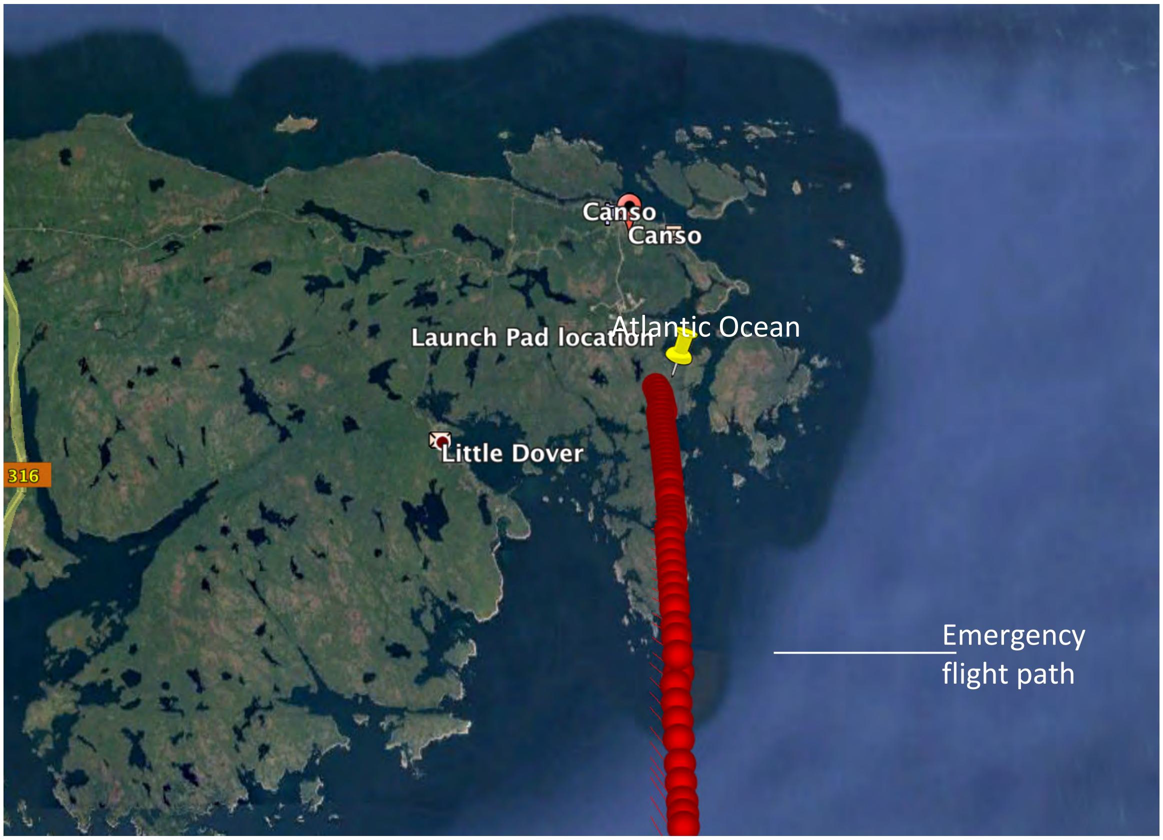

Figure 5.2.1. Emergency Flight Path of a Failed Integrated Launch Vehicle

The worst-case scenario in terms of potential environmental impact is a launch vehicle explosion due to contact with the surface if an emergency engine shutdown occurs within the first 70 seconds of flight. A launch vehicle that fails within the first 70 seconds of flight could impact either land or water. Both scenarios are discussed in the sections below.

1. *Fall of failed launch vehicle on the ground*

The possible effects of damage from excessive pressure to soil and vegetation in case of a launch vehicle explosion before the 70th second of flight are presented in Tables 5.2.2 and 5.2.3.

Table 5.2.2. The Worst-Case Impacts to Soil and Vegetation from Integration Launch Vehicle Explosion

Excessive Pressure (kPa)	Impact Radius (m)	% of Forest Area Damage	Soil Damage
more than 100	up to 154	from 70% to 100%	A crater up to 10 m deep
from 99 to 70	up to 227		
from 69 to 28	up to 388	from 30% to 50%	Local damage
from 27 to 14	up to 1133	up to 15%	
from 13 to 2	up to 2266	Not expected	

kPa - kilopascal

Table 5.2.3. The Worst-Case Impacts to Soil and Vegetation from Explosion of Launch Vehicle Fragments (Separate Falling of the First and Second Stages)

Excessive Pressure (kPa)	Impact Radius (m)		% of Forest Area Damage	Soil Damage
	First Stage	Second Stage		
more than 100	up to 139	up to 67	from 70% to 100%	A crater up 7 m deep
from 99 to 70	up to 205	up to 99		
from 69 to 28	up to 351	up to 169	from 30% to 50%	Local damage
from 27 to 14	up to 1023	up to 493	up to 15%	
from 13 to 2	up to 2045	up to 987	Not expected	

kPa - kilopascal

The worst-case effects from thermal radiation of the fireball on soil and vegetation are presented in Tables 5.2.4 and 5.2.5.

Table 5.2.4. The Worst-Case Effects on Soil and Vegetation from Thermal Radiation from a Launch Vehicle Explosion Fireball

Heat Flow (kW/m^2)	Impact Radius (m)	Forest Area Damage	Soil Damage
more than 77	up to 104	Fire	Soil thermodestruction
more than 30	up to 230	Not expected	
more than 10	up to 370		Not expected
more than 1.4	up to 730		

kW/m^2 – kilowatts per square metres

Table 5.2.5. The Worst-Case Effects on Soil and Vegetation Caused by Thermal Radiation from Explosion Of Launch Vehicle Fragments Containing Propellants (Separate Falling of the First and Second Stages)

Heat Flow (kW/m^2)	Impact Radius (m)		Forest Area Damage	Soil Damage
	First Stage	Second Stage		
more than 77	up to 91	up to 39	Fire	Soil thermodestruction
more than 30	up to 200	up to 87	Not expected	
more than 10	up to 330	up to 145		Not expected
more than 1.4	up to 640	up to 295		

kW/m^2 – kilowatts per square metres

2. Fall of failed Launch Vehicle into water bodies

The following lakes in the territory of Canada, Nova Scotia province: Publicover Lake, Seven Island Lake, Hazel Hill Lake, Eastern Lake, Negrowac Lake, Warrens Lake, Maguire Lake, and Snyders Lake were analyzed for the probability of the fall of a failed launch vehicle or its fragments containing propellants. These lakes are shown in Figure 5.2.2. The probabilities of a failed launch vehicle falling in lakes are given in Table 5.2.6. For context, the probability of one in a million is expressed as 1×10^{-6} .

Table 5.2.6. Total Probability of Fall of Failed Integrated Launch Vehicle or Its Fragments Containing Propellants Into The Lakes

Lake Name	The Closest Distance to the Launch Point of Integrate Launch Vehicle (km)	Trajectory		
		Trajectory #1	Trajectory #2	Trajectory #3
Publicover Lake	0.65	$3.09 \cdot 10^{-5}$	$3.98 \cdot 10^{-5}$	$4.09 \cdot 10^{-5}$
Seven Island Lake	1.45	$4.21 \cdot 10^{-7}$	$5.18 \cdot 10^{-6}$	$5.20 \cdot 10^{-6}$
Hazel Hill Lake	2.75	$2.44 \cdot 10^{-8}$	$3.26 \cdot 10^{-7}$	$3.34 \cdot 10^{-7}$
Eastern Lake	4.40	$2.15 \cdot 10^{-9}$	$1.97 \cdot 10^{-7}$	$1.62 \cdot 10^{-7}$
Negrowac Lake	1.61	$1.60 \cdot 10^{-6}$	$3.93 \cdot 10^{-6}$	$4.14 \cdot 10^{-6}$
Warrens Lake	2.33	$3.43 \cdot 10^{-7}$	$2.37 \cdot 10^{-6}$	$2.00 \cdot 10^{-6}$
Maguire Lake	5.00	$3.01 \cdot 10^{-9}$	$6.56 \cdot 10^{-7}$	$5.61 \cdot 10^{-7}$
Snyders Lake	5.77	$2.72 \cdot 10^{-9}$	$1.98 \cdot 10^{-6}$	$1.67 \cdot 10^{-6}$

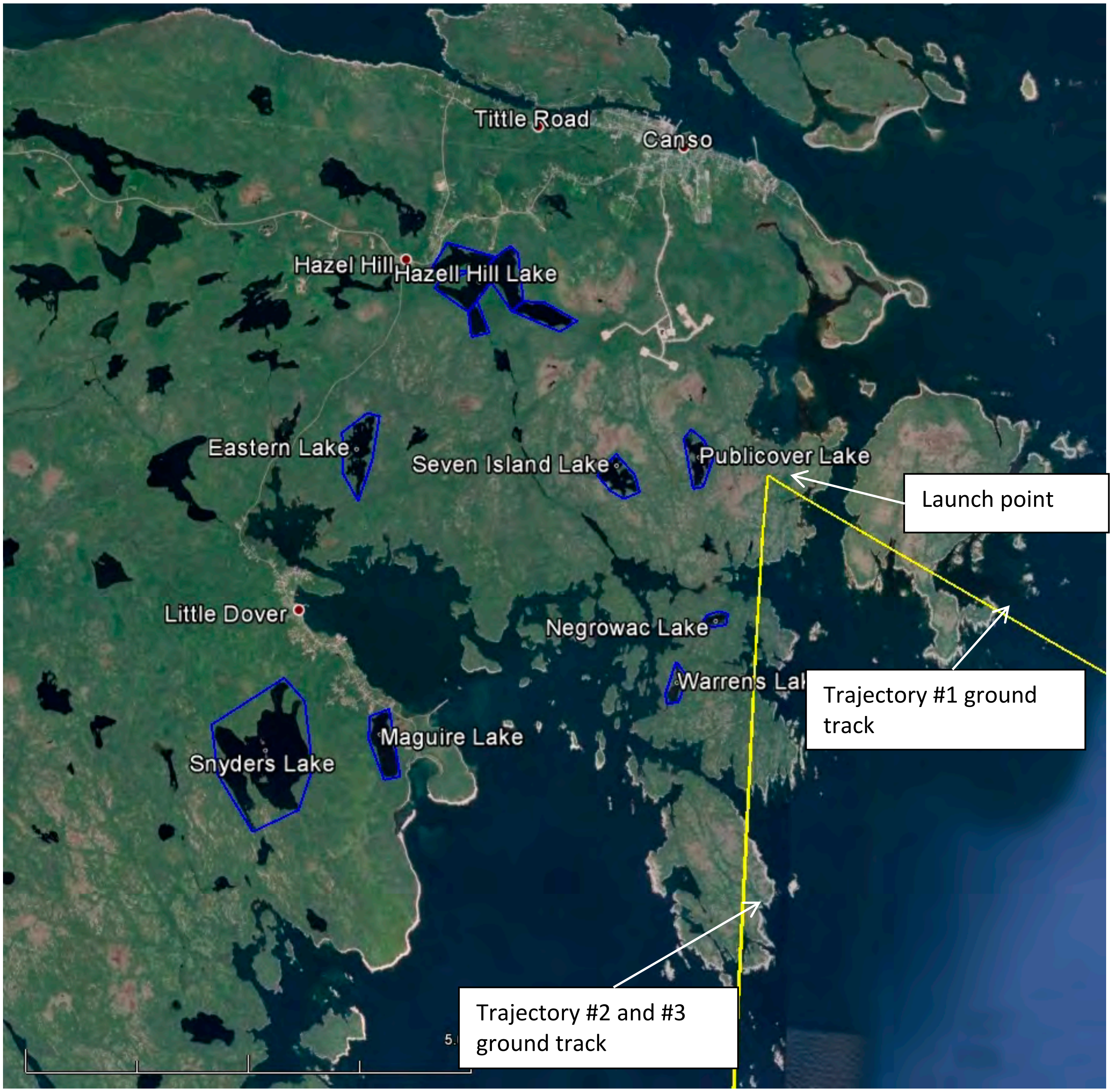

Figure 5.2.2 – Lakes In The Territory Of Nova Scotia (Canada)

Destruction of the launch vehicle structure (stages) is expected upon submersion in water to a depth of 10 m. Upon destruction of the launch vehicle structure, the propellants would mix and explode. Based on the quantities of the propellants contained in the launch vehicle, the maximum pressure of the shock wave front could exceed the lethal level for fishes - 40 kilogram force per square centimeter (kgf/cm^2) or 4 megaPascal (MPa) at the distances about 200 m from the epicenter of the explosion.

5.2 Provide predictive and conceptual modelling for each credible worst-case accident and malfunction scenario, and assess potential Project related impacts on water (surface water including wetlands, groundwater and marine water) and soil (including concentrations and distribution) resulting from:

- ***Other major accident and malfunction (e.g., major spills or leaks on site);***

Other major accidents and malfunctions could include: the explosion of a RP-1 tank at the launch pad, explosion of a unsymmetrical dimethyl hydrazine (UDMH) tank container at the processing complex, or a fire of spilled propellants. These accidents are discussed in the sections below:

1. The explosion of an RP-1 tank at the launch pad

The worst case scenario from excessive pressure to soil and vegetation outside the launch complex in case of a kerosene tank explosion are presented in Table 5.2.7.

Table 5.2.7. Worst-Case Scenario From Excessive Pressure To Soil And Vegetation From an RP-1 Tank Explosion

Excessive Pressure (kPa)	Impact Radius (m)	% of Forest Area Damage	Soil Damage
from 69 to 28	up to 90	from 30% to 50%	Local damage
from 27 to 14	up to 150	up to 15%	
from 13 to 2	up to 770	not expected	

kPa - kilopascal

The estimated effects from thermal radiation of the fireball on soil and vegetation outside the launch complex would not be expected. The nearest lake is about 700 m from the RP-1 tank. No adverse impact is expected on water, aquatic fauna or flora in the case of an RP-1 tank explosion.

2. Explosion of a UDMH tank container at the processing complex

The worst-case scenario from excessive pressure to soil and vegetation outside the processing complex from a UDMH tank container explosion are presented in Table 5.2.8.

Table 5.2.8. The Worst Scenario From Excessive Pressure To Soil And Vegetation From an Explosion Of Tank Container With UDMH

Excessive Pressure (kPa)	Impact Radius (m)	% of Forest Area Damage	Soil Damage
more than 100	up to 50	from 70% to 100%	Local damage
from 99 to 70	up to 65		
from 69 to 28	up to 110	from 30% to 50%	
from 27 to 14	up to 180	up to 15%	
from 13 to 2	up to 920	not expected	

kPa - kilopascal

Effects from thermal radiation of the fireball on soil and vegetation outside the processing complex would not be anticipated.

The nearest lake is about 400 m from the UDMH tank container. No adverse impact is expected on water or aquatic fauna and flora in the case of UDMH tank container explosion.

3. Fire of spilled propellants

A fire of spilled propellants would result in similar, lower intensity impacts to vegetation and soil in the affected area as described for the launch failures. No adverse impact of harmful factors of spill fire on water bodies would be anticipated.

5.2 Provide predictive and conceptual modelling for each credible worst-case accident and malfunction scenario, and assess potential Project related impacts on water (surface water including wetlands, groundwater and marine water) and soil (including concentrations and distribution) resulting from:

- ***Normal launch exhaust fallout;***

The composition of the first stage propulsion system combustion products (volume fraction) is given in Table 5.2.9.

Table 5.2.9. Contaminant Content

Component	Volume Concentration
Elemental Oxygen (O)	0.9025×10^{-7}
Molecular Oxygen (O_2)	0.1665×10^{-6}
Hydrogen (H)	0.000199
Hydrogen (H_2)	0.098579
Alcohol (OH)	0.000058
Water (H_2O)	0.415593
Carbon monoxide (CO)	0.234489
Carbon dioxide (CO_2)	0.251081

As seen in the table above, the combustion products do not contain SOx, NOx or other substances which could cause acid precipitation or contamination of surface water, underground water or sea water.

Emissions of combustion products from the second stage propulsion system dissipate at an altitude above 100 km and would not reach the Earth’s surface.

The National Aeronautics and Space Administration (NASA) documents related to Falcon 9 and Falcon 9 Heavy Launch vehicles indicate that surface waters near the launch site could be affected by the exhaust cloud that would form near the launch pad at lift-off as a result of the exhaust plume, evaporation, and condensation of deluge water (NASA 2011). Since liquid oxygen (LOX) and RP-1 are used for the first stage, the exhaust cloud would consist primarily of steam and would not contain significant amounts of hazardous materials. As the volume of water expected to condense from the exhaust cloud is expected to be minimal, the exhaust cloud would generate less than significant impacts on surface water quality near the launch site.

Waste water (deluge water) associated with a launch would be sampled and analyzed prior to disposal. However, since only LOX and RP-1 would be used as propellants, the waste water is likely to be characterized as non-hazardous.

5.2 Provide predictive and conceptual modelling for each credible worst-case accident and malfunction scenario, and assess potential Project related impacts on water (surface water including wetlands, groundwater and marine water) and soil (including concentrations and distribution) resulting from:

- ***Re-entry debris fallout.***

During launches the separation of the used fist stages and jettison of payload fairing shells occur at specified times during flight. The second stage of the launch vehicle will remain in orbit and will not impact the Earth's surface. The impact areas of the used stage and payload fairing shells are within the Atlantic Ocean.

The nominal coordinates of impact points of launch vehicle separated parts as well as distances of impact points of separated parts and payload fairing shells from launch point for Trajectory 3 are shown in Table 5.2.10. A graphical depiction of the impact areas for Trajectory 3 are presented in Figure 5.2.3.

Table 5.2.10. Nominal Coordinates and Distances of Impact Points of Integrated Launch Vehicle Separated Parts

Trajectory	Launch Vehicle Separated Parts	Φ	λ	L_{sph} (km)
Trajectory 3	First Stage	27.480°	-62.418°	1982
	Payload fairing shells	26.946°	-62.453°	2041

Note:
φ, λ – latitude and longitude of spaceport impact point;
L_{sph} – spherical distance from launch point to corresponding center of spaceport impact.

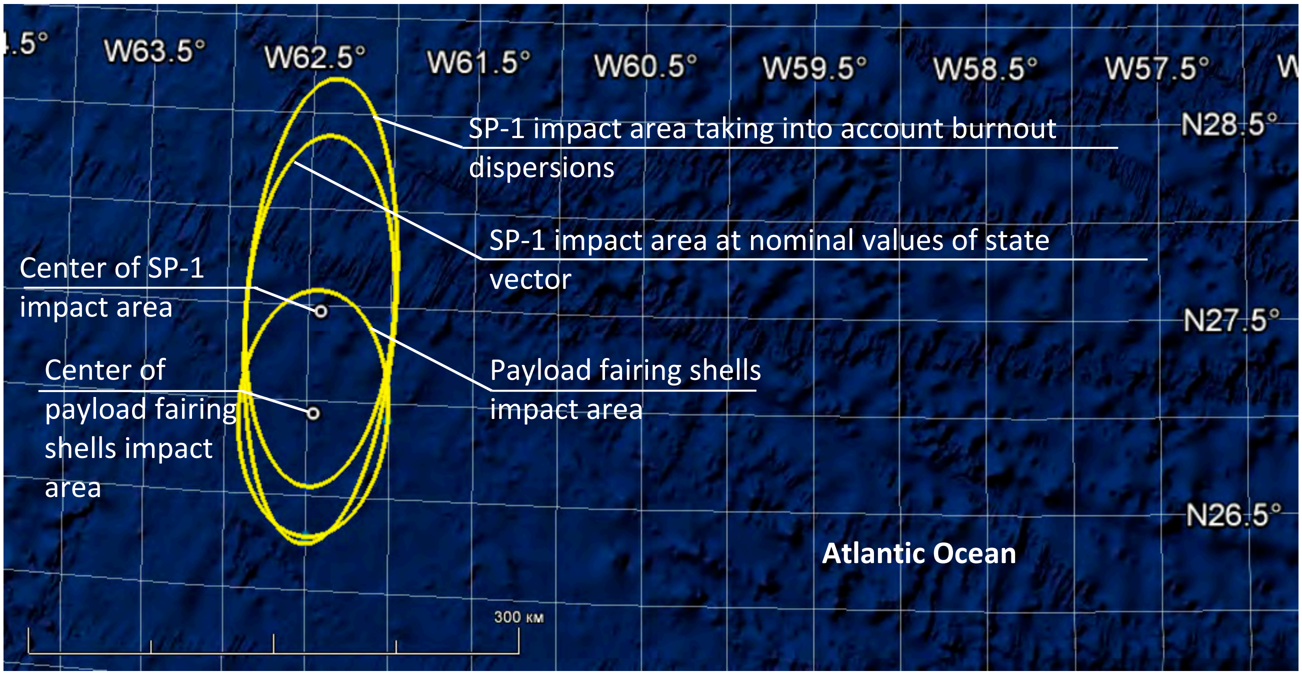

Figure 5.2.3. Location of Impact Areas Associated with First Stage and Payload Fairing Shells for Trajectory 3.

Impact on the aquatic environment from first stage and payload fairing shells debris within the impact areas would consist of metal fragments (tank shells, propulsion system design elements, turbopump assembly, etc.) that do not contain harmful substances. Any residual RP-1 or LOX from the first stage would be small and, due to the vastness of the ocean and mixing processes, would be quickly diluted. Statistically, it is unlikely that debris would strike marine mammals or fish. As indicated above, the second stage of the launch vehicle will remain in orbit; therefore no residual UDMH/dinitrogen tetroxide enter the ocean.

5.3 Assess potential Project impacts on the sustainability of water supply (e.g., water quantity) in the general Project area.

The launch site will require water supply for:

- Domestic and drinking needs;
- Industrial needs, including for water cooling of gas duct during integrated launch vehicle launch; and
- Firefighting.

The estimated water consumption needs at the launch site are:

- 30 to 50 cubic metres per day (m^3/day) for domestic and drinking needs;
- 15 to 20 m^3/day for industrial (non-deluge) needs;
- Up to 950 m^3 per launch for the deluge water tower;
- 600 m^3 for filling the common tank of the gas duct water cooling system and firefighting system of the launch complex; and

- 30 m^3 per day for the firefighting system.

The required amounts of water will be refined during the design process.

The water would most likely be obtained from wells. The Canso water supply system could be an alternative source subject to agreement. The city water supply system is a gravity water supply with a accumulator tank located on a hill. The system pressure is within 1.2 – 1.4 kgf/cm^2. The diameter of pipe at the potential connection point is 12 inches (304.8 millimetres [mm]). Launch site water supply would be obtained by means of pipes with 6 inches (152.4 mm) in diameter. Should city water be utilized for the project, new infrastructure such as a pump station would likely be required. The project would assist with this infrastructure if it is needed.

If new water supply sources are needed, they would be developed in accordance with the Nova Scotia Guide to Surface Water Withdrawal Approvals (NSE 2016) or the Guide to Groundwater Withdrawal Approvals (NSE 2010).

Overall, impacts to water supply sustainability would not be anticipated.

5.4 Provide and update suitable avoidance, mitigation and/or monitoring measures (where necessary) to confirm impact predictions, and to prevent and minimize potential Project impacts on water and soil resources.

Historical data from launch operations at other operational launch complexes has shown no long-term impacts to surface water, ground water, or marine waters (NASA 2009, NASA 2018, Schmalzer et al. 2018). Soil impacts could include deposition of exhaust products including metals or residual RP-1 propellant in the immediate vicinity of the launch pad. Should contaminants be detected at concentrations above regulatory standards appropriate mitigation would be carried out to reduce pollutant concentrations to acceptable levels. Vegetation scorching would be limited to small areas (less than one hectare) and close (less than 150 m) to the launch pad.

Mitigation Measures (normal operations)

- The deluge water will be captured in the retention basin underneath the launch pad.
- Deluge water will be sampled for contaminants that exceed water quality standards.
- Contaminated water will be removed and transported to an approved waste water treatment facility.
- Water which does not exceed guidelines will be pumped back into the water tower.
- Deluge water would also be used for fire protection.

Mitigation Measures (emergency situations)

- Adequate and appropriate secondary containment provides first level protection of soil and water resources.
- Accidental releases would be addressed in accordance with the site spill contingency plan.
- Fire or explosion impacts would be addressed in accordance with the site emergency management plan.

Water and Soil Resources References

CCME (Canadian Council of Ministers of the Environment). 2016. Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment, Volume 4, Analytical Methods, PN 1557.

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6.0 AIR QUALITY

6.1 Quantify emissions of air contaminants (e.g., total particulate matter, fine particulate matter, sulphur dioxide, nitrogen compounds, carbon monoxide, hydroxyls, organic compounds, etc.) from Project related activities.

6.2 Quantify the ambient concentrations from Project emissions, as well as the secondary formation of pollutants (e.g. total suspended particulate formed through the condensation of primary emissions, acid deposition products formed through reactions with primary emissions of SO_x and NO_x, and/or ground-level ozone formation resulting from primary emissions of NO_x, VOCs) using an appropriate methodology (e.g., air dispersion modelling) considering routine operation as well as accident and malfunction scenarios including potential catastrophic launch failure.

Air contaminants can be generated through the emissions associated with:

- **Construction activities** - Emissions associated with construction activities include fugitive dust emissions of particulate matter composed mainly of soil minerals and can include salt, pollen, spores, and other particles. Ambient fugitive dust concentrations associated with construction activities will dissipate as you move further away from the source and will be dependent on atmospheric conditions.

  Exhaust emissions associated with normal and construction vehicle operations includes particulate matter, nitrogen oxide, sulfur dioxide, hydrocarbons, and carbon monoxide (CO). These emissions would be short-term, localized, and are expected to be negligible and managed using best management practices (BMPs). Ambient concentrations from these activities are expected to meet Nova Scotia Ambient Air Quality Objectives.

  Specific construction emissions associated with this project have not been calculated. However, the National Aeronautics and Space Administration (NASA) estimated construction emission using the Air Conformity Applicability Model for a three year construction project associated with the expansion of the Wallops Flight Facility Launch Range. This project included modifications to a boat dock, construction of a payload processing facility, a payload fueling facility, and a horizontal integration facility, construction of new roads and upgrades to existing roads, and interior modifications to existing launch support facilities. The modeled values for CO, nitrogen oxides (NOx), sulfur dioxide (SO_2), volatile organic compounds (VOC), particulate matter 10 micrometers or less in diameter (PM_{10}), and particulate matter 2.5 micrometers or less in diameter ($PM_{2.5}$) are provided in Table 6.1.

Table 6.1: Emissions from Proposed Construction Activities in Metric Tonnes per Year (Tons per Year)[1]

Year	CO	NO_X	SO_2	VOC	PM_{10}	$PM_{2.5}$
2009	1.67 (1.84)	4.19 (4.62)	0.51 (0.58)	0.45 (0.50)	18.00 (19.85)	0.00 (0.00)
2010	22.56 (24.87)	5.17 (5.70)	0.64 (0.70)	0.58 (0.64)	0.42 (0.46)	0.00 (0.00)
2011[2]	0.049 (0.054)	0.085 (0.094)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
2012	2.4 (2.64)	5.75 (6.34)	0.70 (0.77)	0.52 (0.58)	4.76 (5.25)	0.00 (0.00)
TOTAL (2009–2012)	26.68 (29.41)	15.2 (16.78)	1.85 (2.05)	1.56 1.73)	23.18 (25.56)	0.00 (0.00)

[1] Source: NASA 2009
[2] No construction is planned in 2011.

- **Diesel emissions** - Diesel generator emissions during launch vehicle transportation to the launch site would include CO, nitrogen dioxide (NO_2), and hydrocarbons (see Table 6.2). Typical emissions associated with a diesel generator for this operation would include 550.8 grams (g) of carbon monoxide, 1309.4 g of nitrogen dioxide, and 173.6 g of hydrocarbons.[1]

6.2. Maximum Emission Concentrations of Diesel Generators Combustion Products*

r (m)	CO			NO_2			Hydrocarbons		
	mg/m^3	ppm	$\frac{ppm}{OSHA\ TLV}$	mg/m^3	ppm	$\frac{ppm}{OSHA\ PEL}$	mg/m^3	ppm	$\frac{ppm}{ACGIH\ 8-hr\ TWA\ for\ diesel\ fuel}$
10	0.537	0.5	50	1.128	0.7	5	0.17	0.3	100
50	0.021	0.02	50	0.051	0.03	5	$6.79x10^{-3}$	0.01	100
100	$5.35x10^{-3}$	$5x10^{-3}$	50	0.0128	$7x10^{-3}$	5	$1.7x10^{-3}$	$3x10^{-3}$	100

* A linear source model was used in the calculation of the maximum concentrations of hazardous substances at distances r = 10, 50 and 100 m from T/E for various weather conditions (for turbulence coefficients from 0.1 to 0.2 square metres per second [m^2/s]).
m - metres; mg/m3 – milligrams per cubic metres; ppm – parts per million; TLV – threshold limit value

Analyses on generator and transportation emissions conducted at Kodiak Island Launch Complex showed that emissions associated with the use of the facility and associated equipment for launches would be below the 90.7-mt (100-ton) per year criteria pollutant Federal *de minimis* levels that apply to a non-attainment area. (NASA 2011)

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[1] Emissions of hazardous substances were determined on the basis of their compliance with the Euro-3 standards declared by a potential supplier. Respectively: CO – 2.1 (g/kW*h), NO_2 – 5 (g/kW*h), hydrocarbons – 0.66 (g/kW*h); Total fuel consumption - 90 l/h; Transporting path - 1200 m; Transportation speed - 2 km/h (0.56 .m/s).

- **Kerosene** – Based on the time of the first stage fuel tank filling with RP-1 , drainage emissions during fueling and defueling would include approximately 200 g of RP-1 per launch. During launch vehicle fueling the ambient concentration of RP-1 vapors will not exceed the threshold limit value of 28.3 parts per million (ppm) (worker exposure limits).

- **Neutralization activities** – Neutralization sets are designed to thermochemically (850-1000°C) treat the vapors and industrial waste associated with dinitrogen tetroxide (NTO), unsymmetrical dimethyl hydrazine (UDMH), and hydrazine, reducing the level of hazardous substance. During neutralization activities, ambient concentrations from neutralization sets (NTO and UDMH) will not exceed the threshold limit values for nitrogen oxides (3 ppm) and sulfur dioxide (2 ppm). The process of neutralization of drainage gases and water solution of NTO is based on the reactions of decomposition of oxides and reduction of nitrogen with a solution of carbamide ($(NH_2)2CO$), resulting in minimal emissions of nitrogen oxides and sulfur dioxide. The anticipated concentrations of hazardous substances associated with the exhaust gas of a neutralization set are presented in Table 6.3.

Table 6.3. Anticipate Concentrations of Hazardous Substances in the Exhaust Gas of a Neutralization Set

Emitted Substance	Concentration in the exhaust gases (mg/m^3)	
	Water Solution Neutralization	Drainage Gases Neutralization
UDMH neutralization		
NOx	13.12	18.18
SO_2	0.761	not present
Hydrazine neutralization		
NOx	13.00	16.46
SO_2	0.94	not present
NTO neutralization		
NOx	12.57	18.75
SO_2	2.49	8.71

- **First stage combustion products** - First stage combustion products would include water, carbon dioxide (CO_2), CO, hydrogen, alcohol, and oxygen. Based on repeated observations in aeronautical meteorology, it had been accepted that launch emissions at altitudes of more than 1 km do not reach the surface layer of the atmosphere. The time for the launch vehicle to reach 1 km is approximately 37 seconds. The total emission of combustion products during this leg of the flight is approximately 39 tonnes. The relative concentrations (volume fraction) of the emissions would be approximately:

Component	Volume Fraction
Water (H_2O)	0.415593
Carbon Dioxide (CO_2)	0.251081
Carbon Monoxide (CO)	0.234489

Component	Volume Fraction
Hydrogen (H_2)	0.098579
Hydrogen (H)	0.000199
Alcohol (OH)	0.000058
Molecular Oxygen (O_2)	$0.1665\text{x}10^{-6}$
Elemental Oxygen (O)	$0.9025\text{x}10^{-7}$

The ambient concentrations of combustion products associated with the vehicle launch should not exceed threshold limit values beyond 200 m of the launch pad. Based on the composition of the combustion products, at heights up to 1 km, approximately 2.3 tonnes of carbon monoxide would be emitted. The majority of the carbon monoxide will be oxidized in the air into carbon dioxide. At altitudes of more than 1 km, studies associated with previous launches using liquid oxygen (LOX) and RP-1 have indicated that emissions do not pollute the surface layer of the atmosphere. The mass of combustion products in a cloud includes carbonic oxide; sulfur dioxide, nitrogen oxides, volatile organic compounds, and other substances that can cause the secondary formation of pollutants are absent in the composition of the combustion products.

To estimate the dissipation of emissions in the atmosphere, a Gaussian model modified for the volume source in the form of a surface cloud was used in combination with the “puffs” method. The results of the forecast calculations show, that outside the 200 m area from the launch point, carbon monoxide emissions do not reach the surface in concentrations exceeding the maximum permissible value of 25 ppm.

The Final Environmental Impact Statement for the Mars 2020 Mission specifically addresses emissions associated with launch activities using the liquid propellants, RP-1 and LOX. The analysis specifically states (NASA 2014):

> “Rocket launches can cause short-term impacts on local air quality from routine launch vehicle exhaust emissions. After ignition of the first stage and the first few seconds of liftoff through launch vehicle ascent, the exhaust emissions would form a buoyant cloud at the launch pad. This high-temperature cloud would rise quickly and stabilize at an altitude of several hundred meters near the launch area. The cloud would then dissipate through mixing with the atmosphere. The exhaust products would be distributed along the launch vehicle's trajectory as the vehicle moves through the atmosphere. Airborne emissions from a normal launch of the Mars 2020 mission at CCAFS/KSC would not be expected to result in adverse impacts to the public (USAF 1998, USAF 2000, NASA 2005a, NASA 2006, NASA 2011). The nearest residential areas to SLC-37, LC-39A, or SLC-41 are about 10 to 20 kilometers (km) (6 to 12 miles) in the cities of Merritt Island to the southwest, Cape Canaveral and Cocoa Beach to the south, and Titusville to the west.”
>
> “First-stage liquid propellant engines that use rocket propellant-1 (RP-1) and liquid oxygen (LOX), such as the Atlas V and Falcon Heavy, would primarily produce carbon monoxide (CO), carbon dioxide (CO_2), and water vapor as combustion products.”

> No short- or long-term air quality impacts are expected as a result of the handling and usage of liquid propellants and ODSs during a normal launch. Previous analyses have shown that emissions from a normal launch of an Atlas V with SRBs would not create short- or long-term adverse impacts to air quality in the region (USAF 2000, NASA 2005a, NASA 2011). The same result would be expected from the launch of a Delta IV Heavy or Falcon Heavy rocket. Section 4.1.2.14 discusses local as well as global ozone impacts."

Furthermore, the 2011 NASA Environmental Assessment for Routine Payload provide specific data for the Atlas V Heavy that uses RP-1 and LOX in the first stage. The air emissions for the Atlas V Heavy into the lowest 916 m (3,000 feet [ft]) of atmosphere showed no VOCs, SO_2, PM_{10} or Hydrogen Chloride emissions (NASA 2011).

In addition, the Aerospace Corporation produced three separate reports on the cloud dispersion for three separate Titan IV launches. Each report includes tables that show the cloud height and dispersion over time as well as discussions regarding weather conditions and distance of the cloud away from the launch site. Although the Titan rockets use solid propellants, the general information regarding cloud dispersion would likely be similar and in all three cases, the cloud was approximately 200 meters above the ground within a minute. (Aerospace Corporation 1996a, 1996b, 1998)

Based on the repeated observations in aeronautical meteorology, it had been accepted that the emissions of the combustion products from the second stage propulsion system are dissipated at altitudes above 30 km and do not reach the Earth's surface.

- **Spills** – Emissions associated with a spill would be dependent on the chemical(s) involved, the amount and potential surface area of release, and weather conditions. NASA conducted mean hazard distance predictions downwind for releases of 1,000 kilograms (kg) (2,200 pounds [lb]) total propellant load of hydrazine, 1,000 kg (2,200 lb) of monomethylhydrazine (MMH), and 1,200 kg (2,640 lb) of NTO using the US Air Force Toxic Chemical Dispersion Model (AFTOX) Version 4.0. The selected concentrations used for this analysis were the Short-Term Emergency Guidance Levels for hydrazine (0.12 ppm 1-hour average), MMH (0.26 ppm 1-hour average), and NO_2 (1.0 ppm 1-hour average). AFTOX runs were conducted for daytime and nighttime conditions at two different wind speeds (2 and 10 metres per second (m/s) [7 and 32 feet per second (ft/s)]). The modeling results for Cape Canaveral Air Force Station (CCAFS) and Kennedy Space Centre (KSC) are presented in Table 6.3. (NASA 2011)

  Using the volumes indicated above, an unconfined spill of hydrazine would produce a spill area of 107 square metres (m^2) (1,156 square feet [ft^2]) and a mean hazard distance of up to 1,493 m (4,897 ft). An unconfined spill of MMH would produce a spill area of 114 m^2 (1,231 ft^2) and a mean hazard distance of up to 1,452 m (4,763 ft). An unconfined spill of NTO would produce a spill area of 80 m2 (864 ft^2) and a mean hazard distance of up to 5,680 m (18,630 ft) for NTO. (NASA 2011)

  This worst-case scenario assumes that the spills are unconfined and evaporation will occur without dilution or other mitigating actions. The modeling results indicate that the hydrazine, MMH and NTO are diluted to non-hazardous levels within relatively short distances. (NASA 2011)

Table 6.3. Mean Hazard Distances to SPEGL (1-Hr Average) Exposure Limits as Predicted by AFTOX for Payload Maximum Liquid Propellant Spills at CCAFS and KSC

Chemical (SPEGL)	Spill Quantity	Wind speed	Day (32°C [90°F])	Night (5°C [41°F])
Hydrazine (0.12 ppm)	1,000 kg (2,200 lb)	2 m/s (6.6 ft/s)	655 m (2,148 ft)	669 m (2,194 ft)
		10 m/s (33 ft/s)	1,493 m (4,897 ft)	747 m (2,450 ft)
MMH (0.26 ppm)	1,000 kg (2,200 lb)	2 m/s (6.6 ft/s)	641 m (2,102 ft)	769 m (2,522 ft)
		10 m/s (33 ft/s)	1,452 m (4,763 ft)	773 m (2,535 ft)
NTO (1.0 ppm)	1,200 kg (2,640 lb)	2 m/s (6.6 ft/s)	1,230 m (4,034.4 ft)	2,574 m (8,443 ft)
		10 m/s (33 ft/s)	5,680 m (18,630 ft)	3,411 m (11,188 ft)

Note: AFTOX predicts that NTO liquid spills would be gas releases at 32°C (90° F) ambient temperature. For modeling purposes, the gas release was assumed to have a duration of 5 minutes. In summary, all mean hazard distances for toxic air releases from payload accidents at CCAFS and KSC would be less than 5.7 km (3.4 mi) for the meteorological conditions considered. This would be the maximum distance downwind that would require evacuation and control by Range Safety authorities.
SPEGL=Short-Term Emergency Guidance Levels.
Source: NASA 2011.

- **Explosion** - Emissions during an explosion would include carbon monoxide and nitrogen oxide. Applying the Gaussian model for the instantaneous source, ambient concentrations of combustion products generated by an explosion on the launch pad could exceed the threshold limit values for CO (25 ppm) and NOx (3 ppm) covering an area 3-10 km long by 1.5 km wide, lasting 5 to 20 minutes depending on meteorological conditions. With the first stage combustion products, the mass of combustion products in a cloud includes carbonic oxide. SO_2, NOx, VOCs, and other substances that can cause the secondary formation of pollutants are absent in the composition of the combustion products.

6.3 Provide and update suitable avoidance, mitigation and/or monitoring measures (where necessary) to confirm impact predictions, and to prevent and minimize potential Project impacts on air quality.

Uncontained release of large quantities of propellants and oxidizers is the primary risk to air quality associated with project activities. Normal launch activities would have minimal impact to air quality since the emissions would be primarily CO, CO_2 and water vapor. Previous environmental assessments prepared for the Antares Expendable Launch Vehicle which has a similar configuration and emissions to the Cyclone-4M has shown that air quality impacts are minimal and do not exceed threshold limits for launch byproducts (NASA 2015).

An Environmental Protection Plan (EPP), including the Erosion and Sediment Control Plan, spill prevention plan, and contingency plans (as necessary) will be developed prior to construction and assessed on a regular basis. An example Emergency Response Plan from United PARADYNE Corporation is included in Appendix C and provides an example of spill prevention planning activities. In addition, the EPP will provide BMPs and detailed protective measures to include air quality monitoring and storage and handling of hazardous materials.

Engineering design and operation features aimed at avoidance and mitigation will include:

- Filtered exhausts on buildings containing dangerous goods;
- All exposed soils and stockpiles capable of producing particular matter will be stabilized and covered according to provincial regulations and BMPs;
- Where required (including unpaved road surfaces), dust will be controlled in a timely manner using water or an approved dust suppressant; and
- Engine idling and driving speeds will be restricted and all vehicles and equipment will be kept in good working order, and will be properly muffled.

Launch specific programs aimed at avoidance and mitigation will include:

- Upon completion of rocket design, rocket plume emissions modeling will be completed and provided to regulatory agencies for review. Launch go/no- go criteria will be adjusted based on results of the rocket plume emissions modeling.
- Maritime Launch Services, Ltd will be conducting air dispersion modelling for any rockets launched from the site. The modelling will be completed and provided to regulatory agencies well in advance of launch operations.
- Monitoring programs would be designed in collaboration with regulators to verify impact predictions, as appropriate.

Air Quality References

Aerospace Corporation. 1996a. Ground Cloud Dispersion Measurements During the Titan IV Mission #K19 (10 July 1995) at Cape Canaveral Air Station. Prepared for Space and missile Systems Center Air Force Materiel Command. March 22, 1996

Aerospace Corporation. 1996b. Ground Cloud Dispersion Measurements During the Titan IV Mission #K21 (6 November 1995) at Cape Canaveral Air Station. Prepared for Space and missile Systems Center Air Force Materiel Command. June 21, 1996

Aerospace Corporation. 1998. Ground Cloud Dispersion Measurements During the Titan IV Mission #B33 (15 October 1997) at Cape Canaveral Air Station. Prepared for Space and missile Systems Center Air Force Materiel Command. June 30, 1998

NASA. 2009. Environmental Assessment for the Expansion of the Wallops Flight Facility Launch Range. National Aeronautics and Space Administration, Wallops Island, VA. August 2009.

NASA 2011. Final Environmental Assessment for Launch of NASA Routine Payloads. November 2011. Accessed at: https://repository.library.noaa.gov/view/noaa/12540

NASA 2014. Final Environmental Impact Statement for the Mars 2020 Mission. Accessed at https://mars.nasa.gov/mars2020/files/mep/Mars2020_Final_EIS.pdf

NASA. 2015. Final Supplemental Environmental Assessment, Antares 200 Configuration Expendable Launch Vehicle at Wallops Flight Facility. September 2015.

7.0 NOISE

7.1 Identify the nearest residents and seasonal cottages to the launch pad and propellant storage area.

Figure 7.1.1 provides the locations of the nearest residents, nearest campground, and nearest seasonal cottages. The distances from the launch pad and storage area to the nearest residential home, campground, and seasonal cottage is provided in Table 7.1.1.

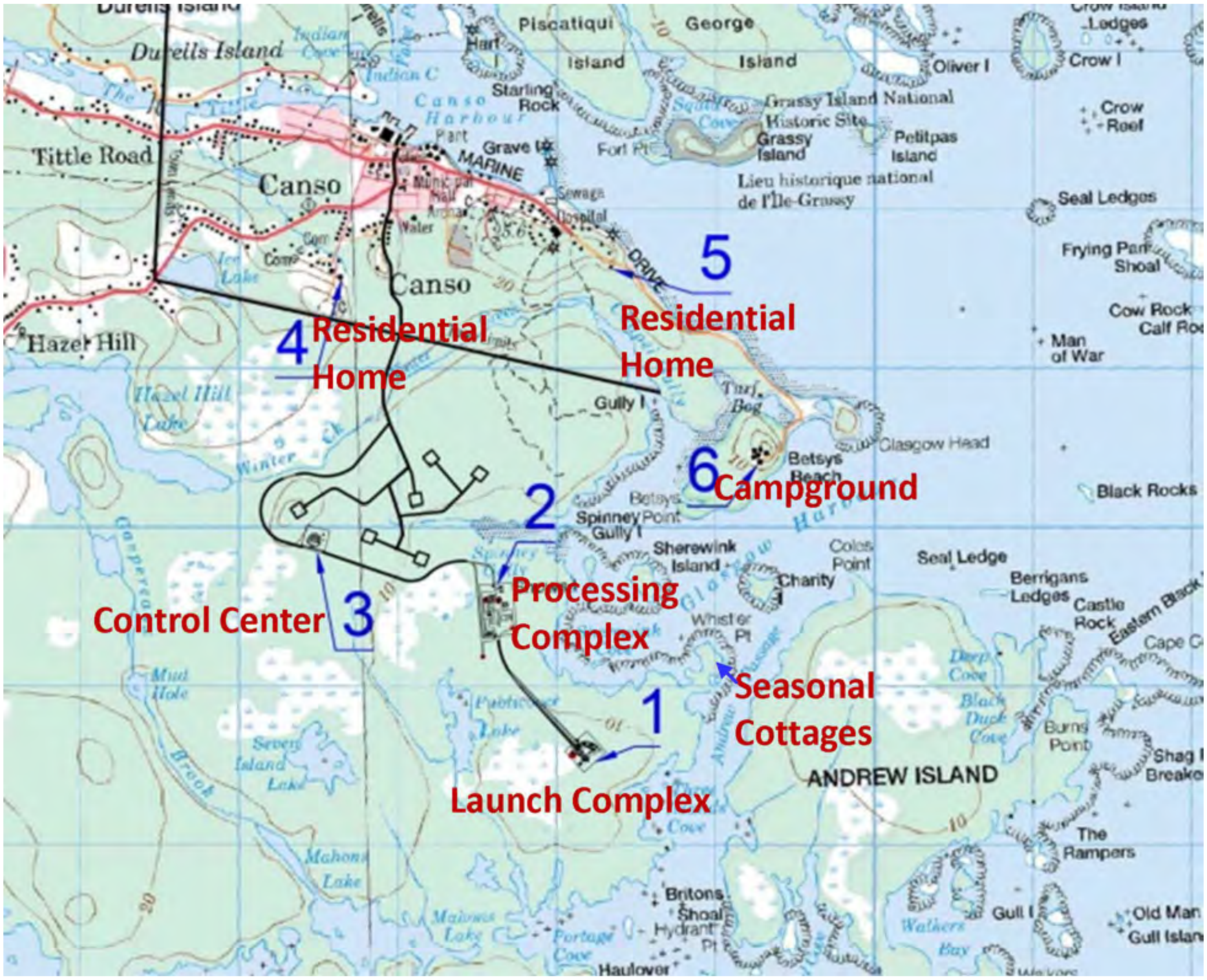

Figure 7.1.1. Nearest Residents, Campground and Seasonal Cottages

Table 7.1.1. Minimum Distances Between Noise Sources and Nearest Residential Home, Campground, and Seasonal Cottages

	Distance to Canso Habitable Objects metres (feet)	
	Launch Complex	Processing Complex
Nearest Residence	3073 (10080)	2210 (7250)
Campground	2147 (7040)	1860 (6100)
Seasonal Cottages	510 (1673)	1300 (4265)

7.2 Provide noise modelling information (e.g., model assumptions and output sheets). It is recommended Health Canada's *Guidance for Evaluating Human Health Impacts in Environmental Assessment: Noise*, be reviewed and applied in the model where relevant.

Modeling assumptions include:

- Launch Site Coordinates
- Atmospheric Profile with respect to altitude, temperature, pressure , relative humidity
- Vehicle and Engine Modeling Parameters
    - Vehicle length – 38.9 metres (m)
    - Gross Vehicle Weight – 261,813 kilograms (kg)
    - Number of Engines - 2
    - Maximum Net Thrust Per Engine – 1,824 kilonewton (kN)
    - Nozzle Exit Diameter – 1.3 m
    - Propellant Description – liquid oxygen (LOX)/RP-1 (highly pure kerosene)
- Day versus Night Launch hours

Blue Ridge Research and Consulting, LLC (BRRC) prepared the original noise report included in the Environmental Assessment (EA). BRRC is an acoustical engineering consultancy focused on critical noise and vibration challenges for aerospace, aviation, and Department of Defense projects. BRRC's modeling experience ranges from publicly available models such as AEDT and TNM to military noise and sonic boom models including NoiseMap, MR_NMAP, SARNAM, BNoise, PCBoom, and BoomMap. BRRC also has advanced in-house modeling capabilities with BRRC noise models such as The Launch Vehicle Acoustic Simulation Model (RUMBLE), flight safety models, and flight optimization models. Their modeling programs are designed to generate contours and figures, not traditional output sheets. The generated contours and figures from the modeling were incorporated into the original report that was provided with the EA.

BRRC used Transport Canada Noise Exposure Forecasts (NEF), which is more aviation focused, along with other supplemental metrics specific to rocket launch activities. Health *Canada's Guidance for*

Evaluating Human Health Impacts in Environmental Assessment: Noise was reviewed but not followed implicitly.

BRRC provides (or has provided) noise analyses as the prime launch vehicle noise consultant in over twenty rocket noise environmental studies, twelve of which were performed as part of the Federal Aviation Administration (FAA) commercial space licensing applications. The noise effects on the local communities and environment were evaluated based on the FAA Order 1050.1F, Environmental Impacts: Policies and Procedures, on a cumulative basis in terms of human annoyance, measured by DNL (day-night average sound level). The launch vehicle propulsion noise analyses, performed using RUMBLE, were often supplemented with single-event metrics in regard to hearing conservation and structural damage criteria. In addition to the propulsion noise, the sonic boom analyses were performed using PCBoom which calculates the magnitude and location of sonic boom overpressures on the ground from supersonic flight. Sonic boom impacts from launch and reentry were evaluated on a single-event basis in regard to hearing conservation and structural damage criteria.

BRRC’s commercial space launch vehicle noise study experience includes:

- EA for United Launch Alliance Vulcan Centaur Launch Operations, Cape Canaveral Air Force Station, LC-41 (2019 - Present);
- Space Florida’s Launch Site Operators License for the Shuttle Landing Facility (2018 - Present);
- Space Florida’s Landing Site Operators License for the Shuttle Landing Facility (2018 - Present);
- EA for Canso, Nova Scotia, Canada Launch Site (2017-Present);
- EA for NASA Kennedy Space Center, LC-48 (2017);
- Space Florida’s Launch Site Operators License for the Shuttle Landing Facility (2017-2018);
- Environmental Impact Statement (EIS) for Spaceport Camden (Submitted, 2016-2017);
- EA for the Blue Origin Cape Canaveral Air Force StationLC-36 Launch Site (2016);
- EA for the Cecil Spaceport (Submitted, 2015-2017);
- Site-wide Programmatic EIS (PEIS) for expanding operations at NASA Wallops Flight Facility (2014-2016);
- EA for the Hawaii Air and Space Port (2014-Present);
- EA for the Titusville Spaceport (2014-2018);
- EIS for the Shiloh Launch Complex (2013-2014);
- EA for Issuing an Experimental Permit to SpaceX for Operation of the DragonFly Vehicle at the McGregor Test Site (2013-2014);
- Preliminary Site Evaluation for Space Florida’s Shiloh Launch Facility (2013);
- EIS for the SpaceX Texas Launch Site (2012-2014);
- Site-wide PEIS for expanding operations at Wallops Flight Facility (2012-2013);
- EA for the Midland International Airport and Space Port (2012-2014);
- PEIS for Wallops Flight Facility (2010)

Further qualification of the BRRC team are included as part of Appendix A.

7.3 Provide and update suitable avoidance, mitigation and/or monitoring measures (where necessary) to confirm impact predictions, and to prevent and minimize potential Project impacts on acoustic environment.

An upper limit noise level of 115 A-weighted decibels (dBA) is used as a guideline to protect human hearing from long-term continuous daily exposures to high noise levels and to aid in the prevention of noise-induced hearing loss. At a sound level of 115 dBA, the allowable exposure duration is 28 seconds for Canadian Centre of Occupational Health and Safety (CCOHS) (in Nova Scotia). A single medium class launch vehicle event may generate levels at or above an $L_{A,max}$ of 115 dBA within 1.1 km of the launch pad. (Blue Ridge Research and Consulting, LLC. 2017)

The seasonal cottages are within 1.1 km of the launch site and will receive noise exposure in excess of 115 dBA. However, taking this into account, Maritime Launch Services, Ltd has made arrangements with the cottage owners to ensure that no one will be in these areas during launch activities. In addition, agreements are in progress for compensation of any structural damage due to noise propagation. With these avoidance measures, there should be no noise exposure to humans at the seasonal cottages.

The campground is further away from the launch site at approximately 2.1 km, with noise exposure less than 115 dBA for no more than 30 seconds (Blue Ridge Research and Consulting, LLC. 2017). During launches, the campground may be used for planned media and controlled viewing activities. Individuals at the campground will be exposed to noise levels within the CCOHS allowable exposure limits.

The nearest residence will be exposed to noise that is comparable to a motorcycle or ambulance at 25 meters for a short duration. This is well within the CCOHS allowable exposure limits. The communities of Canso and Dover will be exposed to noise levels less than 25 Noise Exposure Forecast (NEF) and below the 25 NEF where Transport Canada has no restrictions or limitations to noise sensitive land uses. In addition, local communities would be notified of launch activities and predicted noise levels will be confirmed by monitoring during launch.

A sonic boom is not predicted to intercept the mainland of Nova Scotia; it will occur down range and at high altitudes, over open ocean. As such, it will not exceed hearing conservation and structural damage criteria. (Blue Ridge Research and Consulting, LLC. 2017)

Noise References

Blue Ridge Research and Consulting, LLC. 2017. Technical Report: Launch Noise Study for the Nova Scotia Environmental Assessment. Final. December 2017.

8.0 FLORA AND FAUNA

8.1 Further baseline studies for shorebirds and seabirds will be required, and this requirement can be deferred before commencement of the Project, if the Project is approved.

Maritime Launch Services, Ltd. conducted baseline studies as part of the environmental registration process for the facility. Other baseline studies such as the National Geography In-Shore Areas (NaGISA) project (Miller 2010) have been conducted in the project area. As needed, additional baseline studies would be completed before commencement of launch operations.

Probable breeding birds in the Project area are American oystercatcher, Brown-headed cowbird, Ruby-crowned kinglet, Spotted sandpiper, and Tennessee warbler. Avian field assessments included passerines, shorebirds and an acoustical study. American crow was the most common passerine observed during winter surveys. The wintering passerine bird population in the area appears to be low in both diversity and abundance, comprised of common winter residents. The spring population was fairly robust and comprised largely of resident birds (crows, seagulls) and common songbirds. Of the individual birds observed in breeding surveys, 24 species were assessed as possible breeders, 12 as probable breeders, and one as a confirmed breeder. Because of habitat (lack of forest), the Project site was sparsely occupied by breeding birds. Fall migrants were observed stopping at the Project site. Waterfowl were observed using the bogs and open waters. Data indicate a relatively constant population of common resident species in the fall, as well as an influx of the variety of passerine and shorebird species that utilize the area as a stopover locations during fall migration.

The many sheltered coves and bays, especially areas with sandy beaches and saltmarsh habitat, in the vicinity of the Project site likely host overwintering sea ducks and also serve as stopover locations for migrating waterfowl, shorebirds and passerine species during spring and fall migrations. Small to medium-sized colonies of seagulls and terns that are occupied throughout most of the spring and summer are present in the general area. There is a healthy breeding population of Willet and likely other shorebirds in the area. In addition, there was *a Historical Bird Data Review and 2012 Fall Migration Surveys* Report completed for the Sable Wind Project. The objective of the assessment was to identify fall migration species and migration corridors with the area of the Sable Ind Project un Guysborough County, and to compare the findings to earlier surveys. (Strum Environmental 2012)

Seven terrestrial mammal species have been recorded within a 100-kilometer (km) radius of the Project site. Target surveys for mainland moose and bats were completed. No evidence of mainland moose was observed. However, eight other common and ubiquitous mammal species were recorded. Acoustic surveys for bats detected only a single bat, indicating that the bat population is likely very low in the vicinity of the Project site and likely comprised of seasonal and migrant individuals.

There are 14 priority fish species potentially occurring in the vicinity of the project site. Watercourse 1 provides fish habitat, but does not provide suitable spawning habitat due to soft substrate, nor good overwintering habitat due to shallow water. A fish habitat assessment has not been completed on Watercourse 2.

As needed, a baseline monitoring plan will be developed that will describe the rationale for baseline study design including collection methods, parameters analyzed, sampling frequency and period, site locations, statistical considerations and quality assurance/quality control protocols.

8.2 Assess potential noise impacts on birds and other wildlife.

Rocket launches generate a significant amount of acoustic energy. The primary source of rocket noise is the high jet exhaust velocity required to boost a launch vehicle during takeoff. Typical noise levels at the launch site are around 170 – 200 decibels (dB), and are concentrated in the low to mid frequency range (Lupert 2017).

Data provided by Yuzhnoye State Design Office indicates that sound pressure levels of the integrated launch vehicle in flight would decrease significantly with distance. Model results of free sound field, excluding terrain feature, location of infrastructure objects and their activities, are shown in Table 8.2.1.

Table 8.2.1 The Levels Of Sound Pressure (dBA) at Liftoff and In Flight

Time, c	Distance to the Reference Point (km)						
	0.5	1	2	3	5	7	10
5	122.2	113.7	102.4	93.7	78.9	65.5	46.8
10	122.1	113.6	102.3	93.7	78.8	65.5	46.8
15	121.2	113.3	102.2	93.6	78.8	65.5	46.8
20	119.1	112.5	101.9	93.5	78.7	65.5	46.7
25	115.7	110.8	101.2	93.1	78.5	65.3	46.6
30	111.5	108.1	100.0	92.3	78.1	65.0	46.5
40	100.1	98.9	94.4	88.7	76.3	63.9	45.9
50	87.6	87.3	85.2	81.2	72.2	61.4	44.6
60	73.2	73.2	72.6	70.8	64.8	56.5	42.0

dBA - A-weighted decibels

The sound pressure threshold ranges of vertebrates vary significantly within classes and even more so between different classes. Overall, there is a demonstrated general pattern of decline with the evolutionary complication of the organization of vertebrates, with birds and mammals being the most sensitive to sound.

Birds are particularly sensitive recipients of anthropogenic acoustic effects, typical representatives of coastal and riparian ecosystems, and often priority objects of protection. Information regarding threshold levels of sound pressure disturbing birds is often contradictory due to the diversity of species and the specifics of the exposure itself. For example, it is known that nesting terns react to noise with an intensity of 90–95 A-weighted decibels (dBA) (4% of birds are frightened, 2–4% take off). Black geese and peganki feeding in shallow water began to respond to aircraft noise with a sound level of 65 dBA. Nesting gulls did not react to ordinary jet aircraft at a sound level of 91.8 dBA, but reacted to the supersonic Concorde (108.2 dBA). It was observed that the flight of the helicopter at a distance of 700 m does not affect birds at sound levels of 71.5 dBA and below, the observed threshold of behavioral response is 80.5 dBA.

Taking into account the data in Table 8.2.1 and the above observations, it can be assumed that when a launch vehicle is launched five to eight times a year within a 7-km zone from the starting point, fauna representatives may experience noise discomfort and other negative reactions for a short period of time (from one up to five minutes). At other times outside of actual launch activities, the level of technogenic noise during all types of work is not expected to exceed 80 dBA.

For comparison, it should be noted that the average intensity of thunderstorm activity in the area of launch site location is 10 days a year with an average duration of 1 hour. Thunder peals have sound power (100-120 dBA) commensurate with the launch vehicle jet, and can be heard at distances of up to 15-20 km. Under these conditions, fauna representatives developed adaptive mechanisms for the relatively short-term effects of high-level noise.

In summary, noise impacts on birds and other wildlife is expected to be short-term and temporary and are likely to respond similar to that seen during thunderstorms.

8.3 Assess potential impacts of all chemical substances used in launch activities and/or its byproducts or daughter products on wildlife and wildlife habitat, from routine Project operation and/or accidents involving these chemicals.

Liquid Oxygen (LOX) and RP-1 (highly pure kerosene) would be consumed during launch and combustion products would not cause acid precipitation or other contamination. Adverse effects on fauna and flora during normal operation are not expected.

The greatest potential impact to the wildlife and wildlife habitat would be due to the release of hazardous materials from an accident (e.g., leak, fire, or explosion) at a storage location or, to a lesser degree, from an accidental release during fueling, payload processing, or launch activities (e.g., spills). The short- and long-term effects of an accident would vary greatly depending upon the type of accident and the substances involved.

Hydrazine fuels are highly reactive substances that quickly oxidize to form amines and amino acids when released to the environment. Prior to oxidation, there is some potential for exposure of terrestrial and aquatic organisms to toxic levels, but for a very limited area and time. Hydrazine does not meet the criteria for persistence or bioaccumulation potential as set out in the *Persistence and Bioaccumulation Regulations* (Canada 2000).

Unsymmetrical dimethyl hydrazine (UDMH) vapors quickly react with ozone in the troposphere. Hydrazine compounds are rapidly biodegraded in soil. Biodegradation of UDMH occurs in both water and soil. In the screening assessment for hydrazine, Environment Canada (2011) determined that:

- If released to air, hydrazine will not partition to alkaline hardwater, but will partition to slightly acid softwater;
- If released to surface water, hydrazine will not readily partition to other environmental media;
- If released to soil, hydrazine will not readily partition to other environmental media in alkaline hardwater areas and will partition significantly in slightly acidic softwater.

Bioconcentration of UDMH does occur, but biomagnification through the food chain is unlikely due to rapid degradation. Hydrazine does not meet the criteria for persistence or bioaccumulation potential as set out in the Persistence and Bioaccumulation Regulating (Canada 2000). In small quantities UDMH does not inhibit, but stimulates the growth of algae.

Hydrazine is miscible with water. The oxidation of UDMH in sea water differs from the oxidation process in fresh water where various elements in sea water, including transition metal ions serve as catalysts for the oxidation of UDMH. The main product of UDMH oxidation in sea water is tetramethyltetrazene. The maximum permissible concentration of tetramethyltetrazene in water is 0.1 milligrams per liter (mg/l). Because of rapid degradation, persistence in the environment is unlikely and UDMH is not expected to be found in measurable concentrations in environmental media.

Hydrazine fluid is corrosive and can cause dermatitis to humans and animals when in contact with skin. Effects in the lungs, liver, spleen, thyroid gland were observed for animals after chronic (prolonged) inhalation exposure to hydrazine. Rodents exposed to hydrazine experienced damage to the lungs, nasal cavity and liver, as well as developing tumors.

Tests on rats, mice, rabbits and guinea pigs showed high acute toxicity from inhalation and ingestion.

An increase in the incidence of lung and liver tumors was observed in mice exposed to hydrazine through inhalation, drinking water and injections. Tumors in the nasal cavity were observed in rats and hamsters after inhalation exposure to hydrazine (NCBI 2019a).

Carcinogenic effects were observed in mice and rats exposed to 1,1-dimethylhydrazine through inhalation; however, because of the presence of impurities in the study, the results were inconclusive. 1,1-dimethylhydrazine is a carcinogen for mice and hamsters exposed orally. Birth defects were not observed in offspring of animals exposed to 1,1-dimethylhydrazine on the abdominal cavity (NCBI 2019b). Effects of acute poisoning in rats, mice, hamsters, rabbits, and guinea pigs has shown that 1,1-dimethylhydrazine vapors are highly toxic.

For a single 4-hour exposure to 1,1-dimethylhydrazine, lethal concentrations for 50% of animals are as follows:

1) for mice – 0.42 milligrams per cubic decimeter ($mg/dm^{3)}$;

2) for rats – 0.62 mg/dm3; and

3) for guinea pigs – 0.10 mg/dm3.

At repeated 6-hour exposures of 5 parts per million (ppm) hydrazine for 6 months, 2 of 2 dogs survived; 2 of 4 dogs lived after 194 6-hour exposures to 14 ppm while 2 died during the third and fifteenth weeks in a debilitated condition. The dog that died during the fifteenth week had a severe convulsive seizure prior to death. Prior to death, both dogs showed signs of anorexia and general fatigue. Changing diets and forced

Dinitrogen tetroxide (NTO) is highly toxic and corrosive, but evaporates faster than water at room temperature resulting in rapid volatilization in the event of a spill.

Unburned RP-1 propellant could be released onto vegetation and to adjacent wetlands in the event of a launch failure. Summarizing the results of 32 published studies of oil spills, Michel and Rutherford (2014) found that light refined petroleum products, such as kerosene (which is similar to RP-1), showed the highest acute toxic effects on marsh vegetation. The time of year in which the release occurs would likely dictate the magnitude of potential effects, with times of dormancy in winter resulting in the least, and times of active growth, the greatest effects (NASA 2015).

Terrestrial wildlife, aquatic organisms, and vegetation could be adversely affected in the event of a spill where contaminants were released to the environment. Wildlife would likely avoid close proximity to the launch complex because of lighting and human activity. Spill containment measures would be in place to mitigate the effect of an accidental spill or leak. A site-specific Environmental Protection Plan (EPP) will be developed before initiation of construction to minimize and mitigate potential adverse effects to wildlife and their habitat. The EPP will provide best management practices and detailed protective measures to include air quality monitoring, noise management and sound monitoring, watercourse and wetland monitoring, marine environment protective measures, tree removal, wildlife and habitat protection, and storage and handling of hazardous materials.

8.4 Provide additional details regarding mitigation, management and/or monitoring measures to confirm impact prediction, and to mitigate potential Project impacts on wildlife and wildlife habitat (e.g., noise, lighting, release of sediments and hazardous materials, Project accident and malfunction, etc.).

The project is anticipated to have minimal effect on wildlife and wildlife habitat. Potential project impacts on wildlife and wildlife habitat will be minimized by implementation of engineering and design safeguards such as:.

- Launch vehicle processing complex, spacecraft and payload unit processing complex, fueling/neutralization station premises will be equipped with ventilation systems with filter-absorbers for propellants vapors, fire protection equipment, television surveillance and telecommunications equipment, fire and air pollution sound and light alarm systems (arrangement and placement of equipment in the premises will be made with a view to ensuring quick evacuation of personnel in case of an emergency);
- Human error is reduced by excluding the possibility of improper installation or mating of units, components, pneumatic, hydraulic and electrical connectors during installation and testing, as well as by developing a safe procedure for operations, including safety measures that personnel must follow and procedures for emergency situations in the operational documentation; and
- Only certified personnel will be allowed to work with hydrazine fuel. Safety training will be provided prior to operations and personnel will be equipped with personal protective equipment (helmets, seat belts, acid protective gloves, gas masks, protective suits). The duration of work time with propellants will be limited, and after the end of the shift the personnel will undergo obligatory sanitary treatment and medical control.

An environmental monitoring system will be developed to measures and ensure the collection, processing, analysis and storage of information on the status of ecosystems in the area of the launch site. The main objectives of the launch site environmental monitoring (control) system will be to monitor the state of the environment and any changes due to the launch site construction and operation; and to verify implementation of the plans and measures for environmental protection, compliance with the requirements of environmental legislation and environmental quality standards applied in the area of launch site operation.

Monitoring programs will include:

- Soil;
- Air of working area, localities;
- Open bodies of water;

- Industrial waste water;
- Solid waste; and
- Fauna and flora in areas of possible launch site effect.

Flora and Fauna References

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Lubert, Caroline Parsons. 2017. Sixty years of launch vehicle acoustics. Proceedings of Meetings on Acoustics, 174th Meeting of the Acoustical Society of America, New Orleans, Louisiana. Noise: Paper 1aNS1. December 2017. Accessed at https://asa.scitation.org/doi/abs/10.1121/2.0000704

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Strum Environmental. 2012. Historical Bird Data Review and 2012 Fall Migration Surveys. Sable Wind Project. November 13, 2012.

NASA (National Aeronautics and Space Administration). 2015. Final Supplemental Environmental Assessment, Antares 200 Configuration Expendable Launch Vehicle at Wallops Flight Facility. September 2015.

9.0 FISH AND FISH HABITAT

9.1 Further baseline studies to collect fish habitat information for Publicover Lake and its two tributaries (Watercourse 1 and 2) will be required, and this requirement can be deferred before commencement of the Project, if the Project is approved.

Maritime Launch Services, Ltd. conducted baseline studies as part of the environmental registration process for the facility. Other baseline studies such as the National Geography In-Shore Areas (NaGISA) project (Miller 2010) have been conducted in the project area. As required, additional baseline studies to characterize existing site conditions would be completed before commencement of launch operations.

As needed, the baseline monitoring will characterize conditions before commencement of launch operations. The objective is to collect appropriate baseline data either from existing sources or environmental monitoring studies to characterize pre-operational environmental media quality. The baseline monitoring plan will describe the rationale for baseline study design including collection methods, parameters analyzed, sampling frequency and period, site locations, statistical considerations and QA/QC protocols. Methods and quality assurance/quality control (QA/QC) procedures will comply with the latest edition of the Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment, Volume 4, Analytical Methods, PN 1557 (CCME 2016) or other applicable and approved methods. Results will be compared to provincial water quality guidelines as appropriate. Key environmental indicators and action thresholds (such as existing national, provincial or regional standards) for adaptive management will be described. Baseline environmental media will be sampled quarterly, semi-annually or annually depending upon the medium of interest and location relative to the launch complex.

Prior to the initiation of launch activities, an environmental monitoring plan will be developed to measures and ensure the collection, processing, analysis and storage of information on the status of ecosystems in the area of the launch station.

The main objectives of the environmental monitoring plan will be to monitor the state of the environment and any changes due to the launch system construction and operation and verification of implementation of the plans and measures for environmental protection, compliance with the requirements of environmental legislation and environmental quality standards applied in the area of launch site operation.

For surface water specifically, deposition of emission particulates or metals could occur immediately outside of the launch pad, and in the case of a launch failure on the pad or accidental spill, petroleum products from RP-1 (highly pure kerosene) fuel could be deposited in surface water. Post-construction water quality monitoring and testing for metals and petroleum products in Watercourse 1 and nearby waterbodies/wetlands, including Publicover Lake, will be conducted. Representative samples of surface water will be obtained and water quality parameters and selected analyte concentrations will be compared to provincial water quality guidelines.

Fish and Fish Habitat References

CCME (Canadian Council of Ministers of the Environment). 2016. Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment, Volume 4, Analytical Methods, PN 1557.

Miller, Sarah. 2010 Biodiversity of macroalgae on rocky coastal shores of Nova Scotia, Canada – the NaGISA project. Thesis advisor: Dr. Melisa Wong; Panel of Judges: PR. Dominique Davoult, Dr. Ann Andersen.

10.0 PROTECTED AREAS AND PARKS

10.1 Assess potential Project related impacts on nearby protected areas and parks (potential impacts including but not limited to air, water and noise).

There are a few protected areas within 5 kilometres of the launch site. However, as shown in Figure 10.1.1, the launch trajectory and associated corridor does not overfly any protected lands.

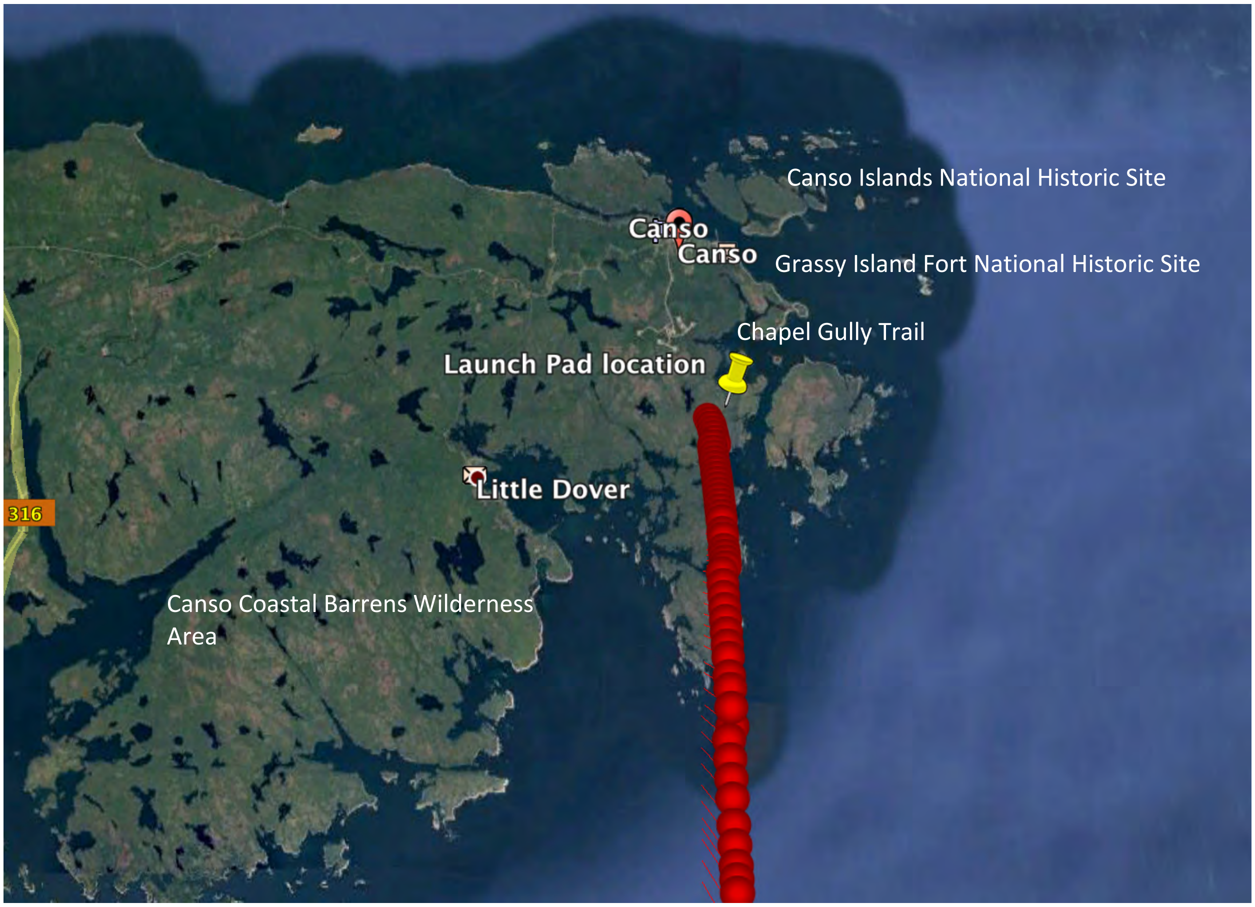

Figure 10.1.1. Launch Trajectory

Given the distance between the protected areas and the launch site, no negative impacts are anticipated. In case of a vehicle launch explosion at the launch pad, as well as emergency termination of flight and fall of the launch vehicle (fragments), these protected areas are not in the area of possible negative impact.

10.2 Provide and update suitable avoidance, mitigation and/or monitoring measures (where necessary) to confirm impact predictions, and to prevent and minimize potential Project impacts on protected areas and parks.

Given the distance between the national parks and the launch site, the project is anticipated to have minimal effect on these areas. Any minimal effect will be further minimized by implementation of engineering and design safeguards such as:

- Launch vehicle processing complex, spacecraft and payload unit processing complex, fueling/neutralization station premises will be equipped with ventilation systems with filter-absorbers for propellants vapors, fire protection equipment, television surveillance and telecommunications equipment, fire and air pollution sound and light alarm systems (arrangement and placement of equipment in the premises will be made with a view to ensuring quick evacuation of personnel in case of an emergency);
- Human error is reduced by excluding the possibility of improper installation or mating of units, components, pneumatic, hydraulic and electrical connectors during installation and testing, as well as by developing a safe procedure for operations, including safety measures that personnel must follow and procedures for emergency situations in the operational documentation; and
- Only certified personnel will be allowed to work with hydrazine fuel. Safety training will be provided prior to operations and personnel will be equipped with personal protective equipment (helmets, seat belts, acid protective gloves, gas masks, protective suits). The duration of work time with propellants will be limited, and after the end of the shift the personnel will undergo obligatory sanitary treatment and medical control.

11.0 HUMAN HEALTH

11.1 Assess potential impacts of hydrazine related chemicals used in launch activities and/or its byproducts or daughter products on human health, from routine Project operation and/or accidents involving these chemicals. Provide references from studies done in other jurisdictions and indicate how the information in these studies is relevant to this particular Project.

Hydrazine and its derivatives in the form of vapor or aerosol penetrate into the body by inhalation and through the skin. The effect of unsymmetrical dimethyl hydrazine (UDMH) on the human body is irritation of the mucous membranes of the eyes, respiratory tract and lungs, damage to the central nervous system, and damage to the digestive tract. Concentrations of 240 milligrams per cubic metres (mg/m^3) is considered human-tolerated during exposures up to 10 minutes, and concentrations up to 120 mg/m^3 for 30 minutes. A dose of 20 –10 milligrams per kilogram (mg/kg) can cause mild poisoning.

The most hazardous nitrogen oxides are nitric oxide and nitrogen dioxide (NO_2). NO_2 exists in equilibrium with dinitrogen tetroxide (NTO), so the toxic properties observed in clinical and toxicological cases have not distinguished between the two. Nitrogen oxides irritate the lungs and upper respiratory tract at low concentrations. NTO is considered highly toxic; concentrations of 25-50 parts per million (ppm) have caused irritation of the eyes and nose while 50-100 ppm can cause pulmonary edema and death. Most experience on human exposure is from farmers exposed to nitrates associated with crops stored in silos. Members of the Apollo/Soyuz Test Project crew were exposed to an estimated average concentration of 250 ppm in flight and each member displayed signs and symptoms of chemical pneumonitis and increased methemoglobin levels.

According to Bogdanov and Gembitskiy (1968), the following Classification of injuries (poisoning by propellants) is adopted:

- Acute damage:
    - Chemical burns (degree of damage: I, II, III, IV)
    - Inhalation poisoning (degree of damage: mild, medium, severe)
    - Combined damage (degree of damage: mild, medium, severe)
- Chronic damage: mild, medium, severe degree of damage

Nominal Operation

The adopted design, technological processes and layout decisions (see the responses to questions on Items 11.2-11.5) make it possible to exclude emissions of propellant vapors and spills during standard operation of the space launch system, thus preventing adverse exposures.

Accidents

Propellant spills would occur only in the event of malfunction (wear) of ground support equipment and/or personnel errors. The probability of spill occurrence is $1x10^{-5}$ (for details see response to Item 3.3).

In case of accidental propellant spills, the procedure of collection and neutralization in combination with personal protective equipment allows quick elimination of the spill with minimal risk of acute and chronic exposures.

The areas of potential excess exposure are localized in the vicinity of the launch site, thus they do not endanger the health of people outside the launch site.

11.2 Identify the nearest residents and seasonal cottages to the launch pad and propellant storage area.

The minimum distances between environmentally hazardous launch site facilities and Canso habitable structures are presented in the Table 11.2.1.

Table 11.2.1 – Minimum Distances to Offsite Habitable Structures

	Distance to Canso Habitable Objects metres (feet)	
	Launch Complex	Processing Complex
Nearest Residence	3073 (10080)	2210 (7250)
Campground	2147 (7040)	1860 (6100)
Seasonal Cottages	510 (1673)	1300 (4265)

Figure 11.2.1 shows the proximity of habitable structures to the launch complex.

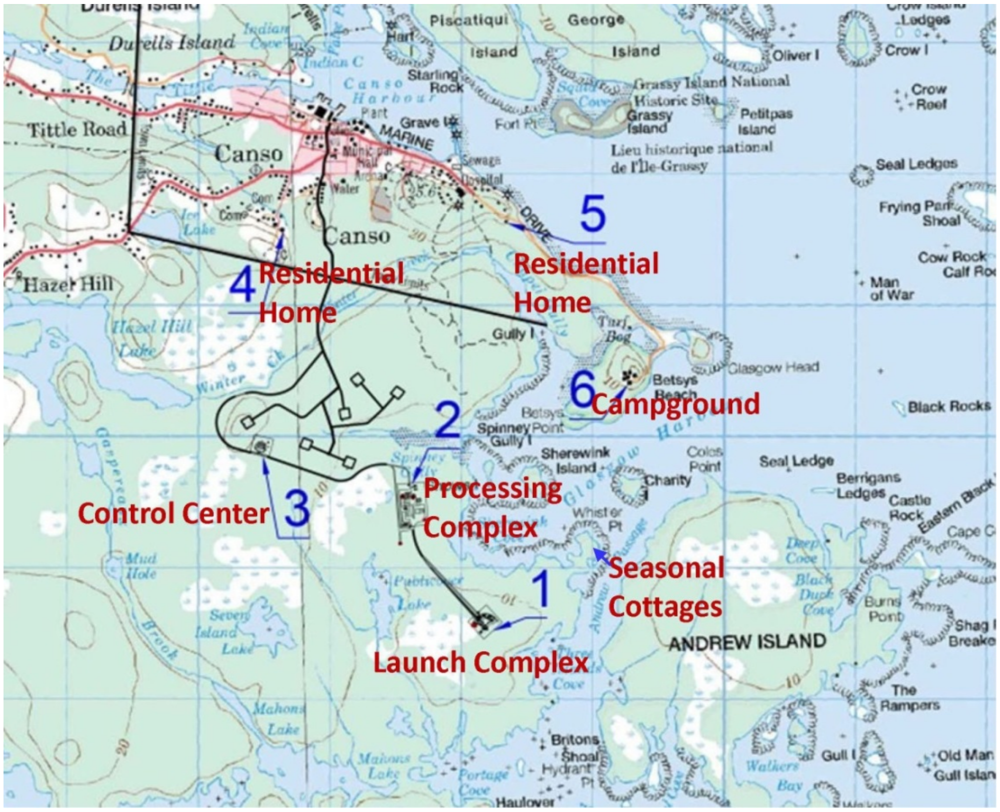

Figure 11.2.1. Proximity of Closest Habitable Structures to the Canso Launch Complex

11.3 Discuss minimum separation distance between the public and energetic fluids co-located in a launch vehicle and how this setback distance is determined.

The minimum actual distance between possible human receptors and the Canso launch site was shown previously in Table 11.2.1. The minimum separation distance for storage of hazardous materials is shown in Table 11.3.1 below. All distances assume that positive measures will be taken to prevent mixing of hydrazines and oxidizers in the event of a spill.

Table 11.3.1. Minimum Distances Between Energetic Liquids*

Chemical/ Item	Use	Location	Public Area Distance m (ft)	Public Traffic Route Distance m (ft)
LOX	First Stage	Vertical Launch Area	15.24 (50)**	15.24 (50)**
RP-1	First Stage	Vertical Launch Area	420 (1,377)	252 (826)
NTO	Second Stage	Horizontal Integration Facility	381 (1,250)	229 (750)
UDMH	Second Stage	Horizontal Integration Facility	366 (1,200)	219 (720)

* Values were calculated using US 14 CFR Appendix E to Part 420, Tables for Explosive Site Plan.

** - From NFPA 55, Table 9.3.2 (Public assembly/Combustible liquids)

LOX – liquid oxygen; RP-1 (highly pure kerosene)

Sources: LOX (hazard group II): NFPA 2005, Table 9.3.2; RP-1 (hazard group I; class II): NFPA 2008; NTO: NASA 2018, Table 5-31; UDMH: NASA 2018, Table 5-33.

Note that the required safety distance for NTO is the same for an inhabited building distance (IBD), i.e. human receptors, as for intraline distance (ILD), intermagazine distance (IMD), and public transport route distance (PTR). Where ILD is the distance between operating locations and is meant to prevent propagation of a mishap and where IMD is the distance between storage locations. For UDMH, this table presents the minimum protected IBD and PTR, where protection from fragments is afforded through physical restrictions like terrain, barricades, or nets. The unprotected IBD and PTR is 691 ft for UDMH and the ILD for UDMH is 97 ft.

The minimum required setback distance between humans and energetic fluids co-located in the launch vehicle at the Canso launch complex is determined using the most stringent requirements for the most energetic compound. The safe separation of the launch pad and propellant storage areas from service personnel and from the population is determined by the risk fields of the adverse factors of emergencies (air shock wave, fragmentation, “fireball”, dispersion of toxic substances) during operations at the launch and processing complexes. An accident (explosion) of the launch vehicle at the launch pad has the highest impact risk of adverse factors.

Based on the Requirement for Orbital and Sub-orbital Rockets in Canada, categories of injuries, shown in Table 11.3.2, and probable levels of occurrence, shown in Table 11.3.3, help ensure a ranking of the severity of injuries and their occurrence. In addition, the off-nominal (hazardous) situations are classified in accordance with the risk assessment matrix given in Table 11.3.4.

Table 11.3.2. Size of Possible Injury Zones and Risk of Occurrence In Case of a Launch Vehicle Accident at Launch Pad or Fuel Site

Severity of Effects	Injury Category	Probability of injury	Radius of Injury Zone (m)	Risk
Catastrophic (lethal injuries)	I	1.5×10^{-6} (D level) for equipment	Up to 200	8 – undesirable, subject to additional analysis and coordination by the cosmodrome security service
		1.5×10^{-9} (E level) for personnel*		12- acceptable, subject to analysis
Critical (severe injuries)	II	1×10^{-4} (D level) for equipment	Up to 210	10 - acceptable, subject to analysis
		1×10^{-7} (E level) for personnel *		15- acceptable, subject to analysis
Limit (slight injuries)	III	1×10^{-4} (D level) for equipment	Up to 440	14 - acceptable, subject to analysis
		1.5×10^{-7} (E level) for personnel*		17- acceptable, subject to analysis

* In the event of safety requirement violations on the regulatory distance from the launch pad by launch complex personnel, the probability of mistake would be $P_p=10^{-3}$.

Table 11.3.3. Categories of Severity of Injuries from Hazardous Situations for Personnel, Population, Property and Natural Environments

Category definition	Injury Category	Effects (for project purposes)
Catastrophic (lethal injuries)	I	Dangerous phenomenon in which the worst effects result in death or loss of equipment or system
Critical (severe injuries)	II	Dangerous phenomenon that could cause serious injury or property damage equal to or greater than $25,000
Limit (slight injuries)	III	Dangerous phenomenon that could cause insignificant injury or material damage, less than $25,000
Insignificant (insignificant injuries)	IV	A phenomenon that probably will not affect the health of personnel or cause material damage under $10,000.

Table 11.3.4. Levels of Probability of Hazard Occurrence

Level	Description	For Personnel and Cosmodrome Objects, Population and Objects Located Outside Cosmodrome, Natural Environments
A	Frequent	more than 1×10^{-1}
B	Probable	from 1×10^{-2} to $1 \times 10^{-}1$ inclusive
C	Casual	from 1×10^{-3} to 1×10^{-2} inclusive
D	Distant	from 1×10^{-6} to 1×10^{-3} inclusive
E	Hardly probable	1×10^{-6}, no more

Outside the radii of injury in Table 11.3.2, the risk of exposure to personnel, systems and units of the launch site is considered acceptable.

Categories and levels according to the Requirement for Orbital and Sub-orbital Rockets in Canada, shown in Tables 11.3.3 and 11.3.4, ensure a ranking of the severity of injuries and probability of off-nominal situations and hazards occurrence.

Transport Canada requires a ground safety analysis that evaluates worst-case scenarios from an explosion and considers the appropriate safety setback distances for the general public from blast overpressure and fragments.

11.4 Discuss minimum separation distance between the public and launch pad during launch operations, and how this setback distance is determined.

The minimum separation distance for storage of hazardous materials is provided in Table 11.3.1. All distances assume that positive measures will be taken to prevent mixing of hydrazines and oxidizers in the event of a spill. The safe distance from the launch pad and propellant storage areas for service personnel and the population is determined by the risk of adverse effects from emergencies (air shock wave, “fireball”, dispersion of toxic substances) during operations at the launch and processing complexes.

Explosion of the launch vehicle at the launch pad has the highest risk of adverse impact.

Table 11.3.2 contains integrated risk values for impact of adverse factors, taking into account the probability of injury and the category of severity of effects, classified in accordance with Tables 11.3.3, 11.3.4, and 11.4.1.

Table 11.4.1. Probability and Severity of Hazard Occurrence

Levels of Probability of Off-nominal Situation (hazards) Occurrence	Severity of Injury Category			
	Catastrophic I	Critical II	Limit III	Insignificant IV
Frequent A	1	3	7	13
Probable B	2	5	9	16
Casual C	4	6	11	18
Distant D	8	10	14	19
Hardly probable E	12	15	17	20

Risk indicator:
1-5 Unacceptable
6-9 Undesirable – subject to additional analysis and coordination by the cosmodrome security service
10-17 Acceptable, subject to analysis
18-20 Acceptable without analysis

Applying the minimum distances between energetic liquids provided in Table 11.3.1:

- The nearest public location is more than double the distance of the worst-case scenario and the nearest residential home is more than double the distance of the worst-case scenario.
- The campground location is more than double the distance of the worst-case scenario and will be used for planned media and controlled viewing activities during launches. The campground is in disrepair and has not been used as a campground in many years. The campground is used to house the performers associated with the Stanfest Festival that occurs over a weekend in late July. The actual concert venue is in Canso (http://www.stanfest.com/). Other than this one activity, the campgroup is empty for the remaining 350 days plus per year.
- The seasonal cottages/fishing huts are within the minimum distances. They are mainly used for lobster fisherman to be able to work their traps more easily during lobster season in May and June. They are virtually never used during the winter. The cottages/fish huts are on the provincial crown land and are used with the Ministry of Lands and Forestry permission. They are assigned to individuals. They cannot be developed into permanent residences and are estimated to be used less than 5% of the time in a typical year. One of the fish hut owners indicated that he had not been to his place in over three years. Agreements have been made with owners to ensure that no one will be in these areas during launch activities and sweeps of these areas will occur prior to launch.

Furthermore, the spaceport operations manual will establish strict guidelines for site controls and public access.

11.5 Provide and update suitable avoidance, mitigation and/or monitoring measures (where necessary) to confirm impact predictions, and to prevent and minimize potential Project impacts on human health.

The project is anticipated to have minimal effect on human health and will be verified prior to and during launch operations through active monitoring measures.

Maritime Launch Services (MLS) is coordinating with the Guysborough County Inshore Fisherman's Association (GCIFA) to supplement their in-place water monitoring program. The GCIFA has been conducting water sampling in the project area for years to monitor the health of the water as it relates to their industry. MLS has committed to increasing the water sampling program frequency in the waters around the project area and to include additional analysis for any potential project related concerns. This will be run independently by the GCIFA and baseline work is already in place.

MLS will also be validating the noise model predictions by contracting Blue Ridge Research and Consulting (BRRC) to set up and collect data for launches and will modify the hearing protection protocols if needed. MLS will implement an air emissions monitoring program by setting up collection stations in and around the project area. The monitoring station locations will be selected in consultation with the appropriate regulatory agencies. Full dispersion modeling will be conducted as a part of the launch preparations in anticipation of setting up the typical go-no go criteria for a launch. Wind direction and velocity along with other weather conditions fold into the decision to launch based on the worst-case scenarios and the nearby communities to ensure the safety to the general public. MLS will use the air monitoring program to validate those go-no go criteria developed from the dispersion modelling and modify the launch criteria as needed. This data collection will also inform the predictions and measurements that have been made at other launch sites that MLS has reviewed and provided reference to in the report.

Additional potential project impacts on human health will be minimized by implementation of engineering and design safeguards and the implementation of safe work practices for the employees at the site to include:

- Safety protocols and requirements of the launch vehicle, payload unit and ground support equipment were designed according to manufacturer's specifications (C4M YZH ANL 065 00 space launch system safety requirements [Yuzhnoye 2018]) and applicable regulatory documents;
- Maintaining standard temperature and humidity conditions in facilities, including monitoring of oxygen and propellants vapor content in the air of working areas by a gas monitoring system;
- Launch vehicle processing complex, spacecraft and payload unit processing complex, fueling/neutralization station premises will be equipped with ventilation systems with filter-absorbers for propellants vapors, fire protection equipment, television surveillance and telecommunications equipment, fire and air pollution sound and light alarm systems (arrangement and placement of equipment in the premises will be made with a view to ensuring quick evacuation of personnel in case of an emergency);
- Human error is reduced by excluding the possibility of improper installation or mating of units, components, pneumatic, hydraulic and electrical connectors during installation and testing, as

well as by developing a safe procedure for operations, including safety measures that personnel must follow and procedures for emergency situations in the operational documentation; and

- Only certified personnel will be allowed to work with hydrazine fuel. Safety training will be provided prior to operations and personnel will be equipped with personal protective equipment (helmets, seat belts, acid protective gloves, gas masks, protective suits). The duration of work time with propellants will be limited, and after the end of the shift the personnel will undergo obligatory sanitary treatment and medical control.

Human Health References

Bogdanov N.A., Gembitskiy Y.V. Classification of injuries (poisoning by propellants), 1968

NASA (National Aeronautics and Space Administration). 2018. Safety Standard for Explosives, Propellants, and Pyrotechnics. NASA Technical Standard NASA-STD-8719.12A. Revised/Approved May 23, 2018.

NFPA (National Fire Protection Agency). 2005. NFPA 55 Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks – 2005 Edition.

NFPA (National Fire Protection Agency). 2008. NFPA 30 Flammable and Combustible Liquids Code – 2008 Edition.

US 14 CFR Appendix E to Part 420, Tables for Explosive Site Plan.

Yuzhnoye Design Office. 2018. Cyclone-4M Program Space Launch System Requirements. August 30, 2018.

12.0 CONTINGENCY PLANNING

12.1 Provide a detailed contingency plan that includes the following:

- ***A full hazard identification and qualitative risk assessment associated with Project construction and operation, including those which have or may have an environmental impact (directly or indirectly);***

Transport Canada requires a full quantitative risk assessment prior to launch site activation per Launch Safety Office requirements (under revision). The initial risk assessments on the layouts presented herein have been completed by MLS and have been reviewed and accepted by Transport Canada which included the following. These assessments are continually reviewed as the site design and layout matures and will be ongoing through construction and site commissioning:

- Expected Casualty Analysis;
- Flight Safety Analysis; and
- Ground Safety Analysis.

12.1 Provide a detailed contingency plan that includes the following:

- ***Prevention, mitigation and contingency measures to mitigate potential Project impacts;***

All launch facilities globally have the primary requirement of protection to the general public and environment. The means of ensuring this protection is primarily founded on separation distance from the general public. Most orbital launch facilities are near the oceans and have a controlled launch trajectory that launches over water and avoids overflying populated areas. That is specifically the case for the launch site near Canso. The launch trajectory will place satellites into orbit by flying over two thousand kilometers of open ocean and does not overfly the general public. No launch site can be accepted without meeting the flight safety requirements that are internationally accepted. Associated with the separation distances for public safety is the ground safety separation from any nearby communities. The worst case scenarios are evaluated with an output of minimum separation distance from the general public living near the site that dictates the site layout, again, against international standards. As described in this report, there are significant buffers away from the general public well in excess of accepted international standards. The location selected for the Canso spaceport has been evaluated for these key safety attributes and easily meets the safety standards.

Prior to the site selection, MLS also evaluated the area based on the potential environmental consequences. The Sable Wind Farm went through a rigorous environmental assessment prior to construction and a thorough review of this documentation was completed to assess the environmental conditions of the area. There were no indicators of any significant environmental concerns for the development area as seen through the lens of a launch facility. This was followed by an extensive environmental assessment conducted by Strum Consulting over a 16 month period which was submitted for review in June of 2018. Extensive efforts to assess all aspects of the site were completed.

Engineering controls are the next steps in the design and operation of a launch site. First you eliminate any and all unsubstantiated or unsupported ambiguities and demonstrate thoroughness. This is accomplished by developing a very thorough Risk/Mitigation Analysis. This is not an exercise in paper work, but a very important part of the facilities, launch support, and operations design to incorporate risk mitigations into the design to reduce risks to an acceptable and manageable level. The Hazards Analysis standards that the MLS team brings through their decades of experience are being implemented as the detailed design within the basic footprint outlined is developed over the coming months. This design methodology first works to remove the hazard and then to control and mitigate the hazard if it cannot be removed.

These potential project impacts will be minimized by implementation of engineering and design safeguards such as:

- Launch vehicle processing complex, spacecraft and payload unit processing complex, fueling/neutralization station premises will be equipped with ventilation systems with filter-absorbers for propellants vapors, fire protection equipment, television surveillance and telecommunications equipment, fire and air pollution sound and light alarm systems (arrangement and placement of equipment in the premises will be made with a view to ensuring quick evacuation of personnel in case of an emergency);
- Human error is reduced by excluding the possibility of improper installation or mating of units, components, pneumatic, hydraulic and electrical connectors during installation and testing, as well as by developing a safe procedure for operations, including safety measures that personnel must follow and procedures for emergency situations in the operational documentation; and
- Only certified personnel will be allowed to work with hydrazine fuel. Safety training will be provided prior to operations and personnel will be equipped with personal protective equipment (helmets, seat belts, acid protective gloves, gas masks, protective suits). The duration of work time with propellants will be limited, and after the end of the shift the personnel will undergo obligatory sanitary treatment and medical control.

In addition, a site-specific emergency response plan, including a spill contingency plan will be developed to address accident and malfunction scenarios including launch failures. A United PARADYNE Corporation Emergency Response Plan is included in Appendix C and will be modified to include site specific issues such as:

- Description of the site’s Emergency Response Organization;
- Emergency Communication Procedures;
- Hazard Awareness and Recognition including a list of the hazardous chemicals and their locations on the facility;
- Training Requirements; and
- Hazard specific procedures for emergency assessment, notification, action, post-emergency action, and post-emergency evaluation including, but not limited to:
    - Fire (internal and external to the site facilities),
    - Power Failure,
    - Hypergolic Liquid Releases,
    - Hypergolic Vapor Releases/Low Level Alarms,
    - Hazardous Chemical Spill, Containment, and Control,
    - Launch and Aircraft Failure,
    - In-Flight Emergency,

- Emergency Protective Actions to Declare Hazardous Materials Incidents, and
- Emergency Response related to Tanking/Filling Operations (as applicable).

12.1 Provide a detailed contingency plan that includes the following:

- ***A discussion of measures to mitigate potential impacts or damages on the environment, properties and human health (e.g., liability insurance, financial security, etc.).***

Maritime Launch Services, Ltd (MLS) will have a phased insurance policy that is designed to increase throughout the stages of the project, based on potential risk factors. A copy of the draft policy is included in Appendix G.

Phase 1 is designed to address the initial phase of the project including initial road work, site preparation, and office construction. The liability terms include:

- $10,000,000 – General Liability
- $1,000,000 – Forest Fire Fighting Expenses
- $50,000 – Medical Expense Coverage

Phase 2 is designed to cover the construction of the launch facilities and systems. The liability terms include:

- $50,000,000 – General Liability
- $5,000,000 – Forest Fire Fighting Expenses
- $50,000 – Medical Expense Coverage

Phases 3 and 4 are designed to include pre-launch and launch activities and will be further negotiated based on the Government requirements/regulations. The tentative liability terms include:

- $50-$250,000,000 – Third Party Liability
- 50-$250,000,000 – Annual Aggregate Products and Completed Operations

12.2 Discuss potential Project impacts on emergency and health services in communities near the Project area, and associated mitigation and contingency measures in the events of major Project related accidents and malfunctions.

The launch site location under consideration is located in a sparsely populated remote area within the Municipality District of Guysborough, Nova Scotia, near the town of Canso. This location has a clear access downrange to the desired orbit. The Cyclone-4M launch trajectory would be over the Atlantic Ocean, away from populated areas. If a failure occurs in the first stage of the launch, there is a 99.7 percent chance that the launch vehicle would fall into the Atlantic Ocean, along with some scattered debris, on a trajectory due south from the launch site. Although unlikely, other launch failure scenarios include incidents on the launch pad, during flight, and failure to perform when in orbit. In the event of a launch failure on the pad, the debris impacts would be expected to be contained within an approved hazard area which for a fully fueled Cyclone-4M rocket, is a radius of less than 500 metres surrounding the launch pad based on the U.S. Department of Defense Explosives Safety Manual 6055 (DoD 2008). A launch vehicle failure on the launch pad represents the most substantial potential for impact and explosion, a scenario that would likely require local emergency and health services (MLS 2018). Falling debris would be expected to land on or near the launch pad resulting in potential secondary ground-level explosions and localized fires (NASA 2014).

In Nova Scotia, municipalities provide the first level of response to an emergency. The Nova Scotia Emergency Management Office, a division of the Department of Municipal Affairs, prepares for emergencies and aims to ensure the safety and security of Nova Scotians, their property and the environment. Each municipality has an Emergency Management Coordinator. That Coordinator is responsible for developing and exercising a municipal emergency plan. MLS will consult with the Nova Scotia Emergency Management Office for emergency planning and to optimize available resources in the area (Government of Canada 2015).

In 2015, the Province of Nova Scotia implemented a fully digital state-of-the-art radio communications network for public safety commonly referred to as TMR2. TMR2 is a wireless mobile radio system that connects all emergency response agencies and public sector agencies in the field on the same communications system. This allows for a coordinated multi-agency response to large emergency incidents. Responding agencies have the ability to communicate directly with each other on an ongoing basis. This allows for preplanning to be done in route to the scene, and the real time coordination of personnel, materials and equipment needs. Every hospital in the Province is setup with TMR2 radio. Through partnerships with neighboring provinces, coverage was extended to maritime users as well. Military and Civil Aviation Search and Rescue Association aircraft, and other private or commercial entities are not part of this system (NOVA Communications 2019).

If the situation warrants it, the Province will request help from the federal government through the Office of Critical Infrastructure Protection and Emergency Preparedness Canada (EPC). EPC is the federal liaison between the provincial and municipal emergency preparedness communities (Municipality of the County of Antigonish 2019).

Local resources in case of emergency include a Volunteer Fire Department located at 1134 Union Street in Canso (1.4 kilometres (km) to the north). Emergency health services in the region include the Eastern Memorial Hospital, a six bed facility located in Canso and the Guysborough Memorial Hospital, a 10 bed located in Guysborough about 48 km away (MLS 2018). In the event of an accident requiring services greater than those provided at local hospitals, or if the quantity of injured people exceeds local capacity, patients could be taken from the accident scene or from the heliport at Eastern Memorial Hospital to larger hospitals equipped with heliports at:

- St. Martha's Regional Hospital, Antigonish, NS – 112 km northwest;
- Inverness (Consolidated Memorial Hospital) Heliport - approximately 180 km north east; and
- New Glasgow (Aberdeen Hospital) Heliport - approximately 170 km north (Sky Vector 2019)

While the fire and emergency services run times to the launch site in the case of an emergency have adequate response times given the distances, being a volunteer department may cause less than desirable turn out times (the time it takes for the department staff to gear up and leave). Also, with the addition of liquid oxygen and non-traditional fuels at the launch site, additional training and gear will be required. MLS envisions developing an agreement with Municipality of the District of Guysborough to place a paid staff that is able to respond to any possible responses needed at the site as well as those in the community they currently support. Likewise, MLS will evaluate the emergency medical response services capabilities in place at the hospital against potential response scenarios and address any necessary additional training or skill levels increases (MLS 2018).

As part of the permitting evaluation process, MLS and Transport Canada would conduct the appropriate reviews including a payload review, financial determination, and safety review. MLS has completed initial Expected Casualty Analysis and Flight Safety Analysis as a part of the initial site selection process and Transport Canada has reviewed these analyses. These analyses are continuously reevaluated as part of the safety review to ensure the safety to the general public. All approved trajectories would be based on specific launch vehicle performance and characteristics. MLS will also refine the Ground Safety Analysis as site design continues, which identifies each hazard, each associated cause, and each hazard control that will be established and maintained to keep each identified hazard from affecting the public (MLS 2018). MLS will also consult with the Nova Scotia Emergency Management Office to coordinate emergency planning and to optimize available resources in the area.

Contingency Plan References

DoD (U.S. Department of Defense). 2008. DOD Ammunition and Explosives Safety Standards. DoD 6055.09-STD. February 29, 2008.

Government of Canada 2015. Emergency Management Organizations. Accessed 2/5/2019 at https://www.getprepared.gc.ca/cnt/rsrcs/mrgnc-mgmt-rgnztns-en.aspx#ns

Maritime Launch Services Ltd. 2018. Canso Spaceport Facility - Environmental Assessment Registration Document (2018). Accessed at https://novascotia.ca/nse/ea/canso-spaceport-facility/

Municipality of the County of Antigonish, 2019. Emergency Preparedness. Accessed 2/5/2019 at https://www.antigonishcounty.ns.ca/emergency-management/

NASA 2014. Final Environmental Impact Statement for the Mars 2020 Mission. Accessed at https://mars.nasa.gov/mars2020/files/mep/Mars2020_Final_EIS.pdf

NOVA Communications 2019. Nova Scotia TMR2 Network. Accessed 2/5/2019 at https://solutions.novacommunications.com/two-way-radios/nova-scotia-tmr2-network/

Sky Vector Aeronautical Charts 2019. Airports in Nova Scotia, Canada. Accessed 2/5/2019 at https://skyvector.com/airports/Canada/Nova%20Scotia

APPENDIX A

RESUMES

Roberta (Bobbie) Hurley

Project Manager

Education

MS, Chemistry, College of William and Mary
BS, Biology and Chemistry, Mary Washington College

Years of experience

35

Qualifications

National Recognition in Preparing NEPA Documentation
Previous experience with NASA Flight Programs
Development of Applicant Prepared Environmental Reports
Siting Studies
Cumulative Impact Assessments
Public Meeting Facilitation
Environmental Permitting

Professional history

Ms. Hurley is a senior manager within AECOM, having managed more than $350 million in task order, IDIQ type contracts involving a wide range of engineering and regulatory programs, including a broad range of NEPA documentation for Federal projects with specific expertise in NEPA and natural resources projects related to spacecraft launches, power production, and general construction. As a senior manager within AECOM she has the authority to commit and dedicate resources, negotiate task orders, and ensure quality and performance of project activities.

Selected project experience

NASA Kennedy Space Center, Environmental Monitoring and Research Support Programs, Cape Canaveral, FL. Technical Director for off-site services supporting a dedicated program to monitor the environmental impacts associated with launches at Kennedy Space Center as well as biological research programs related to the effects of spaceflight on plant growth.

Patrick AFB and Cape Canaveral Air Force Station, FL, Water System Compliance and Modeling. Program Manager for a drinking water system assessment and GeoBase updates, hydraulic modeling, sampling and analysis and regulatory support to 45 Space Wing installations to address DBR2 regulations. Within the scope of this project, two separate Florida Department of Environmental Protection compliance issues were resolved for 45 SW related to Corrosion Control for Lead and Copper rule and Cross-connection/Backflow protection.

Clean Air Act Technical Support, Vandenberg AFB, CA. Program Manager for the technical engineering analysis and environmental compliance support to the AFCEC Air Quality Subject Matter Expert, Regional Support Teams, Installation Support Teams and base level environmental managers throughout the Air Force. Technical services include performing combined stationary and mobile AEIs utilizing APIMS; generating technical compliance reports; assisting with research, engineering analysis and development of appropriate language and strategy for use when developing technically related policies, guidelines and standards; and supporting the implementation of the Air Force Vehicle Inspection and Maintenance Program.

Department of Veterans Affairs, Programmatic Environmental Assessment (EA) for a New Medical Center Campus, New Orleans, LA. Program Manager for the preparation of a highly visible and contentious Programmatic EA and a Programmatic Agreement (PA) in compliance with the National Environmental Policy Act (NEPA) and the National Historic Preservation Act (NHPA) Since one of the partners was utilizing Community Development Block Grant funds, the NEPA document had to be incompliance with all Department of Housing and Urban Development (HUD) requirements, including HUD specific noise, safety, and runway clear zone issues.

Exelon Generation, LLC., Peach Bottom Atomic Power Station (PBAPS), Environmental Report (ER) for Subsequent License Renewal (SLR), Delta, PA. Technical Director for the PBAPS SLR ER. Participated in pre-application meetings with the U.S. Nuclear Regulatory Commission (NRC); performed a detailed comparison of the facility's ER for their first license renewal against the NRC's revised Generic EIS for inclusion in the project Methodology Paper; developed New and Significant interview checklists and methodology; participated in an industry peer review of the Draft SLR ER prior to submittal to NRC; participated in the NRC site audits and reviewed the NRC Draft Supplemental EIS. In addition to her overall management responsibilities, Ms. Hurley served as the primary author of for Purpose and Need; New and Significant; Summary of License Renewal Impacts and Mitigating Actions; Alternatives, and Comparison of Environmental Impact of License Renewal with the Alternatives sections of the SLR ER.

U.S. Nuclear Regulatory Commission (NRC), Supplemental Environmental Impact Statements (SEIS) for License Renewal, Multiple Locations. Under three consecutive contracts, served as the program manager and

team leader for development of SEISs to assess the environmental impacts associated with renewing the operating license at seven nuclear power plants. Responsible for coordinating an interdisciplinary team of technical specialists in the review and evaluation of the ER submitted by the applicant. This included performing an acceptance review of the ER to determine completeness as well as detailed technical reviews and evaluations and development of Requests for Additional Information (RAIs). Responsible for overall contract management, client coordination, development of internal AECOM program guidance, preparation and negotiation of task orders, staff assignment, staff training, progress reporting, invoice review, and tracking overall contract expenditures based on individual task order projections and contract ceiling values.
U.S. Nuclear Regulatory Commission (NRC), Technical Assistance in Support of Design Certification, Early Site Permit, Combined License (COL), Environmental, and Pre-Application Activities Related to the New Reactor License Applications for the US Advanced Pressurized Water Reactor (APWR) Design Center, Somervell County, TX. Served as AECOM team lead for the Luminant Power Generation, Comanche Peak COL Environmental Report (ER). s Responsible for the coordination and direction of a multi-discipline team preparing technical evaluations (alternatives, terrestrial ecology, cultural resources, and air and meteorology) for inclusion in the Third-Party Draft and Final Environmental Impact Statement (EIS) for the COL. Participated in public scoping meetings, attended site visits, and assisted in the preparation of the alternatives analysis chapter. As the AECOM team lead (as a subcontractor), Ms. Hurley was responsible for the preparation of subcontract agreements, cost proposals and negotiations, staff assignment, status reporting and invoice reviews, and regular communications with the prime contractor and NRC staff.

Tennessee Valley Authority (TVA), Small Modular Reactor (SMR) Environmental Report (ER), Clinch River Site, Oak Ridge, TN. Technical Director for TVA's ER section of an Early Site Permit (ESP) for the deployment of two or more SMRs (including associated transmission corridors). Responsible for the preparation of the ER in accordance with NRC regulations and guidance (10 CFR Part 51 and NUREG 1555). Facilitated client meetings where the Purpose and Need and Alternates were discussed. Oversaw the drafting the Purpose and Need statement, which included the secure power for U.S. Department of Energy (DOE) and U.S. Department of Defense (DoD) sites. Served as the lead author in the preparation of a siting study that includes the identification and evaluation of potential site alternatives, including DoD installations within the TVA service area. The siting study includes the development of a decision tree and ranking criteria for the evaluation of site requirements associated with the selection of the most preferred sites suitable for SMR deployment. Also served as the lead author the development of the initial Need for Power and Alternatives Chapters of the ER.

NRG, Inc. Environmental Information Volume (EIV), Houston, TX. In support of a DOE grant application for a Carbon Capture and Sequestration (CCS) demonstration project, Ms. Hurley managed the preparation of an applicant prepared environmental report, the EIV, for submission to DOE. The EIV was prepared to provide information regarding existing environmental conditions at the selected site in a format that can be used by DOE to develop an Environmental Assessment (EA) or Environmental Imapct Statement (EIS) in accordance with NEPA and Council on Environmental Quality (CEQ).

CEMEX Environmental Information Volume (EIV), Odessa, TX. In support of a Department of Energy grant application for a CCS demonstration project, managed the preparation of an applicant prepared environmental report, the EIV, for submission to DOE. The EIV was prepared to provide information regarding existing environmental conditions at the selected site in a format that can be used by DOE to develop an EA or EIS in accordance with NEPA and CEQ. Managed an interdisciplinary team in the collection of biological and cultural resources field data for incorporation into the EIV. Also, coordinated closely with the geotechnical contractor, integrating their field data and reports into the EIV in a more readable and understandable format. In addition, as part of the EIV, coordinated the development of a strategy document for obtaining the necessary approvals from appropriate environmental and other regulatory bodies for the Demonstration Project. As an initial part of the project, also coordinated the development of an environmental, liability, and public acceptance (ELPA) audit check sheet. The objective of this activity was to gather and document data and information needed to make an informed selection of a plant host site for the CCS demonstration project. Participated in a 2-day risk review meeting to evaluate the cost/benefits for proceeding with the project. The results of this meeting concluded in a recommendation to discontinue the project and not proceed to the Phase II submittal to DOE.

U.S. Department of Veterans Affairs, Vibration Monitoring for the New Medical Center Campus, New Orleans, LA. Project Manager for the conduct of a pre-construction vibration analysis building survey and development of vibration monitoring recommendations plan to protect nearby historical structures during construction of the replacement medical center. Because the project was located within an historic neighborhood, noise and vibration were a significant concern to nearby residents and property owners. During the vibration survey, all structures within a one block radius from the project boundary were surveyed. A pre-construction baseline vibration measurement was conducted and recommended vibration thresholds were established.

John Shaffer

Ecologist

Education
Bachelors of Science, Biology, Florida Institute of Technology

Years of experience
32

Qualifications
NEPA documentation
Environmental permitting
Historical/cultural resource Section 106 documentation
Endangered species Section 7 ESA documentation
Phase I/II site assessments
Construction monitoring
Extensive NASA experience and familiarity with NASA processes and procedures
Knowledge of Commercial Space Launch Programs

Professional history

Mr. Shaffer is an ecologist with extensive experience in Environmental Planning, National Environmental Policy Act (NEPA) documentation, Environmental Resource Permitting (State and Federal), Environmental Site Assessments (ESAs), Historical/Cultural resource management, federal land management, ecological monitoring, project planning, construction monitoring for compliance with permitting requirements including waste management, stormwater pollution prevention plans, Disaster Recovery and Assessment Team for hurricane response. Prior to AECOM, he was the NEPA Manager for National Aeronautics and Space Administration (NASA) at Kennedy Space Center. His duties included: managing NEPA experts, engineers, and biologists in the ecological program and compliance oversight of construction of facilities and KSC multi-user spaceport activities; implementation of Interagency Agreements with commercial partners to support a multi-user spaceport; coordinate daily land management actions with Fish and Wildlife Service (USFWS) and the National Park Service (NPS); and to ensure effective management of NASA programs and operations to complete the mission safely, successfully, and in full compliance with all environmental regulations.

Selected project experience

National Aeronautics and Space Administration (NASA), Kennedy Space Center, Environmental Planning Group.

- Developed NASA policies, processes, and procedures to fully implement NEPA documentation pertaining to all Federal actions at Kennedy Space Center as well as other NASA Centers and Department of Defense sites including Patrick Air Force Base, Cape Canaveral Air Force Station, and Edwards Air Force Base.
- Provided oversight to Environmental Planning group actions including preparation of NEPA documents, federal and state environmental resource permitting, historical and cultural resource management actions under Section 106 of the Historic Preservation Act.
- Provided oversight to the Kennedy Environmental and Medical contractor in Ecological Program, Support to Construction Activities, and NEPA. Work with NASA project managers to resolve support issues.
- Provided oversight to the Ecological Program at Kennedy Space Center, a contractor run program of approximately 20 scientists and researchers whose goal and objective is to monitor NASA program activities and their potential impact to the natural resources at KSC. Provide input, prioritization and review of annual Ecological Monitoring Program.
- Provided oversight to the USFWS and NPS who manage non-operational areas as part of the Merritt Island National Wildlife Refuge and Canaveral National Seashore.
- Managed NASA Construction of Facilities and Ground Systems Development Operations, tenants and commercial partners to ensure compliance with all NEPA, and regulatory requirements.
- Supported Center Planning and Development office with Commercial Space Launch Agreements, Enhanced Use Leases and Space Act Agreements for tenant and commercial entities use of KSC infrastructure, land and utilities.

EG&G Florida, Kennedy Space Center, Environmental Sanitation and Pollution Control. Supported the NASA Environmental Management Office in Solid Waste Management Unit evaluations including soil, groundwater and surface water monitoring and RCRA site clean-up activities. Prepared reports documenting potential contamination caused by historic operations at KSC and propose site clean-up activities

Additional skills and accomplishments:

- Environmental Impact Statement for KSC Center wide Master Plan
- Environmental Assessment for KSC Shoreline Protection Project
- Environmental Assessments for the Multi-Use of Launch Complexes 39A and 39B; Expanded use of the Shuttle Landing Facility, and Central Campus Complex, Kennedy Space Center
- Space Flight Awareness Award, Center Directors Certificate of Appreciation, and Silver Snoopy Award

Served as full time member of the Kennedy Environmental and Medical Contract (KEMCON) procurement development team and Source Selection Board. Duties included identification of requirements, development of an independent government cost estimate, development of acquisition strategy, development of evaluation factors, disposition of industry comments regarding the Request for Proposals, and evaluation of offeror's proposals for equitability and comprehensiveness.

FEMA support for Hurricane Harvey, Irma, and Maria. Program manager deployed specifically to deal with programmatic NEPA evaluations for municipal government. Routinely supports the Orlando AECOM office with natural resource site assessments and permitting for utility/natural gas pipeline operations and maintenance. Lead author of the I95 Managed Lanes Mainline Master Plan from south of Linton Blvd. to the Palm Beach/Martin County line and has been a contributing author and/or conducted quality reviews of NEPA deliverables for the Department of Veterans Affairs and the USFWS. Currently assisting the Harris Corporate Headquarters with the rollout of their corporate sustainability strategy, goals and metrics that support the development, execution and improvement of the organizations strategic Environmental Health and Safety (EHS) plan.

Gerald Baribeau

Senior Chemical Engineer

Education

BS, Chemical Engineering, California State University

Years of experience

22

Qualifications

Extensive experience in the solid rocket motor and liquid rocket engine industry
Prepare Risk Management Plans for liquid rocket engine fuels and oxidizers (hydrazine, methyl hydrazine, unsymmetrical dimethyl hydrazine, and nitrogen tetroxide)
Provided long-term air permit compliance support for a rocket manufacturer
Risk Management
Compliance Auditing
Air Quality Compliance
Hazardous Materials/Waste Management
Waste Minimization

Professional history

Mr. Baribeau is a senior engineer in the Environmental Services Division in the Sacramento office. He is the West Coast technical lead on federal Risk Management Plans and California Accidental Release Prevention Planning (Cal-ARP) projects for AECOM. His other responsibilities include Clean Air Act permitting, Hazardous Risk Assessments, dispersion modeling studies, exposure and hazard analysis, off-site consequence analysis, waste minimization, emergency response planning, incident investigations, and environmental auditing.

Selected project experience

NASA, Various Environmental Functional Reviews, USA, Various States, Various Locations . Participated in 20 environmental functional reviews for NASA as the evaluator of the air quality management program at every NASA center since 2009, in accordance with federal, state, and local regulations, as well as permit and NASA specific requirements. These week-long audits are conducted by a team of 7-9 media specific experts.

Risk Management

Technical lead on numerous federal Risk Management Plans (RMPs), California Accidental Release Prevention (CalARP) Program, and Process Safety Management (PSM) programs for a variety of industrial and government clients.

Aerojet. Solid rocket motor and liquid rocket engine manufacturer. Completed seven Risk Management Prevention Program (RMPP) updates and addenda over a three-year period in mid-1990s. Developed the initial federal RMP and CalARP submittals in 1999. Prepared presentation materials and attended January 2000 public meeting. Provided RMP program support including completion of several updates to CalARP submittal. Supported 2003 RMP audit by EPA Region IX and Sacramento County. The RMP chemicals used included solid rocket motor ingredients (toluene 2,4-diisocyanate, isophorone diisocyanate, phenol, and sodium azide) and liquid rocket engine fuels and oxidizers (hydrazine, methyl hydrazine, unsymmetrical dimethyl hydrazine, nitrogen tetroxide, red fuming nitric acid, and hydrofluoric acid).

Aerojet Fine Chemicals. Developed CalARP submittal for pharmaceutical and specialty chemical manufacturer that uses anhydrous ammonia, anhydrous hydrogen chloride, and phosphorous oxychloride above CalARP thresholds.

Regulatory Development. Developed formal comments on draft CalARP program regulations. Former member of Region IV Local Emergency Planning Committee (LEPC). Attended 18 months of Administering Agency subcommittee meetings during development of the CalARP program.

El Paso Power. Completed initial RMP and CalARP submittals and developed PSM program for ten gas-turbine cogeneration sites in California. Prepared materials for and attended January 2000 public meetings. Developed original RMPs (federal and state) in 1999, and prepared updates in July 2003 for all 10 sites. These facilities use anhydrous ammonia for air pollution control.

Travis AFB. Developed initial CalARP program for several small chlorination facilities on Base. Completed update to program, due to several process changes, in 2003.

Marine Corps Air Station, Yuma, Arizona. Developed PSM and RMP program for 6 million gallons-per-day water treatment facility chlorination system. Prepared initial federal RMP submittal and public meeting materials.

Franzia, The Wine Group.   Developed RMP and PSM programs for three wineries that use anhydrous ammonia for refrigeration and sulfur dioxide for food preservation. Prepared initial federal RMP and CalARP submittals in 1999. Prepared materials and attended public meetings in January 2000.

GenCorp Polymers. A latex and synthetic rubber manufacturing facility using 1,3 butadiene, aqueous ammonia, and acrylonitrile. Many unique design and risk mitigation features were involved because plant is located in the center of a small town in Ohio. (High school across street, city hall next door) Developed offsite consequence analysis and federal RMP document for submittal.

Griffiths Micro Science. Developed federal RMP and CalARP submittals for two facilities that use ethylene oxide for sterilization of medical instruments and spices.

Compliance Auditing

Performed over 100 comprehensive multi-media environmental, and health and safety audits for numerous industrial and government facilities for compliance with federal, state and local laws and regulations. Facilities have included Army, Navy, Air Force, Marine and Coast Guard facilities, aerospace contractors, national parks, food processors, medical instruments manufacturer, electronic manufacturing, mining and aggregate, and chemical and pharmaceutical manufacturing facilities

Air Quality Compliance

Aerojet. Provided long-term air permit compliance support for rocket manufacturer. Completed initial AB2588 Air Toxics “Hot Spots” emissions inventory, health risk assessment, and required public meeting. Completed case-by-case MACT determination under section 112(g) of the Clean Air Act, and health risk assessments in support of Air District permit for rocket testing activities. This required some creativity and negotiation and resulted in first permit ever issued from District with specific meteorological restrictions as permit conditions.

Lockheed. Provided long-term air permit compliance support including regulatory review and comment; permit applications, renewals, and emissions fees; and development of emissions offsets acquisition strategies. Evaluated operations and developed recommendations and strategies for facilities to achieve compliance with federal, state, and local air quality regulations. Led investigation into compliant coatings, low-VOC materials, and paint application equipment in order to meet new air quality regulations.

El Paso Power. Developed Title V permit renewals for five and new permit applications for two gas-turbine cogen facilities. This included development of facility-wide and unit-specific permit conditions and alternative compliance strategies.

Confidential Food Processor. Client received NOV for not completing required source testing of boiler. Boiler failed source test and another NOV was issued. Client called for help. Prepared materials and attended settlement hearing with client at Air District offices.

Nella Oil. Completed air quality modeling analysis for new gasoline station (6-dispenser, 12-nozzle), convenience market, and a co-branded fast food drive-thru window. Quantified mobile source emissions associated with the proposed project that were limited to impacts associated with vehicular traffic and construction activities.

Hazardous Materials/Waste Management

Boeing Aircraft. Led an eight-person team on a six-week project characterizing hazardous waste at several Boeing manufacturing sites in Washington.

National Park Service. Developed hazardous waste management plan “tool” for National Park Service, Pacific West Region. This template document allowed numerous similar facilities throughout the western U.S. to develop their own Park-specific hazardous waste management plan. Typical waste streams and management alternatives were presented in a format where the individual facilities could then pick their own waste streams and customize the management plan to their Parks operations.

Confidential Aerospace Composite Manufacturer. Developed a complex hazardous materials and hazardous waste handling and tracking system for a composite manufacturing facility. Instituted several process and procedural changes which greatly reduced and simplified waste handling and management practices.

Waste Minimization

Lockheed. On-site waste minimization coordinator. Responsible for elimination of over 400,000 pounds of hazardous waste during year-long assignment.

Boeing Aircraft. Developed detailed waste minimization procedures for aircraft manufacturing sites based upon completion of hazardous waste characterization project.

Naval Air Station, Fallon, Nevada. Developed pollution prevention plan for the Navy’s “Top Gun” school. Assessed processes that generate hazardous waste and provided alternative approaches to assist in attaining Base pollution prevention goals.

National Park Service. Developed generic waste minimization plan for National Park Service, Pacific West Region. The template could then be used by the individual facilities to develop site-specific waste minimization plans. Typical waste streams and several minimization alternatives were presented within the template document for the facilities to choose from for insertion into their site plan.

Yosemite National Park. Completed pollution prevention plan for Yosemite National Park that presented opportunity assessments and feasibility analysis for several alternatives for each of the 12 largest hazardous waste streams in the Park.

Carol Freeman, PG

Senior Scientist

Education
MS, Geological Sciences/Planetary Geology, Arizona State University
MS, Space Studies, University of North Dakota
BS, Geology, Colorado State University

Registrations
Professional Geoscientist: LA (#207)

Years of experience
25

Qualifications
Aeronautic systems technical studies
Aeronautic scientific and technical documentation and procedure development
Satellite and Spacecraft photography imagery analysis
NEPA Compliance (Environmental Impact Assessments and Environmental Assessments)
Applicant Prepared Environmental Reports
Examination of Raw Data/Reports and Preparation of Descriptions of Impacts Quality Assurance
Project Controls (including Primavera)
Alternatives Analysis
Energy Facilities (including nuclear and natural gas)
Siting Studies
Public Outreach
Educational document preparation

Professional history

Ms. Freeman has provided project management, conducted research, and prepared technical documents for NASA programs and on in support of National Environmental Policy Act (NEPA) and National Historic Preservation Act (NHPA) compliance including several large-scale Environmental Impact Statements (EISs) and Environmental Assessments (EAs), and an Environmental Baseline Survey (EBS). Technical tasks have included research and analysis related to engineering design and planning of various NASA vehicles, facilities, programs, and procedures in addition to research and impacts analysis for geological resources, water resources, land use, socioeconomics, environmental justice, cultural resources, transportation, and noise resources for several NEPA projects. She also specializes in using satellite photography and GIS analysis for land use and environmental justice impacts analysis, and the use of spacecraft photography for the analysis of land form changes on the Moon and Mars. She has worked on NEPA and NHPA compliance for multiple federal projects with lead agencies including the Tennessee Valley Authority (TVA), the U.S. Department of Veterans Affairs, U.S. Army Corps of Engineers, Federal Emergency Management Agency (FEMA), U.S. Army, U.S. Air Force, National Park Service, Bureau of Land Management, and U.S. Nuclear Regulatory Commission (NRC).

Selected project experience

NASA Lyndon B. Johnson Space Center (JSC), JSC Oral History Project, Houston, TX. First permanent employee of the JSC Oral History Project. The purpose of the project was to record the scientific, technical, and administrative history of the U.S. space flight program, by recording oral history sessions with NASA employees and contractors. Research and oral history topics included detailed investigations of engineering design, medical assessment, field and laboratory testing, procedural development, training, monitoring, and analysis to record institutional knowledge regarding specific NASA programs such as the Mercury, Gemini, Apollo, Skylab, and Space Shuttle programs, training and testing systems, and Flight Control Center from those individuals who performed and managed the space agency's activities. As a Project Manager and Lead Historian, conducted background research on the various NASA programs/facilities and prospective interviewees to prepare research reports, identify oral history session topics, and conduct oral history recording sessions. Additionally, designed and managed the training program for research interns. Contributed articles reporting the results of select oral history interviews in *Before this Decade is Out…: Personal Reflections on the Apollo Program* and on multiple occasions in *Quest – The History of Spaceflight Magazine*. Also assisted in editing and compiling the NASA History Series book *Shuttle-Mir: The United States and Russia Share History's Highest Stage*. Also performed editorial review for former flight director Gene Kranz's monograph *Failure is Not an option: Mission Control from Mercury to Apollo*.

U.S. Space Foundation, Colorado Springs, CO. As Education Resource Coordinator, specialized in creating materials for teachers to translate technical and scientific information from the space program into their classrooms. Led teacher training workshops and prepared materials for lesson plans.

Tennessee Valley Authority (TVA), Small Modular Reactor (SMR) Environmental Report (ER), Clinch River Site, Oak Ridge, TN. Technical Lead for Land Use, Historic and Cultural Resources, Socioeconomics, and Environmental Justice sections of the ER. Developed the integrated work plan (IWP) for all aspects of ER implementation. Maintained the multicomponent integrated ER schedule in coordination with the client and the client's other contractors using Primavera (P6). Coordinated with team members regarding status updates and deadlines. Tested and implemented use of Reference Manager Version 12 software to manage all references used in production of the ER. Authored multiple

ER sections evaluating impacts to land, land use, socioeconomics, environmental justice, groundwater, and geology. Technical Lead for Socioeconomic/EJ, Land Use, Groundwater, and Geology-related portions of the NRC's DEIS Review. In an innovative approach to the prime farmlands analysis, Correlated soil maps from 1942 with modern soil classification systems to complete the prime farmlands assessment and consultation with the Natural Resources Conservation Service.

Exelon Generation, LLC., Peach Bottom Atomic Power Station (PBAPS), Environmental Report (ER) for Subsequent License Renewal (SLR), Delta, PA. Technical Lead for Land Use, Cultural Resources, Socioeconomics and Environmental Justice sections for the preparation of an SLR ER for PBAPS Units 2 and 3. To determine minority and low-income characteristics within this area, a combination of Geographic Information System (GIS) software, block group data sourced from the decennial census, and tract-boundary spatial data was used. Socioeconomic analysis included the identification of subsistence-like subpopulations in neighboring counties by conducting phone interviews with government and social welfare organizations, an analysis of the plant's effects on housing and employment, worker residence by city and county, property tax payments to several local taxing authorities, transportation and recreation.

U.S. Department of Veterans Affairs, TRIGA Research Reactor Decommissioning Support, Omaha, NE. Quality control representative for development of a characterization report and revision of the decommissioning plan for the Alan J. Blotcky (AJB) nuclear research reactor located in the basement of the VAMC. AECOM assisted the VA with decommissioning in response to comments from the NRC on its draft decommissioning plan. Provided quality control support for preparation of the characterization report and decommissioning plan to ensure document quality and accuracy and adherence to VA's quality standards and expectations.

Department of Veterans Affairs, Programmatic Environmental Assessment (EA) for the Replacement VAMC, New Orleans, LA. Deputy Project Manager, public outreach coordinator, and principal author for the preparation of a highly visible and contentious Programmatic EA and a Programmatic Agreement (PA) in compliance with NEPA the NHPA. Deputy Project Manager for two Site-Specific EAs (SEAs) tired from the Programmatic EA, one of the construction and operations of the replacement VAMC and one for the demolition of Building #2 associated with the old VAMC hospital. As Project Coordinator and Deputy Project Manager, responsibilities included ensuring incorporation of multiple partner concerns into all documentation and deliverables, attending weekly client and partner meetings, and completing monthly progress reporting. Managed the internal project schedule, monitored task progress and coordinated with internal staff for completing project deliverables, and coordinated the editing, formatting, quality checking, and production of the final documents. As public outreach coordinator, organized and arranged eight public meetings. Coordinated publication of meeting announcements in the local newspapers, radio, and on the AECOM designed and maintained public website designed for sharing project news and documents. Assisted in the conduct of five NHPA Section 106 consulting party meetings. Authored the Finding of No Significant Impact (FONSI) for all documents. Maintained all project files and coordinated the compilation of the Administrative Record in support of the legal efforts. The sufficiency of the Programmatic EA was challenged in court, with the primary focus being the requirement for an EIS. The court held in favor of the VA and FEMA, finding that the document met the requirements of NEPA.

U.S. Department of Veterans Affairs, Vibration Monitoring for the New Medical Center Campus, New Orleans, LA. Deputy Project Manager for the conduct of a pre-construction vibration analysis building survey and development of vibration monitoring recommendations plan to protect nearby historical structures during construction of the replacement medical center. Because the project is located within an historic neighborhood, noise and vibration were a significant concern to nearby residents and property owners. During the vibration survey, all structures within a one block radius from the project boundary were surveyed. A pre-construction baseline vibration measurement was conducted and recommended vibration thresholds were established.

Emera CNG, LLC, Port of Palm Beach - Compressed Natural Gas Environmental Assessment (EA), Riviera Beach, FL. Lead author for an EA for the construction and operation of a natural gas compression and loading facility at the Port of Palm Beach, Florida for the export of compressed natural gas (CNG) to Grand Bahama. Prepared a preliminary environmental report briefly describing existing conditions at the proposed project site and potential impacts associated with implementation of the proposed project. Expanded the environmental report into a full EA in compliance with NEPA guidelines and DOE and Federal Energy Regulatory Commission regulations. Developed text for the majority of the EA. Binned and drafted responses to public comments for this first of its kind project.

Air Force Center for Engineering and the Environment (AFCEE), Edwards Air Force Base (AFB), California. Hydrologist/modeler that conducted well placement optimization modeling for groundwater remediation sites. Prepared and edited graphics of modeling results for a variety of pumping scenarios in support of report preparation.

Larry W. Neal

Senior Scientist/Risk Assessor

Education
MS, Oceanography with emphasis in Biological Oceanography, Institute of Oceanography, Old Dominion University
BS, Biology with Minor in Chemistry, Emory and Henry College

Years of experience
46

Qualifications
NEPA Documentation
Human Health and Ecological Risk Assessment
Permitting
Natural Resources Management
Aquatic/Terrestrial Ecology
Aquatic Toxicology

Professional history

Mr. Neal has more than 40 years of experience as a Senior Environmental Scientist who serves as Program/Project Manager and Principal Scientist on projects for industrial and government clients. He is responsible for providing technical direction, managing, and/or performing environmental studies and risk assessment services for environmental assessments (EAs), environmental impact statements (EISs), natural resources and management. He represents clients' interests at regulatory agency and public meetings on technical issues related to facility siting, permitting, construction, and operation. He has provided expert testimony on environmental impact and risk assessment issues for utilities and industry in South Carolina and Florida.

Selected project experience

U.S. Air Force Space Command, Environmental Assessment, Colorado Springs, CO: Project manager and lead author for EA prepared for the construction of a 38,000 square foot Satellite Control Facility and associated 2.75 acre expansion of a parking lot at Falcon AFB. In addition to the proposed action of building the new facility on base, two other alternatives were considered. Issues that were considered included air quality, water resources, geology and soils, land use, health and safety, socioeconomics, solid waste, and transportation. A companion EA also was prepared for the construction of a support facility.

Shaw Air Force Base, Baseline Human Health Risk Assessment, Sumter, SC: Prepared baseline human health risk assessment as part of RCRA Part B application for an open burning/open detonation (OB/OD) unit on the base. Constituents of concern included munitions compounds and combustion products. Exposures to workers, off-unit residents, and hunters were evaluated using both empirical and modeled data. Models included air dispersion and deposition to soils, fugitive dust generation, and bio-uptake and transfer models for consumption of homegrown produce and deer meat.

USFWS Eastern Collier County Multiple Species Habitat Conservation Plan (ECMSHCP) EIS. Technical lead and author for Biological Resources sections of third-party EIS for a proposed ECMSHCP in Collier County, FL. The HCP was prepared to address applications by several landowners for Incidental Take Permits under Section 10 of the Endangered Species Act (ESA). The EIS evaluated proposed landscape level actions and conservation efforts proposed by the applicants related to ongoing and future development activities. The proposed HCP included preservation of approximately 107,000 acres of privately held land, cluster development on approximately 45,000 acres, and other on-going activities and land management actions. Evaluated ecological communities, general wildlife, wildlife habitat linkages and dispersal corridors, and potential species-specific effects on eight federally listed species and 11 state listed species potentially affected by the proposed HCP.

U.S. Army Corps of Engineers (USACE), Mobile District, Mobile Harbor General Reevaluation Report (GRR) and Integrated Supplemental Environmental Impact Statement (SEIS), Mobile, Alabama. Senior Ecologist supporting the preparation of the biological and physical resources sections associated with the cumulative impacts of implementation of the Tentatively Selected Plan (deepening and widening of the Mobile Harbor). Key resource areas evaluated include wetlands, submerged aquatic vegetation, oyster resources, benthic communities, fisheries, threatened and endangered species, essential fish habitat, and salinity gradients.

U.S. Army Toxic and Hazardous Materials Agency (USATHAMA), Preliminary Baseline Human Health Risk Assessment for Multiple Solid Waste Management Units (SWMU), Aberdeen Proving Ground, MD: Manager of a preliminary baseline human health risk assessment for multiple solid waste management units at Tooele Army Depot - North Area. The SWMUs evaluated included industrial areas, open burning/open detonation disposal areas, industrial wastewater lagoons and sites associated with the chemical testing range and TNT washout facility.

Robins AFB, Integrated Natural Resources Management Plan (INRMP) Update and Natural Resource Management Support, Robins AFB, Georgia. Senior Ecologist for the 5-year update of Robins AFB's INRMP and coordinated the U.S. Fish and Wildlife Service (USFWS) and Georgia Department of Natural Resources review. Directed update/preparation of component plans (Native Ecosystem Management, Best Practices for Landscaping, Loblolly and Longleaf Pine Management, Longleaf Pine Management Plan, Rare Plant Monitoring and Management Plan, Threatened and Endangered (T&E) Animal Species Monitoring and Management Plan, Wetland Protection Plan, Invasive Species Management Plan, and Outdoor Recreation Plan) to align with AFI 32-7064. Prepared companion document to preserve key elements of legacy studies and management activities. Provided oversight or other simultaneous tasks including coordination of controlled burn.

Wilmington District U.S. Army Corps of Engineers, MCB Camp Lejeune New River Shoreline Protection Study. Project manager and senior scientist for development of shoreline stabilization and protection measures and preparation of programmatic EA for shoreline stabilization within the boundaries of MCB Camp Lejeune.

Wilmington District U.S. Army Corps of Engineers, Onslow Beach Nourishment. Project manager and senior scientist for preparation of EA, Coastal Area Management Act (CAMA) major development permit, individual Section 404 permit, and Section 404(b) determination for beach renourishment project using sand dredged from disposal islands and the Atlantic Intracoastal Waterway (AIWW) within and near MCB Camp Lejeune.

Wilmington District U.S. Army Corps of Engineers, Wilmington Harbor Dredged Material Management Plan (DMMP). Task manager and senior scientist for environmental impact assessment and National Environmental Policy Act (NEPA) documentation for the Final Phase DMMP. Project involves evaluation of ocean disposal, upland disposal, and beneficial reuse of dredged material from maintenance of the navigation channel in upper Wilmington Harbor.

Galveston District U.S. Army Corps of Engineers, Bayport Channel Container/Cruise Terminal Environmental Impact Statement, Galveston, Texas. Lead author for Shoreline Erosion section and peer reviewer for Sediment and Dredged Material Management sections for the Port of Houston's proposed Bayport Channel Container/Cruise Terminal EIS. Represented EIS findings at public meetings and responded to public comments on the draft EIS.

South Carolina State Ports Authority/Norbridge, Inc., Navy Base Container Terminal Facility Financial Feasibility Study, North Charleston, South Carolina. Project manager leading a team of senior professionals in performing an environmental feasibility assessment as part of an overall financial feasibility study for the SC Ports Authority's Navy Base Container Terminal facility. Project involved an independent technical review of the Final EIS, Record of Decision, supporting studies, and permit documents to validate the adequacy and completeness of the process and to provide an opinion as to the environmental feasibility of the project as proposed for development.

Wilmington District U.S. Army Corps of Engineers, Dredged Material Management Plan (DMMP) for the Atlantic Intracoastal Waterway (AIWW), Wilmington, North Carolina. Project manager for the DMMP for the AIWW in North Carolina. Development of management plan considering multiple dredged material management and beneficial use alternatives. Project involves field surveys, EA and Biological Assessment for the DMMP, and development of an Operations Manual for use in implementation of the DMMP. Development and coordination of Interagency Working Group, conceptual mitigation design and plan for reuse of submerged former upland disposal area, Section 7 consultation for T&E species, Section 404(b) evaluations for permitting, and real estate evaluations.

U.S. Environmental Protection Agency, Region IV, Environmental Assessment of Coastal Marinas, Various Locations. Directed team of engineers, planners, and scientists in preparation of a handbook for use by planners and regulatory agencies in determining the most environmentally acceptable practices for marina siting, design and operation; prepared and conducted interagency committee meetings.

Wilmington District U.S. Army Corps of Engineers, Peletier Creek Side Channel Sediment Quality Sampling and Analysis, Wilmington, North Carolina. Project manager for sediment quality sampling and analysis for proposed dredging of the Peletier Creek Side Channel on the AIWW in Carteret County, NC. Project involved study design, sediment sampling and analysis, conceptual design and environmental effects evaluation for dredging and dredged material disposal.

Southern Company, Wetland Identification, Threatened/Endangered Species and Animal Species Survey, Multiple Locations: Task leader for wetland identification and T/E plant and animal species surveys as part of site selection studies for multiple locations in the Carolinas and Georgia. These surveys were conducted to better define environmental attributes of potential sites following initial desk-top screening of candidate properties in the southeast.

Robert Federico MPA

Principal

EDUCATION

Master of Public Administration, Graduate Program in Public Policy and Administration, Columbia University, School of International and Public Affairs, New York, New York, 1986

Bachelor of Arts, Philosophy, State University of New York, College at Purchase, Purchase, New York, 1978

Robert is a Principal who has been with Stantec for over 28 years managing numerous environmental studies including impact assessments and other approval applications and management plans. Robert is a member of Stantec's national leadership committee for environmental assessment practice and procedures and acts as senior advisor for major Stantec assessments. He has participated in major environmental assessments and regulatory reviews (federal and provincial) as a senior reviewer/advisor for such projects as: offshore oil and gas exploration projects in Nova Scotia and Newfoundland and Labrador for Shell, BP and Husky, and a strategic environmental assessment for offshore exploration activities for the CNSOPB; mining projects such as Lynn Lake Gold Project (MB); GGM Gold Project (ON); Muskowekwan Potash Project (SK); the Donkin Mine (NS); the Maritime Link Project (NS/NL); Prince Rupert Gas Transmission Project (BC); Pacific Northwest and Shell LNG projects (BC); Lower Churchill Hydroelectric Project (NL); the Sydport Marine Terminal (NS); the PEV marine terminal (NS); Eider Rock Refinery (NB); Fairview Terminal Phase II Expansion (NB); Halifax Shipyards Pier 6 Expansion Project (NS); Pier C expansion project (NS); Hibernia Atlantic Transatlantic Cable Project (NS); the Alton Gas storage project and pipeline (NS); several wind power projects (NS/NB); the Bear Head LNG Project and pipeline project (NS); Sydney Tar Ponds Clean-up (NS); Deep Panuke Project (NS); the Fundy Tidal Power Strategic Environmental Assessment (NS/NB); the Halifax Harbour Solutions Project (NS); several marine infrastructure projects for the Halifax Port Authority (NS);, development of numerous highways in Nova Scotia; Halifax Lateral and Point Tupper Lateral Pipeline Projects (NS); and many quarries (NS/NB).

PROJECT EXPERIENCE

Offshore Petroleum Environmental Impact Assessments

- Shelburne Basin Exploration Drilling Project, Nova Scotia (Shell Canada) (Senior Reviewer/Advisor);
- Husky Exploration Drilling Project Environmental Impact Statement, Newfoundland and Labrador, (Husky Canada) (Senior Reviewer/Advisor);
- BP Newfoundland Orphan Basin Exploration Drilling Program Environmental Impact Statement, Newfoundland and Labrador (BP Canada) (Senior Reviewer/Advisor);
- BP Scotian Basin Exploration Drilling Project Environmental Impact Statement, Nova Scotia, (BP Canada (Senior Reviewer/Advisor);
- White Rose Extension Project Environmental Assessment, Newfoundland and Labrador, (Husky Canada) (Senior Reviewer/Advisor)

Environmental Impact Assessments, 2012 – present. Client: Shell Canada, BP Canada, and Husky Canada. Stantec was contracted by Shell Canada, BP Canada, and Husky Canada to complete several Environmental Impact Assessments under CEAA 2012 and offshore Petroleum Boards for offshore petroleum exploration (exploration drilling) and development. These assessments were completed over the years from 2012 until the present/ongoing.

Deep Panuke Decommissioning and Abandonment, Environmental Study, Nova Scotia (Senior Reviewer/Advisor), 2017-present. Client: Encana. Stantec was contracted by Encana to update the previous EIS for the decommissioning phase including development of management plans to meet requirements of CNSOPB and NEB.

Muskowekwan Potash Mine, Environmental Assessment, Muskowekwan First Nation, Saskatchewan (Senior Review/Advisor), 2012-2014. Client: First Potash Ventures (FVP). Stantec was contracted by FVP to prepare an environmental assessment to satisfy provincial and federal guidelines for a new potash mine on Muskowekwan First Nation lands. The mine plans to use a solution mining technique and provide potash to world markets. The EA included a number of physical, ecological and socio-economic components and related studies as well as First Nation and public engagement activities.

Pacific NorthWest LNG Project. Environmental Impact Assessment and Application, Prince Rupert, British Columbia (Senior Reviewer/Advisor), 2012-present.Client: Pacific NorthWest LNG (Petronas). Stantec was contracted by Pacific NorthWest LNG to complete an environmental assessment and application under CEAA 2012 and BCEAA for an LNG export terminal in Prince Rupert, B.C.

Prince Rupert Gas Transmission Project. Environmental Assessment Application, British Columbia (Senior Reviewer/Advisor), 2012-present. Client: Prince Rupert Gas Transmission. Stantec was contracted by Prince Rupert Gas Transmission to complete an environmental assessment application under BCEAA for a natural gas transmission pipeline system to transport gas from northern BC to the Pacific Northwest LNG export terminal in Prince Rupert B.C.

Energy East Pipeline Project. Environmental Impact Assessment, New Brunswick (Senior Reviewer), 2013-present, Client: TransCanada. Stantec was contracted by TransCanada to complete an environmental assessment application under CEAA 2012 and the NEB Act for a trans transmission pipeline system to transport oil from Alberta to marine export terminals in Quebec and New Brunswick. Robert was a reviewer and advisor for the marine aspects of the assessment.

Trans Mountain Pipeline Project Expansion. Environmental Impact Assessment, Burnaby, British Columbia (Senior Reviewer), 2013-present. Client: Kinder Morgan. Stantec is a subconsultant for an environmental assessment application under CEAA 2012 and the NEB Act for expansion of an oil transmission pipeline system and marine terminal. Robert was a reviewer for some marine aspects of the assessment.

National Gypsum Mine Extension. Environmental Assessment, Nova Scotia (Senior Reviewer/Advisor), 2013-present. Client: National Gypsum. Stantec was contracted by National Gypsum to complete an environmental assessment registration under the Nova Scotia Environmental Assessment Regulations for a Class I Undertaking pertaining to an expansion of their existing gypsum mine near Milford, NS to extend the life of the mine.

Environmental Assessment for Hardrock Goldmine Project, Ontario (Senior Advisor), 2015-2016. Client: Premier Goldmines Limited. Federal and provincial environmental assessment for gold mine project.

Environmental Assessment for Canada Express Telecommunications Cable, Herring Cove, Nova Scotia (Project Manager), 2010-2016. Client: Hibernia Atlantic. Federal environmental assessment for new transatlantic telecommunications cable landing near Herring Cove, Nova Scotia.

John Henderson P.Eng.

Senior Environmental Engineer

EDUCATION

Bachelor of Engineering, Technical University of Nova Scotia, Halifax, Nova Scotia, 1988

REGISTRATIONS

Site Professional, Nova Scotia Environment
Professional Engineer #5982, Engineers Nova Scotia

Mr. Henderson is a senior environmental engineer and risk assessment specialist. John is also the office specialist in the area of contaminated sites, environmental response and dangerous goods management. He has 26 years of experience as a consultant and as a former regulator. He has extensive experience in the delivery of a range of environmental projects as a senior advisor/reviewer including phased environmental site assessment (ESA) programs, human health and ecological risk assessments, risk management and remediation plans.

John has been identified as a pragmatic leader having significant experience in the development of regulatory programs for contaminated site assessment and management. He co-chaired the public/private sector PIRI committee which developed the Risk Based Corrective Action (RBCA) process for Atlantic Canada, and has also participated on several CCME committees including the Hazardous Waste Task Group, Contaminated Sites Advisory Group, CWS Development Committee for Petroleum Hydrocarbons, as well as the Regulations Development Advisory Committee for hazardous waste regulations under CEPA 1999. From 2007 to 2010 he was again active with the PIRI committee as the co-chair of the Technical Working Group for the development of RBCA Version 3.

In 2012, he had full time responsibility as technical coordinator for the delivery of the Human Health and Ecological Risk Assessment of pipeline spills for the Northern Gateway Project. He is currently the discipline lead for Ecological Risk Assessments for the Trans-Mountain Pipeline Expansion project, and senior team member for the risk assessment of marine spills for Energy East Pipeline.

PROJECT EXPERIENCE

Emergency Planning / Response

New Brunswick Marine Oil Spill Waste Management Study, Fredericton, New Brunswick (Project Director). Primary author for this a two phase project initiated by the New Brunswick Department of Environment. The program was modelled after similar waste management studies completed in Nova Scotia and Newfoundland. Part 1 of the study included the identification of high risk coastal zones based on vessel traffic patterns, waste handling procedures and lifecycle management of oil spill waste, a review of legislation and an assessment of the level of preparedness within the province, GIS data sources for identification of potential handling sites. The objective of Part 2 of the study was to develop a defendable process for the identification and selection of potential temporary storage, handling and treatment sites for marine oily wastes including consideration of Net Environmental Benefits Analysis, and approval processing during an environmental emergency.

Marine Oil Spill Waste Management Study for Nova Scotia, Halifax, Nova Scotia (Sole Source Contractor, Lead Author). Development plan and recommendation for the Province of Nova Scotia for a marine spill waste management strategy including risk assessment, siting and construction of facilities for the management (collection, storage, sorting and segregation and disposal) of marine oil spill wastes. **Departmental Emergency Planning Officer*, Halifax, Nova Scotia (Emergency Planning Officer).** Responsible for the development and management of policies and procedures for provincial response to environmental emergencies in Nova Scotia including coordination of provincial emergency response team.

Response to Swissair 111 Disaster*, Halifax, Nova Scotia (Regional Environmental Emergencies Team Member, Provincial Representative). Coordination of Provincial

** denotes projects completed with other firms* environmental emergency response to Swissair disaster related to waste management and disposal.

Policy & Regulatory Review & Development Rationale for the Development of Environmental Quality Standards for Contaminated Sites in Nova Scotia (Lead Author). This project involved the development of a hierarchy for the selection of existing national and provincial standards for contaminated site remediation and the development of pathway specific and tier 1 standards in support of proposed Nova Scotia Contaminated Site Regulations.

Canadian Council of Ministers of the Environment (CCME)*, Halifax, Nova Scotia (Committee Member). Various Task Groups responsible for the development of National Guidance on Management of Contaminated Sites and Hazardous Materials.

Update User Guidance and Risk Based Corrective Action (Version 3.0), Atlantic Region (Lead Author, Version 3.0). Author of Version 3.0 Revisions of RBCA User Guidance document which supports contaminated site regulatory programs throughout Atlantic Canada.

Guidance Document for the Application of Canada Wide Standards for Petroleum Hydrocarbons at Federal Sites, Canada (Lead Author). Lead author of technical guidance document for PWGSC.

Nova Scotia Emergency Spill Regulations*, Halifax, Nova Scotia (Lead Technical Editor). Developed technical framework and wording for Nova Scotia Emergency Spill Regulations implemented under the Nova Scotia Environment Act.

Guidelines for the Management of Contaminated Sites in Nova Scotia*, Halifax, Nova Scotia (Committee Chair). Chair of steering committee in the development policy and procedures for implementation of the guidelines including risk assessment and professional certification.

12 Preliminary Quantitative Risk Assessments (PQRAs), DFO Light Stations, Various Locations, Newfoundland and Labrador (Risk Assessor). Completed and reported PQRA and Ecological Risk Evaluations for 12 DFO Light Stations in Newfoundland and Labrador. Work included assessment reviews, risk modelling and reporting.

Development of Risk Assessment Process for Chlorinated Solvent Risk Assessment in Atlantic Canada (Leader of Technical Working Group). Responsible for technical review and recommendations for chlorinated solvent risk assessments in Atlantic Canada, included review and recommendations for toxicity reference values, physical and chemical properties, and site characterization protocols.

Jurisdictional Review of Hazardous Materials Management Programs in Canada. N/A, Nova Scotia (Lead Researcher and Author). In 2014, Stantec was engaged by Nova Scotia Environment to complete a jurisdictional review of hazardous materials management programs in Canada. John was the primary author of this report. The hazardous materials program review involved gathering information on selected regulatory programs for Canadian jurisdiction related to operating approvals, chemical storage, processing and/or disposal of dangerous goods and waste dangerous goods, asbestos waste, used oil and program aspects related to hazardous materials spills and emergencies. Information was gathered using Stantec's expertise and resources from across the country, through internet web searches and commercial databases of environmental legislation, and direct contact/discussion with program staff. The results of the review were summarized in a matrix/table format to facilitate a comparison of program information from across the country. The project was extremely challenging given the broad nature and range of hazardous materials programs, given a limited budget and timeline.

RAYMOND (RICK) SPAULDING
6765 NE Day Rd.
Bainbridge Island, WA 98110
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Current Position

Sr. Wildlife Biologist/ Project Manager

Discipline Areas

- > Wildlife Biology
- > Ecology
- > Threatened & Endangered Species
- > Endangered Species Act (ESA) compliance
- > Marine Mammal Protection Act (MMPA) compliance
- > Migratory Bird Treaty Act (MBTA) compliance
- > National Environmental Policy Act (NEPA) compliance

Years' Experience:

34

Education

- 1996/MS/Wildlife and Fisheries Science/ Univ. of Arizona
- 1982/BA/Biology/ Univ. of California-Santa Cruz

Professional Registrations

- Certified Wildlife Biologist – The Wildlife Society
- USFWS Certified Observer for Implementation of the Marbled Murrelet Marine Monitoring Protocol
- Master Bird Bander

Summary of Experience

Rick is a Senior Wildlife Biologist and Project Manager experienced in preparing Environmental Assessments (EAs), Environmental Impact Statements (EISs), and Biological Assessments (BAs) to document environmental conditions for a variety of projects. Proven expertise in:

- project management of NEPA documents (EAs and EISs) for a wide variety of actions, clients, and locations;
- managing natural resources field work;
- preparing biological survey reports, natural resources management plans, and NEPA documents;
- evaluating wildlife habitat; and
- preparing documents for Endangered Species Act (ESA), Marine Mammal Protection Act (MMPA), Bald and Golden Eagle Protection Act (BGEPA), and Migratory Bird Treaty Act (MBTA) compliance.

Rick has completed over 40 BAs and assisted with the associated informal or formal ESA section 7 consultations with the U.S. Fish and Wildlife Service (USFWS) and/or National Marine Fisheries Service (NMFS) for a variety of ESA-listed terrestrial and marine species.

He has over 25 years of experience conducting baseline inventories to document wildlife species occupying project sites for the purposes of environmental impact analyses and MBTA and ESA compliance on utility and communication, military, space launch, and transportation projects.

Rick has conducted natural resources surveys and monitoring efforts in a wide range of habitats and states and countries including WA, OR, CA, AK, TX, AZ, NM, CO, NV, MT, ID, UT, MI, GA, FL, CT, Guam, CNMI, Haiti, Italy, Belgium, Spain, and Greece (Crete).

Employment

Dates: Dec 2017 – present
Title: Senior Wildlife Biologist/Project Manager
Employer/Supervisor: ManTech International Corp., Solana Beach, CA/Karen Waller.
Duties: Oversee technical analysts in the preparation of biological resource sections for NEPA documents (e.g., EAs, EISs). Prepare BAs and BEs under section 7 of the ESA for analysis of potential impacts of federal projects to ESA-listed species and critical habitat. Conduct formal and informal section 7 consultations with the USFWS and NMFS. Project manager for EAs, biological resource inventory reports, and environmental baseline reviews.

Dates: Jan 1999 – Dec 2017
Title: Senior Wildlife Biologist/Project Manager
Employer/Supervisor: Cardno GS, Santa Barbara, CA/Craig Bloxham.
Duties: Oversee technical analysts in the preparation of biological resource sections for NEPA documents (e.g., EAs, EISs). Prepare and review Integrated Natural Resource Management Plans (INRMPs) for the Air Force and Navy. Prepare BAs and BEs under section 7 of the ESA for analysis of potential impacts of federal projects to ESA-listed species and critical habitat. Conduct formal and informal section 7 consultations with the USFWS and NMFS. Project manager for EISs, EAs, biological resource inventory reports, and environmental baseline reviews. Conduct sensitive species surveys, biological resource inventories, and biological monitoring programs throughout the U.S.

Affiliations

- The Wildlife Society (Chair, Wildlife Publication Awards Committee; President, Military Lands Working Group)
- American Ornithological Society
- Raptor Research Foundation
- Wilson Ornithological Society

Continuing Education and Training

- Interagency Consultation for Endangered Species – USFWS National Conservation Training Center

and Europe. Responsible for Quality Assurance/Quality Control and technical editing of documents. Supervision of 5 junior biologists/environmental analysts.

Dates: May 1997 – Jan 1999
Title: Wildlife Biologist/Environmental Analyst/Specialist
Employer: Ogden Environmental and Energy Services, Santa Barbara, CA; (Note: Ogden is no longer in operation).
Duties- Prepare biological sections for EAs and EISs and prepare BAs in conjunction with formal and informal section 7 consultations with the USFWS. Prepare INRMPs for the Air National Guard. Conducted field studies on infrared survey techniques for bighorn sheep and Sonoran pronghorn. Provided interagency coordination between Department of Defense agencies, USFWS, state game and fish departments, Bureau of Land Management, and Army Corps of Engineers (USACE).

Representative Projects

EIS, Federal Aviation Administration (FAA), SpaceX Launch Site, Cameron County, TX. Senior Biologist for preparation of biological resources section of the EIS and BA for vertical launch and control center sites in coastal South Texas. The Proposed Action under NEPA review by the FAA was the issuance of licenses and/or experimental permits to SpaceX that would allow SpaceX to launch the Falcon 9 and Falcon Heavy orbital vertical launch vehicles and a variety of reusable suborbital launch vehicles from a launch site on privately owned property in Cameron County, TX. All Falcon 9 and Falcon Heavy launches would be expected to have commercial payloads, including satellites or experimental payloads. In addition to standard payloads, the vehicles may also carry a capsule, such as the SpaceX Dragon capsule. All launch trajectories would be to the east over the Gulf of Mexico. The EIS covered a wide range of resource areas and several special studies were being completed as part of this project including: wetlands delineation, architectural survey, archaeological survey (including metal detection survey), biological assessment, coastal consistency determination, and far-field noise impact assessment by Blue Ridge Research and Consulting (BRRC). Advanced acoustic models were used to model the launch and sonic boom noise generated by the proposed operations, and to develop noise contours for assessing the noise levels and exposures in the area surrounding the proposed launch site. Cooperating agencies included the National Park Service, National Aeronautics and Space Administration (NASA), White Sands Missile Range, and the USACE. Formal consultation with the USFWS, Texas Historical Commission, and Advisory Council on Historic Preservation was required for this project. This EIS had a high level of political and public interest. Over 500 people attended the public scoping meeting and over 588 comments, resolutions, and letters were received. The Record of Decision (ROD) was signed on schedule.

The EIS addressed potential noise from launch operations and construction impacts to ESA-listed species, migratory birds, wetlands, and vegetation communities from proposed construction and operation of control center and launch site in coastal south Texas. The BA addressed the ESA-listed piping plover and designated critical habitat, aplomado falcon, ocelot, jaguarundi, and nesting green, leatherback, loggerhead, hawksbill, and Kemp's ridley sea turtles. The red knot, an ESA candidate species, was also addressed. Formal ESA consultation was on schedule and concluded with a Biological Opinion from the USFWS concurring with the may affect, but would not adversely affect ESA-listed species and critical habitat.

EA, Midland International Air and Space Port, City of Midland, Midland County, Texas – Senior Biologist for preparation of biological resources section of an EA addressing the City of Midland's proposal to operate a commercial space launch site at the Midland International Airport (MAF). The site would be utilized by XCOR Aerospace, Inc. (XCOR) for the operation of the Lynx horizontal take-off and horizontal landing reusable launch vehicle (RLV) and other associated activities, such as engine testing. In order to operate a commercial space launch site, the City of Midland must obtain a commercial space launch site license from the FAA. Under the Proposed Action addressed in the EA, the FAA would: (1) issue a launch site operator license to the City of Midland for the operation of a commercial space launch site at MAF, (2) issue experimental permits and/or launch licenses to XCOR that would allow XCOR to conduct launches of the Lynx RLV from MAF, and (3) provide unconditional approval to modify the existing Airport Layout Plan to reflect the launch site boundary and installation of several aboveground propellant storage tanks and construction of a concrete pad for engine testing. This EA evaluated all resources as outlined in FAA Order 1050.1E and Order 5050.4B and in addition, as part of the project, a baseline noise assessment and sonic boom analysis was conducted by BRRC and the license application was prepared by SilverWing Enterprises, LLC.

The EA addressed potential noise impacts to ESA-listed species and migratory birds from proposed flight operations and construction activities at MAF. The only ESA-listed species within the Region of Influence was the lesser prairie-chicken. Informal ESA consultation was on schedule and concluded with a Letter of Concurrence from the U.S. Fish and Wildlife Service regarding no adverse effects to the lesser prairie-chicken.

Site-Wide Programmatic EIS NASA Wallops Flight Facility (WFF), Wallops Island, VA – Senior Biologist and Technical Oversight for preparation of biological resources section for a Site-Wide Programmatic EIS assessing current and proposed future operations at NASA WFF over a 20-year planning horizon. The proposed action included a wide range of new and expanding projects at WFF including commercial launch activities and human space flight and their impact to a broad list of resource categories. A noise monitoring plan was prepared to address potential noise impacts on the Main Base, Mainland, and Wallops Island and to establish baseline noise levels for evaluation of mission impacts to nearby receptors. BRRC assessed the baseline background noise levels at WFF by performing long-term sound monitoring in the area surrounding the facility to determine the total acoustic soundscape at various representative locations. BRRC used advanced acoustic models to generate noise contours for both liquid and solid fueled heavy and intermediate class launch vehicles to allow assessment of noise levels and exposures in the area surrounding the proposed launch site. The EIS is still in preparation.

The EIS is addressing potential noise from launch operations and construction impacts to ESA-listed species, migratory birds, wetlands, and vegetation communities from proposed construction activities and launch operations. The EIS addresses potential impacts to state-listed species and nesting and roosting bald eagles, protected under the BGEPA and the MBTA. The BA addresses the ESA-listed piping plover and designated critical habitat, and nesting loggerhead sea turtle. The red knot, an ESA candidate species, is also addressed. Formal ESA consultation will be conducted with the USFWS.

EIS, Shiloh Launch Complex, Brevard and Volusia Counties, Florida – Project Manager and Natural Resources Task Manager for an EIS and BA addressing the construction and operation of a highly controversial commercial space launch complex in Brevard and Volusia counties, Florida. The Proposed Action under

NEPA review by the FAA is the issuance of a launch site operator license to Space Florida for the operation of a commercial space launch site. The EIS will address the potential environmental consequences of Space Florida's construction and operation of a commercial space launch site; construction and operation of up to two off-site operations support facilities, and the conduct of annual operations of liquid-fueled, medium- to heavy-lift class orbital and suborbital vertical launch vehicles as well as annual static fire engine tests. Formal ESA consultation will be conducted with the USFWS. This project is ongoing.

EIS for U.S. Marine Corps Relocation to Guam, NAVFAC Pacific, HI. Natural Resources Task Manager for an EIS and BA addressing the relocation of US Marines from Okinawa, Japan to Guam and Tinian, CNMI; harbor modifications and construction of infrastructure to support a visiting nuclear aircraft carrier, establishment of an Army Air and Missile Defense Task Force, and upgrading or constructing associated road and utilities infrastructure on Guam. Potential impacts included habitat removal; noise from construction, aircraft, and live-fire range operations; and vehicle and troop training operations. The project involved the preparation of the natural resource sections of the EIS; preparation of a BA and assisting with ESA section 7 formal consultation with USFWS; conducting avian surveys, herpetological surveys, land snail surveys, and vegetation and rare plant surveys on Guam, and preparation of associated natural resources survey report. Natural resource surveys were conducted on Guam on DoD lands.

Supplemental EIS for U.S. Marine Corps Relocation to Guam, NAVFAC Pacific, HI. Natural Resources Task Manager for an SEIS addressing the relocation of US Marines from Okinawa, Japan to Guam. Potential impacts included habitat removal; and noise from construction and live-fire range operations. The project involved the preparation of the natural resource sections of the SEIS; assisting with ESA section 7 formal consultation with USFWS; conducting avian surveys, herpetological surveys, land snail surveys, vegetation and rare plant surveys, and vegetation and wetlands mapping on Guam; and preparation of associated natural resources survey report. Natural resource surveys were conducted on Guam on DoD lands and non-DoD lands.

EIS/OEIS for Commonwealth of the Northern Mariana Islands (CNMI) Joint Military Training (CJMT), NAVFAC Pacific, Pearl Harbor, HI. Natural Resources Task Manager for an EIS/Overseas EIS addressing the potential environmental impacts of establishing a collection of live-fire and maneuver ranges and training areas on two islands, Tinian and Pagan, within the CNMI. Potential impacts included habitat removal; noise from construction, aircraft and live-fire operations; and vehicle and troop training operations. In addition to managing the preparation of the EIS/OEIS biological resource sections, Mr. Spaulding was the Task Manager for biological surveys of forest birds and ESA-listed and candidate species on Tinian. This included conducting avian surveys on 15 transects across the island of Tinian, the preparation of the field survey report, and coordination with the U.S. Geological Survey regarding detailed quantitative analysis of forest bird survey data to estimate bird abundance, density and distribution on Tinian. Also managed and conducted surveys for ESA-listed plant species on Tinian, as well as vegetation mapping.

Supplemental Environmental Report (SER) and Environmental Compliance Support for the Ocean Observatories Initiative (OOI), Consortium for Ocean Leadership, Washington, DC. Project Manager for the preparation of an Supplemental Environmental Report (SER) to assess the potential impacts on the human and natural environment associated with proposed modifications in the design, installation, and operation and maintenance of components of the Coastal-Scale Nodes (CSN) Endurance Array, CSN Pioneer Array, Regional-Scale Nodes

(RSN), and the Global-Scale Nodes (GSN) of the OOI that were previously assessed in a Site-Specific Environmental Assessment (SSEA). The purpose of the SER was to determine if the proposed OOI design modifications would result in significant impacts to the environment not previously assessed in the SSEA, including cumulative impacts. Also providing on-call environmental compliance support for the deployment and operation of the OOI network.

Site-Specific EA (SSEA) for the OOI, Consortium for Ocean Leadership, Washington, DC. Project Manager and Senior Biologist for an SSEA that assessed the potential site-specific impacts on the human and natural environment associated with the installation and operation of the National Science Foundation (NSF-) funded OOI components within the marine environment off the coasts of Washington, Oregon, Massachusetts, and at other locations within the Pacific and Atlantic oceans. This SSEA is a tiered document from the previously completed Programmatic EA for OOI that Mr. Spaulding also managed. The proposed OOI would be an interactive, globally distributed and integrated network of cutting-edge technological capabilities for ocean observatories at the coastal, regional, and global scale. The OOI infrastructure would include cables, buoys, deployment platforms, moorings, junction boxes, electric power generation (solar, wind, fuel cells, and/or diesel), mobile assets (i.e., AUVs and gliders), and two-way communications systems. This large-scale infrastructure would support sensors located at the sea surface, in the water column, and at or beneath the seafloor.

Programmatic EA for the OOI Network, Consortium for Ocean Leadership, Washington, DC. Project Manager and Senior Biologist for a Programmatic EA assessing the potential impacts on the human and natural environment associated with the installation and operation of components of the OOI funded by the NSF. The project was located within the marine environment off the coasts of Washington, Oregon, Connecticut, and at other locations within the Pacific and Atlantic oceans. The proposed OOI would be an interactive, globally distributed and integrated network of cutting-edge technological capabilities for ocean observatories at the coastal, regional, and global scale. The OOI infrastructure would include cables, buoys, deployment platforms, moorings, junction boxes, electric power generation (solar, wind, fuel cells, and/or diesel), mobile assets (i.e., autonomous underwater vehicles [AUVs] and gliders), and two-way communications systems. This large-scale infrastructure would support sensors located at the sea surface, in the water column, and at or beneath the seafloor.

EA for Airfield Operations, NAS Fallon, NV. Project Manager for an EA addressing potential impacts from current and potential airfield operations at NAS Fallon, including aircraft transitions; an increase in the number of annual airfield operations and associated noise contours; construction, demolition, and renovation of facilities to support new aircraft; and construction of runways and facilities to support Unmanned Aircraft Systems such as the RQ-7B Shadow. Legacy aircraft would be replaced with next generation aircraft: FA-18C would be replaced by the F-35C, the EA-6B with the EA-18G, and the E-2C with the E-2D.

EIS for F-35C Homebasing, West Coast Locations, NAVFAC Atlantic, VA. Senior Biologist and QA/QC Manager for EIS addressing potential impacts of homebasing F-35C aircraft at either NAS Lemoore or NAF El Centro, CA. EIS focused on potential impacts to the environment due to increases in air quality emissions, changes in noise contours, and associated changes in land use. The EIS won the FY14 Chief of Naval Operations Environmental Planning, Team Award.

Programmatic EIS/OEIS for Impacts on the Marine Environment from Seismic Research, National Science Foundation, Washington, DC. Project Manager for a Programmatic EIS/OEIS that addressed potential impacts on the marine environment related to the use of seismic sources in support of research funded by the National Science Foundation (NSF), and conducted by the USGS, involving U.S. academic scientists across the world's oceans. Impacts were addressed in accordance with the ESA, MMPA, and Magnuson-Stevens Fishery Conservation and Management Act. Specific exemplary seismic source airgun arrays, as well as the range of source characteristics expected under different research configurations, were acoustically modeled for seven locations across the world's oceans at various depths and acoustic source levels. Based on the acoustic modeling, marine mammal mitigation measures were proposed including defined safety radii, visual observations, and passive acoustic monitoring.

Qualifications

The following sections provide an overview of our team and the qualification and experience of the key personnel related to the commercial space sector.

Blue Ridge Research and Consulting, LLC

29 N Market St, Suite 700, Asheville, NC 28801
Contact: Michael James
Phone: 828-252-2209
Website: BlueRidgeResearch.com

Blue Ridge Research and Consulting, LLC (BRRC) is an acoustical engineering consultancy focused on critical noise and vibration challenges for aerospace, aviation, and Department of Defense projects. With a combined experience from 200+ civilian and military noise studies, BRRC's team of exceptional acoustical engineers are trusted advisors to public, private and academic clients around the world. BRRC's expertise comprises measurement, modeling, and analysis of outdoor acoustics, including airports, spaceports, highways, railways, industrial plants, outdoor warning siren systems, and natural soundscapes. BRRC's modeling capabilities enable the company to address unique conditions and impacts and relate that information to decision makers and the public using specialized visualization tools. BRRC's modeling experience ranges from publicly available models such as AEDT and TNM to military noise and sonic boom models including NoiseMap, MR_NMAP, SARNAM, BNoise, PCBoom, and BoomMap. BRRC also has advanced in-house modeling capabilities with BRRC noise models such as The Launch Vehicle Acoustic Simulation Model (RUMBLE), flight safety models, and flight optimization models. BRRC has the expertise to address complex environmental noise modeling that requires interdisciplinary teams and unique acoustical knowledge.

Michael James, *Chief Engineer*

Mr. Michael James' areas of expertise include applied research, measurement, and analysis of atmospheric acoustics, and technical management of consulting studies focused on military and community noise. He has been the principal investigator for a diverse set of rocket environmental noise and launch load prediction studies. These studies have included propulsion and sonic boom noise analysis for static, launch and landing operations of both vertical and horizontal launch vehicles. He has led the development of multiple rocket noise models including The Launch Vehicle Acoustic Simulation Model, RUMBLE, developed by BRRC. Mr. James research focus is developing innovative measurement, analysis, and modeling techniques to characterize and map the noise emitted from jet and rocket engines/motors. These advances have led to improvements in both near-field noise modeling used to predict vibroacoustic loading on space vehicles and far-field noise modeling to predict community impact.

He has performed over 40 large-scale sound and vibration measurements for military and civilian aviation, rockets, weaponry, and blast noise to develop reference noise data and advanced propagation algorithms. Mr. James, as members of working groups, has coauthored two American National Standards Institute standards (S12.75, S12.76) on aircraft noise source characterization. He has extensive experience in sound and vibration measurements, data acquisition, signal processing, data analysis, and software development. Mr. James has been instrumental in developing complete measurement systems including an energy-based acoustic measurement system for rocket noise, a Near-field Acoustic Holography system for jet plume characterization, and the Aero-Acoustic Research Complex for aircraft source noise characterization in White Sands, NM. Prior to the founding of BRRC, Mr. James worked for Wyle Laboratories where he conducted aviation research for the DOD and provided technical management for airport noise studies. His MS research at Virginia Tech's Vibration and Acoustic Laboratory included designing and testing passive and active turbofan engine-noise reduction and control technologies for the NASA Langley Acoustics Research Group.

Alex Salton, *Principal Engineer*

Ms. Alex Salton is a Principal Engineer at BRRC, responsible for a variety of applied research and consulting tasks focusing on the physical acoustics of jet and rocket noise. She has been heavily involved in the development of RUMBLE, used to perform the noise analysis associated with environmental reviews of launch vehicles, and further refined as part of ACRP Project 02-66. As part of a NASA Phase II SBIR, Ms. Salton participated in the full-scale measurement of a GEM-60 rocket motor, with a focus on improving predictions of the vibroacoustic loading. Ms. Salton's field experience also includes the recent large-scale testing of the F-35 and F/A-18 military jets, in which she participated in collecting ground run-up and flyover measurements as well as post-processing efforts. Ms. Salton received her M.S. from The Pennsylvania State University's Graduate Program in Acoustics, where she researched the feasibility of measuring the acoustic pressure of a pipe's internal fluid using externally mounted accelerometers.

J. Micah Downing, Ph.D., *Chief Scientist*

Dr. Micah Downing's primary research focus is on aircraft noise and sonic boom modeling, measurement and assessment. Over his 27 years of experience in environmental and transportation noise research, Dr. Downing has served as the Principal Investigator for over 40 field measurement projects for the USAF, USN, USA, NATO, and NPS. He coauthored with Dr. Plotkin DOD's aircraft noise source characterization protocol, which lead to the development of two American National Standards Institute standards (S12.75, S12.76) on aircraft noise source characterization. He has directed the develop and refinement of DOD noise models: NoiseMap 7, MRNMap 3, Air Gunnery Model, and the Flight Trajectory Optimizer.

In addition to his applied research experience, he has been the acoustical expert for over 10 major Environmental Impact Studies for the DOD as well as many Environmental Assessments, DOD's Air Installation and Range Compatible Use Zone studies. Before the founding of BRRC, Dr. Downing was responsible for research projects and environmental noise analysis of military noise issues at Wyle Laboratories. Concurrent to his work toward his PhD, Dr. Downing worked for the Air Force Research Laboratory in the Noise Effects Branch as a Research Physicist. In this position, he became responsible for sonic boom modeling and measurements, and he was the lead for aircraft-noise data collection for environmental noise applications.

Accomplishments

LAUNCH VEHICLE ENVIRONMENTAL NOISE STUDIES

Blue Ridge Research and Consulting, LLC
Various Primes *Date: 2010 to Present*

BRRC provides (or has provided) noise analyses as the prime launch vehicle noise consultant in over twenty rocket noise environmental studies, twelve of which were performed as part of FAA commercial space licensing applications. The noise effects on the local communities and environment were evaluated based on the FAA Order 1050.1F, Environmental Impacts: Policies and Procedures, on a cumulative basis in terms of human annoyance, measured by DNL. The launch vehicle propulsion noise analyses, performed using RUMBLE, were often supplemented with single-event metrics in regard to hearing conservation and structural damage criteria. In addition to the propulsion noise, the sonic boom analyses were performed using PCBoom which calculates the magnitude and location of sonic boom overpressures on the ground from supersonic flight. Sonic boom impacts from launch and reentry were evaluated on a single-event basis in regard to hearing conservation and structural damage criteria.

BRRC's commercial space launch vehicle noise study experience includes:

- EA for United Launch Alliance Vulcan Centaur Launch Operations, Cape Canaveral Air Force Station, LC-41 (2019 - Present);
- Space Florida's Launch Site Operators License for the Shuttle Landing Facility (2018 - Present);
- Space Florida's Landing Site Operators License for the Shuttle Landing Facility (2018 - Present);
- EA for Canso, Nova Scotia, Canada Launch Site (2017-Present);
- EA for NASA Kennedy Space Center, LC-48 (2017);
- Space Florida's Launch Site Operators License for the Shuttle Landing Facility (2017-2018);
- EIS for Spaceport Camden (Submitted, 2016-2017);
- EA for the Blue Origin Cape Canaveral Air Force StationLC-36 Launch Site (2016);
- EA for the Cecil Spaceport (Submitted, 2015-2017);
- Site-wide PEIS for expanding operations at NASA Wallops Flight Facility (2014-2016);
- EA for the Hawaii Air and Space Port (2014-Present);
- EA for the Titusville Spaceport (2014-2018);
- EIS for the Shiloh Launch Complex (2013-2014);
- EA for Issuing an Experimental Permit to SpaceX for Operation of the DragonFly Vehicle at the McGregor Test Site (2013-2014);
- Preliminary Site Evaluation for Space Florida's Shiloh Launch Facility (2013);
- EIS for the SpaceX Texas Launch Site (2012-2014);
- Site-wide PEIS for expanding operations at Wallops Flight Facility (2012-2013);
- EA for the Midland International Airport and Space Port (2012-2014);
- PEIS for Wallops Flight Facility (2010)

ACRP 02-81: COMMERCIAL SPACE OPERATIONS NOISE AND SONIC BOOM MEASUREMENTS

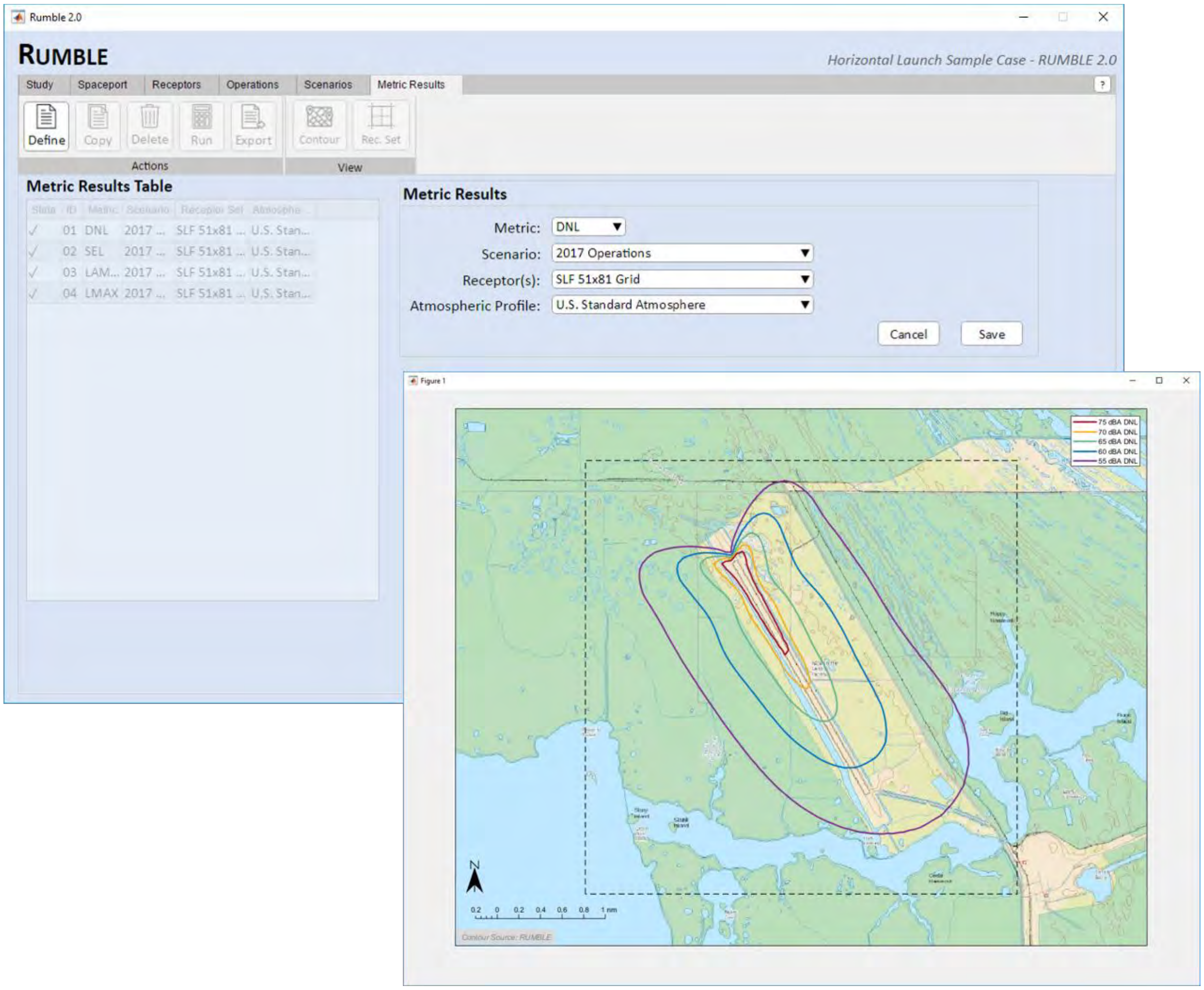
Blue Ridge Research and Consulting, LLC
National Academies of Science *Date: 2017-Present*

BRRC is conducting a measurement campaign on a diverse set of operations of commercial space vehicles to obtain high-fidelity rocket propulsion noise and sonic boom signatures along with supporting operational data, under ACRP Project 02-81. The project objectives also include developing a community noise measurement protocol for commercial space operations noise and sonic booms and compiling a database of rocket propulsion noise and sonic booms that will serve as model source characteristics for the purpose of facilitating community noise model development and validation.

ACRP 02-66: COMMERCIAL SPACE VEHICLE NOISE MODEL DEVELOPMENT FOR AEDT INTEGRATION

Blue Ridge Research and Consulting, LLC
National Academies of Science *Date: 2015 to 2017*

BRRC's Launch Vehicle Acoustic Simulation Model, RUMBLE, was selected for the ACRP Project 02-66. RUMBLE provides an efficient noise prediction model that produces accurate output relevant to environmental analysis of commercial space operations and airport/space launch site facilities. The RUMBLE modeling methodology reflects the best available science and practices and has been reviewed and accepted by FAA AEE for use in over ten commercial space studies. RUMBLE includes an updateable database of essential input parameters that compiles the available spacecraft airframe and engine data pertaining to commercial space launch operations for actively licensed launch sites and vehicles. The model's input parameters and user-interface were specifically designed to maintain a level of consistency with the AEDT modeling platform to ensure smooth future integration. A user manual and example cases will highlight the model's features and provide potential users with a better understanding of the model's operation and capabilities. This effort has resulted in improved performance and efficiency of RUMBLE with the goal of making the tool accessible to a larger community of users.



Horizontal Launch Sample Case - RUMBLE 2.0

Metric Results Table

State	ID	Metric	Scenario	Receptor Set	Atmosphe...
✓	01	DNL	2017 ...	SLF 51x81 ...	U.S. Stan...
✓	02	SEL	2017 ...	SLF 51x81 ...	U.S. Stan...
✓	03	LAM...	2017 ...	SLF 51x81 ...	U.S. Stan...
✓	04	LMAX	2017 ...	SLF 51x81 ...	U.S. Stan...

Metric Results

Metric: DNL
Scenario: 2017 Operations
Receptor(s): SLF 51x81 Grid
Atmospheric Profile: U.S. Standard Atmosphere

Cancel Save

Appendix A: Abbreviated Curricula Vitae

MICHAEL JAMES, M.S.
Chief Engineer

PRINCIPAL DUTIES AND RESPONSIBILITIES

Conceives, directs and conducts applied research and consulting studies on high-amplitude noise sources and their effects on communities and the environment.

PROFESSIONAL EXPERIENCE

Blue Ridge Research and Consulting, Asheville, NC **2006 – Present**
Chief Engineer

- Founding member of BRRC. Responsible for developing innovative measurement, analysis, and modeling techniques to characterize and map the noise emitted from rocket engines/motors and jets (co-author of over 100 technical papers and reports).
- PI for over fifteen rocket environmental noise studies consisting of propulsion noise and sonic boom impact analysis for projects involving a diverse collection of vertical and horizontal launches vehicles. Led the development of BRRC's Launch Vehicle Acoustic Simulation Model, RUMBLE.
- PI for three Airport Cooperative Research Program (ACRP) projects designed to develop commercial space noise (Project 02-66) and emission (Project 02-85) modeling tools, and conduct a measurement campaign to gather launch vehicle noise and sonic boom data (Project 02-81).
- Performed over forty large-scale sound and vibration measurements for military and civilian aviation, rockets, sonic boom, weaponry, and blast noise to develop reference noise data and validate models. Extensive experience in sound and vibration measurements, data acquisition, signal processing, data analysis, and software development.
- Co-Authored two ANSI standards on "Methods for the Measurement of Noise Emissions from High Performance Military Jet Aircraft (ANSI S12.75)" and "Methods for Measurement of Supersonic Jet Noise from Uninstalled Military Aircraft Engines (ANSI S12.76 (Draft))". Provided technical expertise, including jet noise measurement procedures, signal processing, data acquisition systems, testing logistics and error / variability analysis.
- Co-PI of a NASA SBIR to develop an acoustic energy-based probe to facilitate greater understanding of the noise generation characteristics of rocket engine/motors. Performed multiple static fire measurements to evaluate the probes, producing significant advances in the characterization of the rocket acoustic source sound levels, directivity, and spatial extent.
- Co-PI of an Air Force SBIR to develop a near-field acoustic holography measurement system to characterize and map the noise emitted from jet engines. The system produced the first 3D holographic representation of the sound radiation from a military jet aircraft (F-22).

Wyle Acoustics Group, Arlington, VA **2002 – 2006**
Senior Engineer

- Researched and developed innovative measurement procedures and propagation models for the new generation of fighter aircraft with different engine geometries and thrust vectoring. Performed measurement of F/A-18E and F-22 to examine nonlinear propagation characteristics.
- Performed airport Master Plan and FAR Part 150 aviation noise studies. Developed advanced analysis and processing tools for community noise exposure, radar data, model validation, and soundscape studies.

EDUCATION

M.S., Mechanical Engineering, Virginia Tech	2003
B.S., Mechanical Engineering, Virginia Tech	2000

Alexandria Salton, M.S.
Principal Engineer

PRINCIPAL DUTIES AND RESPONSIBILITIES

Principal duties include research, measurement, analysis, and modeling of acoustics with a focus on aircraft and launch vehicle noise as related to its environmental impacts on the community.

PROFESSIONAL EXPERIENCE

Blue Ridge Research and Consulting, Asheville, NC 2011 – Present

Sr. Engineer

- Researched and developed advanced acoustic models to predict launch vehicle noise levels and exposures in the vicinity of a launch site for the purpose of evaluating potential risks associated with human hearing, human annoyance, and structural damage.
- Developed and refined BRRC's launch noise modeling tool, RUMBLE, as part of the Airport Cooperative Research Program (ACRP) Project 02-66 and is currently performing launch noise and sonic boom measurements under ACRP Project 02-81 which will be used to benchmark and improve the models in future efforts.
- Developed flight safety analysis tools to complete the multistep process (in accordance with FAA 14 CFR Part 420) which includes a review and redistribution of US Census data, determination of flight corridors, and calculation of expected casualty (E_c) for each individual populated area.
- Performed measurements of a static test fire at ATK Space Systems Test Services in Promontory, UT, as part of a Phase II SBIR grant funded by the NASA Stennis Space Center. Leveraged the acoustic measurements in the Phase III SBIR to further research the non-dimensional empirical curve fits used in historical rocket plume noise prediction models.

Penn State University College of Engineering and ARL, State College, PA 2009 – 2011

Graduate Research Assistant

- Completed a Master's Thesis in acoustics entitled, "Determination of Pipe Interior Pressures Using External Accelerometers." Researched pipe interior pressures using external accelerometers as a graduate research assistant to Dr. Dean Capone. Programmed an analytical model to identify limiting factors of in-situ conditions on vibration measurements. Designed and implemented experimental set up to perform pipe vibration measurements. Collected and analyzed accelerometer and hydrophone data to predict pipe internal acoustic pressure.

Laboratoire Vibrations Acoustique, Lyon, France 2010

Graduate Research Assistant

- Analyzed behavior of propagating waves in fluid filled pipes through analytical modeling and vibration measurements as a research assistant to Dr. Goran Pavic. Collected and analyzed vibration measurements of a thin-walled small diameter aluminum pipe.

Boston University College of Engineering, Boston, MA 2009

Research Assistant

- Built numerical model to determine velocity potential due to neighboring values using the finite-difference equation as a research assistant to Dr. Michael Howe.

EDUCATION

Master of Science, Acoustics, Pennsylvania State University	2011
Bachelor of Arts, Mathematics, Bates College	2007

J. MICAH DOWNING, Ph.D.

President/Chief Scientist

PRINCIPAL DUTIES AND RESPONSIBILITIES

Conceives, directs and conducts research in physical acoustics and noise and its environmental impacts. Provides consultations on acoustics for military, aviation, and environmental issues.

PROFESSIONAL EXPERIENCE

Blue Ridge Research and Consulting, Asheville, NC **2006 – Present**

President / Chief Scientist

- Founding member of Blue Ridge Research and Consulting responsible for the overall technical efforts in support of clients' needs and initiatives. Provides expertise in physical acoustics and environmental noise.
- Directed the validation of NPS Sonic Boom Detector at White Sands National Monument, NM. Developed the test plan and test cards for F-5 aircrews for the proper placement of the sonic booms at the measurement location. Recorded independent acoustic data to verify NPS's system.
- Invited advisor to operational fighter squadrons to train aircrews on sonic booms. Part of this training includes development of supersonic trajectories for input to PCBoom for aircrews use in planning supersonic maneuvers.
- Principal investigator for the developments of a new modeling system for calculating airborne weapon noise foot prints. This study required innovative methods to measure, characterize, and model these unique noise sources.
- Directed the development of an operational tool for show of force missions. The tools provide aircrews with operational trajectories for the placement of sonic booms at a desired location.

Wyle Acoustics Group, Arlington, VA **1998 – 2006**

Senior Staff Scientist

- Research and consultation on the evaluation, prediction, and measurement of aircraft noise and sonic boom, on the analytical modeling of aircraft noise and sonic boom generation and propagation, and on the assessment of noise impacts to the environment.
- Directed the development of two new military noise models for the next generation of noise modeling technology.
- Oversaw noise studies focused on environmental impacts from aviation and military operations.

Air Force Research Laboratory, Wright-Patterson AFB, OH **1990 – 1998**

Research Physicists

- Technical Advisor to the USAF Test Pilot School for the HaveBEAR sonic boom project. This project demonstrated that aircrews could accurately place a focus sonic boom at a targeted location.
- Principal Investigator for USAF environmental and occupational noise and sonic boom measurements. Involved in over 25 aircraft noise measurements.
- Assisted with the development of PCBoom 3, and was the DOD expert for sonic boom incident investigations.
- Provided aircraft noise and sonic boom consultations to major commands and individual airbases.

EDUCATION

Ph.D., Mechanical Engineering, Georgia Institute of Technology	1993
M.S., Aeronautics, George Washington University	1988
B.S., *cum laude*, Physics, Davidson College	1986

APPENDIX B

MATERIAL SAFETY DATA SHEETS

SAFETY DATA SHEET

Oxygen, Refrigerated Liquid

Airgas
an Air Liquide company

Section 1. Identification

GHS product identifier : Oxygen, Refrigerated Liquid

Chemical name : Oxygen Refrigerated Liquid

Other means of identification : Liquid Oxygen; LOX; Liquid Oxygen USP

Product type : Liquefied gas

Product use : Synthetic/Analytical chemistry.

Synonym : Liquid Oxygen; LOX; Liquid Oxygen USP

SDS # : 001190

Supplier's details : Airgas USA, LLC and its affiliates
259 North Radnor-Chester Road
Suite 100
Radnor, PA 19087-5283
1-610-687-5253

24-hour telephone : 1-866-734-3438

Section 2. Hazards identification

OSHA/HCS status : This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Classification of the substance or mixture : OXIDIZING GASES - Category 1
GASES UNDER PRESSURE - Refrigerated liquefied gas

GHS label elements

Hazard pictograms :

Signal word : Danger

Hazard statements : May cause or intensify fire; oxidizer.
Contains refrigerated gas; may cause cryogenic burns or injury.
May cause frostbite.
Combustibles in contact with Liquid Oxygen may explode on ignition or impact.

Precautionary statements

General : Read and follow all Safety Data Sheets (SDS'S) before use. Read label before use. Keep out of reach of children. If medical advice is needed, have product container or label at hand. Close valve after each use and when empty. Use equipment rated for cylinder pressure. Do not open valve until connected to equipment prepared for use. Use a back flow preventative device in the piping. Use only equipment of compatible materials of construction. Open valve slowly. Use only with equipment cleaned for Oxygen service. Always keep container in upright position. Do not change or force fit connections. Avoid spills. Do not walk or roll equipment over spills.

Prevention : Wear cold insulating gloves and face shield. Keep away from clothing, incompatible materials and combustible materials. Keep reduction valves free from grease and oil. Use and store only outdoors or in a well ventilated place.

Response : Thaw frosted parts with lukewarm water. Do not rub affected area. Get immediate medical advice/attention. In case of fire: Stop leak if safe to do so.

Storage : Store in a well-ventilated place.

Disposal : Not applicable.

Hazards not otherwise classified : Liquid can cause burns similar to frostbite.

Section 3. Composition/information on ingredients

Substance/mixture : Substance

Chemical name : Oxygen Refrigerated Liquid

Other means of identification : Liquid Oxygen; LOX; Liquid Oxygen USP

Product code : 001190

CAS number/other identifiers

CAS number : 7782-44-7

Ingredient name	%	CAS number
Oxygen Refrigerated Liquid	100	7782-44-7

Any concentration shown as a range is to protect confidentiality or is due to batch variation.

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Description of necessary first aid measures

Eye contact : Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 minutes. Get medical attention.

Inhalation : Remove victim to fresh air and keep at rest in a position comfortable for breathing. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention if adverse health effects persist or are severe. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Skin contact : Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur. In case of contact with liquid, warm frozen tissues slowly with lukewarm water and get medical attention. Do not rub affected area. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion : Remove victim to fresh air and keep at rest in a position comfortable for breathing. Get medical attention if adverse health effects persist or are severe. Ingestion of liquid can cause burns similar to frostbite. If frostbite occurs, get medical attention. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband. As this product rapidly becomes a gas when released, refer to the inhalation section.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact : Extremely cold material. Liquid can cause burns similar to frostbite.

Inhalation : No known significant effects or critical hazards.

Skin contact : Extremely cold material. Dermal contact with rapidly evaporating liquid could result in freezing of the tissues or frostbite.

Frostbite : Try to warm up the frozen tissues and seek medical attention.

Ingestion : Ingestion of liquid can cause burns similar to frostbite.

Over-exposure signs/symptoms

Eye contact : Adverse symptoms may include the following:, frostbite

Inhalation : No specific data.

Skin contact : Adverse symptoms may include the following:, frostbite

Ingestion : Adverse symptoms may include the following:, frostbite

Section 4. First aid measures

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.

Specific treatments : No specific treatment.

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media : Use an extinguishing agent suitable for the surrounding fire.

Unsuitable extinguishing media : None known.

Specific hazards arising from the chemical : Contains gas under pressure. Contains refrigerated gas. Oxidizing material. This material increases the risk of fire and may aid combustion. Contact with combustible material may cause fire. In a fire or if heated, a pressure increase will occur and the container may burst or explode.

Hazardous thermal decomposition products : No specific data.

Special protective actions for fire-fighters : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Contact supplier immediately for specialist advice. Move containers from fire area if this can be done without risk. Use water spray to keep fire-exposed containers cool.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode. For incidents involving large quantities, thermally insulated undergarments and thick textile or leather gloves should be worn.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel : No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Shut off all ignition sources. No flares, smoking or flames in hazard area. Avoid breathing gas. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders : If specialized clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions : Ensure emergency procedures to deal with accidental gas releases are in place to avoid contamination of the environment. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Small spill : Immediately contact emergency personnel. Stop leak if without risk. Use spark-proof tools and explosion-proof equipment.

Section 6. Accidental release measures

Large spill : Immediately contact emergency personnel. Stop leak if without risk. Use spark-proof tools and explosion-proof equipment. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Protective measures : Put on appropriate personal protective equipment (see Section 8). Contains gas under pressure. Contains refrigerated gas. Do not get in eyes or on skin or clothing. Avoid breathing gas. Do not puncture or incinerate container. Use equipment rated for cylinder pressure. Close valve after each use and when empty. Protect cylinders from physical damage; do not drag, roll, slide, or drop. Use a suitable hand truck for cylinder movement.

Never allow any unprotected part of the body to touch uninsulated pipes or vessels that contain cryogenic liquids. Prevent entrapment of liquid in closed systems or piping without pressure relief devices. Some materials may become brittle at low temperatures and will easily fracture. Empty containers retain product residue and can be hazardous. Keep away from clothing, incompatible materials and combustible materials. Keep reduction valves free from grease and oil.

Advice on general occupational hygiene : Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.

Conditions for safe storage, including any incompatibilities : Store in accordance with local regulations. Store in a segregated and approved area. Store in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10). Cylinders should be stored upright, with valve protection cap in place, and firmly secured to prevent falling or being knocked over. Cylinder temperatures should not exceed 52 °C (125 °F). Separate from reducing agents and combustible materials. Store away from grease and oil. Keep container tightly closed and sealed until ready for use. See Section 10 for incompatible materials before handling or use.

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

Ingredient name	Exposure limits
Oxygen Refrigerated Liquid	None.

Appropriate engineering controls : Good general ventilation should be sufficient to control worker exposure to airborne contaminants.

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Eye/face protection : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: safety glasses with side-shields.

Skin protection

Section 8. Exposure controls/personal protection

Hand protection	Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. If contact with the liquid is possible, insulated gloves suitable for low temperatures should be worn. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated.
Body protection	Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.
Other skin protection	Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.
Respiratory protection	Based on the hazard and potential for exposure, select a respirator that meets the appropriate standard or certification. Respirators must be used according to a respiratory protection program to ensure proper fitting, training, and other important aspects of use.
Thermal hazards	If there is a risk of contact with the liquid, all protective equipment worn should be suitable for use with extremely low temperature materials.

Section 9. Physical and chemical properties

Appearance

Physical state	Cryogenic Liquid
Color	Colorless. Blue.
Odor	Odorless.
Odor threshold	Not available.
pH	Not available.
Melting point	-218.4°C (-361.1°F)
Boiling point	-183°C (-297.4°F)
Critical temperature	-118.15°C (-180.7°F)
Flash point	[Product does not sustain combustion.]
Evaporation rate	Not available.
Flammability (solid, gas)	Extremely flammable in the presence of the following materials or conditions: reducing materials, combustible materials and organic materials.
Lower and upper explosive (flammable) limits	Not available.
Vapor pressure	Not available.
Vapor density	1.1 (Air = 1)
Specific Volume (ft ^{3}/lb)	12.0482
Gas Density (lb/ft ^{3})	0.083
Relative density	Not applicable.
Solubility	Not available.
Solubility in water	Not available.
Partition coefficient: n-octanol/water	0.65
Auto-ignition temperature	Not available.
Decomposition temperature	Not available.
Viscosity	Not applicable.
Flow time (ISO 2431)	Not available.
Molecular weight	32 g/mole

Section 10. Stability and reactivity

Reactivity	: No specific test data related to reactivity available for this product or its ingredients.
Chemical stability	: The product is stable.
Possibility of hazardous reactions	: Under normal conditions of storage and use, hazardous reactions will not occur.
Conditions to avoid	: No specific data.
Incompatible materials	: Highly reactive or incompatible with the following materials: combustible materials reducing materials grease oil
Hazardous decomposition products	: Under normal conditions of storage and use, hazardous decomposition products should not be produced.
Hazardous polymerization	: Under normal conditions of storage and use, hazardous polymerization will not occur.

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity

Not available.

Irritation/Corrosion

Not available.

Sensitization

Not available.

Mutagenicity

Not available.

Carcinogenicity

Not available.

Reproductive toxicity

Not available.

Teratogenicity

Not available.

Specific target organ toxicity (single exposure)

Not available.

Specific target organ toxicity (repeated exposure)

Not available.

Aspiration hazard

Not available.

Information on the likely routes of exposure : Not available.

Potential acute health effects

Section 11. Toxicological information

Eye contact : Extremely cold material. Liquid can cause burns similar to frostbite.

Inhalation : No known significant effects or critical hazards.

Skin contact : Extremely cold material. Dermal contact with rapidly evaporating liquid could result in freezing of the tissues or frostbite.

Ingestion : Ingestion of liquid can cause burns similar to frostbite.

Symptoms related to the physical, chemical and toxicological characteristics

Eye contact : Adverse symptoms may include the following:, frostbite

Inhalation : No specific data.

Skin contact : Adverse symptoms may include the following:, frostbite

Ingestion : Adverse symptoms may include the following:, frostbite

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Long term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Potential chronic health effects

Not available.

General : No known significant effects or critical hazards.

Carcinogenicity : No known significant effects or critical hazards.

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : No known significant effects or critical hazards.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : No known significant effects or critical hazards.

Numerical measures of toxicity

Acute toxicity estimates

Not available.

Section 12. Ecological information

Toxicity

Not available.

Persistence and degradability

Not available.

Bioaccumulative potential

Product/ingredient name	LogP_{ow}	BCF	Potential
Oxygen Refrigerated Liquid	0.65	-	low

Mobility in soil

Section 12. Ecological information

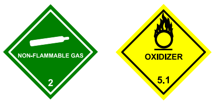
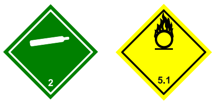
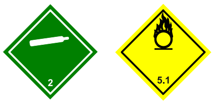
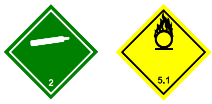
Soil/water partition coefficient (K_{oc}) : Not available.

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods : The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Waste should not be disposed of untreated to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Empty Airgas-owned pressure vessels should be returned to Airgas. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Empty containers or liners may retain some product residues. Do not puncture or incinerate container.

Section 14. Transport information

	DOT	**TDG**	**Mexico**	**IMDG**	**IATA**
UN number	UN1073	UN1073	UN1073	UN1073	UN1073
UN proper shipping name	Oxygen, Refrigerated Liquid	Oxygen, Refrigerated Liquid	Oxygen, Refrigerated Liquid	Oxygen, Refrigerated Liquid	Oxygen, Refrigerated Liquid
Transport hazard class(es)	2.2 (5.1) 	2.2 	2.2 (5.1) 	2.2 (5.1) 	2.2 (5.1) 
Packing group	-	-	-	-	-
Environmental hazards	No.	No.	No.	No.	No.

"Refer to CFR 49 (or authority having jurisdiction) to determine the information required for shipment of the product."

Additional information

DOT Classification : **Limited quantity** Yes.
Quantity limitation Passenger aircraft/rail: 75 kg. Cargo aircraft: 150 kg.
Special provisions A52

TDG Classification : Product classified as per the following sections of the Transportation of Dangerous Goods Regulations: 2.13-2.17 (Class 2), 2.23-2.25 (Class 5).
Explosive Limit and Limited Quantity Index 0.125
ERAP Index 3000
Passenger Carrying Ship Index 50
Passenger Carrying Road or Rail Index 75
Special provisions 42

IATA : **Quantity limitation** Passenger and Cargo Aircraft: 75 kg. Cargo Aircraft Only: 150 kg.

Special precautions for user : **Transport within user's premises:** always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Section 14. Transport information

Transport in bulk according to Annex II of MARPOL and the IBC Code : Not available.

Section 15. Regulatory information

U.S. Federal regulations : **TSCA 8(a) CDR Exempt/Partial exemption**: This material is listed or exempted.

Clean Air Act Section 112 (b) Hazardous Air Pollutants (HAPs) : Not listed

Clean Air Act Section 602 Class I Substances : Not listed

Clean Air Act Section 602 Class II Substances : Not listed

DEA List I Chemicals (Precursor Chemicals) : Not listed

DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 302/304

Composition/information on ingredients

No products were found.

SARA 304 RQ : Not applicable.

SARA 311/312

Classification : Refer to Section 2: Hazards Identification of this SDS for classification of substance.

State regulations

Massachusetts : This material is listed.

New York : This material is not listed.

New Jersey : This material is listed.

Pennsylvania : This material is listed.

International regulations

Chemical Weapon Convention List Schedules I, II & III Chemicals

Not listed.

Montreal Protocol (Annexes A, B, C, E)

Not listed.

Stockholm Convention on Persistent Organic Pollutants

Not listed.

Rotterdam Convention on Prior Informed Consent (PIC)

Not listed.

UNECE Aarhus Protocol on POPs and Heavy Metals

Not listed.

Inventory list

Australia : This material is listed or exempted.

Canada : This material is listed or exempted.

China : This material is listed or exempted.

Europe : This material is listed or exempted.

Japan : **Japan inventory (ENCS)**: Not determined.
Japan inventory (ISHL): Not determined.

Malaysia : Not determined.

Section 15. Regulatory information

New Zealand	:	This material is listed or exempted.
Philippines	:	This material is listed or exempted.
Republic of Korea	:	This material is listed or exempted.
Taiwan	:	This material is listed or exempted.
Thailand	:	Not determined.
Turkey	:	Not determined.
United States	:	This material is listed or exempted.
Viet Nam	:	Not determined.

Section 16. Other information

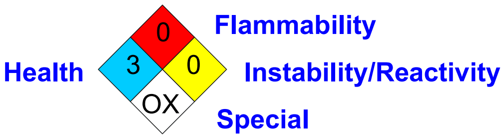
Hazardous Material Information System (U.S.A.)

Health	/	3
Flammability		0
Physical hazards		2

Caution: HMIS® ratings are based on a 0-4 rating scale, with 0 representing minimal hazards or risks, and 4 representing significant hazards or risks. Although HMIS® ratings and the associated label are not required on SDSs or products leaving a facility under 29 CFR 1910.1200, the preparer may choose to provide them. HMIS® ratings are to be used with a fully implemented HMIS® program. HMIS® is a registered trademark and service mark of the American Coatings Association, Inc.

The customer is responsible for determining the PPE code for this material. For more information on HMIS® Personal Protective Equipment (PPE) codes, consult the HMIS® Implementation Manual.

National Fire Protection Association (U.S.A.)



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Copyright ©2001, National Fire Protection Association, Quincy, MA 02269. This warning system is intended to be interpreted and applied only by properly trained individuals to identify fire, health and reactivity hazards of chemicals. The user is referred to certain limited number of chemicals with recommended classifications in NFPA 49 and NFPA 325, which would be used as a guideline only. Whether the chemicals are classified by NFPA or not, anyone using the 704 systems to classify chemicals does so at their own risk.

Procedure used to derive the classification

Classification	Justification
OXIDIZING GASES - Category 1 GASES UNDER PRESSURE - Refrigerated liquefied gas	Expert judgment Expert judgment

History

Date of printing	:	1/31/2018
Date of issue/Date of revision	:	1/31/2018
Date of previous issue	:	2/12/2016
Version	:	0.02

Section 16. Other information

Key to abbreviations : ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
UN = United Nations

References : Not available.

◤ **Indicates information that has changed from previously issued version.**

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

SAFETY DATA SHEET

Nitrogen, Refrigerated Liquid

Airgas
an Air Liquide company

Section 1. Identification

GHS product identifier : Nitrogen, Refrigerated Liquid

Chemical name : NITROGEN, REFRIGERATED LIQUID

Other means of identification : LIN, Cryogenic Liquid Nitrogen, Liquid Nitrogen, Liquid Nitrogen NF, Liquid Nitrogen FG

Product type : Liquefied gas

Product use : Synthetic/Analytical chemistry.

Synonym : LIN, Cryogenic Liquid Nitrogen, Liquid Nitrogen, Liquid Nitrogen NF, Liquid Nitrogen FG

SDS # : 001188

Supplier's details :

Airgas USA, LLC and its affiliates
259 North Radnor-Chester Road
Suite 100
Radnor, PA 19087-5283
1-610-687-5253

24-hour telephone : 1-866-734-3438

Section 2. Hazards identification

OSHA/HCS status : This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Classification of the substance or mixture : GASES UNDER PRESSURE - Refrigerated liquefied gas

GHS label elements

Hazard pictograms :

Signal word : Warning

Hazard statements :

Contains refrigerated gas; may cause cryogenic burns or injury.
May cause frostbite.
May displace oxygen and cause rapid suffocation.

Precautionary statements

General : Read and follow all Safety Data Sheets (SDS'S) before use. Read label before use. Keep out of reach of children. If medical advice is needed, have product container or label at hand. Close valve after each use and when empty. Use equipment rated for cylinder pressure. Do not open valve until connected to equipment prepared for use. Use a back flow preventative device in the piping. Use only equipment of compatible materials of construction. Always keep container in upright position. Do not change or force fit connections. Avoid spills. Do not walk or roll equipment over spills.

Prevention :

Wear cold insulating gloves and face shield.
Use and store only outdoors or in a well ventilated place.

Response : Thaw frosted parts with lukewarm water. Do not rub affected area. Get immediate medical advice/attention.

Storage : Store in a well-ventilated place.

Disposal : Not applicable.

Hazards not otherwise classified : Liquid can cause burns similar to frostbite.

Section 3. Composition/information on ingredients

Substance/mixture	:	Substance
Chemical name	:	NITROGEN, REFRIGERATED LIQUID
Other means of identification	:	LIN, Cryogenic Liquid Nitrogen, Liquid Nitrogen, Liquid Nitrogen NF, Liquid Nitrogen FG
Product code	:	001188

CAS number/other identifiers

CAS number : 7727-37-9

Ingredient name	%	CAS number
NITROGEN, REFRIGERATED LIQUID	100	7727-37-9

Any concentration shown as a range is to protect confidentiality or is due to batch variation.

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Description of necessary first aid measures

Eye contact	:	Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 minutes. Get medical attention if irritation occurs.
Inhalation	:	Remove victim to fresh air and keep at rest in a position comfortable for breathing. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention if adverse health effects persist or are severe. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband. In case of inhalation of decomposition products in a fire, symptoms may be delayed. The exposed person may need to be kept under medical surveillance for 48 hours.
Skin contact	:	Wash contaminated skin with soap and water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur. In case of contact with liquid, warm frozen tissues slowly with lukewarm water and get medical attention. Do not rub affected area. Wash clothing before reuse. Clean shoes thoroughly before reuse.
Ingestion	:	Remove victim to fresh air and keep at rest in a position comfortable for breathing. Get medical attention if adverse health effects persist or are severe. Ingestion of liquid can cause burns similar to frostbite. If frostbite occurs, get medical attention. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband. As this product rapidly becomes a gas when released, refer to the inhalation section.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact	:	Extremely cold material. Liquid can cause burns similar to frostbite.
Inhalation	:	No known significant effects or critical hazards.
Skin contact	:	Extremely cold material. Dermal contact with rapidly evaporating liquid could result in freezing of the tissues or frostbite.
Frostbite	:	Try to warm up the frozen tissues and seek medical attention.
Ingestion	:	Ingestion of liquid can cause burns similar to frostbite.

Over-exposure signs/symptoms

Eye contact	:	Adverse symptoms may include the following:, frostbite
Inhalation	:	No specific data.

Section 4. First aid measures

Skin contact : Adverse symptoms may include the following:, frostbite

Ingestion : Adverse symptoms may include the following:, frostbite

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician : In case of inhalation of decomposition products in a fire, symptoms may be delayed. The exposed person may need to be kept under medical surveillance for 48 hours.

Specific treatments : No specific treatment.

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media : Use an extinguishing agent suitable for the surrounding fire.

Unsuitable extinguishing media : None known.

Specific hazards arising from the chemical : Contains gas under pressure. Contains refrigerated gas. In a fire or if heated, a pressure increase will occur and the container may burst or explode.

Hazardous thermal decomposition products : Decomposition products may include the following materials:
nitrogen oxides

Special protective actions for fire-fighters : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Contact supplier immediately for specialist advice. Move containers from fire area if this can be done without risk. Use water spray to keep fire-exposed containers cool.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode. For incidents involving large quantities, thermally insulated undergarments and thick textile or leather gloves should be worn.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel : No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Avoid breathing gas. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders : If specialized clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions : Ensure emergency procedures to deal with accidental gas releases are in place to avoid contamination of the environment. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Small spill : Immediately contact emergency personnel. Stop leak if without risk.

Large spill : Immediately contact emergency personnel. Stop leak if without risk. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Protective measures : Put on appropriate personal protective equipment (see Section 8). Contains gas under pressure. Contains refrigerated gas. Do not get in eyes or on skin or clothing. Avoid breathing gas. Do not puncture or incinerate container. Use equipment rated for cylinder pressure. Close valve after each use and when empty. Protect cylinders from physical damage; do not drag, roll, slide, or drop. Use a suitable hand truck for cylinder movement.

Never allow any unprotected part of the body to touch uninsulated pipes or vessels that contain cryogenic liquids. Prevent entrapment of liquid in closed systems or piping without pressure relief devices. Some materials may become brittle at low temperatures and will easily fracture. Empty containers retain product residue and can be hazardous.

Advice on general occupational hygiene : Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.

Conditions for safe storage, including any incompatibilities : Store in accordance with local regulations. Store in a segregated and approved area. Store in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10). Cylinders should be stored upright, with valve protection cap in place, and firmly secured to prevent falling or being knocked over. Cylinder temperatures should not exceed 52 °C (125 °F). Keep container tightly closed and sealed until ready for use. See Section 10 for incompatible materials before handling or use.

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

Ingredient name	Exposure limits
NITROGEN, REFRIGERATED LIQUID	None.

Appropriate engineering controls : Good general ventilation should be sufficient to control worker exposure to airborne contaminants.

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Eye/face protection : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: safety glasses with side-shields.

Skin protection

Hand protection : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. If contact with the liquid is possible, insulated gloves suitable for low temperatures should be worn. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated.

Section 8. Exposure controls/personal protection

Body protection : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection : Based on the hazard and potential for exposure, select a respirator that meets the appropriate standard or certification. Respirators must be used according to a respiratory protection program to ensure proper fitting, training, and other important aspects of use.

Thermal hazards : If there is a risk of contact with the liquid, all protective equipment worn should be suitable for use with extremely low temperature materials.

Section 9. Physical and chemical properties

Appearance

Physical state : Liquid. [Cryogenic liquid]

Color : Colorless.

Odor : Odorless.

Odor threshold : Not available.

pH : Not available.

Melting point : -210°C (-346°F)

Boiling point : -195.8 °C

Critical temperature : -146.95°C (-232.5°F)

Flash point : Not applicable.

Evaporation rate : Not available.

Flammability (solid, gas) : Not available.

Lower and upper explosive (flammable) limits : Not available.

Vapor pressure : Not available.

Vapor density : 0.967 (Air = 1) Liquid Density@BP: 50.46 lb/ft3 (808.3 kg/m3)

Specific Volume (ft ^{3}/lb) : 13.8889

Gas Density (lb/ft ^{3}) : 0.072

Relative density : Not available.

Solubility : Not available.

Solubility in water : 0.023 g/l

Partition coefficient: n-octanol/water : 0.67

Auto-ignition temperature : Not available.

Decomposition temperature : Not available.

Viscosity : Not available.

Flow time (ISO 2431) : Not available.

Molecular weight : 28.01 g/mole

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.

Chemical stability : The product is stable.

Possibility of hazardous reactions : Under normal conditions of storage and use, hazardous reactions will not occur.

Conditions to avoid : No specific data.

Section 10. Stability and reactivity

Incompatible materials : No specific data.

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Hazardous polymerization : Under normal conditions of storage and use, hazardous polymerization will not occur.

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity

Not available.

Irritation/Corrosion

Not available.

Sensitization

Not available.

Mutagenicity

Not available.

Carcinogenicity

Not available.

Reproductive toxicity

Not available.

Teratogenicity

Not available.

Specific target organ toxicity (single exposure)

Not available.

Specific target organ toxicity (repeated exposure)

Not available.

Aspiration hazard

Not available.

Information on the likely routes of exposure : Not available.

Potential acute health effects

Eye contact : Extremely cold material. Liquid can cause burns similar to frostbite.
Inhalation : No known significant effects or critical hazards.
Skin contact : Extremely cold material. Dermal contact with rapidly evaporating liquid could result in freezing of the tissues or frostbite.
Ingestion : Ingestion of liquid can cause burns similar to frostbite.

Symptoms related to the physical, chemical and toxicological characteristics

Eye contact : Adverse symptoms may include the following:, frostbite
Inhalation : No specific data.
Skin contact : Adverse symptoms may include the following:, frostbite
Ingestion : Adverse symptoms may include the following:, frostbite

Section 11. Toxicological information

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Long term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Potential chronic health effects

Not available.

General : No known significant effects or critical hazards.

Carcinogenicity : No known significant effects or critical hazards.

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : No known significant effects or critical hazards.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : No known significant effects or critical hazards.

Numerical measures of toxicity

Acute toxicity estimates

Not available.

Section 12. Ecological information

Toxicity

Not available.

Persistence and degradability

Not available.

Bioaccumulative potential

Product/ingredient name	$\log P_{ow}$	BCF	Potential
NITROGEN, REFRIGERATED LIQUID	0.67	-	low

Mobility in soil

Soil/water partition coefficient (K_{OC}) : Not available.

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods : The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Waste should not be disposed of untreated to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Empty Airgas-owned pressure vessels should be returned to Airgas. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Empty containers or liners may retain some product residues. Do not puncture or incinerate container.

Section 14. Transport information

	DOT	**TDG**	**Mexico**	**IMDG**	**IATA**
UN number	UN1977	UN1977	UN1977	UN1977	UN1977
UN proper shipping name	NITROGEN, REFRIGERATED LIQUID	NITROGEN, REFRIGERATED LIQUID	NITROGEN, REFRIGERATED LIQUID	NITROGEN, REFRIGERATED LIQUID	NITROGEN, REFRIGERATED LIQUID
Transport hazard class(es)	2.2 	2.2 	2.2 	2.2 	2.2 
Packing group	-	-	-	-	-
Environmental hazards	No.	No.	No.	No.	No.

“Refer to CFR 49 (or authority having jurisdiction) to determine the information required for shipment of the product.”

Additional information

DOT Classification : **Limited quantity** Yes.
Quantity limitation Passenger aircraft/rail: 75 kg. Cargo aircraft: 150 kg.

TDG Classification : Product classified as per the following sections of the Transportation of Dangerous Goods Regulations: 2.13-2.17 (Class 2).
Explosive Limit and Limited Quantity Index 0.125
Passenger Carrying Road or Rail Index 75

IATA : **Passenger and Cargo Aircraft**Quantity limitation: 50 kg
Cargo Aircraft Only Quantity limitation: 500 kg

Special precautions for user : **Transport within user’s premises:** always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Transport in bulk according to Annex II of MARPOL and the IBC Code : Not available.

Section 15. Regulatory information

U.S. Federal regulations : **TSCA 8(a) CDR Exempt/Partial exemption**: This material is listed or exempted.

Clean Air Act Section 112 (b) Hazardous Air Pollutants (HAPs) : Not listed

Clean Air Act Section 602 Class I Substances : Not listed

Clean Air Act Section 602 Class II Substances : Not listed

DEA List I Chemicals (Precursor Chemicals) : Not listed

DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 302/304

Composition/information on ingredients

No products were found.

SARA 304 RQ : Not applicable.

SARA 311/312

Classification : Refer to Section 2: Hazards Identification of this SDS for classification of substance.

State regulations

Massachusetts : This material is listed.
New York : This material is not listed.
New Jersey : This material is listed.
Pennsylvania : This material is listed.

International regulations

Chemical Weapon Convention List Schedules I, II & III Chemicals

Not listed.

Montreal Protocol (Annexes A, B, C, E)

Not listed.

Stockholm Convention on Persistent Organic Pollutants

Not listed.

Rotterdam Convention on Prior Informed Consent (PIC)

Not listed.

UNECE Aarhus Protocol on POPs and Heavy Metals

Not listed.

Inventory list

Australia : This material is listed or exempted.
Canada : This material is listed or exempted.
China : This material is listed or exempted.
Europe : This material is listed or exempted.
Japan : **Japan inventory (ENCS)**: Not determined.
Japan inventory (ISHL): Not determined.
Malaysia : Not determined.
New Zealand : This material is listed or exempted.
Philippines : This material is listed or exempted.
Republic of Korea : This material is listed or exempted.

Section 15. Regulatory information

Taiwan : Not determined.
Thailand : Not determined.
Turkey : Not determined.
United States : This material is listed or exempted.
Viet Nam : Not determined.

Section 16. Other information

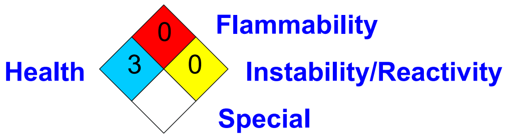
Hazardous Material Information System (U.S.A.)

Health	/	3
Flammability		0
Physical hazards		0

Caution: HMIS® ratings are based on a 0-4 rating scale, with 0 representing minimal hazards or risks, and 4 representing significant hazards or risks. Although HMIS® ratings and the associated label are not required on SDSs or products leaving a facility under 29 CFR 1910.1200, the preparer may choose to provide them. HMIS® ratings are to be used with a fully implemented HMIS® program. HMIS® is a registered trademark and service mark of the American Coatings Association, Inc.

The customer is responsible for determining the PPE code for this material. For more information on HMIS® Personal Protective Equipment (PPE) codes, consult the HMIS® Implementation Manual.

National Fire Protection Association (U.S.A.)



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Copyright ©2001, National Fire Protection Association, Quincy, MA 02269. This warning system is intended to be interpreted and applied only by properly trained individuals to identify fire, health and reactivity hazards of chemicals. The user is referred to certain limited number of chemicals with recommended classifications in NFPA 49 and NFPA 325, which would be used as a guideline only. Whether the chemicals are classified by NFPA or not, anyone using the 704 systems to classify chemicals does so at their own risk.

Procedure used to derive the classification

Classification	Justification
GASES UNDER PRESSURE - Refrigerated liquefied gas	Expert judgment

History

Date of printing : 7/16/2018
Date of issue/Date of revision : 7/16/2018
Date of previous issue : 1/30/2018
Version : 1

Key to abbreviations :
ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)

Section 16. Other information

UN = United Nations

References : Not available.

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

Safety Data Sheet

Material Name: Kerosene K1 and K2 **SDS No. 0290**

US GHS

Synonyms: K-1 and K-2 Kerosene; Kero; Kerosene Motor Fuel; Tax Exempt Kerosene; #1 Diesel; #1 Distillate; Dyed Kerosene

* * * Section 1 - Product and Company Identification * * *

Manufacturer Information

Hess Corporation
1 Hess Plaza
Woodbridge, NJ 07095-0961

Phone: 732-750-6000 Corporate EHS
Emergency # 800-424-9300 CHEMTREC
www.hess.com (Environment, Health, Safety Internet Website)

* * * Section 2 - Hazards Identification * * *

GHS Classification:

Flammable Liquids - Category 3
Skin Corrosion/Irritation – Category 2
Eye Damage/Irritation – Category 2B
Carcinogenicity – Category 2
Specific Target Organ Toxicity (Single Exposure) – Category 3 (respiratory irritation, narcosis)
Aspiration Hazard - Category 1

GHS LABEL ELEMENTS

Symbol(s)

Signal Word

Danger

Hazard Statements

Flammable liquid and vapor.
Causes skin irritation.
Causes eye irritation.
Suspected of causing cancer.
May cause respiratory irritation.
May cause drowsiness or dizziness.
May be fatal if swallowed and enters airways.

Precautionary Statements

Prevention

Keep away from heat/sparks/open flames/hot surfaces. No smoking
Keep container tightly closed.
Ground/bond container and receiving equipment.
Use explosion-proof electrical/ventilating/lighting/equipment.

Use only non-sparking tools.
Take precautionary measures against static discharge.
Wear protective gloves/protective clothing/eye protection/face protection.
Wash hands and forearms thoroughly after handling.
Obtain special instructions before use.
Do not handle until all safety precautions have been read and understood.
Avoid breathing fume/mist/vapors/spray.
Use only outdoors or in a well-ventilated area.

Response
In case of fire: Use water spray, fog or foam.
IF ON SKIN (or hair): Wash with plenty of soap and water. Remove/Take off immediately all contaminated clothing and wash before reuse. If skin irritation occurs: Get medical advice/attention.
If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. If eye irritation persists: Get medical advice/attention.
If exposed or concerned: Get medical advice/attention.
If inhaled: Remove person to fresh air and keep comfortable for breathing. Call a poison center or doctor if you feel unwell.
IF SWALLOWED: Immediately call a poison center or doctor/physician. Do NOT induce vomiting.

Storage
Store in a well-ventilated place. Keep cool.
Keep container tightly closed.
Store locked up.

Disposal
Dispose of contents/container in accordance with local/regional/national/international regulations.

* * * Section 3 - Composition / Information on Ingredients * * *

CAS #	Component	Percent
8008-20-6	Kerosene	100
91-20-3	Naphthalene	0.04

A complex combination of hydrocarbons including naphthenes, paraffins, and aromatics.

* * * Section 4 - First Aid Measures * * *

First Aid: Eyes

In case of contact with eyes, immediately flush with clean, low-pressure water for at least 15 min. Hold eyelids open to ensure adequate flushing. Seek medical attention.

First Aid: Skin

Remove contaminated clothing. Wash contaminated areas thoroughly with soap and water or with waterless hand cleanser. Obtain medical attention if irritation or redness develops. Thermal burns require immediate medical attention depending on the severity and the area of the body burned.

First Aid: Ingestion

DO NOT INDUCE VOMITING. Do not give liquids. Obtain immediate medical attention. If spontaneous vomiting occurs, lean victim forward to reduce the risk of aspiration. Monitor for breathing difficulties. Small amounts of material which enter the mouth should be rinsed out until the taste is dissipated.

First Aid: Inhalation

Remove person to fresh air. If person is not breathing, provide artificial respiration. If necessary, provide additional oxygen once breathing is restored if trained to do so. Seek medical attention immediately.

* * * Section 5 - Fire Fighting Measures * * *

General Fire Hazards

See Section 9 for Flammability Properties.

Vapors may be ignited rapidly when exposed to heat, spark, open flame or other source of ignition. When mixed with air and exposed to an ignition source, flammable vapors can burn in the open or explode in confined spaces. Being heavier than air, vapors may travel long distances to an ignition source and flash back. Runoff to sewer may cause fire or explosion hazard.

Hazardous Combustion Products

Carbon monoxide, carbon dioxide and non-combusted hydrocarbons (smoke).

Extinguishing Media

SMALL FIRES: Any extinguisher suitable for Class B fires, dry chemical, CO2, water spray, fire fighting foam, and other gaseous agents.

LARGE FIRES: Water spray, fog or fire fighting foam. Water may be ineffective for fighting the fire, but may be used to cool fire-exposed containers.

Unsuitable Extinguishing Media

None

Fire Fighting Equipment/Instructions

Small fires in the incipient (beginning) stage may typically be extinguished using handheld portable fire extinguishers and other fire fighting equipment. Firefighting activities that may result in potential exposure to high heat, smoke or toxic by-products of combustion should require NIOSH/MSHA- approved pressure-demand self-contained breathing apparatus with full facepiece and full protective clothing. Isolate area around container involved in fire. Cool tanks, shells, and containers exposed to fire and excessive heat with water. For massive fires the use of unmanned hose holders or monitor nozzles may be advantageous to further minimize personnel exposure. Major fires may require withdrawal, allowing the tank to burn. Large storage tank fires typically require specially trained personnel and equipment to extinguish the fire, often including the need for properly applied fire fighting foam.

* * * Section 6 - Accidental Release Measures * * *

Recovery and Neutralization

Carefully contain and stop the source of the spill, if safe to do so.

Materials and Methods for Clean-Up

Take up with sand or other oil absorbing materials. Carefully shovel, scoop or sweep up into a waste container for reclamation or disposal. Caution, flammable vapors may accumulate in closed containers.

Emergency Measures

Evacuate nonessential personnel and remove or secure all ignition sources. Consider wind direction; stay upwind and uphill, if possible. Evaluate the direction of product travel, diking, sewers, etc. to confirm spill areas. Spills may infiltrate subsurface soil and groundwater; professional assistance may be necessary to determine the extent of subsurface impact.

Personal Precautions and Protective Equipment

Response and clean-up crews must be properly trained and must utilize proper protective equipment (see Section 8).

Environmental Precautions

Protect bodies of water by diking, absorbents, or absorbent boom, if possible. Do not flush down sewer or drainage systems, unless system is designed and permitted to handle such material. The use of fire fighting foam may be useful in certain situations to reduce vapors. The proper use of water spray may effectively disperse product vapors or the liquid itself, preventing contact with ignition sources or areas/equipment that require protection.

Prevention of Secondary Hazards

None

* * * Section 7 - Handling and Storage * * *

Handling Procedures

Handle as a combustible liquid. Keep away from heat, sparks, excessive temperatures and open flame! No smoking or open flame in storage, use or handling areas. Bond and ground containers during product transfer to reduce the possibility of static-initiated fire or explosion.

Special slow load procedures for "switch loading" must be followed to avoid the static ignition hazard that can exist when higher flash point material (such as fuel oil) is loaded into tanks previously containing low flash point products (such as this product) - see API Publication 2003, "Protection Against Ignitions Arising Out Of Static, Lightning and Stray Currents."

Storage Procedures

Keep away from flame, sparks, excessive temperatures and open flame. Use approved vented containers. Keep containers closed and clearly labeled. Empty product containers or vessels may contain explosive vapors. Do not pressurize, cut, heat, weld or expose such containers to sources of ignition.

Store in a well-ventilated area. This storage area should comply with NFPA 30 "Flammable and Combustible Liquid Code". Avoid storage near incompatible materials. The cleaning of tanks previously containing this product should follow API Recommended Practice (RP) 2013 "Cleaning Mobile Tanks In Flammable and Combustible Liquid Service" and API RP 2015 "Cleaning Petroleum Storage Tanks."

Incompatibilities

Keep away from strong oxidizers.

* * * Section 8 - Exposure Controls / Personal Protection * * *

Component Exposure Limits

Kerosene (8008-20-6)

ACGIH: 200 mg/m3 TWA (application restricted to conditions in which there are negligible aerosol exposures, total hydrocarbon vapor)
Skin - potential significant contribution to overall exposure by the cutaneous route
NIOSH: 100 mg/m3 TWA

Naphthalene (91-20-3)

ACGIH: 10 ppm TWA
15 ppm STEL
Skin - potential significant contribution to overall exposure by the cutaneous route
OSHA: 10 ppm TWA; 50 mg/m3 TWA
NIOSH: 10 ppm TWA; 50 mg/m3 TWA
15 ppm STEL; 75 mg/m3 STEL

Engineering Measures

Use adequate ventilation to keep vapor concentrations of this product below occupational exposure and flammability limits, particularly in confined spaces.

Personal Protective Equipment: Respiratory

A NIOSH/MSHA-approved air-purifying respirator with organic vapor cartridges or canister may be permissible under certain circumstances where airborne concentrations are or may be expected to exceed exposure limits or for odor or irritation. Protection provided by air-purifying respirators is limited.

Use a positive pressure, air-supplied respirator if there is a potential for uncontrolled release, exposure levels are not known, in oxygen-deficient atmospheres, or any other circumstance where an air-purifying respirator may not provide adequate protection.

Personal Protective Equipment: Hands

Gloves constructed of nitrile, neoprene, or PVC are recommended.

Personal Protective Equipment: Eyes

Safety glasses or goggles are recommended where there is a possibility of splashing or spraying.

Personal Protective Equipment: Skin and Body

Chemical protective clothing such as of E.I. DuPont TyChem®, Saranex® or equivalent recommended based on degree of exposure. Note: The resistance of specific material may vary from product to product as well as with degree of exposure. Consult manufacturer specifications for further information.

* * * Section 9 - Physical & Chemical Properties * * *

Appearance:	Pale yellow to water-white. May be dyed red.	**Odor:**	Characteristic petroleum distillate odor
Physical State:	Liquid	**pH:**	ND
Vapor Pressure:	0.4 mm Hg @ 68 °F (20 °C)	**Vapor Density:**	AP 4.5
Boiling Point:	300 to 580 °F (149 to 304 °C)	**Melting Point:**	ND
Solubility (H2O):	Negligible	**Specific Gravity:**	0.784-0.834
Evaporation Rate:	Slow; varies with conditions	**VOC:**	ND
Percent Volatile:	100%	**Octanol/H2O Coeff.:**	ND
Flash Point:	>100 °F (38 °C)	**Flash Point Method:**	TCC
Upper Flammability Limit (UFL):	5.0	**Lower Flammability Limit (LFL):**	0.7
Burning Rate:	ND	**Auto Ignition:**	410°F (210°C)

* * * Section 10 - Chemical Stability & Reactivity Information * * *

Chemical Stability

This is a stable material.

Hazardous Reaction Potential

Will not occur.

Conditions to Avoid

Avoid high temperatures, open flames, sparks, welding, smoking and other ignition sources.

Incompatible Products

Keep away from strong oxidizers such as nitric and sulfuric acids.

Hazardous Decomposition Products

Carbon monoxide, carbon dioxide and non-combusted hydrocarbons (smoke).

* * * Section 11 - Toxicological Information * * *

Acute Toxicity

A: General Product Information

Harmful if swallowed.

B: Component Analysis - LD50/LC50

Kerosene (8008-20-6)

Inhalation LC50 Rat >5.28 mg/L 4 h; Oral LD50 Rat >5000 mg/kg; Dermal LD50 Rabbit >2000 mg/kg

Naphthalene (91-20-3)

Inhalation LC50 Rat >340 mg/m3 1 h; Oral LD50 Rat 490 mg/kg; Dermal LD50 Rat >2500 mg/kg; Dermal LD50 Rabbit >20 g/kg

Potential Health Effects: Skin Corrosion Property/Stimulativeness

Practically non-toxic if absorbed following acute (single) exposure. May cause skin irritation with prolonged or repeated contact. Liquid may be absorbed through the skin in toxic amounts if large areas of skin are repeatedly exposed.

Potential Health Effects: Eye Critical Damage/ Stimulativeness

Contact with eyes may cause mild to moderate irritation.

Potential Health Effects: Ingestion

Ingestion may cause gastrointestinal disturbances, including irritation, nausea, vomiting and diarrhea, and central nervous system (brain) effects similar to alcohol intoxication. In severe cases, tremors, convulsions, loss of consciousness, coma, respiratory arrest, and death may occur.

Potential Health Effects: Inhalation

Excessive exposure may cause irritations to the nose, throat, lungs and respiratory tract. Central nervous system (brain) effects may include headache, dizziness, loss of balance and coordination, unconsciousness, coma, respiratory failure, and death.

WARNING: the burning of any hydrocarbon as a fuel in an area without adequate ventilation may result in hazardous levels of combustion products, including carbon monoxide, and inadequate oxygen levels, which may cause unconsciousness, suffocation, and death.

Respiratory Organs Sensitization/Skin Sensitization

This product is not reported to have any skin sensitization effects.

Generative Cell Mutagenicity

This product is not reported to have any mutagenic effects.

Carcinogenicity

A: General Product Information

Dermal carcinogenicity: positive - mice

Studies have shown that similar products produce skin tumors in laboratory animals following repeated applications without washing or removal. The significance of this finding to human exposure has not been determined. Other studies with active skin carcinogens have shown that washing the animal's skin with soap and water between applications reduced tumor formation.

B: Component Carcinogenicity

Kerosene (8008-20-6)

ACGIH: A3 - Confirmed Animal Carcinogen with Unknown Relevance to Humans

Naphthalene (91-20-3)

ACGIH: A4 - Not Classifiable as a Human Carcinogen
NTP: Reasonably Anticipated To Be A Human Carcinogen (Possible Select Carcinogen)
IARC: Monograph 82 [2002] (Group 2B (possibly carcinogenic to humans))

Reproductive Toxicity

This product is not reported to have any reproductive toxicity effects.

Specified Target Organ General Toxicity: Single Exposure

This product is not reported to have any specific target organ general toxicity single exposure effects.

Specified Target Organ General Toxicity: Repeated Exposure

This product is not reported to have any specific target organ general toxicity repeat exposure effects.

Aspiration Respiratory Organs Hazard

The major health threat of ingestion occurs from the danger of aspiration (breathing) of liquid drops into the lungs, particularly from vomiting. Aspiration may result in chemical pneumonia (fluid in the lungs), severe lung damage, respiratory failure and even death.

* * * Section 12 - Ecological Information * * *

Ecotoxicity

A: General Product Information

Keep out of sewers, drainage areas and waterways. Report spills and releases, as applicable, under Federal and State regulations.

B: Component Analysis - Ecotoxicity - Aquatic Toxicity

Naphthalene (91-20-3)

Test & Species		Conditions
96 Hr LC50 Pimephales promelas	5.74-6.44 mg/L [flow-through]	
96 Hr LC50 Oncorhynchus mykiss	1.6 mg/L [flow-through]	
96 Hr LC50 Oncorhynchus mykiss	0.91-2.82 mg/L [static]	
96 Hr LC50 Pimephales promelas	1.99 mg/L [static]	
96 Hr LC50 Lepomis macrochirus	31.0265 mg/L [static]	
72 Hr EC50 Skeletonema costatum	0.4 mg/L	
48 Hr LC50 Daphnia magna	2.16 mg/L	
48 Hr EC50 Daphnia magna	1.96 mg/L [Flow through]	
48 Hr EC50 Daphnia magna	1.09 - 3.4 mg/L [Static]	

Persistence/Degradability

No information available.

Bioaccumulation

No information available.

Mobility in Soil

No information available.

* * * Section 13 - Disposal Considerations * * *

Waste Disposal Instructions

See Section 7 for Handling Procedures. See Section 8 for Personal Protective Equipment recommendations.

Disposal of Contaminated Containers or Packaging

Dispose of contents/container in accordance with local/regional/national/international regulations.

* * * Section 14 - Transportation Information * * *

DOT Information

Shipping Name: Kerosene

UN #: 1223 **Hazard Class:** 3 **Packing Group:** III

Placard:

* * * Section 15 - Regulatory Information * * *

Regulatory Information

Component Analysis

This material contains one or more of the following chemicals required to be identified under SARA Section 302 (40 CFR 355 Appendix A), SARA Section 313 (40 CFR 372.65) and/or CERCLA (40 CFR 302.4).

Naphthalene (91-20-3)

CERCLA: 100 lb final RQ; 45.4 kg final RQ

SARA Section 311/312 – Hazard Classes

Acute Health	Chronic Health	Fire	Sudden Release of Pressure	Reactive
X	X	X	--	--

SARA SECTION 313 - SUPPLIER NOTIFICATION

This product may contain listed chemicals below the de minimis levels which therefore are not subject to the supplier notification requirements of Section 313 of the Emergency Planning and Community Right- To-Know Act (EPCRA) of 1986 and of 40 CFR 372. If you may be required to report releases of chemicals listed in 40 CFR 372.28, you may contact Hess Corporate Safety if you require additional information regarding this product.

State Regulations

Component Analysis - State

The following components appear on one or more of the following state hazardous substances lists:

Component	CAS	CA	MA	MN	NJ	PA	RI
Kerosene	8008-20-6	No	Yes	No	Yes	Yes	No
Naphthalene	91-20-3	Yes	Yes	Yes	Yes	Yes	No

The following statement(s) are provided under the California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65):

WARNING! This product contains a chemical known to the state of California to cause cancer.

Component Analysis - WHMIS IDL

No components are listed in the WHMIS IDL.

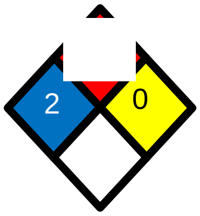
Additional Regulatory Information

Component Analysis - Inventory

Component	**CAS #**	**TSCA**	**CAN**	**EEC**
Kerosene	8008-20-6	Yes	DSL	EINECS
Naphthalene	91-20-3	Yes	DSL	EINECS

* * * Section 16 - Other Information * * *

NFPA® Hazard Rating		
	Health	2
	Fire	2
	Reactivity	0



HMIS® Hazard Rating			
	Health	2*	Moderate
	Fire	2	Moderate
	Physical	0	Minimal
			*Chronic

Key/Legend

EPA = Environmental Protection Agency; TSCA = Toxic Substance Control Act; ACGIH = American Conference of Governmental Industrial Hygienists; IARC = International Agency for Research on Cancer; NIOSH = National Institute for Occupational Safety and Health; NTP = National Toxicology Program; OSHA = Occupational Safety and Health Administration., NJTSR = New Jersey Trade Secret Registry.

Literature References

None

Other Information

Information presented herein has been compiled from sources considered to be dependable, and is accurate and reliable to the best of our knowledge and belief, but is not guaranteed to be so. Since conditions of use are beyond our control, we make no warranties, expressed or implied, except those that may be contained in our written contract of sale or acknowledgment.

Vendor assumes no responsibility for injury to vendee or third persons proximately caused by the material if reasonable safety procedures are not adhered to as stipulated in the data sheet. Additionally, vendor assumes no responsibility for injury to vendee or third persons proximately caused by abnormal use of the material, even if reasonable safety procedures are followed. Furthermore, vendee assumes the risk in their use of the material.

End of Sheet

SAFETY DATA SHEET

Nitrogen Dioxide

Airgas
an Air Liquide company

Section 1. Identification

GHS product identifier : Nitrogen Dioxide

Chemical name : nitrogen dioxide

Other means of identification : Nitrogen oxide; Nitrogen dioxide (dinitrogen tetroxide); Nitrogen oxide (NO2); Nitrogen peroxide; Dinitrogen tetroxide

Product type : Gas.

Product use : Synthetic/Analytical chemistry.

Synonym : Nitrogen oxide; Nitrogen dioxide (dinitrogen tetroxide); Nitrogen oxide (NO2); Nitrogen peroxide; Dinitrogen tetroxide

SDS # : 001041

Supplier's details :
Airgas USA, LLC and its affiliates
259 North Radnor-Chester Road
Suite 100
Radnor, PA 19087-5283
1-610-687-5253

24-hour telephone : 1-866-734-3438

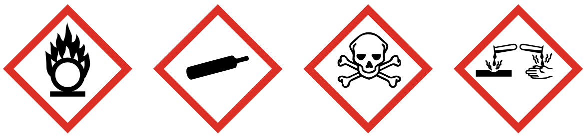
Section 2. Hazards identification

OSHA/HCS status : This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Classification of the substance or mixture :
OXIDIZING GASES - Category 1
GASES UNDER PRESSURE - Compressed gas
ACUTE TOXICITY (inhalation) - Category 1
SKIN CORROSION - Category 1
SERIOUS EYE DAMAGE - Category 1

GHS label elements

Hazard pictograms :



Signal word : Danger

Hazard statements :
May cause or intensify fire; oxidizer.
Contains gas under pressure; may explode if heated.
Fatal if inhaled.
Causes severe skin burns and eye damage.

Precautionary statements

General : Read and follow all Safety Data Sheets (SDS'S) before use. Read label before use. Keep out of reach of children. If medical advice is needed, have product container or label at hand. Close valve after each use and when empty. Use equipment rated for cylinder pressure. Do not open valve until connected to equipment prepared for use. Use a back flow preventative device in the piping. Use only equipment of compatible materials of construction. Open valve slowly. Use only with equipment cleaned for Oxygen service.

Prevention : Wear protective gloves. Wear eye or face protection. Wear protective clothing. Wear respiratory protection. Keep away from clothing, incompatible materials and combustible materials. Keep reduction valves, valves and fittings free from oil and grease. Use only outdoors or in a well-ventilated area. Do not breathe gas. Wash hands thoroughly after handling.

Section 2. Hazards identification

Response : In case of fire: Stop leak if safe to do so. IF INHALED: Remove person to fresh air and keep comfortable for breathing. Immediately call a POISON CENTER or physician. IF SWALLOWED: Immediately call a POISON CENTER or physician. Rinse mouth. Do NOT induce vomiting. IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water or shower. Wash contaminated clothing before reuse. Immediately call a POISON CENTER or physician. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a POISON CENTER or physician.

Storage : Store locked up. Protect from sunlight. Store in a well-ventilated place.

Disposal : Dispose of contents and container in accordance with all local, regional, national and international regulations.

Hazards not otherwise classified : In addition to any other important health or physical hazards, this product may displace oxygen and cause rapid suffocation.

Section 3. Composition/information on ingredients

Substance/mixture : Substance

Chemical name : nitrogen dioxide

Other means of identification : Nitrogen oxide; Nitrogen dioxide (dinitrogen tetroxide); Nitrogen oxide (NO2); Nitrogen peroxide; Dinitrogen tetroxide

Product code : 001041

CAS number/other identifiers

CAS number : 10102-44-0

Ingredient name	**%**	**CAS number**
nitrogen dioxide	100	10102-44-0

Any concentration shown as a range is to protect confidentiality or is due to batch variation.

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Description of necessary first aid measures

Eye contact : Get medical attention immediately. Call a poison center or physician. Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 minutes. Chemical burns must be treated promptly by a physician.

Inhalation : Get medical attention immediately. Call a poison center or physician. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband. In case of inhalation of decomposition products in a fire, symptoms may be delayed. The exposed person may need to be kept under medical surveillance for 48 hours.

Skin contact : Get medical attention immediately. Call a poison center or physician. Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Wash contaminated clothing thoroughly with water before removing it, or wear gloves. Continue to rinse for at least 10 minutes. Chemical burns must be treated promptly by a physician. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion : As this product is a gas, refer to the inhalation section.

Most important symptoms/effects, acute and delayed

Section 4. First aid measures

Potential acute health effects

Eye contact : Causes serious eye damage. Contact with rapidly expanding gas may cause burns or frostbite.

Inhalation : Fatal if inhaled.

Skin contact : Causes severe burns. Contact with rapidly expanding gas may cause burns or frostbite.

Frostbite : Try to warm up the frozen tissues and seek medical attention.

Ingestion : As this product is a gas, refer to the inhalation section.

Over-exposure signs/symptoms

Eye contact : Adverse symptoms may include the following:, pain, watering, redness

Inhalation : No specific data.

Skin contact : Adverse symptoms may include the following:, pain or irritation, redness, blistering may occur

Ingestion : Adverse symptoms may include the following:, stomach pains

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician : In case of inhalation of decomposition products in a fire, symptoms may be delayed. The exposed person may need to be kept under medical surveillance for 48 hours.

Specific treatments : No specific treatment.

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Wash contaminated clothing thoroughly with water before removing it, or wear gloves.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media : Use an extinguishing agent suitable for the surrounding fire.

Unsuitable extinguishing media : None known.

Specific hazards arising from the chemical : Contains gas under pressure. Oxidizing material. This material increases the risk of fire and may aid combustion. Contact with combustible material may cause fire. In a fire or if heated, a pressure increase will occur and the container may burst or explode.

Hazardous thermal decomposition products : Decomposition products may include the following materials:
nitrogen oxides

Special protective actions for fire-fighters : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Contact supplier immediately for specialist advice. Move containers from fire area if this can be done without risk. Use water spray to keep fire-exposed containers cool. If involved in fire, shut off flow immediately if it can be done without risk.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel	: No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Shut off all ignition sources. No flares, smoking or flames in hazard area. Do not breathe gas. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.
For emergency responders	: If specialized clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".
Environmental precautions	: Ensure emergency procedures to deal with accidental gas releases are in place to avoid contamination of the environment. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Small spill	: Immediately contact emergency personnel. Stop leak if without risk. Use spark-proof tools and explosion-proof equipment.
Large spill	: Immediately contact emergency personnel. Stop leak if without risk. Use spark-proof tools and explosion-proof equipment. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Protective measures	: Put on appropriate personal protective equipment (see Section 8). Contains gas under pressure. Do not get in eyes or on skin or clothing. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Do not puncture or incinerate container. Use equipment rated for cylinder pressure. Close valve after each use and when empty. Protect cylinders from physical damage; do not drag, roll, slide, or drop. Use a suitable hand truck for cylinder movement. Empty containers retain product residue and can be hazardous. Keep away from clothing, incompatible materials and combustible materials. Do not breathe gas. Keep reduction valves free from grease and oil.
Advice on general occupational hygiene	: Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.
Conditions for safe storage, including any incompatibilities	: Store in accordance with local regulations. Store in a segregated and approved area. Store away from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10). Cylinders should be stored upright, with valve protection cap in place, and firmly secured to prevent falling or being knocked over. Cylinder temperatures should not exceed 52 °C (125 °F). Store locked up. Separate from reducing agents and combustible materials. Store away from grease and oil. Keep container tightly closed and sealed until ready for use. See Section 10 for incompatible materials before handling or use.

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

Section 8. Exposure controls/personal protection

Ingredient name	**Exposure limits**
nitrogen dioxide	**ACGIH TLV (United States, 6/2013).** STEL: 9.4 mg/m³ 15 minutes. STEL: 5 ppm 15 minutes. TWA: 5.6 mg/m³ 8 hours. TWA: 0.2 ppm 8 hours. **NIOSH REL (United States, 4/2013).** STEL: 1.8 mg/m³ 15 minutes. STEL: 1 ppm 15 minutes. **OSHA PEL (United States, 2/2013).** CEIL: 9 mg/m³ CEIL: 5 ppm **OSHA PEL 1989 (United States, 3/1989).** STEL: 1.8 mg/m³ 15 minutes. STEL: 1 ppm 15 minutes.

Appropriate engineering controls : Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits.

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Eye/face protection : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: chemical splash goggles and/or face shield. If inhalation hazards exist, a full-face respirator may be required instead.

Skin protection

Hand protection : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated.

Body protection : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection : Based on the hazard and potential for exposure, select a respirator that meets the appropriate standard or certification. Respirators must be used according to a respiratory protection program to ensure proper fitting, training, and other important aspects of use. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance

Physical state : Gas.

Color : Yellowish-brown. Brownish-red. Yellow. Brown. Red.

Odor : Pungent.

Odor threshold : Not available.

pH : Not available.

Melting point : -11.2°C (11.8°F)

Boiling point : 21.2°C (70.2°F)

Critical temperature : 157.8°C (316°F)

Flash point : [Product does not sustain combustion.]

Evaporation rate : Not available.

Flammability (solid, gas) : Not available.

Lower and upper explosive (flammable) limits : Not available.

Vapor pressure : 14.7 (psia)

Vapor density : 1.58 (Air = 1)

Specific Volume (ft ^{3}/lb) : 4.902

Gas Density (lb/ft ^{3}) : 0.204

Relative density : Not applicable.

Solubility : Not available.

Solubility in water : Not available.

Partition coefficient: n-octanol/water : Not available.

Auto-ignition temperature : Not available.

Decomposition temperature : Not available.

Viscosity : Not applicable.

Flow time (ISO 2431) : Not available.

Molecular weight : 46.01 g/mole

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.

Chemical stability : The product is stable.

Possibility of hazardous reactions : Hazardous reactions or instability may occur under certain conditions of storage or use.
Conditions may include the following:
contact with combustible materials
Reactions may include the following:
risk of causing fire

Conditions to avoid : No specific data.

Incompatible materials : Highly reactive or incompatible with the following materials:
combustible materials
reducing materials
grease
oil

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Section 10. Stability and reactivity

Hazardous polymerization : Under normal conditions of storage and use, hazardous polymerization will not occur.

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity

Product/ingredient name	Result	Species	Dose	Exposure
nitrogen dioxide	LC50 Inhalation Gas.	Rat	115 ppm	1 hours

Irritation/Corrosion

Not available.

Sensitization

Not available.

Mutagenicity

Not available.

Carcinogenicity

Not available.

Reproductive toxicity

Not available.

Teratogenicity

Not available.

Specific target organ toxicity (single exposure)

Not available.

Specific target organ toxicity (repeated exposure)

Not available.

Aspiration hazard

Not available.

Information on the likely routes of exposure : Not available.

Potential acute health effects

Eye contact : Causes serious eye damage. Contact with rapidly expanding gas may cause burns or frostbite.

Inhalation : Fatal if inhaled.

Skin contact : Causes severe burns. Contact with rapidly expanding gas may cause burns or frostbite.

Ingestion : As this product is a gas, refer to the inhalation section.

Symptoms related to the physical, chemical and toxicological characteristics

Eye contact : Adverse symptoms may include the following:, pain, watering, redness

Inhalation : No specific data.

Skin contact : Adverse symptoms may include the following:, pain or irritation, redness, blistering may occur

Ingestion : Adverse symptoms may include the following:, stomach pains

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure

Section 11. Toxicological information

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Long term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Potential chronic health effects

Not available.

General : No known significant effects or critical hazards.

Carcinogenicity : No known significant effects or critical hazards.

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : No known significant effects or critical hazards.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : No known significant effects or critical hazards.

Numerical measures of toxicity

Acute toxicity estimates

Not available.

Section 12. Ecological information

Toxicity

Product/ingredient name	Result	Species	Exposure
nitrogen dioxide	Acute LC50 8640 µg/l Fresh water	Crustaceans - Macrobrachium rosenbergii	48 hours
	Acute LC50 19600 µg/l Fresh water	Fish - Tinca tinca - Larvae	96 hours

Persistence and degradability

Not available.

Bioaccumulative potential

Not available.

Mobility in soil

Soil/water partition coefficient (K_{OC}) : Not available.

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods : The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Waste should not be disposed of untreated to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Empty Airgas-owned pressure vessels should be returned to Airgas. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Empty

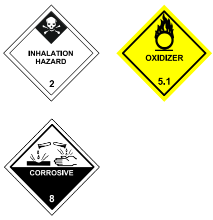
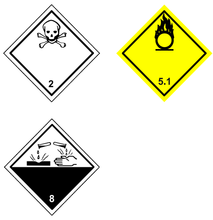
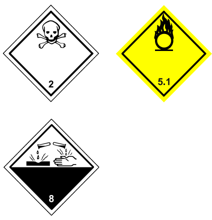
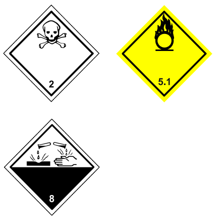
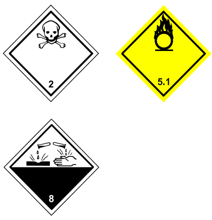
Section 13. Disposal considerations

containers or liners may retain some product residues. Do not puncture or incinerate container.

United States - RCRA Acute hazardous waste "P" List

Ingredient	CAS #	Status	Reference number
Nitrogen dioxide; Nitrogen oxide NO2	10102-44-0	Listed	P078

Section 14. Transport information

	DOT	TDG	Mexico	IMDG	IATA
UN number	UN1067	UN1067	UN1067	UN1067	UN1067
UN proper shipping name	DINITROGEN TETROXIDE	DINITROGEN TETROXIDE	DINITROGEN TETROXIDE	DINITROGEN TETROXIDE	DINITROGEN TETROXIDE
Transport hazard class(es)	2.3 (5.1, 8) 	2.3 (5.1, 8) 	2.3 (5.1, 8) 	2.3 (5.1, 8) 	2.3 (5.1, 8) 
Packing group	-	-	-	-	-
Environmental hazards	No.	No.	No.	No.	No.

“Refer to CFR 49 (or authority having jurisdiction) to determine the information required for shipment of the product.”

Additional information

DOT Classification : Toxic - Inhalation hazard Zone A
Reportable quantity 10 lbs / 4.54 kg. Package sizes shipped in quantities less than the product reportable quantity are not subject to the RQ (reportable quantity) transportation requirements.
Limited quantity Yes.
Quantity limitation Passenger aircraft/rail: Forbidden. Cargo aircraft: Forbidden.
Special provisions 1, B7, B9, B14, B45, B46, B61, B66, B67, B77

TDG Classification : Product classified as per the following sections of the Transportation of Dangerous Goods Regulations: 2.13-2.17 (Class 2), 2.23-2.25 (Class 5), 2.40-2.42 (Class 8).
Explosive Limit and Limited Quantity Index 0
ERAP Index 0
Passenger Carrying Ship Index Forbidden
Passenger Carrying Road or Rail Index Forbidden
Special provisions 38

IATA : **Quantity limitation** Passenger and Cargo Aircraft: Forbidden. Cargo Aircraft Only: Forbidden.

Special precautions for user : **Transport within user’s premises:** always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Transport in bulk according to Annex II of MARPOL and the IBC Code : Not available.

Section 15. Regulatory information

U.S. Federal regulations : **TSCA 8(a) CDR Exempt/Partial exemption**: Not determined
Clean Water Act (CWA) 311: nitrogen dioxide

Clean Air Act Section 112 (b) Hazardous Air Pollutants (HAPs) : Not listed

Clean Air Act Section 602 Class I Substances : Not listed

Clean Air Act Section 602 Class II Substances : Not listed

DEA List I Chemicals (Precursor Chemicals) : Not listed

DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 302/304

Composition/information on ingredients

			SARA 302 TPQ		SARA 304 RQ	
Name	**%**	**EHS**	**(lbs)**	**(gallons)**	**(lbs)**	**(gallons)**
nitrogen dioxide	100	Yes.	100	-	10	-

SARA 304 RQ : 10 lbs / 4.5 kg

SARA 311/312

Classification : Refer to Section 2: Hazards Identification of this SDS for classification of substance.

State regulations

Massachusetts : This material is listed.
New York : This material is listed.
New Jersey : This material is listed.
Pennsylvania : This material is listed.

International regulations

Chemical Weapon Convention List Schedules I, II & III Chemicals

Not listed.

Montreal Protocol (Annexes A, B, C, E)

Not listed.

Stockholm Convention on Persistent Organic Pollutants

Not listed.

Rotterdam Convention on Prior Informed Consent (PIC)

Not listed.

UNECE Aarhus Protocol on POPs and Heavy Metals

Not listed.

Inventory list

Australia : This material is listed or exempted.
Canada : This material is listed or exempted.
China : This material is listed or exempted.
Europe : This material is listed or exempted.
Japan : **Japan inventory (ENCS)**: This material is listed or exempted.
Japan inventory (ISHL): Not determined.
Malaysia : Not determined.

Section 15. Regulatory information

New Zealand : This material is listed or exempted.
Philippines : This material is listed or exempted.
Republic of Korea : This material is listed or exempted.
Taiwan : This material is listed or exempted.
Thailand : Not determined.
Turkey : Not determined.
United States : This material is listed or exempted.
Viet Nam : Not determined.

Section 16. Other information

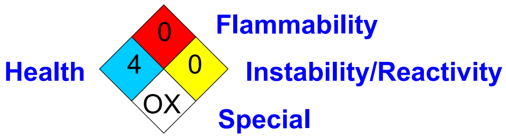
Hazardous Material Information System (U.S.A.)

Health	/	4
Flammability		0
Physical hazards		3

Caution: HMIS® ratings are based on a 0-4 rating scale, with 0 representing minimal hazards or risks, and 4 representing significant hazards or risks. Although HMIS® ratings and the associated label are not required on SDSs or products leaving a facility under 29 CFR 1910.1200, the preparer may choose to provide them. HMIS® ratings are to be used with a fully implemented HMIS® program. HMIS® is a registered trademark and service mark of the American Coatings Association, Inc.

The customer is responsible for determining the PPE code for this material. For more information on HMIS® Personal Protective Equipment (PPE) codes, consult the HMIS® Implementation Manual.

National Fire Protection Association (U.S.A.)



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Copyright ©2001, National Fire Protection Association, Quincy, MA 02269. This warning system is intended to be interpreted and applied only by properly trained individuals to identify fire, health and reactivity hazards of chemicals. The user is referred to certain limited number of chemicals with recommended classifications in NFPA 49 and NFPA 325, which would be used as a guideline only. Whether the chemicals are classified by NFPA or not, anyone using the 704 systems to classify chemicals does so at their own risk.

Procedure used to derive the classification

Classification	Justification
OXIDIZING GASES - Category 1	Expert judgment
GASES UNDER PRESSURE - Compressed gas	According to package
ACUTE TOXICITY (inhalation) - Category 1	Expert judgment
SKIN CORROSION - Category 1	Expert judgment
SERIOUS EYE DAMAGE - Category 1	Expert judgment

History

Date of printing : 2/14/2018
Date of issue/Date of revision : 2/14/2018
Date of previous issue : No previous validation
Version : 1

Section 16. Other information

Key to abbreviations :
ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
UN = United Nations

References : Not available.

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

SAFETY DATA SHEET

1. Identification

Product identifier	**1,1-Dimethylhydrazine**
Other means of identification	
Item	N-10128
Recommended use	For Laboratory Use Only
Recommended restrictions	None known.

Manufacturer/Importer/Supplier/Distributor information

Manufacturer

Company name	Chem Service, Inc.	
Address	660 Tower Lane West Chester, PA 19380 United States	
Telephone	Toll Free	800-452-9994
	Direct	610-692-3026
Website	www.chemservice.com	
E-mail	info@chemservice.com	
Emergency phone number	Chemtrec US	800-424-9300
	Chemtrec outside US	+1 703-527-3887

2. Hazard(s) identification

Physical hazards	Flammable liquids	Category 2
Health hazards	Acute toxicity, oral	Category 3
	Acute toxicity, dermal	Category 2
	Acute toxicity, inhalation	Category 2
	Skin corrosion/irritation	Category 1
	Serious eye damage/eye irritation	Category 1
	Carcinogenicity	Category 1B
Environmental hazards	Hazardous to the aquatic environment, acute hazard	Category 2
	Hazardous to the aquatic environment, long-term hazard	Category 2
OSHA defined hazards	Not classified.	

Label elements

Signal word Danger

Hazard statement Highly flammable liquid and vapor. Toxic if swallowed. Fatal in contact with skin. Causes severe skin burns and eye damage. Causes serious eye damage. Fatal if inhaled. May cause cancer. Toxic to aquatic life. Toxic to aquatic life with long lasting effects.

Precautionary statement

Prevention Obtain special instructions before use. Do not handle until all safety precautions have been read and understood. Keep away from heat/sparks/open flames/hot surfaces. - No smoking. Use only outdoors or in a well-ventilated area. Keep container tightly closed. Ground/bond container and receiving equipment. Use explosion-proof electrical/ventilating/lighting equipment. Use only non-sparking tools. Take precautionary measures against static discharge. Do not breathe vapor. Do not get in eyes, on skin, or on clothing. Wash thoroughly after handling. Do not eat, drink or smoke when using this product. Avoid release to the environment. Wear protective gloves/protective clothing/eye protection/face protection. Wear respiratory protection.

Response	If swallowed: Immediately call a poison center/doctor. If swallowed: Rinse mouth. Do NOT induce vomiting. If on skin (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower. If inhaled: Remove person to fresh air and keep comfortable for breathing. If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a poison center/doctor. Specific treatment is urgent (see this label). Take off immediately all contaminated clothing and wash it before reuse. In case of fire: Use appropriate media to extinguish. Collect spillage.
Storage	Store in a well-ventilated place. Keep container tightly closed. Store in a well-ventilated place. Keep cool. Store locked up.
Disposal	Dispose of contents/container in accordance with local/regional/national/international regulations.
Hazard(s) not otherwise classified (HNOC)	Static accumulating flammable liquid can become electrostatically charged even in bonded and grounded equipment. Sparks may ignite liquid and vapor. May cause flash fire or explosion.
Supplemental information	Not applicable.

3. Composition/information on ingredients

Substances

Chemical name	Common name and synonyms	CAS number	%
1,1-Dimethylhydrazine		57-14-7	100

4. First-aid measures

Inhalation	Remove victim to fresh air and keep at rest in a position comfortable for breathing. Oxygen or artificial respiration if needed. Do not use mouth-to-mouth method if victim inhaled the substance. Induce artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device. Call a physician or poison control center immediately.
Skin contact	Take off immediately all contaminated clothing. Rinse skin with water/shower. Call a physician or poison control center immediately. Chemical burns must be treated by a physician. Wash contaminated clothing before reuse.
Eye contact	Immediately flush eyes with plenty of water for at least 15 minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Call a physician or poison control center immediately.
Ingestion	Call a physician or poison control center immediately. Rinse mouth. Do not induce vomiting. If vomiting occurs, keep head low so that stomach content doesn't get into the lungs. Do not use mouth-to-mouth method if victim ingested the substance. Induce artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device.
Most important symptoms/effects, acute and delayed	Burning pain and severe corrosive skin damage. Causes serious eye damage. Symptoms may include stinging, tearing, redness, swelling, and blurred vision. Permanent eye damage including blindness could result.
Indication of immediate medical attention and special treatment needed	Provide general supportive measures and treat symptomatically. Thermal burns: Flush with water immediately. While flushing, remove clothes which do not adhere to affected area. Call an ambulance. Continue flushing during transport to hospital. Chemical burns: Flush with water immediately. While flushing, remove clothes which do not adhere to affected area. Call an ambulance. Continue flushing during transport to hospital. In case of shortness of breath, give oxygen. Keep victim warm. Keep victim under observation. Symptoms may be delayed.
General information	Take off immediately all contaminated clothing. IF exposed or concerned: Get medical advice/attention. Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves. Wash contaminated clothing before reuse. Discard any shoes or clothing items that cannot be decontaminated.

5. Fire-fighting measures

Suitable extinguishing media	Alcohol resistant foam. Water fog. Carbon dioxide (CO2). Dry chemical powder, carbon dioxide, sand or earth may be used for small fires only.
Unsuitable extinguishing media	Do not use water jet as an extinguisher, as this will spread the fire.
Specific hazards arising from the chemical	Vapors may form explosive mixtures with air. Vapors may travel considerable distance to a source of ignition and flash back. This product is a poor conductor of electricity and can become electrostatically charged. If sufficient charge is accumulated, ignition of flammable mixtures can occur. To reduce potential for static discharge, use proper bonding and grounding procedures. This liquid may accumulate static electricity when filling properly grounded containers. Static electricity accumulation may be significantly increased by the presence of small quantities of water or other contaminants. Material will float and may ignite on surface of water. During fire, gases hazardous to health may be formed.
Special protective equipment and precautions for firefighters	Self-contained breathing apparatus and full protective clothing must be worn in case of fire.

Fire fighting equipment/instructions	In case of fire and/or explosion do not breathe fumes. Move containers from fire area if you can do so without risk.
Specific methods	Use standard firefighting procedures and consider the hazards of other involved materials.
General fire hazards	Highly flammable liquid and vapor.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures	Immediately evacuate personnel to safe areas. Keep unnecessary personnel away. Keep people away from and upwind of spill/leak. Keep out of low areas. Eliminate all ignition sources (no smoking, flares, sparks, or flames in immediate area). Wear appropriate protective equipment and clothing during clean-up. Do not breathe vapor. Fully encapsulating, vapor protective clothing should be worn for spills and leaks with no fire. Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Ventilate closed spaces before entering them. Use appropriate containment to avoid environmental contamination. Transfer by mechanical means such as vacuum truck to a salvage tank or other suitable container for recovery or safe disposal. Local authorities should be advised if significant spillages cannot be contained. For personal protection, see section 8 of the SDS.
Methods and materials for containment and cleaning up	Eliminate all ignition sources (no smoking, flares, sparks, or flames in immediate area). Take precautionary measures against static discharge. Use only non-sparking tools. Keep combustibles (wood, paper, oil, etc.) away from spilled material. This product is miscible in water. This material is classified as a water pollutant under the Clean Water Act and should be prevented from contaminating soil or from entering sewage and drainage systems which lead to waterways. Large Spills: Stop the flow of material, if this is without risk. Dike the spilled material, where this is possible. Cover with plastic sheet to prevent spreading. Use a non-combustible material like vermiculite, sand or earth to soak up the product and place into a container for later disposal. Following product recovery, flush area with water. Small Spills: Wipe up with absorbent material (e.g. cloth, fleece). Clean surface thoroughly to remove residual contamination. Never return spills to original containers for re-use. For waste disposal, see section 13 of the SDS.
Environmental precautions	Avoid release to the environment. Contact local authorities in case of spillage to drain/aquatic environment. Prevent further leakage or spillage if safe to do so. Do not contaminate water. Avoid discharge into drains, water courses or onto the ground. Use appropriate containment to avoid environmental contamination.

7. Handling and storage

Precautions for safe handling	Obtain special instructions before use. Do not handle until all safety precautions have been read and understood. Vapors may form explosive mixtures with air. Do not handle, store or open near an open flame, sources of heat or sources of ignition. Protect material from direct sunlight. Minimize fire risks from flammable and combustible materials (including combustible dust and static accumulating liquids) or dangerous reactions with incompatible materials. Handling operations that can promote accumulation of static charges include but are not limited to: mixing, filtering, pumping at high flow rates, splash filling, creating mists or sprays, tank and container filling, tank cleaning, sampling, gauging, switch loading, vacuum truck operations. Take precautionary measures against static discharges. All equipment used when handling the product must be grounded. Use non-sparking tools and explosion-proof equipment. Do not breathe vapor. Do not get this material in contact with eyes. Do not get this material in contact with skin. Do not taste or swallow. Avoid prolonged exposure. Do not get this material on clothing. Use only outdoors or in a well-ventilated area. Wear appropriate personal protective equipment. Observe good industrial hygiene practices. When using, do not eat, drink or smoke. Wash hands thoroughly after handling. Wash contaminated clothing before reuse. Avoid release to the environment. Do not empty into drains. For additional information on equipment bonding and grounding, refer to the Canadian Electrical Code in Canada, (CSA C22.1), or the American Petroleum Institute (API) Recommended Practice 2003, "Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents" or National Fire Protection Association (NFPA) 77, "Recommended Practice on Static Electricity" or National Fire Protection Association (NFPA) 70, "National Electrical Code".
Conditions for safe storage, including any incompatibilities	Store locked up. Keep away from heat, sparks and open flame. Prevent electrostatic charge build-up by using common bonding and grounding techniques. Avoid spark promoters. Eliminate sources of ignition. Ground/bond container and equipment. These alone may be insufficient to remove static electricity. Store in original tightly closed container. Store in a cool, dry place out of direct sunlight. Store in a well-ventilated place. Refrigeration recommended. Store away from incompatible materials (see Section 10 of the SDS). Keep in an area equipped with sprinklers.

8. Exposure controls/personal protection

Occupational exposure limits

US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000)

Material	Type	Value
1,1-Dimethylhydrazine (CAS 57-14-7)	PEL	1 mg/m3
		0.5 ppm

US. ACGIH Threshold Limit Values

Material	Type	Value
1,1-Dimethylhydrazine (CAS 57-14-7)	TWA	0.01 ppm

US. NIOSH: Pocket Guide to Chemical Hazards

Material	Type	Value
1,1-Dimethylhydrazine (CAS 57-14-7)	Ceiling	0.15 mg/m3
		0.06 ppm

Biological limit values No biological exposure limits noted for the ingredient(s).

Exposure guidelines

US - California OELs: Skin designation

1,1-Dimethylhydrazine (CAS 57-14-7)	Can be absorbed through the skin.

US - Minnesota Haz Subs: Skin designation applies

1,1-Dimethylhydrazine (CAS 57-14-7)	Skin designation applies.

US - Tennessee OELs: Skin designation

1,1-Dimethylhydrazine (CAS 57-14-7)	Can be absorbed through the skin.

US ACGIH Threshold Limit Values: Skin designation

1,1-Dimethylhydrazine (CAS 57-14-7)	Can be absorbed through the skin.

US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000)

1,1-Dimethylhydrazine (CAS 57-14-7)	Can be absorbed through the skin.

Appropriate engineering controls Explosion-proof general and local exhaust ventilation. Good general ventilation (typically 10 air changes per hour) should be used. Ventilation rates should be matched to conditions. If applicable, use process enclosures, local exhaust ventilation, or other engineering controls to maintain airborne levels below recommended exposure limits. If exposure limits have not been established, maintain airborne levels to an acceptable level. Eye wash facilities and emergency shower must be available when handling this product.

Individual protection measures, such as personal protective equipment

Eye/face protection Wear eye/face protection. Wear safety glasses with side shields (or goggles) and a face shield.

Skin protection

Hand protection Wear appropriate chemical resistant gloves.

Other Wear appropriate chemical resistant clothing.

Respiratory protection Wear positive pressure self-contained breathing apparatus (SCBA).

Thermal hazards Wear appropriate thermal protective clothing, when necessary.

General hygiene considerations When using, do not eat, drink or smoke. Do not get this material on clothing. Always observe good personal hygiene measures, such as washing after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing and protective equipment to remove contaminants.

9. Physical and chemical properties

Appearance

Physical state	Liquid.
Form	Liquid
Color	Colorless
Odor	Not available.
Odor threshold	Not available.
pH	Not available.

Melting point/freezing point	-72.4 °F (-58 °C)
Initial boiling point and boiling range	147.02 °F (63.9 °C) 101.325 kPa
Flash point	5.0 °F (-15.0 °C) Closed Cup
Evaporation rate	Not available.
Flammability (solid, gas)	Not available.
Upper/lower flammability or explosive limits	
Flammability limit - lower (%)	2
Flammability limit - upper (%)	95
Explosive limit - lower (%)	Not available.
Explosive limit - upper (%)	Not available.
Vapor pressure	20.93 kPa at 25 °C
Vapor density	1.94
Relative density	Not available.
Solubility(ies)	
Solubility (water)	Miscible
Partition coefficient (n-octanol/water)	Not available.
Auto-ignition temperature	480.2 °F (249 °C)
Decomposition temperature	Not available.
Viscosity	Not available.
Other information	
Density	0.7819 g/cm3 estimated
Dynamic viscosity	0.49 mPa.s
Dynamic viscosity temperature	77 °F (25 °C)
Flammability class	Flammable IB estimated
Kinematic viscosity	0.629236 mm²/s estimated
Molecular formula	C2-H8-N2
Molecular weight	60.1 g/mol
Percent volatile	100 %
Specific gravity	0.78 at 25 °C 0.79 at 22 °C
VOC (Weight %)	100 %

10. Stability and reactivity

Reactivity	The product is stable and non-reactive under normal conditions of use, storage and transport.
Chemical stability	Material is stable under normal conditions.
Possibility of hazardous reactions	Hazardous polymerization does not occur.
Conditions to avoid	Avoid heat, sparks, open flames and other ignition sources. Avoid temperatures exceeding the flash point. Contact with incompatible materials.
Incompatible materials	Strong oxidizing agents.
Hazardous decomposition products	No hazardous decomposition products are known.

11. Toxicological information

Information on likely routes of exposure	
Inhalation	Fatal if inhaled.
Skin contact	Fatal in contact with skin. Causes severe skin burns.
Eye contact	Causes serious eye damage.

Ingestion	Toxic if swallowed. Causes digestive tract burns.
Symptoms related to the physical, chemical and toxicological characteristics	Burning pain and severe corrosive skin damage. Causes serious eye damage. Symptoms may include stinging, tearing, redness, swelling, and blurred vision. Permanent eye damage including blindness could result.

Information on toxicological effects

Acute toxicity	Fatal if inhaled. Fatal in contact with skin. Toxic if swallowed. Expected to be a low hazard for usual industrial or commercial handling by trained personnel.

Product	Species	Test Results
1,1-Dimethylhydrazine (CAS 57-14-7)		
Acute		
Dermal		
LD50	Dog	1200 mg/kg
	Guinea pig	1329 mg/kg
	Rabbit	156 mg/kg
Inhalation		
LC50	Dog	22300 mg/l, 5 Minutes
		3850 mg/l, 15 Minutes
		981 mg/l, 1 Hours
	Hamster	392 mg/l, 4 Hours
	Mouse	172 mg/l, 4 Hours
	Rat	24500 mg/l, 5 Minutes
		8230 mg/l, 15 Minutes
		4010 mg/l, 30 Minutes
		1410 mg/l, 1 Hours
		252 mg/l, 4 Hours
Oral		
LD50	Mouse	265 mg/kg
	Rat	122 mg/kg
Other		
LD50	Cat	30 mg/kg
	Dog	60 mg/kg
	Mouse	113 mg/kg
	Rat	104 mg/kg

* Estimates for product may be based on additional component data not shown.

Skin corrosion/irritation	Causes severe skin burns and eye damage.
Serious eye damage/eye irritation	Causes serious eye damage.

Respiratory or skin sensitization

Respiratory sensitization	Not available.
Skin sensitization	This product is not expected to cause skin sensitization.
Germ cell mutagenicity	No data available to indicate product or any components present at greater than 0.1% are mutagenic or genotoxic.
Carcinogenicity	May cause cancer.

IARC Monographs. Overall Evaluation of Carcinogenicity

1,1-Dimethylhydrazine (CAS 57-14-7)	2B Possibly carcinogenic to humans.

US. National Toxicology Program (NTP) Report on Carcinogens

1,1-Dimethylhydrazine (CAS 57-14-7)	Reasonably Anticipated to be a Human Carcinogen.

US. OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050)

Not listed.

Reproductive toxicity	This product is not expected to cause reproductive or developmental effects.

Specific target organ toxicity - single exposure	Not classified.
Specific target organ toxicity - repeated exposure	Not classified.
Aspiration hazard	Not available.
Chronic effects	Prolonged inhalation may be harmful. Prolonged exposure may cause chronic effects.

12. Ecological information

Ecotoxicity	Toxic to aquatic life with long lasting effects. Accumulation in aquatic organisms is expected.

Product		**Species**	**Test Results**
1,1-Dimethylhydrazine (CAS 57-14-7)			
Aquatic			
Fish	LC50	Channel catfish (Ictalurus punctatus)	5.18 - 18.73 mg/l, 96 hours

* Estimates for product may be based on additional component data not shown.

Persistence and degradability	No data is available on the degradability of this product.
Bioaccumulative potential	No data available.
Mobility in soil	No data available.
Other adverse effects	No other adverse environmental effects (e.g. ozone depletion, photochemical ozone creation potential, endocrine disruption, global warming potential) are expected from this component.

13. Disposal considerations

Disposal instructions	Collect and reclaim or dispose in sealed containers at licensed waste disposal site. This material and its container must be disposed of as hazardous waste. Do not allow this material to drain into sewers/water supplies. Do not contaminate ponds, waterways or ditches with chemical or used container. Dispose of contents/container in accordance with local/regional/national/international regulations.
Local disposal regulations	Dispose in accordance with all applicable regulations.
Hazardous waste code	The waste code should be assigned in discussion between the user, the producer and the waste disposal company.

US RCRA Hazardous Waste U List: Reference

1,1-Dimethylhydrazine (CAS 57-14-7)	U098

Waste from residues / unused products	Dispose of in accordance with local regulations. Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe manner (see: Disposal instructions).
Contaminated packaging	Empty containers should be taken to an approved waste handling site for recycling or disposal. Since emptied containers may retain product residue, follow label warnings even after container is emptied.

14. Transport information

DOT

UN number	UN1163
UN proper shipping name	Dimethylhydrazine, unsymmetrical, MARINE POLLUTANT
Transport hazard class(es)	
Class	6.1(PGI, II)
Subsidiary risk	3, 8
Label(s)	6.1, 3, 8
Packing group	I
Environmental hazards	
Marine pollutant	Yes
Special precautions for user	Read safety instructions, SDS and emergency procedures before handling.
Special provisions	2, B7, B9, B14, B32, T20, TP2, TP13, TP38, TP45
Packaging exceptions	None
Packaging non bulk	227
Packaging bulk	244

IATA

UN number	UN1163
UN proper shipping name	Dimethylhydrazine, unsymmetrical

Transport hazard class(es)	
Class	6.1(PGIII)
Subsidiary risk	3, 8
Packing group	Not applicable.
Environmental hazards	No.
ERG Code	6CH
Special precautions for user	Read safety instructions, SDS and emergency procedures before handling.
Other information	
Passenger and cargo aircraft	Forbidden
Cargo aircraft only	Forbidden
IMDG	
UN number	UN1163
UN proper shipping name	DIMETHYLHYDRAZINE, UNSYMMETRICAL
Transport hazard class(es)	
Class	6.1(PGI, II)
Subsidiary risk	3, 8
Packing group	I
Environmental hazards	
Marine pollutant	Yes
EmS	F-E, S-C
Special precautions for user	Read safety instructions, SDS and emergency procedures before handling.
Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code	Not available.

DOT

IATA

IMDG

Marine pollutant

General information DOT Regulated Marine Pollutant. IMDG Regulated Marine Pollutant.

15. Regulatory information

US federal regulations This product is a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.
All components are on the U.S. EPA TSCA Inventory List.

TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D)

Not regulated.

CERCLA Hazardous Substance List (40 CFR 302.4)

1,1-Dimethylhydrazine (CAS 57-14-7)	Listed.

SARA 304 Emergency release notification

1,1-Dimethylhydrazine (CAS 57-14-7)	10 LBS

US. OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050)

Not listed.

Superfund Amendments and Reauthorization Act of 1986 (SARA)

Hazard categories
Immediate Hazard - Yes
Delayed Hazard - Yes
Fire Hazard - Yes
Pressure Hazard - No
Reactivity Hazard - No

SARA 302 Extremely hazardous substance

Chemical name	CAS number	Reportable quantity	Threshold planning quantity	Threshold planning quantity, lower value	Threshold planning quantity, upper value
1,1-Dimethylhydrazine	57-14-7	10	1000 lbs		

SARA 311/312 Hazardous chemical Yes

SARA 313 (TRI reporting)

Chemical name	CAS number	% by wt.
1,1-Dimethylhydrazine	57-14-7	100

Other federal regulations

Clean Air Act (CAA) Section 112 Hazardous Air Pollutants (HAPs) List

1,1-Dimethylhydrazine (CAS 57-14-7)

Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 68.130)

1,1-Dimethylhydrazine (CAS 57-14-7)

Safe Drinking Water Act (SDWA) Not regulated.

US state regulations

US - New Jersey RTK - Substances: Listed substance

1,1-Dimethylhydrazine (CAS 57-14-7)

US - Pennsylvania RTK - Hazardous Substances: Special hazard

1,1-Dimethylhydrazine (CAS 57-14-7)

US. California Controlled Substances. CA Department of Justice (California Health and Safety Code Section 11100)

Not listed.

US. California. Candidate Chemicals List. Safer Consumer Products Regulations (Cal. Code Regs, tit. 22, 69502.3, subd. (a))

1,1-Dimethylhydrazine (CAS 57-14-7)

US. Massachusetts RTK - Substance List

1,1-Dimethylhydrazine (CAS 57-14-7)

US. New Jersey Worker and Community Right-to-Know Act

1,1-Dimethylhydrazine (CAS 57-14-7)

US. Pennsylvania RTK - Hazardous Substances

1,1-Dimethylhydrazine (CAS 57-14-7)

US. Pennsylvania Worker and Community Right-to-Know Law

1,1-Dimethylhydrazine (CAS 57-14-7)

US. Rhode Island RTK

1,1-Dimethylhydrazine (CAS 57-14-7)

US. California Proposition 65

WARNING: This product contains a chemical known to the State of California to cause cancer.

US - California Proposition 65 - CRT: Listed date/Carcinogenic substance

1,1-Dimethylhydrazine (CAS 57-14-7)	Listed: October 1, 1989

International Inventories

Country(s) or region	Inventory name	On inventory (yes/no)*
Australia	Australian Inventory of Chemical Substances (AICS)	Yes
Canada	Domestic Substances List (DSL)	No
Canada	Non-Domestic Substances List (NDSL)	Yes
China	Inventory of Existing Chemical Substances in China (IECSC)	Yes
Europe	European Inventory of Existing Commercial Chemical Substances (EINECS)	Yes
Europe	European List of Notified Chemical Substances (ELINCS)	No
Japan	Inventory of Existing and New Chemical Substances (ENCS)	Yes
Korea	Existing Chemicals List (ECL)	Yes
New Zealand	New Zealand Inventory	Yes
Philippines	Philippine Inventory of Chemicals and Chemical Substances (PICCS)	Yes
United States & Puerto Rico	Toxic Substances Control Act (TSCA) Inventory	Yes

*A "Yes" indicates that all components of this product comply with the inventory requirements administered by the governing country(s)
A "No" indicates that one or more components of the product are not listed or exempt from listing on the inventory administered by the governing country(s).

16. Other information, including date of preparation or last revision

Issue date	11-19-2014
Revision date	11-25-2015
Version #	02

Disclaimer

The above information is believed to be correct on the date it was last revised and must not be considered all inclusive. The information has been obtained only by a search of available literature and is only a guide for handling the chemicals. OSHA regulations require that if other hazards become evident, an upgraded SDS must be made available to the employee within three months. RESPONSIBILITY for updates lies with the employer and not with CHEM SERVICE, Inc.

Persons not specifically and properly trained should not handle this chemical or its container. This product is furnished FOR LABORATORY USE ONLY! Our products may NOT BE USED as drugs, cosmetics, agricultural or pesticide products, food additives or as household chemicals.

This Safety Data Sheet (SDS) is intended only for use with Chem Service, Inc. products and should not be relied on for use with materials from any other supplier even if the chemical name(s) on the product are identical! Whenever using an SDS for a solution or mixture the user should refer to the SDS for every component of the solution or mixture. Chem Service warrants that this SDS is based upon the most current information available to Chem Service at the time it was last revised. THIS WARRANTY IS EXCLUSIVE, AND CHEM SERVICE, INC. MAKES NO OTHER WARRANTY, EXPRESSED OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. This SDS is provided gratis and CHEM SERVICE, INC. SHALL NOT BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL OR CONTINGENT DAMAGES.

This product is furnished FOR LABORATORY USE ONLY.

SAFETY DATA SHEET

Helium

Section 1. Identification

GHS product identifier : Helium

Chemical name : Helium

Other means of identification : helium (dot); Helium-4; He; o-Helium; UN 1046,Helium USP

Product type : Gas.

Product use : Synthetic/Analytical chemistry.

Synonym : helium (dot); Helium-4; He; o-Helium; UN 1046,Helium USP

SDS # : 001025

Supplier's details : Airgas USA, LLC and its affiliates
259 North Radnor-Chester Road
Suite 100
Radnor, PA 19087-5283
1-610-687-5253

24-hour telephone : 1-866-734-3438

Section 2. Hazards identification

OSHA/HCS status : This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Classification of the substance or mixture : GASES UNDER PRESSURE - Compressed gas

GHS label elements

Hazard pictograms :

Signal word : Warning

Hazard statements : Contains gas under pressure; may explode if heated.
May displace oxygen and cause rapid suffocation.

Precautionary statements

General : Read and follow all Safety Data Sheets (SDS'S) before use. Read label before use. Keep out of reach of children. If medical advice is needed, have product container or label at hand. Close valve after each use and when empty. Use equipment rated for cylinder pressure. Do not open valve until connected to equipment prepared for use. Use a back flow preventative device in the piping. Use only equipment of compatible materials of construction.

Prevention : Not applicable.

Response : Not applicable.

Storage : Protect from sunlight. Store in a well-ventilated place.

Disposal : Not applicable.

Hazards not otherwise classified : In addition to any other important health or physical hazards, this product may displace oxygen and cause rapid suffocation.

Section 3. Composition/information on ingredients

Substance/mixture	:	Substance
Chemical name	:	Helium
Other means of identification	:	helium (dot); Helium-4; He; o-Helium; UN 1046,Helium USP
Product code	:	001025

CAS number/other identifiers

CAS number : 7440-59-7

Ingredient name	%	CAS number
Helium	100	7440-59-7

Any concentration shown as a range is to protect confidentiality or is due to batch variation.

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Description of necessary first aid measures

Eye contact	:	Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 minutes. Get medical attention if irritation occurs.
Inhalation	:	Remove victim to fresh air and keep at rest in a position comfortable for breathing. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention if adverse health effects persist or are severe. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.
Skin contact	:	Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur. Wash clothing before reuse. Clean shoes thoroughly before reuse.
Ingestion	:	As this product is a gas, refer to the inhalation section.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact	:	Contact with rapidly expanding gas may cause burns or frostbite.
Inhalation	:	No known significant effects or critical hazards.
Skin contact	:	Contact with rapidly expanding gas may cause burns or frostbite.
Frostbite	:	Try to warm up the frozen tissues and seek medical attention.
Ingestion	:	As this product is a gas, refer to the inhalation section.

Over-exposure signs/symptoms

Eye contact	:	No specific data.
Inhalation	:	No specific data.
Skin contact	:	No specific data.
Ingestion	:	No specific data.

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician	:	Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.
Specific treatments	:	No specific treatment.

Section 4. First aid measures

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media : Use an extinguishing agent suitable for the surrounding fire.

Unsuitable extinguishing media : None known.

Specific hazards arising from the chemical : Contains gas under pressure. In a fire or if heated, a pressure increase will occur and the container may burst or explode.

Hazardous thermal decomposition products : No specific data.

Special protective actions for fire-fighters : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Contact supplier immediately for specialist advice. Move containers from fire area if this can be done without risk. Use water spray to keep fire-exposed containers cool.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel : No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Avoid breathing gas. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders : If specialized clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions : Ensure emergency procedures to deal with accidental gas releases are in place to avoid contamination of the environment. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Small spill : Immediately contact emergency personnel. Stop leak if without risk.

Large spill : Immediately contact emergency personnel. Stop leak if without risk. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Protective measures : Put on appropriate personal protective equipment (see Section 8). Contains gas under pressure. Avoid breathing gas. Do not puncture or incinerate container. Use equipment rated for cylinder pressure. Close valve after each use and when empty. Protect cylinders from physical damage; do not drag, roll, slide, or drop. Use a suitable hand truck for cylinder movement.
Avoid contact with eyes, skin and clothing. Empty containers retain product residue and can be hazardous.

Section 7. Handling and storage

Advice on general occupational hygiene : Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.

Conditions for safe storage, including any incompatibilities : Store in accordance with local regulations. Store in a segregated and approved area. Store away from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10). Cylinders should be stored upright, with valve protection cap in place, and firmly secured to prevent falling or being knocked over. Cylinder temperatures should not exceed 52 °C (125 °F). Keep container tightly closed and sealed until ready for use. See Section 10 for incompatible materials before handling or use.

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

Ingredient name	Exposure limits
Helium	**ACGIH TLV (United States, 3/2017). Oxygen Depletion [Asphyxiant].**

Appropriate engineering controls : Good general ventilation should be sufficient to control worker exposure to airborne contaminants.

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Eye/face protection : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: safety glasses with side-shields.

Skin protection

Hand protection : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated.

Body protection : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Section 8. Exposure controls/personal protection

Respiratory protection	Based on the hazard and potential for exposure, select a respirator that meets the appropriate standard or certification. Respirators must be used according to a respiratory protection program to ensure proper fitting, training, and other important aspects of use. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance	
Physical state	Gas. [Compressed gas.]
Color	Colorless.
Odor	Odorless.
Odor threshold	Not available.
pH	Not available.
Melting point	-272.2°C (-458°F)
Boiling point	-268.9°C (-452°F)
Critical temperature	-267.9°C (-450.2°F)
Flash point	[Product does not sustain combustion.]
Evaporation rate	Not available.
Flammability (solid, gas)	Not available.
Lower and upper explosive (flammable) limits	Not available.
Vapor pressure	Not available.
Vapor density	0.14 (Air = 1) Liquid Density@BP: 7.8 lb/ft3 (125 kg/m3)
Specific Volume (ft ^{3}/lb)	96.1538
Gas Density (lb/ft ^{3})	0.0104
Relative density	Not applicable.
Solubility	Not available.
Solubility in water	Not available.
Partition coefficient: n-octanol/water	0.28
Auto-ignition temperature	Not available.
Decomposition temperature	Not available.
Viscosity	Not applicable.
Flow time (ISO 2431)	Not available.
Molecular weight	4 g/mole

Section 10. Stability and reactivity

Reactivity	No specific test data related to reactivity available for this product or its ingredients.
Chemical stability	The product is stable.
Possibility of hazardous reactions	Under normal conditions of storage and use, hazardous reactions will not occur.
Conditions to avoid	No specific data.
Incompatible materials	No specific data.
Hazardous decomposition products	Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Section 10. Stability and reactivity

Hazardous polymerization : Under normal conditions of storage and use, hazardous polymerization will not occur.

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity

Not available.

Irritation/Corrosion

Not available.

Sensitization

Not available.

Mutagenicity

Not available.

Carcinogenicity

Not available.

Reproductive toxicity

Not available.

Teratogenicity

Not available.

Specific target organ toxicity (single exposure)

Not available.

Specific target organ toxicity (repeated exposure)

Not available.

Aspiration hazard

Not available.

Information on the likely routes of exposure : Not available.

Potential acute health effects

Eye contact : Contact with rapidly expanding gas may cause burns or frostbite.
Inhalation : No known significant effects or critical hazards.
Skin contact : Contact with rapidly expanding gas may cause burns or frostbite.
Ingestion : As this product is a gas, refer to the inhalation section.

Symptoms related to the physical, chemical and toxicological characteristics

Eye contact : No specific data.
Inhalation : No specific data.
Skin contact : No specific data.
Ingestion : No specific data.

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure

Potential immediate effects : Not available.
Potential delayed effects : Not available.

Long term exposure

Section 11. Toxicological information

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Potential chronic health effects

Not available.

General : No known significant effects or critical hazards.

Carcinogenicity : No known significant effects or critical hazards.

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : No known significant effects or critical hazards.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : No known significant effects or critical hazards.

Numerical measures of toxicity

Acute toxicity estimates

Not available.

Section 12. Ecological information

Toxicity

Not available.

Persistence and degradability

Not available.

Bioaccumulative potential

Product/ingredient name	LogP$_{ow}$	BCF	Potential
Helium	0.28	-	low

Mobility in soil

Soil/water partition coefficient (K$_{OC}$) : Not available.

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods : The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Waste should not be disposed of untreated to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Empty Airgas-owned pressure vessels should be returned to Airgas. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Empty containers or liners may retain some product residues. Do not puncture or incinerate container.

Section 14. Transport information

	DOT	TDG	Mexico	IMDG	IATA
UN number	UN1046	UN1046	UN1046	UN1046	UN1046
UN proper shipping name	HELIUM, COMPRESSED	HELIUM, COMPRESSED	HELIUM, COMPRESSED	HELIUM, COMPRESSED	HELIUM, COMPRESSED
Transport hazard class(es)	2.2 	2.2 	2.2 	2.2 	2.2 
Packing group	-	-	-	-	-
Environmental hazards	No.	No.	No.	No.	No.

"Refer to CFR 49 (or authority having jurisdiction) to determine the information required for shipment of the product."

Additional information

DOT Classification : **Limited quantity** Yes.
Quantity limitation Passenger aircraft/rail: 75 kg. Cargo aircraft: 150 kg.

TDG Classification : Product classified as per the following sections of the Transportation of Dangerous Goods Regulations: 2.13-2.17 (Class 2).
Explosive Limit and Limited Quantity Index 0.125
Passenger Carrying Road or Rail Index 75

IATA : **Quantity limitation** Passenger and Cargo Aircraft: 75 kg. Cargo Aircraft Only: 150 kg.

Special precautions for user : **Transport within user's premises:** always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Transport in bulk according to Annex II of MARPOL and the IBC Code : Not available.

Section 15. Regulatory information

U.S. Federal regulations : **TSCA 8(a) CDR Exempt/Partial exemption**: Not determined

Clean Air Act Section 112 (b) Hazardous Air Pollutants (HAPs) : Not listed

Clean Air Act Section 602 Class I Substances : Not listed

Clean Air Act Section 602 Class II Substances : Not listed

DEA List I Chemicals (Precursor Chemicals) : Not listed

DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 302/304

Composition/information on ingredients

No products were found.

SARA 304 RQ : Not applicable.

Section 15. Regulatory information

SARA 311/312

Classification : Refer to Section 2: Hazards Identification of this SDS for classification of substance.

State regulations

Massachusetts : This material is listed.

New York : This material is not listed.

New Jersey : This material is listed.

Pennsylvania : This material is listed.

International regulations

Chemical Weapon Convention List Schedules I, II & III Chemicals

Not listed.

Montreal Protocol (Annexes A, B, C, E)

Not listed.

Stockholm Convention on Persistent Organic Pollutants

Not listed.

Rotterdam Convention on Prior Informed Consent (PIC)

Not listed.

UNECE Aarhus Protocol on POPs and Heavy Metals

Not listed.

Inventory list

Australia : This material is listed or exempted.

Canada : This material is listed or exempted.

China : This material is listed or exempted.

Europe : This material is listed or exempted.

Japan : **Japan inventory (ENCS)**: Not determined.
Japan inventory (ISHL): Not determined.

Malaysia : Not determined.

New Zealand : This material is listed or exempted.

Philippines : This material is listed or exempted.

Republic of Korea : This material is listed or exempted.

Taiwan : This material is listed or exempted.

Thailand : Not determined.

Turkey : Not determined.

United States : This material is listed or exempted.

Viet Nam : Not determined.

Section 16. Other information

Hazardous Material Information System (U.S.A.)

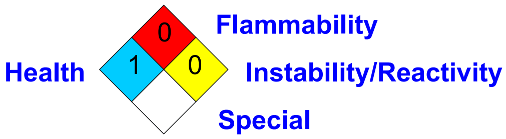
Health	/	1
Flammability		0
Physical hazards		3

Caution: HMIS® ratings are based on a 0-4 rating scale, with 0 representing minimal hazards or risks, and 4 representing significant hazards or risks. Although HMIS® ratings and the associated label are not required on SDSs or products leaving a facility under 29 CFR 1910.1200, the preparer may choose to provide them. HMIS® ratings are to be used with a fully implemented HMIS® program. HMIS® is a registered trademark and service mark of the American Coatings Association, Inc.

Section 16. Other information

The customer is responsible for determining the PPE code for this material. For more information on HMIS® Personal Protective Equipment (PPE) codes, consult the HMIS® Implementation Manual.

National Fire Protection Association (U.S.A.)



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Copyright ©2001, National Fire Protection Association, Quincy, MA 02269. This warning system is intended to be interpreted and applied only by properly trained individuals to identify fire, health and reactivity hazards of chemicals. The user is referred to certain limited number of chemicals with recommended classifications in NFPA 49 and NFPA 325, which would be used as a guideline only. Whether the chemicals are classified by NFPA or not, anyone using the 704 systems to classify chemicals does so at their own risk.

Procedure used to derive the classification

Classification	Justification
GASES UNDER PRESSURE - Compressed gas	Expert judgment

History

Date of printing : 4/23/2018

Date of issue/Date of revision : 4/23/2018

Date of previous issue : 1/29/2018

Version : 1.01

Key to abbreviations :
ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
UN = United Nations

References : Not available.

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

APPENDIX C

UNITED PARADYNE CORPORATION EMERGENCY RESPONSE PLAN

AEROSPACE SUPPORT SERVICES PERFORMANCE WORK INSTRUCTION	
Contract: FA4610-10-C-0008	Procedure Number: PWI-10-S-003
Title: Emergency Response Plan	
Release Date: 06 May 2014	Revision: H

EMERGENCY RESPONSE PLAN

PWI-10-S-003H

C. Martino Date
Safety & Health Manager

H. Lee Davis Date
Quality/Environmental

Shane Cooper Date
Systems Safety

William E. Schwenk Date
Operations Manager

Dan Aldridge Date
Engineer Manager

Randy Cobb Date
Program Manager

PRINTED VERSIONS SHOULD BE VERIFIED FOR CURRENCY PRIOR TO USE

REVISION RECORD

Revisions to this document will be reviewed and approved through the same level of authority as the original document.

REV - CHANGE	DATE	REASON	PAGES AFFECTED
BASIC	07-24-96	Initial Issue	ALL
A	08-01-97	To provide information required to adequately assess environmental impacts on various emergency conditions that require response from United Paradyne Corporation.	ALL
B	01-29-03	Update procedure to include changes as a result of ASSC.	ALL
C	09-04-03	In Section 1.2.B. add PWI-20-O-035, Transient Alert Maintenance (TAM) / Aerospace Ground Equipment (AGE) and AFOSH 91-100, Aircraft Flightline Ground Operations and Activities	2
		In Section 3.1 add paragraph K. Building 1737, PMEL.	25
		In Section 3.2.D, move “UPC Motorola Hand Held Portable Radio Call Signs” to end of paragraph B.	26
		Add to Section 4.1, “Bldg 1737/1720/1723 PMEL – Adhesives, alcohols, compressed gases, lubricants, paints, oils, silicones, solvents and cleaners”	31
		In Section 17.1, add to end of paragraph “For flight line emergencies that might require services i.e., assisting in analyzing systems malfunction and securing of aircraft, tow or removal of aircraft from flightline, use of follow-me vehicle as a control tower escort for emergency team, operation and maintenance of AGE equipment in support of recovery operations etc., please refer to PWI-20-O-035 and AFOSH 91-100”.	78
D	03/27/06	Added a new Section 18.0 for “Emergency Protective Actions to Declared Hazardous Materials Incident” and provided miscellaneous updates to personnel, phone numbers, and minor grammatical editing.	87-90
E	03/04/09	Implementing change to comply with changes in the CEMP10-2 Plan incorporating EOC and removing DCG. Updated Sections 5.0, 6.0, 7.0 and Appendix B to clarify reporting requirements in cases of spills and/or releases. Revised definitions for leak, major spill and spill.	All
F	05/11/10	Changes to Section 17.0 “In-Flight Aircraft Emergency”.	88-89
		Added a new Section 19.0 “LPART Emergency Response in Support of Boeing GMD Tanking Operations”.	94-98
G	03/05/14	Added a new paragraph 2 to Section 1.1	1
		Added a new paragraph 3 to Section 6.1.A.	55
		Revised Section 19.0 LPART Emergency Response in Support of Boeing GMD Tanking Operations.	94-98
H	05/06/14	Update Sect 19.0 LPART Emergency Response to include MAP 1819.	94-98

CONTENTS

PART II EMERGENCY RESPONSE TEAM OPERATIONS

PART II EMERGENCY RESPONSE TEAM OPERATIONS (CONT.)

PART II EMERGENCY RESPONSE TEAM OPERATIONS (CONT.)

FIGURES

APPENDICES

PART I

INTRODUCTION AND ORGANIZATION

1.0 INTRODUCTION TO THE PLAN

Emergencies and the threat of impending emergencies will occur during the course of any normal business cycle. Emergencies can and will happen even when adequate planning and precautions have been taken. However, it is widely accepted in business that careful planning, training, and decision making, prior to an emergency incident, can minimize the impact of an emergency on any organization. To plan for such an event, this emergency response plan and strategic measures have been developed for United Paradyne Corporation (UPC) personnel. This document incorporates current regulatory requirements, relevant UPC policies and procedures, and various response strategies into a single comprehensive emergency response instrument. This document satisfies certain regulatory requirements and provides an effective emergency response plan which enhances the overall environmental and safety programs of UPC.

1.1 OBJECTIVES

The purpose of the United Paradyne Corporation Emergency Response Plan (ERP) is to provide all employees single-source, comprehensive document that clearly states emergency actions (to include decontamination procedures), response strategies, environmental assessments, and contractual and regulatory notifications that UPC emergency response personnel must perform during and after emergency events.

NOTE: Personnel and equipment exposed to, or are suspected of exposure to Hypergols, are to be decontaminated by deluging the affected area with copious amounts of water in a designated containment area until 0.0 ppm on a Portable Vapor Detector is achieved. Per Emergency Instructions (Appendix Z) of applicable operation procedures; Additional notifications are required for personnel directly exposed to Hypergols outside the parameters of SCAPE operations which include: calling 911, staying with the exposed personnel until medical assistance arrives, and reporting the incident to OCC 606-7451 and the Command Center 606-9961.

Response to emergency and disaster conditions will be largely dependent upon the nature and scope of the emergency, the resources and commodity involved, quantity, toxicity, weather conditions, environmental factors, and contractual direction UPC receives from the Vandenberg Air Force Base (VAFB) Emergency Operations Center (EOC) in its integrated response strategy.

Not all emergency conditions and situations can be predicted with a high degree of accuracy. With this in mind, it is important to understand the significance of UPC being prepared for all emergency conditions which can be reasonably expected and anticipated. This plan will be reviewed initially with all new employees and with existing employees when their work center assignments change.

1.2 REFERENCES

A. Regulatory

Part of the preparation mentioned previously is the development and execution of an emergency response plan that protects the interests of employees, customers, clients, and the Corporation. Most regulatory requirements now stipulate that emergency response plans must be in a written format clearly delineating the responses that will be taken by emergency response employees. This document provides that direction.

1.2 REFERENCES (CONT.)

While many goals and requirements of the various regulatory plans are similar, most notably employee and environmental protection, each must have a unique focus and format. In that regard, it is incumbent upon this plan to satisfy the following Federal and Government regulations:

29 CFR1910.119	Process Safety Management of Highly Hazardous Chemicals
29 CFR1910.120(q)(2)	Hazardous Waste Operations Emergency Response
29 CFR1910.1200	Hazard Communication
29 CFR1910.156	Fire Emergencies
29 CFR1910.38	Emergency Plan
29 CFR1910.151	First Aid Emergencies
29 CFR1910.165	Alarm System Activation
40 CFR262	Standards Applicable to Generators of Hazardous Waste
Article 80, UFC	Hazardous Materials, Uniform Fire Code

B. Referenced Publications and Agencies

30 SWI 15-101	Weather Support Procedure
CEMP PLAN 10-2	Comprehensive Emergency Management Plan
30 SW OPLAN 32-1	Disaster Preparedness Operations Plan
30 SW OPLAN 32-4002	Hazardous Materials (HAZMAT) Emergency Response Plan
30 SW PLAN 10-245	Exercise Guidance
30 SWI 10-105	Pyramid Alert and Disaster Notification
UPC-O-038	Contingency Van Checklist
UPC-O-065	UPC PEMO Contingency Van Response Checklist
UPC-P-018	OCC EOC Log
PWI-20-O-035	Transient Alert Maintenance (TAM)/Aerospace Ground Equipment (AGE)
SOP-P-002	PWI/CDRL Guidelines
AFOSH 91-100	Aircraft Flightline-Ground Operations and Activities
40CFR264.16	Standards Applicable to Owners/Operators of Hazardous Waste Treatment Storage and Disposal Facilities
Uniform Fire Code	Article 80, Hazardous Materials
ANSI/ISO 14001-1996	Environmental Management Systems
AFSPCMAN 91-710	Range Safety User Requirements
EWRR 127-1	Eastern and Western Range Requirements
AFI 91-204	Safety Investigations and Reports

1.3 ORGANIZATIONAL STATEMENT

The United Paradyne Corporation Emergency Response Team is comprised of dedicated, highly skilled and trained technicians, lead technicians, supervisors, managers, and professional services personnel. The purpose of the emergency response team is to provide initial response to emergency conditions, preventing and mitigating adverse environmental impacts, and to provide subsequent direct operational support to the Vandenberg Air Force Base Disaster Control Group. This document describes the roles and responsibilities, and the specific operational guidelines for personnel actually responding to an incident or exercise. Most emergency responses will be performed in concert with the Base's Emergency Operations Center under the National Incident Command System.

1.4 DEFINITIONS

Acutely Hazardous Material (AHM). Any chemical designated an extremely hazardous substance which is listed in Appendix A of 40 CFR 355. A list of these substances or materials is found in Appendix A of this plan.

AGE. Aerospace Ground Equipment Maintenance Section.

Appendix Z. In United Paradyne Operating Procedures, Appendix Z stipulates the immediate emergency actions necessary to safely regress from propellant handling operations. This appendix gives safe direction to the operation being performed, permitting operating personnel a safe avenue out of an operational area.

Approval Authority. Agency ultimately responsible for decisions regarding hazardous materials planning or release response. Various aspects of an incident may have a different approval authority.

Azimuth. This is a statement of the arc that would enclose the released vapor.

Base Residents. Government contractors, military units, civilian contractors, government agencies, and commercial space users who operate a facility within the geographical boundaries of VAFB.

Business Plan. (H&S 25500) A “Business Plan” is a hazardous materials contingency planning instrument. It is designed to assist the facility operator, facility staff and emergency planners to better understand the hazards of chemicals in the workplace. The plan consists of four integral parts:

- An inventory of hazardous materials, which describes their behavior, characteristics, and health risk
- Site and facility maps and floor plans indicating the locations of hazardous materials
- A hazardous materials emergency response plan
- A training program for all employees

Check-In. Location where assigned resources check in at an incident. Check in at one location only (Resources Management Crew) using appropriate documentation, or direction provided by the EOC.

Clean Air Act (CAA). Sets forth the list of regulated substances and thresholds, the petition process for adding or deleting substances to the list of regulated substances, and requirements for owners or operators of stationary sources concerning the prevention of accidental releases (40 CFR 68).

Containment. The safe and correct procedure for isolating, containing, and preventing a hazardous material release from spreading to the surrounding environment.

1.4 DEFINITIONS (CONT.)

Contamination. The degradation of naturally occurring water, air, or soil quality either directly or indirectly as a result of human activities.

Contractors. Referred to as Base Residents.

Conventional Propellant. A propellant fuel based upon combustion of fossil or hydrocarbon materials.

Coordination. The process of systematically analyzing a situation, developing relevant information, and informing appropriate command authority (for its decision) of viable alternatives for selection of the most effective combination of available resources to meet specific objectives.

Emergency Operations Center (EOC). The disaster response force element that goes to the scene of a Level III HAZMAT incident to provide command and control under direction of the on-scene commander.

Emergency Coordinator. Person responsible for handling hazardous waste release and emergencies under the Resource Conservation and Recovery Act (RCRA).

Emission Hazard Zone (EHZ). One type of Toxic Hazard Zone (See definition for Toxic Hazard Zone) where a Toxic Hazard Zone (THZ) established prior to a planned emission of toxic materials into the atmosphere (e.g., scrubber venting, tank venting or purging operations, HCl releases from solid propellant combustion during launch operations). Source strength in pounds per minute must be calculated for each EHZ.

Entry Team. Performs the physical reconnaissance of the problem area, if safely possible. Documents and reports the presence of potential life hazards and environmental factors. Assists in plan formulation for control actions. Dons proper protective equipment and enters the cordoned hazardous area to perform control activities.

Environment. Includes water, air, or land and the interrelationship, which exists among and between water, air, and land and all living things.

Environmental Impact. Any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organizations activities, products or services.

Emergency Operations Center Director (EOC Director). The individual designated to direct activities at the scene of an incident. This task is normally exercised by the 30 OG/CC. The senior fire official will serve as the EOC until a designated EOC arrives and is briefed on the situation. Under 40 CFR 300, the National Contingency Plan, the term EOC designates a federal on-scene coordinator. Because DOD provides their own coordinator, the EOC Director fills this role.

Extremely Hazardous Substance. Equivalent to “Acutely Hazardous Material.” A list of these substances or materials is found in Appendix A of this plan.

1.4 DEFINITIONS (CONT.)

Facility. Any building, structure, or complexes thereof (e.g. Space Launch Complexes); or any site where hazardous material is stored or placed, which exceeds a TPQ, pursuant to Chapter 6.95 of the California Health and Safety Code.

First Responders (FR). The disaster response force element that deploys immediately to the scene to provide initial command and control, to save lives, and to suppress and control hazards. This element will respond to all Level II HAZMAT incidents.

Follow-On Elements. The non-emergency response elements of the disaster response force that deploy to the scene of a Level III incident to expand command and control and to perform support functions.

Ground Water. Water in a saturated zone or stratum beneath the surface of land or water.

Hazards Analysis. Used to obtain a clear understanding of what hazards exist and what risk they pose to people, property, missions and the environment. It consists of determining where hazards are likely to exist, what places would most likely be adversely affected, what hazardous materials could be involved, and what conditions might exist during a spill or release. This process also assesses the probability of damage or injury. The information developed in a hazards analysis provides the basis for worst case credible spill criteria, toxic hazard corridor vent rates, calculating potential wetted spill areas, establishing priorities and subsequent planning, and also provides the documentation to support hazardous materials planning and response efforts.

HAZMAT Group. Used to describe selected hazardous materials response team members and other support personnel actively involved in the response to a HAZMAT incident. Contains the functional roles of Hazard Group Supervisor, Safety and Health Monitor, Entry Team, Decontamination Team, Information Management Team and Resource Management Team.

HAZMAT Group Supervisor. Assists the Emergency Operations Center Director (EOC Director) with overall scene management, directly supervises the Hazard Group and keeps the EOC Director fully advised of technical and HAZMAT-specific information.

Hazard Identification. First phase of the hazards analysis process where facilities handling, storing or disposing of hazardous materials above specific screening levels are identified.

Hazardous Material. (H&S 2550(k)) Any material that, because of its quantity, concentration, or physical or chemical characteristics, poses a significant present or potential hazard to human health and safety or to the environment if released into the workplace or the environment. “Hazardous materials” include, but are not limited to, hazardous substances, hazardous waste, and any material which a handler or the administering agency has a reasonable basis for believing would be injurious to the health and safety of persons or harmful to the environment, if released into the workplace or the environment.

Hazardous Material Response Team (HMRT). The team of fire department responders trained to assess, control, and begin recovery from a HAZMAT incident. The purpose of this team is to respond to HAZMAT incidents to prevent or reduce human injury or death, property damage, product loss and environmental damage.

1.4 DEFINITIONS (CONT.)

Hazardous Waste (HW). (H&S 25117) “Hazardous Waste” means either of the following:

- A waste, or combination of wastes, which, because of its quantity, concentration, or physical, chemical, or infectious characteristics may either:
  - ⇒ Cause, or significantly contribute to an increase in mortality, or an increase in serious irreversible, or incapacitating reversible illness.
  - ⇒ Pose a substantial present or potential hazard to human health or environment when improperly treated, stored, transported, or disposed of, or otherwise managed.
- A waste which meets any of the criteria for the identification of a hazardous waste adopted by the Department pursuant to H&S 25141.

Hazardous waste includes, but is not limited to, RCRA hazardous waste. Unless expressly provided otherwise, the term “hazardous waste” shall be understood to also include extremely hazardous waste and acutely hazardous waste.

Hazardous Waste Storage Facility (HWSF). The RCRA permitted storage facility on VAFB where all containerized hazardous waste generated on VAFB is brought for storage for a maximum period of one year prior to final disposition. The HWSF (Bldg. 6830) for VAFB is located on 13th Street.

Hypergolic. Igniting upon contact of components without external aid.

Immediately Dangerous to Life and Health (IDLH). “Immediately dangerous to life or health means conditions that pose an immediate threat to life or health or conditions that pose an immediate threat of severe exposure to contaminants, such as radioactive materials, which are likely to have an adverse cumulative or delayed effect on health.” The IDLH concentration represents the maximum concentration of a substance in air from which healthy workers can escape without loss of life or irreversible health effects under conditions of a maximum 30-minute exposure time. Practically, IDLH’s are concentrations above which a highly reliable breathing apparatus is required for safe escape.

Incident. An occurrence or event, either human-caused or natural phenomena, that requires action by emergency service personnel to prevent or minimize loss or damage to property and/or natural resources. Incidents involving hazardous materials can be divided into two categories; 1) minor incidents handled by qualified, facility operator on-site personnel; and, 2) major incidents requiring the service of emergency response agencies. Major incidents are those releases which are clearly beyond the capability of the organization which released the materials. Typically, these could be expected to involve volumes in the tens to thousands of gallons. Occurrences that might cause this type of release would be a broken drum, burst pipe/tank, burst flex hose, tanker vehicle accident, derailment, or some other type of mechanical failure. The chemical make-up of a substance determines the magnitude of the incident.

Incident Action Plan. The incident action plan, which is initially prepared at the first meeting, contains general control objectives reflecting the overall incident strategy and specific action plans.

1.4 DEFINITIONS (CONT.)

Information Management Team. Assembles and analyzes all technical reference material, incident data and other resources (including site specific contingency plans for known hazardous materials, and interviews with Bioenvironmental Engineering Services or other technical specialists). Makes recommendations to the HAZMAT Group Supervisor concerning evacuation criteria, protective clothing and equipment, and mitigation procedures.

Leak. The accidental release of a liquid or gas from its containment fixture. A leak may be caused by impact or puncture, over-pressurization, faulty valves, defects in container construction, or sabotage. Leak is also referred to as a pollution incident.

Levels of Concern (LOC). EPA term defining the concentration of an extremely hazardous material in the air, above which there may be serious irreversible health effects or death as a result of a single exposure for relatively short periods of time. There are three (3) levels of concern:

- **Level 1: Control access and evacuate**

Concentrations pose significant risk to exposed personnel. Evacuation should be performed unless it creates more risk than seeking shelter or remaining in air-tight shelters.

- **Level 2: Seek shelter or evacuate**

Exposure poses some risk to the average individual. Seek shelter indoors with outside air intakes closed, or evacuate, depending on situation and duration.

- **Level 3: Sensitive individuals**

Exposure poses no hazard to normal healthy individuals. Certain sensitive individuals (asthmatics and certain other lung diseased people) may be at some risk if exposed. Similar to Stage 3 Air Pollution Alert. Notify the public of the confirmed release, provide information on potential public exposure and effects, and advise sensitive individuals to avoid strenuous physical activity, remain indoors and close air intakes. Corresponds with a 1st Tier THC Zone.

NOTE

These levels do not correlate with Incident Command System (ICS) levels of response.

Major Release/Spill. A major hazardous material release/spill is one in which:

- A life threatening condition exists, or personnel injury exposure has occurred.
- Assistance is required from emergency personnel (i.e., fire, police, etc.) beyond the capabilities of the base resident, and
- The condition requires immediate evacuation of all employees from area or building.
- Major release/spill must be immediately in accordance with Section 5 of this procedure.
- A major leak or spill is more than one gallon (AFSPCMAN 91-710, Volume 7 - Glossary).

1.4 DEFINITIONS (CONT.)

Minor Release/Spill. A minor hazardous material release/spill is characterized by:

- The confidence and capability of employees to clean up the release without assistance from emergency personnel is assumed even though the clean up procedure may require specialized knowledge and specialized equipment. It is probably unnecessary to call the emergency number, and no personnel injury exposure has occurred.
- Relatively small area of a shop, laboratory, or room is affected and only a small number of personnel may need to leave the area until the release is cleaned up.
- NOTE: The HSF's typically have a 90 gallon spill kit container on site which is capable of absorbing up to 45 gallons (approximately 50% of container size) of liquid.
- Minor leak or spill is less than one gallon. (AFSPCMAN 91-710, Volume 7 - Glossary)

Minor unplanned, unexpected releases must still be reported to 30 CES/CEV and VAFB Command Post. If a release is planned & expected as due course from a functional task/haz op, notification to 30 CES/CEF & Base Command Post is not required.

Mission Essential. All support personnel, equipment and facilities required to support a specific task.

Multi-Agency Coordination System (MACS). The combination of facilities, equipment, personnel, procedures, and communications integrated into a common system with responsibility for coordination of assisting agency resources and support to agency emergency operations.

National Response Team (NRT). A team of Federal representatives from the primary and advisory Federal agencies that serves as the national body for planning and preparedness actions prior to a pollution discharge, and for coordination and advice during a pollution emergency.

National Incident Command System (NICS). A command structure utilized within the fire department to initiate command and control at the scene of an emergency.

Navigable Waters. The waters of the United States, including territorial seas. The term includes: all waters that are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters subject to the ebb and flow of the tide; all interstate waters, including interstate wetlands; all other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, sloughs, prairie potholes, wet meadows, lakes or natural ponds, the use, degradation, or destruction of which could affect interstate or foreign commerce including any such waters that are or could be used by interstate or foreign travelers for recreational or other purposes, or, from which fish or shellfish are or could be taken and sold in interstate commerce, or, that are used or could be used for industrial purposes by industries in interstate commerce; all impoundment's of waters otherwise defined as waters of the United States under this section; tributaries of waters; the territorial sea; and wetlands adjacent to waters (other than waters that are themselves wetlands) (Clean Water Act).

Oil. Petroleum products of any kind or in any form, including but not limited to lubricants, conventional fuel, oil, sludge, and oil mixed with wastes other than dredged soil.

1.4 DEFINITIONS (CONT.)

Operational Hazard Zone (OHZ). The Toxic Hazard Corridor (THC) established following an accidental spill or unplanned release, based upon actual release, emission source data, or Worst Case Credible Spill amount. In most cases, the OHZ should not be worse than the predicted Potential Hazard Zone. The OHZ is based upon the appropriate concentration level and shall be updated as source strength or meteorological conditions change. For unconventional propellants, an OHZ has a 1st and 2nd tier. For oxidizer, OHZ has a 1st, 2nd and 3rd tier. (See Toxic Hazard Corridor, Figure 2).

Permissible Exposure Limit (PEL). OSHA listed occupational exposure limits (in parts per million) for numerous chemicals.

Planned Release. A scheduled event where relatively small amounts of liquid or vapors are discharged to the environment. Often times accounted for within permits/authorizations.

Planning Meeting. A meeting, held as needed throughout the duration of an incident, to select specific strategies and tactics for incident control operations and for service and support planning.

Pollution Incident. A release or potential release of oil or hazardous material of such magnitude or significance as to require immediate response to contain, clean up, and dispose of the material to prevent a substantial threat to public health or welfare, which includes threats to fish, shellfish, wildlife, shorelines, and beaches.

Potential Hazard Zone (PHZ). One type of Toxic Hazard Zone (see definition for Toxic Hazard Zone) where the potential Toxic Hazard Corridor established for an operation should release or unplanned release occur. The prediction is based upon Worst Case Credible Spill amounts.

Primary Agencies. Federal or State departments or agencies comprising the National Response Team (NRT) and designated to have primary responsibility and resources to promote effective operation of the National Oil and Hazardous Materials Pollution Contingency Plan. These agencies are the Departments of Commerce, Interior, Transportation, Defense, and the Environmental Protection Agency (EPA). The EPA chairs the NRT. The Department of Transportation (i.e., U.S. Coast Guard) serves as Vice-Chair of the NRT.

Process Safety Management (PSM). Federal OSHA mandated program required for facilities utilizing listed hazardous materials in excess of threshold quantities.

Public Health or Welfare. All factors affecting the health and welfare of individuals. They include but are not limited to human health, the natural environment, fish, shellfish, wildlife, and public and private property, shorelines, and beaches.

Qualified Individual. The person required by the Oil Pollution Act of 1990 who has full authority, including contracting authority to implement removal actions.

Regional Response Team (RRT). A team of regional Federal representatives of the primary or selected advisory agencies that acts within its region as an emergency response team performing functions similar to those of the National Response Team.

1.4 DEFINITIONS (CONT.)

Release. Any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment. This definition excludes any release which results in exposure to persons solely within a workplace, with respect to a claim which such persons may assert against the employer of such persons emissions from the engine exhaust of a motor vehicle, rolling stock, aircraft, vessel, or pipeline pumping station engine; or a release of source, byproduct or special nuclear material from a nuclear incident.

Remove or Removal. Refers to removal of oil or hazardous material from the water and shorelines, or the taking of such other actions as may be necessary to minimize or mitigate damage to the public health, welfare, or the environment.

Reportable Quantity (RQ). As defined in 40 CFR 117.1(a), that quantity of a hazardous material determined to be harmful by EPA. A discharge into the environment equal to or greater than the RQ must be reported to the National Response Center and other appropriate state and federal agencies. The RQ is the quantity designated for each hazardous material (approximately 700) in 40 CFR 302, under the provisions of section 102 of CERCLA. These release quantities are for any 24-hour period and include releases on land, water and air.

Reportable Spill. Discharge or release into the environment which requires reporting to state and federal agencies based on the amount spilled (reportable quantity), danger or threat to environment/ public health, and requirements of AFI 32-4002.

Resources. All personnel and major items of equipment available, or potentially available, for assignment to incident tasks on which status is maintained.

Risk Analysis. The third phase in the hazards analysis process which assesses the likelihood of an accidental release of a hazardous material and the consequences that might result, based on the estimated vulnerable zones. The analysis is based on the history of previous incidents, experience at the installation, and the best available information.

Risk Assessment. Activity to assess the risks of hazardous materials (HAZMAT) present on the installation. Assess all HAZMAT and their accidental worst case release scenario.

Risk Management. The effective use of available resources (i.e. time, manpower, and funding) to prioritize and complete actions required to reduce risk, either through preventive actions or increased response capability. Risk management concepts include engineering controls, institutional controls, training requirements, or operational procedures.

Risk Management Prevention Program (RMPP). A state requirement involving an integrated collection of administrative and operational programs designed to prevent acutely hazardous materials accident risks. It includes, but is not limited to, programs which include design safety of new and existing equipment, standard operating procedures, preventive maintenance programs, operator training and accident investigation procedures, risk assessment for unit operations, or operating alternatives, emergency response planning, and internal or external audit procedures to assure that these programs are being executed as planned. RMPP is required for specifically listed substances when present at a facility in excess of threshold quantities.

1.4 DEFINITIONS (CONT.)

Risk Management Program (RMP). A program within the Federal Clean Air Act similar in scope to the RMPP (See Risk Management Prevention Program).

Short Term Exposure Limit (STEL). OSHA exposure limit (parts per million) for the maximum short term (15 minutes or other times specified) exposure for occupational exposure to chemicals.

Short Term Public Emergency Guidance Level (SPEGL). The exposure limit, expressed in parts per million (PPM), related to an unplanned single exposure normally lasting 60 minutes or less and never more than 14 hours, whose occurrence is expected to be rare in the lifetime of any person. SPEGLs are published by the National Academy of Science, National Research Council.

Spill Team. A team of individuals trained in HAZMAT response to clean up an area as part of the emergency responders of the EOC.

Spill. A type of leak and/or release that involves the escape of a liquid. Uncontrolled discharges including intentional and unintentional leaks or releases. Spills will follow the ground's contours and result in puddles or runoff (See release).

TAM. Transient Alert Maintenance Section.

Technical Specialists. Personnel with special skills who are activated when needed to assist in the areas of fire behavior, water resources, environmental concerns, resource use, and training.

THZ Distance. A distance (in feet) derived from the potential source toxicity and weather conditions (See Toxic Hazard Zone).

Threatened Release. A condition creating a substantial probability of harm, when the probability and potential extent of harm make it reasonably necessary to take immediate action to prevent, reduce, or mitigate damages to personnel, property or the environment.

Threshold Limit Value (TLV). Set of standards established by the American Conference of Governmental Industrial Hygienists of concentrations of airborne substances that a worker may be repeatedly exposed to without adverse effects. Values are time-weighted averages and are intended to serve as guides in control of health hazards, rather than a demarcation between safe and unsafe concentrations.

Threshold Planning Quantity (TPQ). TPQ's are the Minimum Reporting Levels (threshold) for hazardous materials business plans. Report, by inventory, hazardous materials (including hazardous wastes) which, at any one time during a calendar year, are stored or used at your establishment in quantities equal to or greater than the amounts listed in the California Health and Safety Code, Chapter 6.95.

Toxic Hazard Corridor (THC). Term used synonomously with Toxic Hazard Zone (THZ). Either term can be used to define a Safety Control Area. See Definition for Toxic Hazard (THZ).

1.4 DEFINITIONS (CONT.)

Toxic Hazard Zone (THZ). A safety control area within which toxic airborne vapor concentrations are calculated to exceed permissible limits for personnel exposure as the result of a toxic commodity release. Its boundary is established by the 30th Weather Squadron forecaster based upon release quantity, location, toxic wetted area, weather conditions, and personnel exposure limits.

Three types of THCs are defined:

- Potential Hazard Zone (PHZ)
- Emission Hazard Zone (EHZ - prior to a planned actual release)
- Operational Hazard Zone (OHZ - accidental release has occurred) (See EWRR 127-1)

Toxic Pollutant. Those pollutants or combinations of pollutants, including disease-causing agents, which after discharge and upon exposure, ingestion, inhalation, or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, will cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction), or physical deformations in such organisms or their offspring.

Unconventional Propellant. A propellant fuel based upon chemical reactions, unlike combustion of fossil or hydrocarbon materials.

Unified Command. A method for all agencies or individuals who have jurisdictional responsibility and in some cases those who have functional responsibility at the incident, to contribute to determining overall objectives for the incident and selection of a strategy to achieve the objectives.

Vulnerability Analysis. The second phase in the hazards analysis process which assesses the areas potentially affected by the release of a hazardous material, including on and off the installation; includes gathering information on the extent of the vulnerable zone, conditions that influence the zone, size and type of population within the zone, missions and critical systems that may be impacted, property that might be damaged, and the environment that might be affected.

Waters of the State. Waters of the State means any water, surface or underground, including saline waters, within the boundaries of the State of California (Porter Cologne Water Quality Control Act).

Wind at Surface. Direction is always in degrees clockwise from the true north and is the direction from which the wind blows.

Worst Case Credible Spill Criteria. Used to facilitate prediction of a realistic Toxic Hazard Zone for operations. The responsible engineer should determine the worst case credible failure mode, then determine the most credible spill quantity, the wetted area or elevated (height of vent source) vent emission for the failure mode identified. This information will then be provided to Base Weather for plotting THZ clearance areas.

1.5 ABBREVIATIONS AND KEY ACRONYMS

-A-

AFI	Air Force Instruction
AFM	Air Force Manual
AFOSH	Air Force Occupational Safety and Health
AFP	Air Force Pamphlet
AFR	Air Force Regulation (obsolete designation)
AFSPC	Air Force Space Command
AGE	Aerospace Ground Equipment
AHM	Acutely Hazardous Material
APCD	Air Pollution Control District
AST	Above Ground Storage Tank

-B-

BCE	Base Civil Engineer
BEE	Base Bioenvironmental Engineering
BMP	Best Management Practices
BOP	Bureau of Prisons
BTU	British Thermal Unit

-C-

CAA	Clean Air Act
Cal-EPA	California Environmental Protection Agency
Cal-OSHA	California Occupational Safety and Health Administration
CAP	Collection Accumulation Point (hazardous waste)
CCR	California Code of Regulations
CEMP	Comprehensive Emergency Management Plan
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CES	Civil Engineer Squadron (30 CES)
CEV	Environmental Management Flight (30 CES/CEV)
CFC	Chlorofluorohydrocarbon
CFR	Code of Federal Regulations
CHEMTREC	Chemical Transportation Emergency Center
CHRIS	Chemical Hazards Response Information System
CP	Command Post
CWA	Clean Water Act

-D-

DHS	Department of Health Services
DoD	Department of Defense
DOT	Department of Transportation
DRF	Disaster Response Force
DRMO	Defense Reutilization and Marketing Office
DTSC	Department of Toxic Substances Control

1.5 ABBREVIATIONS AND KEY ACRONYMS (CONT.)

-E-

ECAMP	Environmental Compliance Assessment and Management Program
ECP	Entry Control Point
EHZ	Emission Hazard Zone
EHS	Extremely Hazardous Substance
EO	Executive Order
EOC	Emergency Operations Center
EOD	Explosive Ordnance Disposal
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-To-Know Act
ER	Explosive Range
ERP	Emergency Response Plan
ERT	Emergency Response Team
ESF	Emergency Support Function

-F-

FEMA	Federal Emergency Management Agency
FOF	Follow-On Force

-G-

GAL	Gallon

-H-

H&S	California Health and Safety Code
HAZMAT	Hazardous Materials
HMIS	Hazardous Materials Information System
HMRT	Hazardous Material Response Team
HOS	Hazardous Operations Support
HQ	Headquarters
HWSF	Hazardous Waste Storage Facility

-I-

IDLH	Immediately Dangerous to Life and Health
IRP	Installation Restoration Program

1.5 ABBREVIATIONS AND KEY ACRONYMS (CONT.)

-K-

kg	Kilogram

-L-

LBS	Pounds
LEL	Lower Explosive Limit
LEPC	Local Emergency Planning Committee
LOC	Level of Concern

-M-

MAJCOM	Major Command
MCP	Mobile Command Post
MDG	Medical Group (30 MDG)
MISC.	Miscellaneous
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MSDS	Material Safety Data Sheet

-N-

NASA	National Aeronautics and Space Administration
NCP	National Contingency Plan
NEC	National Electric Code
NFPA	National Fire Protection Association
NICS	National Incident Command System (Replaces Incident Command System)
NIOSH	National Institute of Occupational Safety and Health
NPDES	National Pollutant Discharge Elimination System
NRC	National Response Center
NRT	National Response Team

-O-

OCC	Operations Control Center
OES	Office of Emergency Services
OHZ	Operational Hazard Zone
OHSPCP	Oil and Hazardous Substance Pollution Contingency Plan
OPA	Oil Pollution Act of 1990
OSHA	Occupational Safety and Health Administration

1.5 ABBREVIATIONS AND KEY ACRONYMS (CONT.)

-P-

PCB	Polychlorinated Biphenyl
PHZ	Potential Hazard Zone
PHE	Propellant Handlers Ensemble
POL	Petroleum, Oils, and Lubricants
PPE	Personal Protective Equipment
PPM	Parts per Million
PPB	Parts per Billion
PSM	Process Safety Management
PVD	Portable Vapor Detector

-R-

RCRA	Resource Conservation and Recovery Act
RMP	Risk Management Plan
RMPP	Risk Management and Prevention Plans
RQ	Reportable Quantity
RRT	Regional Response Team
RWQCB	Regional Water Quality Control Board

-S-

SARA	Superfund Amendments and Reauthorization Act
SBCECC	Santa Barbara County Emergency Communications Center
SEC	Staff Environmental Coordinator
SERC	State Emergency Response Commission
SGPB	Bioenvironmental Engineer (30 AMDS/SGPB)
SLC	Space Launch Complex
SPCC	Spill Prevention Control and Countermeasures (Plan)
SPRP	Spill Prevention and Response Plan
SSCP	Site Specific Contingency Plan
STP	Standard Temperature and Pressure
SW	Space Wing

-T-

TAM	Transient Alert Maintenance
TCA	Trichloroethane
TCE	Trichloroethylene
THZ	Toxic Hazard Zone
TLV	Threshold Limit Value
TPQ	Threshold Planning Quantity
TSCA	Toxic Substances Control Act
TSDF	Treatment, Storage and Disposal Facility

1.5 ABBREVIATIONS AND KEY ACRONYMS (CONT.)

-U-

UBC	Uniform Building Code
UEL	Upper Explosive Limit
UFC	Uniform Fire Code
UPC	United Paradyne Corporation
USAF	United States Air Force
USCG	United States Coast Guard

-V-

VAFB	Vandenberg Air Force Base
VOC	Volatile Organic Hydrocarbon
VP	Vapor Pressure

-W-

WS	Weather Squadron

2.0 THE EMERGENCY ORGANIZATION

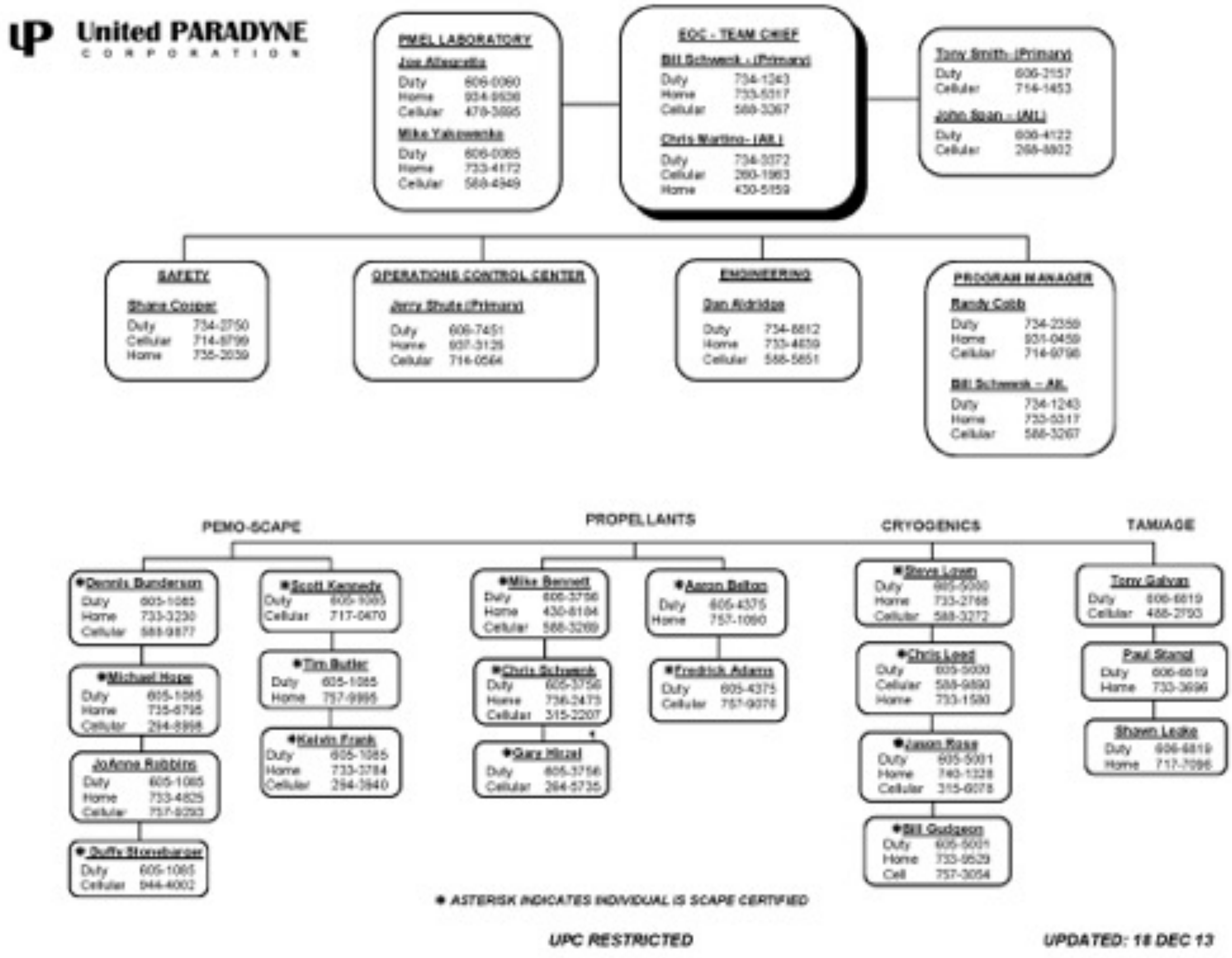
2.1 PURPOSE OF THE EMERGENCY ORGANIZATION

It is essential to provide coordinated and disciplined response to any emergency incident to reduce the potential for loss of life, injury, property and environmental damage. The UPC First Responders are contractually obligated to provide a unified response to emergency incidents utilizing existing resources and equipment, while performing within their respective levels of training. It is not intended for this team to provide structural fire fighting, advanced search and rescue, advanced life support, or assist in any emergency for which appropriate training, direction and resources have not been provided. The UPC First Responders provides such assistance as deemed appropriate for the emergency conditions which are presented. At no time is it permissible for UPC supervisor or Government authority to place UPC personnel in an unsafe condition for which they have not been trained.

The United Paradyne First Responders are contractually obligated to have a representative on call 24 hours per day. This individual must be available upon request within 30 minutes during normal work hours or within 60 minutes after normal work hours. The standby person must meet a Government Representative at a specified location on Vandenberg Air Force Base. UPC's representative is authorized to act on behalf of the Company for all emergency responses.

2. EMERGENCY RESPONSE ORGANIZATION CHART

The Emergency Response Organizational Chart is representative only and should not be relied upon as accurate. Contact OCC for the most up-to-date chart.



2.3 RESPONSIBILITIES OF KEY EMERGENCY PERSONNEL

Operations Manager, Primary EOC Representative

Upon notification of emergency, coordinate formation of UPC emergency response team depending on nature of emergency and the expertise required. Serve as UPC's primary EOC representative during actual or exercise EOC operations.

Program Manager

Notify primary UPC EOC representative when needed if called upon by customer. Assure adequate resources are available for handling emergency response actions. Support UPC emergency response actions as needed to mitigate emergency. Coordinate with the Government Contracting Officer and Program Manager for any off-base emergency response required to support the National Incident Command System.

Quality & Environmental Specialist

Provide adequate resources and personnel to effectively mitigate emergency. Assist, as necessary, in actual or exercise EOC activities as requested. Assist emergency response team as necessary to mitigate emergency effectively. Assist as necessary in actual or exercise EOC activities. Coordinate as required, with the VAFB environmental office and provide information on Hazardous Materials to ERP.

Safety Manager

Upon notification of an actual or Base EOC exercise scenario, assemble EOC support personnel and report to the UPC Operations Control Center emergency messages and provide support as appropriate when specifically requested by operations personnel and UPC/EOC representatives. Provide support to UPC Engineering and Systems Safety and evaluate “real time” risks to UPC personnel and resources. Serve as final authority on matters pertaining to operational safety. Periodically brief UPC Executive Management on status of emergency. Author and issue written report of the emergency, and all actions taken to mitigate the emergency, listing results and/or consequences of emergency and lessons learned.

OCC Monitor

Assist the UPC emergency response team by monitoring the OCC and serving as the communications link between team members, operations and officials. Annotate chronological actions as they occur in the OCC EOC Log (UPC-P-018) and monitor crash net for progress of the emergency. Advise both United Paradyne EOC personnel and field operations of emergency updates and status of both base and company resources. Ensure that EOC support personnel have been notified and activated. Maintain up-to-date emergency call-out rosters and emergency contact information for all UPC personnel.

Systems Safety Representative

Assist emergency response team as requested so that all personnel safety measures are assured while mitigating emergency situations. Participate in actual or exercise EOC activities as necessary. Act as primary alternate for Safety Manager during periods of absence.

2.3 RESPONSIBILITIES OF KEY EMERGENCY PERSONNEL (CONT.)

Engineering Manager

Provide adequate resources and personnel to mitigate emergency effectively. Assist as necessary in actual or exercise EOC activities. Assure there is ready access to drawings and plans on the critical infrastructure under UPC control.

Propellant Engineer

Assist emergency response team as necessary to mitigate emergency effectively. Assist as necessary in actual or exercise EOC activities. Provide relevant schematics, drawings and calculations to ERP on equipment and systems under ASSC control.

Lead Technician (Hypergol Storage Facility)

Assist in coordinating appropriate resources and personnel necessary to effectively mitigate emergency. Participate in actual or exercise EOC activities as requested.

Lead Technician (PEMO)

Assist in coordinating PEMO resources and personnel to effectively mitigate emergency. Participate in actual or exercise EOC activities as requested.

2.4 OPERATIONS CONTROL CENTER

All emergency operations involving United Paradyne personnel will be coordinated through the United Paradyne Corporation (UPC) Operations Control Center (OCC). The operations center is staffed during normal business hours and during hazardous operations at the HSF which are scheduled after normal business hours. UPC OCC personnel have been trained on their individual roles and responsibilities through internal exercise scenarios, official EOC exercises, and actual emergency operations. Except as otherwise noted, OCC personnel will be the principle point of contact and coordinators for all UPC emergency response and will serve as the UPC recorders for emergency operations. For emergency situations occurring after normal business hours, initial annotation will be performed by those individuals on the Emergency Notification Letter. Once the OCC Monitor arrives at the duty location, annotation and recording responsibilities will be transferred to this individual. If the OCC Monitor is not available, or fails to respond, the Operations Manager will assume responsibility or designate a person to fulfill the OCC responsibilities.

2.4.1 Unless noted otherwise, basic reporting requirements to basic reporting requirements to Base agencies after any emergency/incident of a mishap, hazard, handling, malfunction, or other incident creating or contributing to an unsafe condition for personnel or critical hardware, shall be made to the following:

- Base Command Post 606-9961
- 30 SW/SE Range Safety by both email and phone
  - 30swse.report@vandenberg.af.mil
  - 606-4052 (leave voice message)

2.5 DIRECTION AND CONTROL

All operational control for exercise scenarios, and actual events, will be the responsibility of the UPC Operations Manager or a duly appointed representative. Once emergency response exceeds UPC's ability to safely perform the operation, the Vandenberg Air Force Base Command Post will then serve as the focal point for Base response to disasters. Additionally, the Base Disaster Control Group, under the direction of 30th Space Wing, will have ultimate responsibility and decision-making authority unless superseded by the County or State of California Office of Emergency Services (OES) under the OES Incident Command System or other military authority.

2.6 PLANS REQUIRED BY OSHA

The Occupational Safety and Health Administration (OSHA) provides numerous regulations and standards to protect employees in the workplace. OSHA standards are prescriptive in nature and legally enforceable as Public Law. OSHA requires employers, public, private and governmental, to plan and prepare for emergencies in the workplace, and to train employees to perform in their assigned emergency response roles correctly and safely.

United Paradyne employees perform emergency response in two distinct ways; one is within the company, using company resources, and the other is where company personnel and resources are used to support the Vandenberg Air Force Base Disaster Control Group. While these two kinds of emergency responses share many common attributes, it is important to understand that they are not one in the same. The first two cited OSHA standards direct plans that are internal to United Paradyne, while the third standard describes a plan used by the Base Disaster Control Group.

A. <u>Emergency Action Plan (29 CFR 1910.38 (a)):</u>

- Emergency escape procedures and emergency escape routes.
- Procedures for those performing critical actions before evacuating.
- Procedures to account for personnel upon evacuation.
- Rescue and medical duties for select personnel.
- Means of reporting fires and other emergencies.
- Names and titles of those who can provide further information.

B. <u>Fire Prevention Plan (29 CFR 1910.38 (b)):</u>

- List of all major workplace fire hazards and mitigation procedures.
- Names/job titles of those responsible for maintaining fire prevention equipment or systems.
- Names/job titles of those responsible for control of fuel source hazards.
- Housekeeping procedures.
- Maintenance procedures for fire protection equipment.
- Training and roles for employees.

2.6 PLANS REQUIRED BY OSHA (CONT.)

C. Emergency Response Plan (29 CFR 1910.120):

- This plan is at the Base Emergency Operations Center level with requirements fulfilled by the 30 SW Plan 32-4002, Hazardous Materials (HAZMAT) Emergency Response Plan.
- This Emergency Response Plan provides a single source, comprehensive document which satisfies the above mentioned regulation and standards.

2.7 EXTERNAL EMERGENCY ORGANIZATIONS AND PHONE NUMBERS

A. On Base Organizations

On Base Organizations	Duty Hours	After-Duty Hours
Fire Department, ***EMERGENCY***	**911**	**911**
Fire Chief	606-3111	606-5380
Hazardous Material Response Team	606-5380	606-1856
Hospital, *EMERGENCY*	**911**	**911**
Law Enforcement, *EMERGENCY*	**911**	**911**
Law Enforcement Desk	606-3911	606-3911
Central Security Control	605-2154	605-2154
30 SW Command Post	606-9961	606-9961
30 SW SAFETY	606-4052	606-4052
Civil Engineer Emergency Service Desk	606-1856	606-1856
30 CES/CEV (Environmental Management Flight)	606-1921	606-9961
30 AMDS/SGPB (Bioenvironmental Engineering)	606-7811	606-9961
30 CES/CECBB (Base Comprehensive Planning)	606-0686	606-1856
30th Transportation Squadron Dispatch	606-5714	606-9961
30 WS Weather Forecaster	606-8022	606-8022
30 LG/LGQA HAZMAT Self-Inspection	606-2156	N/A
4 SLS Maintenance Operations Coordination Center	605-4465	606-9961

B. Off-Base Organizations

Federal	**Phone**
Association of American Railroad Hazardous	
Material Systems Bureau of Explosives	(800) 424-9300
Center For Disease Control	(404) 633-5313
CHEMTREC	(800) 424-9300
CHLOREP Chlorine Release	(800) 424-9300
EPA Emergency Planning Hotline	(800) 535-0202
EPA RCRA Superfund Hazardous Waste/ Emergency Response	(800) 424-9436
EPA Region IX On-Scene Coordinator	(415) 974-8071
National Response Team (EPA)	(800) 424-8802
NIOSH National Institute of Occupational Safety and Health	(800) 356-4647
Poison Control Center	(800) 777-6476
US Department of Energy	(615) 574-5454
US Coast Guard, 11th District	(213) 499-5330
US Department of Transportation	(800) 424-8802

2.7 EXTERNAL EMERGENCY ORGANIZATIONS AND PHONE NUMBERS (CONT.)

State Phone

Chemical Emergency Planning and Response Commission	(916) 262-1816
Department of Health Services Mitigation Branch	(916) 324-3773
Integrated Waste Management Board	(916) 255-2200
OES, State of California (Warning Center)	(800) 852-7550
Office of Air Quality, Planning and Standards	(919) 541-5616
Pesticides	(800) 845-7378
Poison Control Center (L.A. County Medical)	(800) 825-2722
Department of Toxic Substances Control	(916) 324-1826
Region 3, Burbank, CA	(818) 567-3000
CALTRANS	(805) 736-3615
California Environmental Protection Agency	(916) 445-3846
California Coastal Commission	(415) 904-5200
State Water Resources Control Board (Underground Storage Tanks)	(916) 227-4303
State Water Resources Control Board	(916) 657-2390

County

Sheriff, ***EMERGENCY ONLY***	**911**
Fire Department, ***EMERGENCY ONLY***	**911**
Air Pollution Control District	(805) 961-8800
Department of Fish and Game	(805) 681-4196
Regional Water Quality Control Board (San Luis Obispo)	(805) 543-0387
Environmental Health Services (Santa Maria)	(805) 346-8470
(Goleta)	(805) 681-4900
Local Emergency Planning Committee	(805) 681-4949
Office of Emergency Services (County)	(805) 568-3415

Local

BASE AMBULANCE, *EMERGENCY ONLY*	**911**
Northridge TOX Center	(800) 682-9000
City of Lompoc Utilities, *EMERGENCY*	(805) 736-2431

2.8 LETTER OF AUTHORIZATION FOR MEDICAL TREATMENT AND PROCEDURE

It is unfortunate that in emergency incidents and exercises the probability for accidents increases dramatically over normal situations. The reasons for increased accidents and injuries are many and varied, but often can be centered on personnel attempting to accomplish tasks in the least amount of time or performing tasks outside of their respective levels of training.

In the event one of UPC's employees is injured during an emergency the following procedure is to be followed:

- Whenever a UPC employee becomes involved in an injury or illness as a result of an occupational exposure, the employee is to immediately report the incident to the Facility/ Area Supervisor and follow the directions given.
- The employee's Facility/Area Supervisor will then obtain and complete an "Authorization for Medical Services", UPC-A-026 (Figure 1). Once completed, it is given to the employee pending transportation to the Lompoc Hospital for major injury treatment, assessment and stabilization. For minor injuries they shall be transported to Sansum Medical Foundation in Lompoc, CA.

2.9 UPC INTERFACE WITH THE VAFB EMERGENCY OPERATIONS

United Paradyne Corporation, as a contractor on Vandenberg Air Force Base, will interface with the Emergency Operations Center (EOC) when an emergency situation arises that is beyond the company's capabilities to handle. This interface begins when an emergency notification is made to the Base either directly (**911**) or through the UPC OCC. Base elements make the determination if a EOC response is appropriate. UPC employees can assist in this process when they make the initial notification by stating the nature of the emergency **and** whether or not base assistance is required. The final decision on whether the EOC responds or not resides with the Base, and UPC will not countermand the Base's decision. When the EOC responds, UPC designated facility spokespersons provide information as requested by the EOC (business plan, MSDS information, or personnel accounting, for example).

Also, through its contract statement of work (SOW), UPC is tasked to support the Base EOC during exercises and responses to emergency hypergol situations. This unique support role and membership in the EOC is the second type of interface the company has with the EOC. During the course of EOC activation, UPC personnel assigned to the EOC respond to directions and requests of the EOC Director. Support to the EOC Director is essential during emergency situations; however, should there be a contractual problem with directed response, personnel should advise the EOC Director of this, then proceed as directed. If the EOC Director is not present, any potential contractual conflicts should be resolved with the Program Manager. From time to time UPC may be required to report to any EOC emergency notification. If the incident is not related to the Aerospace Support Services Contract, the UPC representative on the EOC will ask to be released from the incident. UPC personnel are to remain available to the EOC Director until officially released.

3.0 EMERGENCY COMMUNICATION PROCEDURES

3.1 EMERGENCY FIRE ALARM SYSTEMS

This section identifies the Fire Alarm System(s) utilized at UPC facilities managed under the Aerospace Support Services Contract at Vandenberg Air Force Base. It should be noted that at any time the Base Telephone System can be used to contact **911** services. Additionally, hand-held RF radios can be used to contact the UPC Operations Control Center, which, in turn, will notify the Fire Department or other emergency services required for any of the following UPC Facilities:

A. **UPC Offices in Building 7525**. Manual fire alarm pull stations are located in prominent locations throughout the hallways of the building. To activate the fire alarm system, simply pull down on handles or break glass in front of manual fire alarm. Once these alarms have been activated, the VAFB Fire Department will respond as though there were a fire. Do not use the fire alarm systems for other than fire emergencies.

B. **Building 875, Cryogenic and Maintenance**. Manual fire alarm pull stations are located throughout the building. The same precautions as noted above should be observed at all times.

C. **Building 1705 “B” Yard**. **NO** manual fire alarm pull stations are located at this facility. RF Radio communication must be used to contact the OCC if emergency conditions develop when operations are being performed.

D. **Building 878, Storage Building**. A manual fire alarm pull station in located inside of the building. The same precautions as noted above should be observed at all times.

E. **Building 871, PEMO**. Manual fire alarm pull stations are located inside the building. The same precautions as noted above should be observed at all times.

F. **Building 974, Oxidizer HSF**.

1. An Instrument Alarm System (IAS) is used to notify the Fire Department whenever the system detects loss of pressure in one of the six Oxidizer Storage Tanks. This alarm is activated on pressure differentials that exceed 0.5 PSIG in any six (6) minute period or the pressure in the storage tank drops below 5 PSIG or increases over 45 PSIG at any time.

2. Fire alarm pull stations are located in the change house and at two (2) locations across the road from each of the Cluster #1 and #2 Storage Tanks. Each location is clearly marked and personnel who visit the HSF must understand their locations and how to operate the pull stations.

NOTE

Each of these alarm systems will notify Base Fire Department personnel of either a Pressure *Alarm or a Fire Alarm. For either system, an alarm bell will ring at TPQ-18, Building 900 Weather Station , OCC, and at the Fuel HSF.*

3.1 EMERGENCY FIRE ALARM SYSTEMS (CONT.)

G. **Building 976, Fuel HSF**.

1. An Instrument Alarm System (IAS) is used to notify the Fire Department whenever the system detects loss of pressure in one of the six (6) Fuel Storage Tanks. This alarm is activated on pressure differentials that exceed 0.5 PSIG change in any six (6) minute period or the pressure in the storage tanks drops below 5 PSIG or increases over 45 PSIG at any time.

2. UV/IR Detectors are located around each Storage Tank Cluster, on the Hardstand and in the Drum Storage Area. If one UV/IR Detector observes a fire, the Deluge Pumps will start and discharge up to 250,000 Gallons of water on the area where the fire was detected.

3. The Manual Deluge Dump Stations are located inside the change house and outside the Electrical Building next to the Hardstand. Each location has two (2) Pull Stations, one for each Cluster. There are also Manual Deluge Dump Stations located at the exits of the Payload Storage Facility.

4. The fire alarm pull stations are located inside the change house, the Propellant Trailer Storage Area, in front of the stairs coming off each Cluster (front and back stairs), outside the electrical room adjacent to the hardstand, and next to the Scrubber System. Additional units have been installed.

5. Fire Detectors (Smoke and Rate of Rise) are located in the change house, Electrical Building behind the change house, the Propellant Trailer Storage Shed and the Electrical Building next to the Hardstand.

H. **Building 1749, TAM/AGE.** Manual fire alarm pull stations are located throughout the building. The same precautions as noted above should be observed at all times.

I. **Building 1737, PMEL.** Manual fire alarm pull stations are located throughout the building. The same precautions as noted above should be observed at all times.

J. **Building 1755, TAM/AGE Support Hanger.** <u>NO</u> manual fire alarm pull stations are located at this facility. RF Radio communication must be used to contact the OCC if emergency conditions develop when operations are being performed.

NOTE

Each of these alarm systems will notify Base Fire Department personnel of either a Pressure Alarm, a Fire Alarm or a Deluge Alarm. For any system, an alarm bell will sound at TPQ-18, Building 900 Weather Station, OCC and at the Oxidizer HSF.

3.2 USE OF COMMUNICATION EQUIPMENT

During an emergency, particularly when lives are in jeopardy, communications and the ability to communicate effectively are of paramount importance, and must receive the highest degree of attention. When communications have been lost, all organizational resources must be directed toward reestablishing communications with field units as soon as possible.

As important, there is also a crucial need to report and disseminate critical information in an accurate and timely fashion. In that regard, the following types and methods of communication are available in normal pre-emergency operations, but may not be readily available in an actual emergency:

A. Base Telephone System

This system should be used to report all types of emergency conditions. If the telephone system is not operational, seek RF communications and cellular service to report emergency situations and conditions. The Base telephone system has a history of line problems and may not be available during major catastrophic events.

B. RF Communication System

The portable radio communication system is continually monitored by the UPC Operations Control Center during normal business hours. If the radio system is operational it can be electronically patched into the Base EOC network. Additionally, the radios can be used with a relatively high degree of reliability, portable to portable. Radios are provided to individuals who perform work activities away from their assign work center.

UPC MOTOROLA HAND-HELD PORTABLE RADIO CALL SIGNS MATRIX

NAME/SITE	TITLE	CALL SIGN
B. Schwenk	EOC	OPS-1/EOC-1
S. Cooper	System Safety	Safety-2/EOC-1
J. Shute	OCC Monitor	Ops Control
C. Martino	Safety & Health	Safety-1
M. Bennett	HSF Lead Technician	RF-1
HSF	HSF Technicians	RF-2 Thru RF-6
D. Bunderson	PEMO Lead Technician	PEMO-1
PEMO	PEMO Technicians	PEMO-2 Thru PEMO-8
S. Lown	Cryo Lead Technician	M-1
Cryo Shop	Cryo Technicians	M-2 Thru M-8
D. Aldridge	Engineering	ENG -1
T. Galvin	TAM/AGE Lead Technician	TA-1
TAM/AGE	TAM/AGE Technicians	TA-2 Thru TA-6

3.2 USE OF COMMUNICATION EQUIPMENT (CONT.)

C. Cellular Phone Service

UPC key personnel each have a hand held cellular phones which would become available for emergency communications. When using the phone system one should always remember that there is virtually no voice privacy and absolutely no classified information should be discussed over the open airways. Cellular service has a high degree of reliability in most emergency situations but, as with most emergency events, the cells can become overburdened with emergency and non-emergency traffic.

D. Pagers

Pagers are a means of contacting individuals regarding contract related emergencies. It should be noted that the party contacted may not be able to return a phone call due to unavailability of phone service, inoperative phone systems, or they may be out of a service area for cellular contact.

In the event of an actual emergency, the following method of communication will be authorized for immediate use:

1. Sound a verbal alarm to all personnel in or around a facility. State the type of emergency condition that is present or expected.
2. If near a telephone, call **911** or designate someone else to call.
3. If **no** telephone is near, contact the UPC OCC via RF radio communications, Channel #1, and state the nature of the emergency, personnel involved, injuries, emergency actions to date, and type of emergency equipment and resources needed.
4. Remember to always speak slowly, clearly, with purpose, and stay on the line until released by OCC or the **911** Operator.
5. Once you have completed your emergency reporting, assist others in making notification or assist in other ways consistent with your training and education.

3. EMERGENCY CALL-OUT ROSTER

(SEE EMERGENCY RESPONSE ORGANIZATION CHART, SECTION 2.2)

3.4 EMERGENCY AND AIR FORCE INCIDENT MANAGEMENT SYSTEM

Each level of government, federal, state, and local, has organizations which control and participate in emergency and disaster preparedness and response. This hierarchy of organizations is in addition to the direct interface UPC personnel have with Vandenberg Air Force Base and its EOC. Because the Air Force has overall responsibility for activities on the Base, communication and interaction with all other governmental/regulatory agencies is accomplished by the various Air Force offices (Fire Department, Command Post, Environmental, etc.). Only in the extremely rare circumstance where the Air Force is not available to notify outside agencies and an impending regulatory notification deadline is approaching, may UPC personnel notify outside regulatory/disaster response organizations. After notification, UPC must inform the Air Force about the actions taken. While not all inclusive, the following list of organizations provides insight into those involved with emergency and disaster preparedness for hazardous substances releases (For telephone contacts, see Part I, Section 2.7 of this plan).

A. Federal Level

1. Environmental Protection Agency (EPA). The lead Federal agency regulating hazardous materials/substances, which maintains a National Response Team (NRT) and responds and dispatches the NRT through the National Response Center (NRC). The EPA, through its regional offices, can also provide an On-Scene Coordinator to release emergency sites. The EPA also has an Emergency Planning Hotline which provides emergency response planning information.

2. Department of Transportation (DOT). The Federal agency regulating the movement of hazardous materials/substances while in public transport. Supported by Chemical Transportation Emergency Center (CHEMTREC) personnel who man a 24 hour per day emergency notification and response center. These contacts would support state and local highway departments and highway patrols.

3. US Coast Guard. Through regional offices provides release response and coordination. The Coast Guard becomes involved primarily when Federal waterways are affected by releases of hazardous substances.

B. State Level

1. The Office of Emergency Services (OES) is California’s lead agency for emergency planning and response. OES has established the Chemical Emergency Planning and Response Commission (CEPRC) under the State Emergency Response Commission requirements of the federal regulations. OES represents the apex of the State’s emergency planning and response function. All local emergency response plans are forwarded to the State level for coordination and processing.

2. California EPA (CAL-EPA) also plays a role in emergency response. Within CAL-EPA, the Department of Toxic Substances Control (DTSC) is the action agency, and would likely send personnel from its regional offices to the emergency response location. These personnel would provide technical support and interface with the various other State agencies that might become involved in a release response. Should an OES officer also be present, the DTSC people would work through the OES representative.

3.4 EMERGENCY AND AIR FORCE INCIDENT MANAGEMENT SYSTEM (CONT.)

3. State Water Resources Control Board, State Fish and Game, and others could become involved in an emergency response depending upon the type of natural and cultural resources affected by the release. These "specialized" agencies, while not the standard players in emergency planning and response, must be considered when a release occurs.

C. Local Level

1. Local Emergency Planning Committees (LEPC) are the keystone of county/city emergency planning and response. These committees are made up of representatives from several local agencies (County OES, Fire Department, Environmental Health Services, etc.). A member of the Vandenberg Air Force Base Fire Department represents the Base on this committee.

2. As at the County level, local air pollution control district, water quality board personnel, police, fire departments and others may be a part of the local response elements depending upon the nature of the release and the environments affected.

3. Local Administering Agency (AA). Usually the local fire department, which coordinates planning activities. At Vandenberg, the Base Fire Department is the Base's AA and coordinates with the local AA of Santa Barbara County. This is the "bottom up" link of Vandenberg Air Force Base to the other levels of governmental planning and response.

3.5 MEDIA COORDINATION AND GUIDELINES

As stated earlier, effective communication is essential to emergency planning and response. For UPC personnel supporting emergency response this means that **all internal** communication is through the OCC. The UPC EOC Team Chief is the company's channel to the EOC Director. For **all external** communication, Base elements at the scene of the emergency provide the communication channel to requests for information. Should media approach any UPC person, that UPC person is to politely refer the requester to the Air Force Public Affairs Office (606-3595), or to the EOC Director. While media cannot be prevented from obtaining information, they can, for reasons of safety, be restricted from free access to sites where an emergency is in progress. Comments and actions relative to UPC operations can <u>only</u> be released to the press by Joseph Hasay. In the event of any press release, ensure that the UPC Team Chief and Program Manager are appropriately briefed.

4.0 HAZARD AWARENESS AND RECOGNITION

Because chemicals are such a prevalent part of daily activities, it is almost impossible to provide an accurate, current listing of hazardous chemicals in the workplace. The two best sources for this information are the Material Safety Data Sheets (MSDS's) kept in each work center, and the Business Plans for each of the United Paradyne facilities. Reference these documents for the latest, most accurate information.

Listed below are the most prevalent hazardous chemicals used at UPC operated facilities, which may be encountered during the course of employment:

4.1 LISTS OF HAZARDOUS CHEMICALS FOR EACH MAJOR UPC FACILITY

Facility/#	Major Chemicals/Generics
Admin./7525	Printer toner, correction fluid, copier cleaner/anti-static fluid
Cryo-Maintenance/875	Compressed gases: Nitrogen, Helium, Oxygen, Acetylene, isopropyl alcohol, paints and solvents; car wash and waxes; oil, greases and lubricants
He Storage/8350	Compressed Helium, oil and lubricants, paints and solvents
B-Yard/1705	Liquid Oxygen and Liquid Nitrogen
PEMO/871	Compressed Breathing Air, toluene, isopropyl alcohol, paints and solvents, oil and lubricants and liquid breathing air
HSF-Ox/974/975	Dinitrogen Tetroxide, nitric acid, sodium hydroxide, gaseous nitrogen, car wash and waxes, paints and solvents, oil and lubricants, insecticides and herbicides
HSF-Fuel/976/977	Hydrazine, 1,1 Dimethylhydrazine, Monomethyl-hydrazine, gaseous nitrogen, car wash and waxes, paints and solvents, oil and lubricants, insecticides and herbicides
Bldg 1755 - TAM/AGE	Miscellaneous grades of aviation fuel and oil
Bldg 1749 TAM/AGE	Oil, lubricants, adhesives, compressed gases
Bldg 1737/1720/1723 PMEL	Adhesives, alcohols, compressed gases, lubricants, paints, oils, silicones, solvents and cleaners

4.2 HAZARDOUS CHEMICALS BY GROUP

Chemical Group	Principal Hazard(s)
Corrosives: (nitric acid, sodium hydroxide)	Burns tissue, when inhaled or in direct contact with body, causing visible destruction and/or permanent changes to human tissue at the site of contact
Reactives: (explosives, sodium metal)	Unstable, reacting rapidly and violently with water or air to produce burning, explosion, and/or toxic emissions
Ignitables: (toluene, paints and solvents) Aviation Fuel	Fire or bursting into flames spontaneously or by interaction with another substance; easily inhaled because of volatility

Toxics: (Hydrazines, herbicides, pesticides and dinitrogen tetroxide)	Produces an adverse, harmful effect on biological mechanism or organisms, with effects being either acute or chronic; often taken into the body through inhalation or skin contact
Federal or State Listed Chemicals: (Dinitrogen Tetroxide, certain herbicides and insecticides)	Listed principally because of toxicity, but may exhibit other harmful properties as well

5.0 TRAINING REQUIREMENTS

There is no magic formula for what an emergency response training program should consist of (how many members, how much of an investment in time or energy, what equipment to acquire), but there are specific requirements for the level of training each member will need to effectively participate in an emergency response organization. United Paradyne Corporation is governed by the requirements of 29 CFR 1910.120(q), the Hazardous Waste Operations and Emergency Response (HAZWOPER) standard, for those personnel who participate as part of our emergency response organization.

The HAZWOPER standard requires that each responder be trained to the level of the duties and responsibilities they will perform during an emergency incident or in exercise scenarios. It is a fundamental requirement of the program that UPC employees are trained to a skill level consistent with actual responses to actual events. No UPC employee is permitted to take part in an emergency situation as an ERT member without having had the requisite training.

5.1 SCOPE AND FREQUENCY OF TRAINING

The scope of UPC emergency response training for team members covers five response levels. Each level indicates a knowledge domain and an anticipated level of response. The training and response levels are as follows:

Level 1 First Responder Awareness Level ***29 CFR 1910.120(q)(6)(i)***

First responders at the awareness level are employees who are likely to witness or discover a hazardous substance release and who have been trained to initiate an emergency response sequence by notifying the proper authorities of the release. These employees take no further action beyond notifying the authorities of the release. First responders at the awareness level must have sufficient training or experience to objectively demonstrate competency.

Level 2 First Responder Operations Level ***29 CFR 1910.120(q)(6)(ii)***

First responders at the operations level are employees who respond to releases or potential release of hazardous substances as part of the initial response to the incident for purposes of protecting nearby persons, property, or the environment from the effects of release. They are trained to respond in a defensive fashion without actually trying to stop the release. Their function is to contain the release from a safe distance, keep it from spreading, and prevent exposures. First responders at the operational level shall receive at least 8 hours of training or have sufficient knowledge and experience to objectively demonstrate competency.

Level 3 Hazardous Materials Technician ***29 CFR 1910.120(q)(6)(iii)***

Hazardous materials technicians are employees who respond to releases or potential releases for the purpose of stopping the release. They assume a more aggressive role than a first responder at the operations level in that they will approach the point of release in order to plug, patch or otherwise stop the release of a hazardous substance. Hazardous materials technicians must have received at least 24 hours of training equal to the first responder operations level and have sufficient experience to objectively demonstrate competency.

5.1 SCOPE AND FREQUENCY OF TRAINING (CONT.)

Level 4 Hazardous Materials Specialist ***29 CFR 1910.120(q)(6)(iv)***

Hazardous materials specialists are employees who respond with and provide support to hazardous materials technicians. Their duties parallel those of the hazardous materials technician, however, their duties require a more direct or specific knowledge of the various substances they may be called upon to contain. The hazardous materials specialist will also act as site liaison with Federal, State, local and other governmental authorities in regards to emergencies. Hazardous materials specialists must have received at least 24 hours of training equal to the hazardous materials technician and have sufficient experience to objectively demonstrate competency.

Level 5 EOC Director/Incident Commander ***29 CFR 1910.120(q)(6)(v)***

EOC Director/Incident Commanders are those employees who assume control of the incident scene. They must have at least 24 hours of training equal to the first responder operations level and have sufficient experience to objectively demonstrate competency. All EOC Director/Incident Commanders must have attended the NFPA Incident Command Training or equivalent and will be an integral part of the VAFB Emergency Operations Center.

5.2 APPLICABILITY

Under existing Federal regulations all UPC employees who are involved in emergency response to hazardous substance or threatened releases are covered by the standard and are required to be trained. Responses to minor spills within the workplace where there is no potential safety or health hazard are not considered emergency responses.

5.3 RESPONSIBILITIES

5.3.1 Documentation Requirements

All UPC employees who have received and successfully completed the training and field experience as specified under Federal regulations are to be certified by their instructor or training supervisor as having successfully completed the necessary training. A written completion certificate will be issued to each UPC employee. The certificate will clearly indicate the level of training each employee has received.

5.3.2 Qualification of Instructors

UPC certified instructors are qualified to provide employee training in all subject areas. Trainers will have completed a training program or must have academic credentials and instructional experience necessary for teaching the subjects. Instructors must demonstrate competent instructional skills and knowledge of the applicable subject matter.

5.4 REFRESHER TRAINING

UPC employees, supervisors, and managers who are participants in the ERT, shall receive eight hours of refresher training annually on the items specified by Federal regulations, any critique of incidents that have occurred in the past year that can serve as training examples of related work, and other relevant topics deemed appropriate by their certified instructors.

6.0 CONTROL AND REVISION

6.1 DISTRIBUTION

Procedures are posted an available electronically via the ASSC Common/ASSCWEB Folder located on the I:/Drive. No hard copy distribution is made. Any printed versions in use must be verified for currency prior to use in accordance with statement on the front page of this procedure.

6.2 PROCEDURE FOR REVISION

Revisions will be processed in accordance with SOP-P-002 any time there are changes to policies, personnel or procedures which effect emergency response.

6.3 RECORD RETENTION AND PROTECTION

A. Records are maintained in applicable functional area and/or Document Control.

B. Records will be kept for five years or the length of the contract, unless deemed applicable for the life of the process. After this time the records are archived to transfer cases and maintained under Document Control accountability.

C. Access to the records is through the Document Control Administrator.

D. Indexing shall be on a monthly basis or as required by emergency events.

E. Storage shall be by any means which protects the record(s) from damage, destruction or loss.

F. Document Retention will include incident reports, PSM investigations, EOC Exercise Reports, training documentation and correspondence received from the United States Air Force on incident management system.

G. All HSF related records will be kept for the life of the process and filed with the PSM Administrator following the five years help with Document Control.

PART II

EMERGENCY RESPONDER TEAM OPERATIONS

Emergency conditions and situations, and an organization's response to emergencies, can quickly task both personnel and resources. It is critical to understand that organizational and personal response to an emergency condition must never exceed the level of training a person has received or the equipment and materials available to respond appropriately.

In most situations it will be the responsibility of United Paradyne Corporation to provide initial emergency response to safe operations or processes. It is the responsibility of VAFB Emergency Operations Center to provide a higher degree of emergency response and rescue operations. In some instances the most practical response will be no response other than notification to proper VAFB emergency services. Should UPC be directed to respond further, it will be under the direction of proper authorities and based upon the level of training and experience applicable to the particular response.

As the Aerospace Support Services Contractor, UPC has a unique and vital role in emergency operations. UPC is the primary responder to hypergolic and cryogenic emergencies occurring both on and off government property. However, this response is **always directed by the VAFB Emergency Operations Center or the State or Federal Incident Command System**. UPC does not have authorization to commit USAF resources to an emergency without proper direction and authorization. When in doubt, always seek counsel from your immediate Facility/Area Supervisor prior to responding.

Due to the many natural and man-made disasters possible on a military base, the following sections delineate UPC initial response to emergency conditions. It is understood that UPC may be directed to provide a higher degree of response, but this direction must be the result of a coordinated effort by the VAFB EOC.

1.0 FIRE - EXTERNAL TO UPC FACILITIES

1.1 OBJECTIVE

Hypergolic fuels, aviation fuels, and cryogenic liquids are, by their very nature, acutely hazardous, and require special handling and training for all personnel. This is especially true in situations where the commodity is threatened by fire or rapid vapor expansion from a nearby explosion. Aggressive protective measures may be required by UPC personnel to protect USAF assets and UPC personnel when facilities may be threatened by fire.

1.2 EMERGENCY ASSESSMENT

Emergency assessment is a critical responsibility in all emergency situations. In the event of a threatened fire which is close to UPC facilities, it becomes very important to properly assess the degree of threat and the resources which may be required to mitigate the event. Some precautions are universally warranted as part of the assessment, as personnel tend to want to "act" rather than "assess". In that regard, all UPC personnel must:

- Never respond to a fire without proper assessment and notification
- Never use water on electrical fires
- Never combat propellant fires where it is supported by oxidizer
- Never combat solid rocket propellant fires
- Never fight fires in close proximity to ordinance
- Never fight fires involving compressed gas cylinders
- Always assume for all applications that smoke from an unidentified source shall be considered a fire until ruled otherwise.

1.3 EMERGENCY NOTIFICATION

Whenever a fire or suspected fire has been discovered external to our operating facilities which could threaten our personnel or operations immediately do the following:

- If facility is equipped with manual fire alarms that report to the VAFB Fire Department, sound the fire alarm to alert personnel
- Verbally alert personnel inside buildings whenever manual fire alarm reporting is not available
- ALWAYS contact the VAFB Fire Department at **911** to report fire
- Contact the Operations Control Center and advise of the conditions which are present
- Advise UPC Safety and Management on status of personnel and resources

1.4 EMERGENCY ACTION

Person Making The Discovery:

A. Sound alarm and verbally make notification to all personnel in the affected area and predicted area of the fire progression.

B. Immediately instruct the Team Leader or Lead Supervisor of the event. Personnel who may be involved in an operation controlled by a UPC procedure must safe the operation in accordance with Appendix Z of the procedure and prepare for evacuation.

C. Evacuate all facilities which may be affected by the spread of the fire.

D. All personnel are to immediately report to the designated assembly area and remain at that point until released by UPC Management or EOC Director.

E. Immediately account for personnel and report their status to the Operations Control Center and request assistance as deemed appropriate.

F. Attempt to block traffic entering the hazardous area until Security Police can cordon off the area.

Facility/Area Supervisor:

A. Independently evaluate situation as it is presented and assess verbal notification from other personnel. Ensure UPC personnel and resources are not threatened from exposure to fire.

B. Initiate safing and securing operations in accordance with Appendix Z of the procedure being performed.

C. Ensure that emergency assistance has been requested from the VAFB Fire Department **by personally conversing with the person who made the original call**. If the proper reporting has not been made, immediately contact **911** and advise of the emergency conditions.

D. Ensure that the Operations Control Center has been notified of the incident.

E. Coordinate with UPC Safety by telephone or portable radio communications as soon as possible.

F. Ensure that all personnel are evacuated in a timely manner and are 100 percent accounted for at the assembly area.

1.5 POST-EMERGENCY ACTION

A. Facility supervisor must maintain a record of what has transpired and what actions UPC has taken.

B. Complete a UPC Accident Report for any injuries occurring as a result of safing, securing and evacuation.

C. Upon approval from the Government and UPC Safety, a safety assessment team will re-enter the affected facility and provide an assessment of any damage to facilities, processes, and equipment, and immediately start the development of a recovery plan. Facility configuration must be verified to ensure that it is safe for work activities to resume.

D. After the investigation has been completed, report findings to UPC Management, Base Safety, Program Office and Contracts.

E. Prior to re-entry, provide personnel who work in the affected area with return to work instructions and with any work-arounds which will need to be employed during the recovery phase.

1.6 POST-EMERGENCY EVALUATION

The Operations Manager will convene a meeting to critique the Incident/EOC Exercise with the affected Facility/Area Supervisor, Safety, Quality/Environmental Specialist, and OCC representatives. The purpose of the meeting is to identify lessons learned from the Incident/EOC Exercise and develop the following information to be shared with all UPC personnel:

A. What additional personnel support may be needed for similar incidents in the future.

B. Identify any additional equipment or materials that are needed.

C. Any additional coordination needed to accelerate the notification, response and clean-up activities.

D. Identify any additional training requirements and when the additional training will be conducted.

E. Draft a report, as necessary, detailing the incident/exercise and distribute to affected organizations and personnel.

2.0 FIRE - INTERNAL TO UPC FACILITIES

2.1 OBJECTIVE

Hypergolic fuels, aviation fuels, cryogenics, and oxidizers are by their very nature acutely hazardous and require special handling and training. This is especially true in situations where the commodity is directly threatened by fire or shock waves from a nearby explosion. Aggressive incipient protective measures may be required by UPC personnel to protect USAF assets and UPC and contractor personnel when our facilities may be threatened by fire. These situations are generally life-threatening should hypergols become involved.

2.2 EMERGENCY ASSESSMENT

Emergency assessment as previously stated is a critical responsibility in all emergency situations. In the event of a fire which involves UPC facilities, it becomes very important to properly assess the degree of threat and the resources which may be required to mitigate the event. In all events, decisive, accurate, and timely notifications to the proper resources are required to minimize the loss of life and property. Some precautions are universally warranted as part of the assessment as personnel tend to want to “act” rather than “assess”. In that regard, all UPC personnel must:

- Never respond to a fire without proper assessment and notification
- Never respond without the proper personal protective equipment
- Never respond without the proper extinguishing media
- Always understand your limitations and capabilities
- Always know when the fire evolves from incipient response action to structural/industrial fire fighting
- Never use water on electrical fires
- Never combat propellant fires where they are supported by an oxidizer other than normal atmospheric air
- Never combat solid rocket propellant fires
- Never fight fires in close proximity to ordinance
- Never fight fires involving compressed gas cylinders
- Always assume for all applications that smoke from an unidentified source shall be considered a fire until ruled otherwise.

2.3 EMERGENCY NOTIFICATION

Whenever a fire or suspected fire has been discovered at an operating facility immediately do the following:

- Sound the fire alarm to alert personnel if the facility is equipped with manual fire alarms that report to the VAFB Fire Department
- Verbally alert personnel inside of buildings whenever manual fire alarm reporting is not available
- ALWAYS contact the VAFB Fire Department at **911** to report the fire
- Contact the Operations Control Center and advise of the conditions which are present
- Advise UPC Safety and Management on status of personnel and resources

2.4 EMERGENCY ACTION

Person Making The Discovery:

A. Sound alarm and verbally make notification to all personnel in the affected area and predicted area of the fire's progression.

B. Immediately instruct the Team Leader or Lead Supervisor of the event. Personnel who may be involved in an operation controlled by a procedure must safe the operation in accordance with Appendix Z of the procedure and prepare for evacuation.

C. At the Fuel Side of the Hypergolic Storage Facility, activate the fire alarm and deluge pull stations if the fire is on the hardstand or in the tank clusters. This action should be taken if the fire cannot be controlled with the 11/2 inch fire hose or portable fire extinguishers available at the hardstand.

D. If the fire involves other resources away from the Hypergolic Storage Facility, which can be extinguished with incipient action, do the following:

- Determine the type and size of fire you will be extinguishing
- Select the proper fire extinguisher for the commodity
- Activate the fire extinguisher and with a sweeping motion attack the base of the fire until extinguished or until the extinguishing media is exhausted
- Remember to leave sufficient extinguishing media in the fire extinguisher to safely back out of the fire attack area
- If the fire is extinguished, stay in a safe area until you have determined that it is safe to enter the area
- If you are uncertain about whether or not the fire is extinguished, apply additional suppression media and wait for emergency services to arrive for salvaging operations
- If fire is not extinguished, back out of the area and wait for the arrival of professional fire fighting assistance

E. Instruct ancillary personnel to evacuate all facilities which may be affected by the spread of the fire.

F. All evacuated personnel are to immediately report to the designated assembly area and remain at that point until released by UPC Management or EOC Director.

G. Immediately account for personnel and report their status to the Operations Control Center and request assistance as deemed appropriate.

2.4 EMERGENCY ACTION (CONT.)

Facility/Area Supervisor:

A. Independently evaluate situation as it is presented and assess the verbal notification from other personnel.

B. Initiate safing and securing operations in accordance with Appendix Z of the procedure being performed.

C. Ensure that the emergency assistance has been requested from the VAFB Fire Department **by personally conversing with the person who made the original call**. If the proper reporting has not been made, immediately contact **911** and advise of the emergency conditions.

D. Ensure that the Operations Control Center has been notified of the incident.

E. Coordinate with UPC Safety by telephone or portable radio communications as soon as possible.

F. Ensure that all personnel are evacuated in a timely manner and are 100 percent accounted for at the assembly area.

G. Periodically advise the OCC of the fire's status so that the Fire Department may be briefed on it's progress.

H. Assess the environmental impact of the emergency and initiate coordinated efforts with VAFB EOC.

2.5 POST-EMERGENCY ACTION

A. Facility supervisor must maintain a record of what has transpired and what actions UPC has taken in the event.

B. Complete a UPC Accident Report for any injuries which have occurred as a result of safing, securing and evacuation.

C. Upon approval from the Government and UPC Safety, a safety assessment team will re-enter the affected facility and provide an assessment of the environmental impact and any damage to facilities, processes, and equipment, and immediately start the development of a recovery plan. Facility configuration must be verified to ensure that it is safe for work activities to resume.

D. After the investigation has been completed, report findings to UPC Management, Base Safety, Program Office, Bio-Environmental, Environmental Management Flight and Contracts.

E. Prior to re-entry, provide personnel who work in the affected area with return to work instructions and with any work-arounds which will need to be employed during the recovery phase.

2.6 POST-EMERGENCY EVALUATION

The Operations Manager will convene a meeting to critique the Incident/EOC Exercise with the affected Facility/Area Supervisor, Safety, Quality/Environmental Specialist, and OCC representatives. The purpose of the meeting is to identify lessons learned from the Incident/EOC Exercise and develop the following information to be shared with all UPC personnel:

A. What additional personnel support may be needed for similar incidents in the future.

B. Identify any additional equipment or materials that are needed.

C. Any additional coordination needed to accelerate the notification, response and clean-up activities.

D. Identify any additional training requirements and when the additional training will be conducted.

E. Draft a report, as necessary, detailing the incident/exercise and distribute to affected organizations and personnel.

3.0 POWER FAILURE

3.1 OBJECTIVE

During all emergent and non-emergent events which result in the disruption of power to UPC facilities, it is imperative that personnel safe all hazardous operations in accordance with Appendix Z and ready themselves to commence operations when power is restored. Additionally, it may be necessary to evacuate facilities where illumination is diminished to the extent that a safety hazard is presented to personnel.

3.2 EMERGENCY ASSESSMENT

Determine if an operation needs to be safed in accordance with Appendix Z of the procedure being performed should a power failure occur. Once this is accomplished, determine if the power outage is from a local circuit breaker or involves a base-wide outage.

3.3 EMERGENCY NOTIFICATION

If a condition exists where power cannot be restored by re-setting a local circuit breaker, call the Base Civil Engineering Trouble Desk at 606-1856 and report the condition which exists and the building/buildings which may be involved. It is important to notify the UPC Operations Control Center of the power outage.

3.4 EMERGENCY ACTION

As mentioned, if a hazardous operation is in progress and it is safe to do so, UPC personnel will safe the operation and back out of the operation to a safe place in the procedure and standby until Base Civil Engineering can restore power. If it is necessary to evacuate a building or facility, ensure that all personnel have been accounted for at assembly areas. Have someone familiar with the facility, accompanied by an escort, enter the facility using proper portable illumination and ensure that no one is trapped inside or has been left behind.

3.5 POST-EMERGENCY ACTION

A. Facility supervisor must maintain a record of what has transpired and what actions UPC has taken in the event.

B. Complete a UPC Accident Report for any injuries which have occurred as a result of safing, securing and evacuation.

C. Upon approval from the Government and UPC Safety, a safety assessment team will re-enter the affected facility and provide an assessment of the environmental impact and any damage to facilities, processes, and equipment, and immediately start the development of a recovery plan. Facility configuration must be verified to ensure that it is safe for work activities to resume.

D. After the investigation has been completed, report findings to UPC Management, Base Safety, Program Office and Contracts.

E. Prior to re-entry, provide personnel who work in the affected area with return to work instructions and with any work-arounds which will need to be employed during the recovery phase.

F. Ensure that all electrically operated equipment is back on-line and the operations can be safely resumed.

3.6 POST-EMERGENCY EVALUATION

The Operations Manager will convene a meeting to critique the Incident/EOC Exercise with the affected Facility/Area Supervisor, Safety, Quality/Environmental Specialist, and OCC representatives. The purpose of the meeting is to identify lessons learned from the Incident/EOC Exercise and develop the following information to be shared with all UPC personnel:

A. What additional personnel support may be needed for similar incidents in the future.

B. Identify any additional equipment or materials that are needed.

C. Any additional coordination needed to accelerate the notification, response and clean-up activities.

D. Identify any additional training requirements and when the additional training will be conducted.

E. Draft a report, as necessary, detailing the incident/exercise and distribute to affected organizations and personnel.

4.0 PRESSURE VESSEL RELEASE, CONTAINMENT AND CONTROL

4.1 OBJECTIVE

It is recognized that by design and construction the Hypergolic Fuels Storage Tanks, Helium and Nitrogen storage tanks are engineered to provide pressure relief through the relief valve system. It is important to understand how to safely respond to such a failure. This section describes the steps to take when dealing with this type of emergency.

4.2 EMERGENCY ASSESSMENT

In the case of a pressure vessel release from an over-pressurized relief valve system an initial assessment must include insuring that the relief valve will automatically reseat. This information will help determine the magnitude of the emergency.

4.3 EMERGENCY NOTIFICATION

Immediately notify the OCC. The OCC will in turn notify the Operations Manager, Engineering, and Systems Safety and have the Support Team report to the OCC. The OCC will make all normal notifications as required per 2.4.1 of this procedure. If it is a pressure release from an oxidizer storage tank it is of paramount importance to notify TPQ-18 and Building 900. In the case of a release from a toxic commodity storage vessel, the OCC should also notify the UPC Environmental Specialist for any required regulatory reporting.

4.4 EMERGENCY ACTION

Emergency Actions For Pressure Release at the HSF:

* Immediately start the process of suiting up in SCAPE
* When the proper response team is in place and all notifications have been made, including EOC if needed, under the direction of the Operations Manager or a designated representative, the SCAPE operation to repair the system may commence. Repair operations will require assessment information and UPC Engineering concurrence.

Emergency Action For Other Than Toxic Releases:

* Ensure proper PPE is available for use before starting any repairs to a pressurized system.
* When the proper response team is in place and all notifications, including EOC response if needed, under the direction of the Operations Manager or designated representative, the operation to repair the system may commence. Repair operations will require assessment information and UPC Engineering concurrence.

Emergency Action for Other Pressure Vessels.

* Ensure proper PPE is available for use before starting any repairs to a pressurized system.
* When the proper response team is in place and all notifications, including EOC response if needed, under the direction of the Operations Manager or designated representative, the operation to repair the system may commence. Repair operations will require assessment information and UPC Engineering concurrence.

4.5 POST-EMERGENCY ACTION

A. Facility supervisor must maintain a record of what has transpired and what actions UPC has taken in the event.

B. Complete a UPC Accident Report for any injuries which have occurred as a result of safing, securing and evacuation.

C. Upon approval from the Government and UPC Safety, a safety assessment team will re-enter the affected facility and provide an assessment of the environmental impact and any damage to facilities, processes, and equipment, and immediately start the development of a recovery plan. Facility configuration must be verified to ensure that it is safe for work activities to resume.

D. After the investigation has been completed, report findings to UPC Management, Base Safety, Program Office Bio-Environmental, Environmental Management Flight and Contracts.

E. Prior to re-entry, provide personnel who work in the affected area with return to work instructions and with any work-arounds which will need to be employed during the recovery phase.

F. The Environmental Specialist in conjunction with the Base Environmental Management Flight will aid in the preparation of all the necessary documents and reports required by the Santa Barbara County Air Pollution Control District. Additionally, they will assess the environmental impact of the emergency and coordinate efforts with VAFB EOC, and assist UPC personnel as required.

4.6 POST-EMERGENCY EVALUATION

The Operations Manager will convene a meeting to critique the Incident/EOC Exercise with the affected Facility/Area Supervisor, Safety, Quality/Environmental Specialist, and OCC representatives. The purpose of the meeting is to identify lessons learned from the Incident/EOC Exercise and develop the following information to be shared with all UPC personnel:

A. What additional personnel support may be needed for similar incidents in the future.

B. Identify any additional equipment or materials that are needed.

C. Any additional coordination needed to accelerate the notification, response and clean-up activities.

D. Identify any additional training requirements and when the additional training will be conducted.

E. Draft a report, as necessary, detailing the incident/exercise and distribute to affected organizations and personnel.

5.0 HYPERGOLIC LIQUID RELEASES

5.1 OBJECTIVE

A. To identify the emergency response actions required of UPC Employees whenever an unplanned, non-routine Hypergolic Fuel or Oxidizer Propellant liquid release occurs at the Hypergolic Storage Facility. It is understood there are times when small quantities of liquid are expected during normal operations (drops, capful, etc.) These are considered planned, routine releases that do not fall under the requirements of this section.

In the event a propellant trailer liquid release occurs when trailers are in the transportation mode and being escorted by UPC HOS support personnel, the release will be immediately reported via RF Radio, to United Paradyne's OCC. OCC shall notify Base Command Post, 606-9961, 30 CES/CEVCC (606-0016/605-0544), and Range Safety immmediately.

B Reference Appendix B of this plan for classification of the emergency and applicable response levels in accordance with 30 SW Plan 32-4002, Hazmat Emergency Response Plan. As stated in 32-4002:

Minor and Major Incidents. The level of response to a specific release is dependent upon the amount of material that is released and the hazard that it poses to personnel, the environment, and to base facilities and equipment. In general, actual or potential releases of hazardous materials can be divided into two categories.

- Minor releases that can be safely and competently handled by on-site personnel.
- Major releases that require the support of base emergency response elements to control, contain, and/or clean up.

For a liquid hypergol release to be considered minor, it involves very small quantities, typically one gallon or less as defined in Section 1.4 of this plan for definition of major and minor release/spill.

5.2 MINOR SPILL/RELEASE RESPONSE

A. Upon discovery of a minor hypergolic liquid spill/release of either of the HSF'S, perform the following actions:

1. Vacate immediate/affected area and verbally notify all personnel in the immediate area and RF radio to on-site personnel and the UPC OCC. Activate red area warning light.

2. Notify Supervisor and/or Operations Manager if not already notified, and wait for instructions on appropriate steps to stop liquid spill/release.

   NOTE: If rate of liquid release is a rate that will exceed the one gallon size limit before operations can stop the release, it is to be categorized as a major release and dealt with accordingly per 5.3 of the plan.

3. Using appropriate Personal Protective Equipment, SCAPE, perform directed actions to stop liquid spill/release.

5.2 MINOR SPILL/RELEASE RESPONSE (CONT.)

4. UPC Safety and Quality personnel will determine the need for recording the incident or initiating a non-conformance report on the condition.

5. UPC Environmental will notify 30 CEV, regardless of the size of liquid spill/release in accordance with 30 SW 32-4002.

6. UPC OCC or Management personnel shall notify 30 SW/SE Range Safety by both phone and email.

   - 30swse.report@vandnenberg.af.mil
   - 606-4052 (leave voice message)

5.3 MAJOR SPILL/RELEASE EMERGENCY ASSESSMENT

Upon discovery of a unplanned and/or non-routine Hypergolic liquid release of any quantity at either of the HSF’s immediately perform the following actions:

A. **Verbally** Sound Alarm in the immediate area and by RF Radio to on-site personnel and the UPC OCC.

B. **Activate** Fire Alarm Pull Stations as necessary based on the situation. At the Fuel HSF, activate the appropriate Deluge Pull Station as necessary. Activate Red area warning light and verify it is flashing.

C. **Evacuate** the facility if necessary in an upwind or cross wind direction a minimum distance of 2000 feet and report to the designated facility assembly areas. TPQ-18 or South Base Scales are to be utilized based upon established wind direction. Once at the designated assembly area account for all personnel and report status to the UPC OCC. The Badge Board should be used to account for personnel that were on site.

5.4 MAJOR EMERGENCY NOTIFICATION

Report to the UPC OCC and **911** Operator the following information via telephone or RF Radio:

A. Call Sign and Name

B. Nature and Location of Spill

C. Type of commodity spilled (A-50, Hydrazine, MMH or Oxidizer)

D. Report as detailed a description of the situation as possible and include the following:

   1. Personnel injured or exposed.
   2. State direction of vapor cloud and estimated size of wetted area from the liquid spill.
   3. Status of equipment and facility hardware.
   4. Verification that TPQ-18 and Weather Station personnel have been notified of the spill.
   5. Actions taken prior to evacuation.

5.4 MAJOR EMERGENCY NOTIFICATION (CONT.)

6. If a catastrophic release of commodity has occurred, immediately report to the UPC OCC one (1) of the following “worst case” scenarios. This information is necessary so that Base Weather can be notified to plot an OHZ based on the following analysis:
   a. A Propellant Drum has spilled on the Hardstand, with a 100 Square Foot Wetted Area developed equal to approximately 7 gallons, or
   b. A Liquid Flex hose has burst on the Hardstand, with a 100 Square Foot Wetted Area, maximum spill quantity is 7 gallons, or
   c. An Oxidizer Tank is leaking with a 1064 Square Foot wetted area, maximum spill quantity is approximately 25,000 gallons, or
   d. An A-50 Tank leak has occurred with a 952 Square Foot wetted area, maximum spill quantity is approximately 25,000 gallons, or
   e. A Propellant Trailer is leaking on the Hardstand, with a 100 Square Foot wetted area quantity is approximately 2500 gallons.

5.5 MAJOR EMERGENCY ACTION

A. **Facility/Area Supervisor**, immediately initiate safing/securing emergency steps. If the EOC has been formed, access to the facility/equipment must be approved by the EOC Director and the Base Fire Chief assigned to the incident.

1. If an Operation **<u>was being</u>** performed per a UPC Procedure, direct personnel to secure the facility per the **applicable Appendix Z Instructions**.
2. If an Operation **<u>was not</u>** being performed, UPC Engineering will have to provide the necessary procedural steps to be performed by the UPC ERT personnel. All suggested procedures will have to be approved by UPC Quality, Safety, Operations Manager, and 30 SW/SES personnel, in writing or verbally, <u>prior</u> to performance.
3. Upon access to incident location, provide status of facility/equipment and actions taken to the UPC OCC and/or EOC Director. Do not perform any additional actions unless procedures have been approved by UPC Engineering, Operations, Quality and Safety.

B. **UPC OCC Personnel**, maintain a log of all events and communications, and coordinate with the appropriate VAFB agencies as specified in this Plan.

1. Notify Base Command Post 606-9961, 30 CEV/CES, and 30 LRS Unconvential Fuels Representatives.
2. Obtain Toxic Hazard Zone information for an OHZ from Base Weather and transmit original and continuous updates to Facility/Area Supervisor.
3. Provide HSF Storage Tank Pressure readings periodically to Facility/Area Supervisor or EOC Director, if the remote pressure read-out capability is still available.
4. Notify 30 SW/SE Range Safety by both email and phone.
   - 30swse.report@vandnenberg.af.mil
   - 606-4052 (leave voice message)
5. Continually update the UPC Program Manager and Operations Manager.

5.5 MAJOR EMERGENCY ACTION (CONT.)

C. **UPC Operations Manager**, will report to Facility Assembly Area or EOC Assembly Point to approve and direct incident response actions in coordination with Facility/Area Supervisor and EOC Team representatives.

D. **UPC Safety**, will report to the appropriate Assembly Area and coordinate all Safety issues with Facility/Area Supervisor, UPC EOC Representative and Government Safety Representatives.

E. **UPC Environmental Specialist**, will coordinate with the Facility/Area Supervisor, Operations Manager and 30 CES/CEV with regards to the Hazardous Materials HAZMAT) Emergency Response Plan, 30 SW PLAN 32-4002 requirements. In concert with Environmental Management Flight, Environmental Specialist will assess the environmental impact of the emergency and initiate coordinated efforts with VAFB EOC.

5.6 MAJOR POST-EMERGENCY ACTION

A. **UPC Operations Control Center**

1. Prepare the summary of events from the OCC EOC Log (UPC-P-018), and present to the UPC Operations Manager for preparation of the Incident or EOC Exercise Report.

2. Notify appropriate Base Support Agencies, UPC Program Manager and Operations Manager, that the Incident/EOC Exercise is over.

B. **UPC Operations Manager**

1. Coordinate with Facility/Area Supervisor, UPC Safety, UPC Quality/Environmental Specialist and UPC Engineering on actions required to perform clean-up and containerizing of spill residue, including re-entry precautions into affected facilities that define conditions for returning to normal work activities at the facility.

2. Prepare the report on the Incident/EOC Exercise Summary and publish the report within five (5) working days after the event. Reports should be sent to 30 RMS/RMSO Program Officer for the Aerospace Support Services Contract and Range Safety.

C. **UPC Environmental Specialist**

Due to the release of a hypergolic chemical, report the incident in writing to 30 CES/CEV as soon as possible. The report should include the following:

1. Chemical name or identity of any material involved in the release.
2. Quantity released (in pounds).
3. Time and duration of release.
4. Location and type of area into which the release occurred.
5. Actions taken to contain the release.
6. Name and Telephone of person(s) to be contacted for further information.
7. Obtain the Name and Rank of all personnel contacted regarding the incident and annotate this information for future reference.

5.7 MAJOR POST-EMERGENCY EVALUATION

The Operations Manager will convene a meeting to critique the Incident/EOC Exercise with the affected Facility/Area Supervisor, UPC Safety, UPC Quality/Environmental Specialist, and UPC OCC representatives. The purpose of the meeting is to identify lessons learned from the Incident/EOC Exercise and develop the following information to be shared with all UPC personnel:

A. What additional personnel support may be needed for similar incidents in the future.

B. Identify any additional equipment or materials that are needed.

C. Any additional coordination needed to accelerate the notification response and clean-up activities.

D. Identify any additional training requirements and when the additional training will be conducted.

E. Draft a report, as necessary, detailing the incident/exercise and distribute to affected organizations and personnel.

6.0 HYPERGOLIC VAPOR RELEASES/PRESSURE LEVEL ALARM

6.1 OBJECTIVE

A. To identify the required emergency response actions required of UPC employees whenever an unplanned, non-routine Hypergolic, Fuel or Oxidizer Propellant VAPOR RELEASE/PRESSURE LEVEL ALARM occurs at the Hypergolic Storage Facility. It is understood there are times when small quantities of vapor are expected during normal operations. These are considered planned, routine releases that do not fall under the requirements of this section.

In the event a propellant trailer vapor release occurs when trailers are in the transportation mode and being escorted by UPC HOS Support personnel, the vapor release will be immediately reported via RF Radio to United Paradyne's OCC. OCC shall notify Base Command Post, 606-9961, 30 CES/CEVCC (606-0016/605-0544), and Range Safety immediately.

In response to a HSF pressure level alarm after normal working hours; personnel assigned as HSF Emergency Responders, for after hours support, will be contacted/notified by either the Base Command Post or the VAFB dispatch. Personnel shall stage at the PEMO Facility until further notice to ensure personnel enter through the safest control entry point based on VAFB Fire Department's assessment and plotted THZ. Further notifications may be required based on the level of response IAW Appendix B (Emergency Operations Center & Incident Response Levels) per PWI-10-S-003 (Emergency Response Plan).

B Reference Appendix B of this plan for classification of the emergency and applicable response levels in accordance with 30 SW Plan 32-4002, Hazmat Emergency Response Plan.

As stated in 32-4002:

Minor and Major Incidents. The level of response to a specific release is dependent upon the amount of material that is released and the hazard that it poses to personnel, the environment, and to base facilities and equipment. In general, actual or potential releases of hazardous materials can be divided into two categories.

6.2 MINOR INCIDENT RESPONSE

A. Upon discovery of a minor hypergolic vapor release at either of the HSF'S, perform the following actions:

1. Vacate immediate/affected area and verbally notify all personnel in the immediate area and RF radio to on-site personnel and the UPC OCC. Activate red area warning light.

2. Notify Supervisor and/or Operations Manager if not already notified, and wait for instructions on appropriate steps to stop vapor release.

3. Using appropriate Personal Protective Equipment (PPE), which at a minimum will be SCBA, perform directed actions to stop vapor release.

4. UPC Safety and Quality personnel will determine the need for recording the incident or initiating a non-conformance report on the condition.

5. UPC Environmental shall notify 30 CEV, in accordance with 30 SW Plan 32-4002 if applicable.

6. UPC OCC, or Management personnel shall notify 30 SW/SE Range Safety by both email and phone.
   - 30swse.report@vandenberg.af.mil
   - 606-4052 (leave voice message)

6.3 MAJOR EMERGENCY ASSESSMENT

A. Upon discovery of a Major Hypergolic Vapor Release and/or Pressure Level Alarm at either of the HSF's, immediately perform the following actions:

  1. Verbally Sound Alarm in the immediate area and by RF Radio to on-site personnel and the UPC OCC.

  2. Activate Fire Alarm Pull Stations. At the Fuel HSF, if it appears the uncontrollable vapor release can be reduced by the addition of water, activate the appropriate Deluge Pull Station. Verify Red area warning light is flashing. If the Red warning light is not operational, activate the Yellow area warning light.

  3. Evacuate the facility in an upwind or cross wind direction a minimum of 2000 feet and report to the designated facility assembly areas. TPQ-18 or the South Base Scales, are to be used based upon established wind direction. Once at the designated assembly area account for the personnel and report status to the UPC OCC. The Badge Board should be used to account for personnel that were on-site.

  4. Verify that Facilities 900 and TPQ18 have been evacuated.

B. If the Instrument Alarm System (IAS) alarm is activated due to a Pressure Level Alarm, interrogate the Program Logic Controller (PLC) to determine the cause and from which storage tank the alarm originated. Notify UPC Engineering and standby for further direction. The alarm condition should be present on the monitors in the UPC OCC. Verify with the UPC OCC to determine if a similar condition exists. Response to this type of alarm will be directed by UPC Engineering. In addition, this alarm will automatically be sent to the VAFB Fire Department. As soon as the trouble can be isolated, notify Base Fire Department, HSF Ox, HSF Fuel, TPQ-18, Bldg 900 personnel of findings and any action which has been taken.

6.4 MAJOR EMERGENCY NOTIFICATION

A. **Report** to the UPC OCC and **911** Operator the following by telephone or RF Radio:

  1. Call Sign and Name.
  2. Nature and Location of release.
  3. Type of commodity venting (A-50, Hydrazine, MMH or Oxidizer) and if it is from the Scrubber Vent or the Storage Tank Relief Valve Vents.

6.4 MAJOR EMERGENCY NOTIFICATION (CONT.)

B. **Report** as detailed a description of the situation as possible and include the following:

1. Personnel injured or exposed.
2. State direction of vapor cloud and estimated release rate of the venting propellant.
3. Status of equipment and facility hardware.
4. Verification that TPQ-18 and Bldg 900 personnel have been notified of the vent.
5. Actions taken prior to evacuation.
6. If a catastrophic vapor release of commodity has occurred, immediately report to the UPC OCC one (1) of the following “worst case” scenarios. This information is necessary so that Base Weather can be notified to plot an EHZ based on the following analysis:
    a. The Oxidizer Storage Tank Relief Valve is venting or the Scrubber is saturated and vapors are coming from the 50 foot facility vent stack. The vent rate is 30 LBS/Minute of NO2 for the worst case emission.
    b. The A-50 Storage Tank Relief Valve is venting from the 50 foot Vent Stack or the Scrubber is saturated and is venting from the 30 foot Scrubber Vent. The venting rate for both is 5 LBS/Minute of UDMH for the worst case emission.
    c. The Propellant Trailers worst case emission is as follows; the Oxidizer Trailer Relief Valve Vent is 30 LBS/Minute of NO2; and from the Fuel Trailer Relief Valve Vent it is 5 LBS/Minute of UDMH. Both vents are approximately 10 feet above ground level on each Trailer.

6.5 MAJOR EMERGENCY ACTION

A. **Facility/Area Supervisor,** immediately initiate safing/securing emergency steps. If the EOC has been formed, access to the facility/equipment must be approved by the EOC Director and the Base Fire Chief assigned to the incident.

1. If an Operation **was being** performed per a UPC Procedure, direct personnel to secure the facility per the **applicable Appendix Z Instructions**.
2. If an Operation **was not** being performed, UPC Engineering will have to provide the necessary procedural steps to be performed by the UPC Technicians. All procedures will have to be approved by UPC Safety, UPC Quality/Environmental Specialist, Operations Manager, and 30 SW/SES personnel, in writing or verbally, prior to performance.
3. Upon access to incident location, provide status of facility/equipment and actions taken to the UPC OCC and/or EOC Director. Do not perform any additional actions unless procedures have been approved.

6.5 MAJOR EMERGENCY ACTION (CONT.)

B. **UPC OCC Personnel**, maintain a log of all events and communications, and coordinate with the appropriate VAFB agencies as specified in this Plan.

1. Notify Base Command Post, 30 CEV/CES and 30 LRS Uncoventional Fuels Representative.

2. Obtain Toxic Hazard Zone information for an EHZ from Base Weather and transmit original and continuous updates to Facility/Area Supervisor.

3. Provide HSF Storage Tank Pressure readings periodically to Facility/Area Supervisor or EOC Director as requested.

4. Notify 30 SW/SE Range Safety by both email and phone.

   - 30swse.report@vandenberg.af.mil
   - 606-4052 (leave voice message)

5. Continually update the **UPC** Program Manager and Operations Manager.

C. **UPC Operations Manager,** will report to Facility Assembly Area or EOC Assembly Point to approve and direct incident response actions in coordination with Facility/Area Supervisor and EOC Team representatives.

D. **UPC Safety**, will report to the appropriate assembly area and coordinate all Safety issues with Facility/Area Supervisor, UPC EOC Representative and Government Safety Representatives.

E. **UPC Quality/Environmental Specialist**, will coordinate with the Facility/Area Supervisor, Operations Manager and 30 CES/CEV with regards to the Hazardous Materials (HAZMAT) Emergency Response Plan, 30 SW PLAN 32-4002 requirements. In concert with Environmental Management Flight, Environmental Specialist will assess the environment impact of the emergency and initiate coordinated efforts with VAFB EOC.

6.5 MAJOR POST-EMERGENCY ACTION

A. **UPC Operations Control Center**

1. Prepare the summary of events from the OCC EOC Log (UPC-P-018), and present to the UPC Operations Manager for preparation of the Incident or EOC Exercise Report.

2. Notify appropriate Base Support Agencies, UPC Program Manager and Operations Manager, that the Incident/EOC Exercise is over.

B. **UPC Operations Manager**

1. Coordinate with **Facility/Area** Supervisor, UPC Safety, UPC Quality/Environmental Specialist and UPC Engineering on actions required to perform clean-up and containerizing of spill residue, including re-entry procedures into affected facilities. Define conditions for returning to normal work activities at the facility.

2. Prepare the report on the Incident/EOC Exercise Summary and publish the report within five (5) working days after the event. Reports should be sent to 30 RMS/RMSO Program Officer for the Aerospace Support Services Contract and Range Safety.

6.5 MAJOR POST-EMERGENCY ACTION (CONT.)

C. **UPC Quality/Environmental Specialist**

Due to the release of a hypergolic chemical, report the incident in writing to 30 CES/CEV as soon as possible. The report should include the following:

1. Chemical name or identity of any material involved in the release.
2. Quantity released (in pounds).
3. Time and duration of release.
4. Location and type of area into which the release occurred.
5. Actions taken to contain the release.
6. Name and Telephone of person(s) to be contacted for further information.

6.7 MAJOR POST-EMERGENCY EVALUATION

The Operations Manager will convene a meeting to critique the Incident/EOC Exercise with applicable **Facility/Area** Supervisor, UPC Safety, UPC Quality/Environmental Specialist, and UPC OCC representatives. The purpose of the meeting is to identify lessons learned from the Incident/EOC Exercise and develop the following information to be shared with all UPC personnel:

A. What additional personnel support may be needed for similar incidents in the future.

B. Identify any additional equipment or materials are needed.

C. Any additional coordination needed to accelerate the notification, response and clean-up activities.

D. Identify any additional training requirements and when the additional training will be conducted.

E. Draft a report, as necessary, detailing the incident/exercise and distribute to affected organizations and personnel.

7.0 HAZARDOUS CHEMICAL SPILL, CONTAINMENT AND CONTROL

7.1 OBJECTIVE

To identify the emergency response actions required of UPC employees whenever there is an unplanned, non routine hazardous chemical spill/release. UPC procedures and guidance for response to chemical releases will support and comply with the requirements specified in the 30th Space Wing Plan 32-4002, Hazardous Material (HAZMAT) Emergency Response Plan.

7.2 EMERGENCY ASSESSMENT

When a chemical spill/release occurs or is threatened, there are several critical assessments which must be made immediately:

A. Does the incident pose a threat to human health or life?

B. Does the incident pose a threat to the environment or property?

Emergency assessment must also be made within the context of resources available at the scene. That is, are proper and sufficient spill containment and clean-up materials and equipment available; are trained personnel available; and are there means of communication and withdrawal available should circumstances escalate into a more serious situation? Depending upon the circumstances of the spill/release and responses to the above assessment questions, UPC personnel will follow different courses of action. In all cases prompt and prudent action is required to prevent an incident from becoming a disaster.

7.3 EMERGENCY NOTIFICATION

A. For serious injury, threat to life or health, fire or explosion, or serious circumstances requiring immediate assistance, call **911**. Be prepared to provide description of location and nature of injuries, and circumstances of spill/release. Keep the line open until **911** personnel release you.

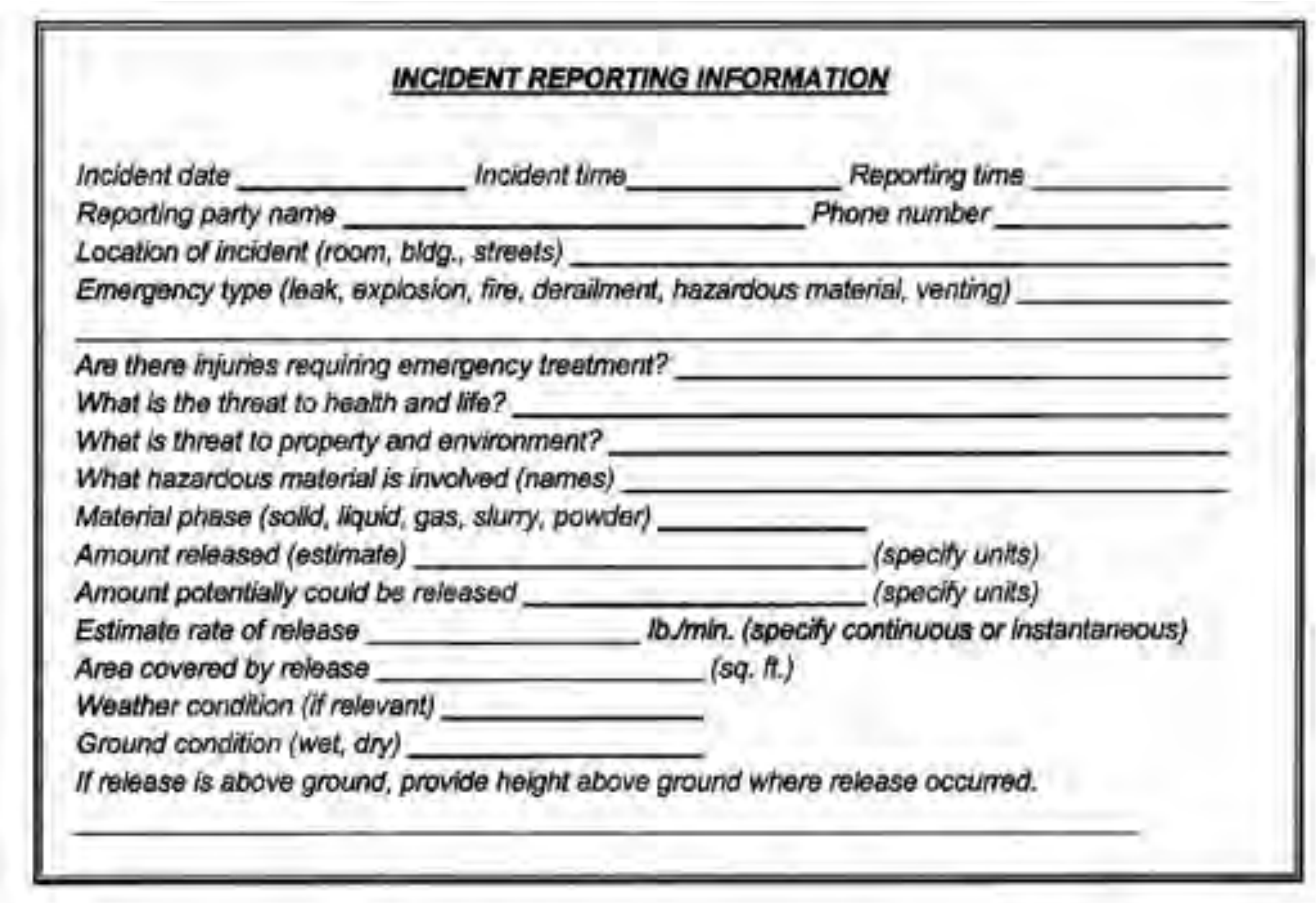
B. If there is a **major** spill/release and no personal injuries or fire, call the **OCC 606-7451**, and request the Base Command Post 606-9961, 30 CEV/CES, and Range Safety be notified and the Base HAZMAT Team respond.

C. For all **minor** spills/releases call the **OCC 606-7451**, and request that 30 CES/CEVCC (606-0016/605-0544) and Base Command Post, 606-9961, be notified. Be prepared to provide an incident report.

D. For all above instances, notify 30 SW/SE Range Safety by both email and phone at the earliest convenience.

- Email: 30swse.report@vandenberg.af.mil
- Phone: 606-4052 (leave voice message)

7.3 EMERGENCY NOTIFICATION (CONT.)



INCIDENT REPORTING INFORMATION

Incident date ______________ Incident time______________ Reporting time ______________

Reporting party name ______________________________ Phone number ______________

Location of incident (room, bldg., streets) ____

Emergency type (leak, explosion, fire, derailment, hazardous material, venting) ______________

____

Are there injuries requiring emergency treatment? ________________________________

What is the threat to health and life? ____

What is threat to property and environment? ____________________________________

What hazardous material is involved (names) ____________________________________

Material phase (solid, liquid, gas, slurry, powder) ______________

Amount released (estimate) ______________________________ (specify units)

Amount potentially could be released _______________________ (specify units)

Estimate rate of release __________________ lb./min. (specify continuous or instantaneous)

Area covered by release ______________________ (sq. ft.)

Weather condition (if relevant) __________________

Ground condition (wet, dry) ____________________

If release is above ground, provide height above ground where release occurred.

____

7.4 EMERGENCY ACTION

Person Making Discovery

A. Sound the alarm, make emergency notification as required above.

B. Determine if evacuation and/or PPE is required. Evacuate all non-essential personnel until the situation is controlled and operations can return to normal, pre-release conditions. If PPE is required , evacuate to a safe area (upwind) to don equipment.

C. Within level of training and capabilities provide first aid to injured.

D. If spill occurred during a procedure, attempt to secure the operation following Appendix Z of the procedure.

E. Within level of training and capabilities attempt to contain release (diking, adsorbents). For releases of known chemicals, obtain the applicable MSDS and follow the recommendations of the “Spills” section.

F. Within level of training and capabilities, stop release, if possible (righting a drum, closing a valve). Aggressive spill control response is to be taken only by those trained in emergency response operations. Simple clean up of a routine, small spill is not considered emergency response.

G. Continue to keep the OCC and/or EOC informed as containment and clean up progress.

H. Notify facility/area supervisor, and keep supervisor informed as situation progresses.

OCC Personnel

A. Perform communication links and notifications as required by circumstances and company and base policy and procedures (Reference 7.3 of this section).

B. Keep UPC Operations Manager and Program Manager informed about spill/release actions and responses.

C. Maintain a chronological log of all events and communications.

UPC Emergency Response Team

A. Respond as directed by the Operations Manager/ Program Manager.

B. Within level of training and capabilities contain and stop release. Use MSDS and other resources to evaluate the situation before response actions begin. During course of response retain a flexible plan for personnel egress should the situation exceed Team capabilities.

C. Assess clean up requirements and report them to the OCC/Operations Manager. Do not proceed with clean up until directed to do so by Operations Manager, or competent government authority (EOC Director, ACO, or Space Fuels Flight Project Officer).

D. Perform decontamination of equipment and supplies. Identify items requiring restocking for subsequent responses.

E. Support after-action investigations and reporting.

7.4 EMERGENCY ACTION (CONT.)

Facility/Area Supervisor

A. Evaluate situation and information provided by those at the scene.

B. Ensure proper response has been initiated, to include medical support, fire fighting, HAZMAT Team, etc. Independently verify response actions by contacting **911** and/or the Base Command Post **606-9961**.

C. Coordinate evacuation activities, and obtain "head count" at the evacuation assembly area.

D. In conjunction with the Operations Manager and the Program Manager mobilize company resources to the extent required to control the situation.

E. If the situation involves an operational/procedural activity, direct securing of the operation per Appendix Z of the procedure in progress.

F. Coordinate with UPC Safety personnel on incident investigation and reporting requirements.

G. Follow up with 30 CES/CEV to verify that all required environmental/emergency release reporting has been accomplished.

7.5 POST-EMERGENCY ACTION

A. Check with medical facility on status of injured personnel.

B. Notify immediate family, as appropriate.

C. Complete incident/accident reports and submit to UPC Safety for filing or forwarding to appropriate Base and governmental agencies.

D. Gather all records/documents associated with the spill/release emergency.

E. Obtain Safety approval to return to normal operations.

F. Provide personnel with re-entry and return to work instructions.

7.6 POST-EMERGENCY EVALUATION

The UPC Operations Manager will convene a meeting to evaluate and critique responses and actions related to the spill/release emergency response. The Operations Manager will be supported by the facility/area affected, UPC Safety, Quality/Environmental Specialist, Engineering, UPC Response Team Chief, and the OCC representative. A report will be written to identify lessons learned, and evaluate effectiveness of emergency planning and response. The purpose of the report is to improve emergency response to chemical spills/releases, and **not** to find fault or place blame. The following information will be developed:

A. Identify any additional personnel support that may be needed for similar incidents in the future.

B. Identify any additional equipment or materials that are required.

C. Identify any additional training that may be required.

D. Identify any means to improve communication and coordination processes.

E. Identify any weaknesses in planning or response documentation.

F. Submit report, as required, on the incident or emergency to affected organizations and personnel.

8.0. CRYOGENIC RELEASES, CONTAINMENT AND CONTROL

8.1 OBJECTIVE

To identify the emergency response actions required of UPC employees whenever a cryogenic liquid release occurs at any UPC Facilities.

8.2 EMERGENCY ASSESSMENT

From a safe distance, determine if there is an actual cryogenic spill or simply a controlled pressure venting of gaseous vapor. If there is an actual spill, immediately implement the emergency notification section of this chapter.

Upon initial discovery of a Cryogenic liquid release immediately perform the following actions:

A. **Verbally** Sound Alarm in the immediate area and via RF Radio to on-site personnel and the UPC OCC.

B. **Activate Emergency Shutdown Appendix Z Instructions**.

C. **Evacuate** from the spill area to a safe distance away from the cryogenic liquid and vapor area and allow liquid to vaporize.

WARNING

LIQUID OXYGEN WHEN IN CONTACT WITH ORGANIC SUBSTANCES (OIL, ASPHALT, AND PETROLEUM-BASED MATERIALS) IS BOTH <u>SHOCK AND IMPACT</u> SENSITIVE AND, IF WALKED ON, CAN INITIATE A FIRE CAUSING SERIOUS INJURY OR DEATH. ANY CRYOGENIC LIQUID CAN CAUSE SEVERE BURNS AND LIQUID NITROGEN, WHEN VAPORIZING, IS AN ASPHYXIANT IN CONFINED SPACES. IF WATER IS AVAILABLE, <u>DO NOT APPLY WATER WITH FORCE, SLOWLY</u> RUN WATER ONTO SPILL AREA TO AID IN VAPORIZATION.

8.3 EMERGENCY NOTIFICATION

A. **Report** to the UPC OCC the following information via telephone or RF Radio:

1. Call Sign and Name.
2. Nature and Location of Spill.
3. Type of commodity spilled (Liquid Nitrogen, Liquid Oxygen, or Liquid Breathing Air)

B. **Report** as detailed a description of the situation as possible and include the following:

1. Personnel injured or exposed.
2. State direction of vapor cloud and estimated size of wetted area from the cryogenic liquid spill.
3. Status of equipment and facility hardware.
4. Actions taken prior to evacuation.

8.4 EMERGENCY ACTION

General

A. Upon initial discovery of a Cryogenic liquid release immediately perform the following actions:

  1. **Verbally** Sound Alarm in the immediate area and via RF Radio to on-site personnel and the UPC OCC.

  2. **Activate Emergency Shutdown Appendix Z Instructions.**

  3. **Evacuate** from the spill area to a safe distance away from the cryogenic liquid and vapor area and allow liquid to vaporize.

Specific

B. **Facility/Area Supervisor,** immediately initiate safing/securing emergency steps. If the EOC has been formed, access to the facility/equipment must be approved by the EOC Director and the Base Fire Chief assigned to the incident.

  1. If an Operation **was being** performed per a UPC Procedure, direct personnel to secure the facility per the **applicable Appendix Z Instructions**.

  2. If an **Operation was not** being performed, UPC Engineering will have to provide the necessary procedural steps to be performed by the UPC ERT personnel. All suggested procedures will have to be approved by UPC Safety, UPC Quality/Environmental Specialist, Operations Manager, and 30 SW/SES personnel, in writing or verbally, prior to performance.

  3. Upon access to incident location, provide status of facility/equipment and actions taken to the UPC OCC and/or EOC Director. Do not perform any additional actions unless procedures have been approved by UPC Engineering, Operations, Safety, Quality/ Environmental.

C. **UPC OCC Personnel,** maintain a log of all events and communications, and coordinate with the appropriate VAFB agencies as specified in paragraph 2.4.1 of this Plan. Continually provide updates to the UPC Program Manager and Operations Manager.

D. **UPC Operations Manager,** will report to the Facility Assembly Area or EOC Assembly Point to approve and direct incident response actions in coordination with **Facility/Area** Supervisor and EOC Team representatives.

E. **UPC Safety**, will report to the appropriate Assembly Area and coordinate all safety issues with Facility/Area Supervisor, UPC EOC Representative and Government Safety Representatives.

F. In concert with Environmental Management Flight, Environmental Specialist will assess the environment impact of the emergency and initiate coordinated efforts with VAFB EOC.

8.5 POST-EMERGENCY ACTION

A. **UPC Operations Control Center**

1. Prepare the summary of events from the OCC EOC Log (UPC-P-018), and present to the UPC Operations Manager for preparation of the Incident or EOC Exercise Report.

2. Notify appropriate Base Support Agencies, UPC Program Manager and Operations Manager, that the Incident/EOC Exercise is over.

B. **UPC Operations Manager**

1. Coordinate with Facility/Area Supervisor, UPC Safety, Quality/Environmental Specialist and UPC Engineering on actions required to perform clean-up and containerizing of spill residue, including re-entry procedures into affected facilities. Define conditions for returning to normal work activities at the facility.

2. Prepare the report on the Incident/EOC Exercise Summary and publish the report within five (5) working days after the event. Reports should be sent to 30 LSS/LGLF Program Officer for the Aerospace Support Services Contract.

8.6 POST-EMERGENCY EVALUATION

The Operations Manager will convene a meeting to critique the Incident/EOC Exercise with the affected Facility/Area Supervisor, Safety, Quality/Environmental Specialist, and OCC representatives. The purpose of the meeting is to identify lessons learned from the Incident/EOC Exercise and develop the following information to be shared with all UPC personnel:

A. What additional personnel support may be needed for similar incidents in the future.

B. Identify any additional equipment or materials that are needed.

C. Any additional coordination needed to accelerate the notification, response and clean-up activities.

D. Identify any additional training requirements and when the additional training will be conducted.

E. Draft a report, as necessary, detailing the incident/exercise and distribute to affected organizations and personnel.

9.0 FLOODING

9.1 OBJECTIVE

In the event of significant flooding due to adverse weather conditions or the failure of Bradbury Dam at Lake Cachuma it may be necessary for personnel who are on-site to prepare for evacuation, if evacuation is possible, or to stay in place until emergency assistance can be provided.

9.2 EMERGENCY ASSESSMENT

Historically, flooding has occurred on South Base due to the damming affect of the 13th Street bridge and other low lying areas surrounding the South Base entrance. Areas as far as the Protective Equipment Maintenance Operations, Building 871, have been affected and should be considered susceptible to flooding when heavy rains occur. In the event of failure of Bradbury Dam, all UPC personnel must adhere to the following:

WARNING

ALL LOW LYING AREAS WILL BE INVOLVED AND PERSONNEL SHOULD IMMEDIATELY EVACUATE ALL SOUTH BASE FACILITIES AND SEEK THE HIGHEST GROUND POSSIBLE. IT IS EQUALLY IMPORTANT FOR ALL PERSONNEL TO EVACUATE AND STAY TOGETHER SO THAT PERSONNEL CAN BE READILY ACCOUNTED FOR. DEPENDING ON THE AMOUNT OF WARNING, THE FIRST WAVE OF WATER RELEASE FROM BRADBURY DAM IS EXPECTED TO STRIKE VANDENBERG AIR FORCE BASE WITHIN 30 MINUTES OF THE FAILURE. PERSONNEL SHOULD NOT USE ANY LOW LYING AREAS FOR EVACUATION. DAMAGE TO FACILITIES, EQUIPMENT AND PROPERTY WILL BE EXTENSIVE!

9.3 EMERGENCY NOTIFICATION

Notification for evacuation will be provided by the Vandenberg Air Force Security Police or the UPC Operations Control Center. Evacuation instructions will be provided by the OCC working in concert with UPC Safety. Depending on the amount of advanced notice which is provided, a decision will be made on a facility-by-facility basis as to the extent of evacuation. It may be necessary to stay in place rather than evacuate.

9.4 EMERGENCY ACTION

It is imperative that all personnel who have been ordered to evacuate do so in an expeditious manner. Personnel should do the following:

A. If performing an operation, safe the operation in accordance with Appendix Z, if time permits.

B. Secure as much equipment as possible.

C. If a SCAPE Van is available, load any survival supplies into the unit and prepare to leave the facility.

D. Drive all personnel to high ground based upon instructions received from the Security Police or UPC Operations Control Center.

E. Report your status to the Operations Control Center as soon as it is safe to do so.

F. Keep all portable radios with you, conserving battery power and limiting radio traffic.

G. Stay at your evacuation location until the emergency is over or until you are directed to move elsewhere.

H. Lead Supervisors will account for all personnel under their charge and report the medical status of each person.

9.5 POST-EMERGENCY ACTION

As soon as the declared emergency is over and all personnel have been accounted for and when it is declared safe to re-enter UPC operated facilities; all facilities and processes must be checked for damage or failure. Once this is accomplished, an assessment report of the findings will be forwarded to the Operations Manager. Additional reporting may be requested by the Air Force.

9.6 POST-EMERGENCY EVALUATION

The Operations Manager will convene a meeting to critique the Incident/EOC Exercise with the affected Facility/Area Supervisor, Safety, Quality/Environmental Specialist, and OCC representatives. The purpose of the meeting is to identify lessons learned from the Incident/EOC Exercise and develop the following information to be shared with all UPC personnel:

A. What additional personnel support may be needed for similar incidents in the future.

B. Identify any additional equipment or materials that are needed.

C. Any additional coordination needed to accelerate the notification response, and cleanup activities.

D. Identify any additional training requirements and when the additional training will be conducted.

E. Draft a report, as necessary, detailing the incident/exercise and distribute to affected organizations and personnel.

10.0 LIGHTNING ACTIVITY

10.1 OBJECTIVE

Due to the possibility of lightning in the area of Vandenberg Air Force Base, all UPC operating areas must be prepared to safely stop hazardous operations until the threat of electrical activity has subsided. This cessation of activity must be accomplished in advance of any significant electrical event.

10.2 EMERGENCY ASSESSMENT

During normal operations, the Base Weather Detachment will provide operational support. In the case of lightning activity, it is expected that an early warning of at least **twenty-five** nautical miles, and in no case less than **ten** nautical miles, will be provided in order to safely stop the operation. It is required that hazardous operations will not commence, and those in progress will terminate, when electrical storms, lightning or severe weather is predicted within **ten** nautical miles of the base.

10.3 EMERGENCY NOTIFICATION

The notification of an impending electrical storm within the designated safety parameters will be received from the Base Weather Detachment and communicated through the UPC OCC. Once the affected UPC operation has been notified, actions must commence to safe any operation in progress.

10.4 EMERGENCY ACTION

Safe the operation as quickly as possible in accordance with Appendix Z of the emergency procedure. Outside operations will be stopped when thunderstorm, with lighting are within 5 nautical miles of operations. In a lighting warning, personnel will evacuate the fuel storage site beyond the PTR of 1800 feet to Ox change house. They will not be able to enter the site under the warning unless there is an alarm or other Emergency Reponses. **Do not use the telephone unless it is absolutely necessary**. Under most circumstances, the OCC should make the first notification of an impending electrical storm. However, if a storm is noticed by field operations personnel, do not wait for official notification to begin safing operations.

10.5 POST-EMERGENCY ACTION

If any problems are encountered in safing the operation a “lessons learned” shall be prepared.

10.6 POST-EMERGENCY EVALUATION

The Operations Manager will convene a meeting to critique the Incident/EOC Exercise with the affected Facility/Area Supervisor, Safety, Quality/Environmental Specialist, and OCC representatives. The purpose of the meeting is to identify lessons learned from the Incident/EOC Exercise and develop the following information to be shared with all UPC personnel:

A. What additional personnel support may be needed for similar incidents in the future.

B. Identify any additional equipment or materials that are needed.

C. Any additional coordination needed to accelerate the notification, response and clean-up activities.

D. Identify any additional training requirements and when the additional training will be conducted.

E. Draft a report, as necessary, detailing the incident/exercise and distribute to affected organizations and personnel.

11.0 LAUNCH AND AIRCRAFT FAILURE

11.1 OBJECTIVE

In the unlikely event of a launch or aircraft failure it is incumbent upon UPC Management and Operations personnel to safely evacuate all operating areas affected by the failure with special emphasis focused on the Hypergolic Storage Facilities.

11.2 EMERGENCY ASSESSMENT

The primary action is to apprise the OCC that a launch or aircraft failure has occurred. This notification should be made as quickly as possible and without conducting a damage assessment. Notify the OCC that a damage assessment will follow momentarily. The next phase of the assessment should concentrate on actual or suspected damage to the HSF facilities. If major damage has occurred, the site or sites are to be immediately evacuated until such time as a EOC entry team can be formed. If any major fires are in progress, follow the procedures for a fire. If no damage can be seen from a visual inspection; the HSF operators should perform a PVC survey to insure no leaks are present. If a leak or leaks are detected follow the procedure for a leak/released.

11.3 EMERGENCY NOTIFICATION

In the case of a launch or aircraft failure the notification to the OCC is made before an assessment is made. This notification will start the process of forming a EOC response strategy.

11.4 EMERGENCY ACTION

If the damage consists of a small leak or leaks it is expected that the repairs will be affected by UPC personnel. If the assessment indicates a larger leak, EOC response action will be developed in concert with UPC Engineering, Operations, Safety and Quality/Environmental. UPC personnel must decide on the side of safety when responding to emergencies of an unknown dimension.

11.5 POST-EMERGENCY ACTION

UPC will re-establish, to the maximum extent possible, operational readiness of all affected areas as soon as possible following the emergency. Any regulatory reporting and notification will be made by the Base with the assistance of appropriate UPC personnel. The UPC PSM investigation team will be convened to work in concert with USAF investigating personnel.

11.6 POST-EMERGENCY EVALUATION

The Operations Manager will convene a meeting to critique the Incident/EOC Exercise with the affected Facility/Area Supervisor, Safety, Quality/Environmental Specialist, and OCC representatives. The purpose of the meeting is to identify lessons learned from the Incident/EOC Exercise and develop the following information to be shared with all UPC personnel:

A. What additional personnel support may be needed for similar incidents in the future.

B. Identify any additional equipment or materials that are needed.

C. Any additional coordination needed to accelerate the notification, response and clean-up activities.

D. Identify any additional training requirements and when the additional training will be conducted.

E. Draft a report, as necessary, detailing the incident/exercise and distribute to affected organizations and personnel.

12.0 SEISMIC ACTIVITY

12.1 OBJECTIVE

Earthquakes and the threat of earthquakes are a fact of life in geologically active area such as Vandenberg Air Force Base. Because seismic activities occur with little to no prior warning, each person must initially react to the emergency for themselves. The course of action taken by each person is to minimize the possibility of injury to themselves and to quickly safe any operation in progress in accordance with UPC emergency procedures.

12.2 EMERGENCY ASSESSMENT

Immediately after a seismic event personnel should take a quick look for any obvious damage to structures, support equipment and injury to personnel. At the HSF, initial assessment should be made from a distance that does not place a person in harm's way should an aftershock occur. If no obvious damage is found it is required that a PVD inspection of the area be conducted to search for leaks or other anomalies. Leaks, no matter how minor, require the use of an approved SCAPE operation to affect any repairs. In all other areas, use normal inspection techniques to discover any damage.

12.3 EMERGENCY NOTIFICATION

All UPC operational sites will notify the OCC and report their status, condition of personnel, and any damage sustained to operational areas or equipment. This notification must be made even if there is no damage to report.

12.4 EMERGENCY ACTION

If an operation is in progress during a seismic event it will be secured as soon as possible in accordance with Appendix Z of the operational procedure. During the seismic event, all personnel shall proceed as follows:

A. If inside a building remain inside unless injury is imminent.

B. Personnel in unprotected areas go immediately to a location against main structural supports, under a work bench, doorway in a load bearing wall, table or other area capable of providing protection from falling objects.

C. Get as far as reasonably possible from rotating machinery, sources of acids or toxic materials, electrical J-boxes, or glass windows.

D. Move out from under ducts, piping, conduits, cable trays or light fixtures.

E. Remain in protected positions until earth movement has subsided.

F. When all the earth movement stops, this is the appropriate time to perform the initial assessment phase.

12.5 POST-EMERGENCY ACTION

Seismic evaluations of the Hypergolic Storage Tanks and associated piping, Helium facility and storage vessels, and PEMO vessels and piping must be initiated as soon as possible after the emergency has been declared static.

Organize an inspection team of knowledgeable facility technicians, along with UPC Quality/ Environmental and Safety Representatives, to inspect each referenced facility. The inspections should encompass obvious damage to piping, vessel penetrations, and associated mountings.

Document findings for UPC Engineering disposition.

Only those facilities which have been determined to be operationally sound will be opened for normal occupancy. UPC Engineering will determine, on a case-by-case basis, what additional testing and evaluations may be necessary for all affected areas. Under no circumstances are areas to be made operational ready without concurrence by UPC Engineering and Safety.

For those areas determined to be operationally sound based upon the concurrence noted above, perform the following:

A. Release support elements

B. Open control areas

C. Re-enter structures

12.6 POST-EMERGENCY EVALUATION

The Operations Manager will convene a meeting to critique the Incident/EOC Exercise with the affected Facility/Area Supervisor, Safety, Quality/Environmental Specialist, and OCC representatives. The purpose of the meeting is to identify lessons learned from the Incident/EOC Exercise and develop the following information to be shared with all UPC personnel:

A. What additional personnel support may be needed for similar incidents in the future.

B. Identify any additional equipment or materials that are needed.

C. Any additional coordination needed to accelerate the notification, response and clean-up activities.

D. Identify any additional training requirements and when the additional training will be conducted.

E. Draft a report, as necessary, detailing the incident/exercise and distribute to affected organizations and personnel.

13.0 BOMB THREAT

13.1 OBJECTIVE

It is very unlikely that you will ever receive a bomb threat while working at VAFB. However, due to the extreme sensitivity of our work, the commodity which we manage, and the critical assets we are responsible for, we must be prepared to provide a coordinated response to such an emergency, should one occur. The possibility of a threat to our resources is greater during declared acts of war, military police action, and political and student unrest. In most cases a bomb threat is never made in person. Usually you will receive notice of a bomb threat from a caller or it will be reported to you by law enforcement or the local new media.

13.2 EMERGENCY ASSESSMENT

It is very important to keep the person phoning a bomb threat on the telephone as long as possible. Be particularly alert to caller's voice, gender, voice inflection, background noise and any other information which may be useful to law enforcement. Once you are certain of the caller's intent, attempt to alert another person and have them initiate contact with the Base Law Enforcement officials, using another telephone line or other means of communication.

13.3 EMERGENCY NOTIFICATION

Once you have obtained the maximum amount of information from the caller, immediately contact the following personnel:

A. Co-Worker, if possible

B. Facility and Area Supervisor

C. Operations Control Center

D. USAF Security Police

13.4 EMERGENCY ACTION

Bomb Threat Recipient

A. Stay calm, **do not hang up** on the caller. Keep the person on the telephone as long as possible.

B. Without alerting the caller, notify a fellow employee to contact the base operator to initiate tracing action.

C. Try to obtain the following information and note the time of day:

1. Time bomb is set for detonation
2. Type of bomb
3. Location
4. Why was it placed in that area
5. Identity of caller or organization represented
6. Any other information the caller will give (recent problems with Government, family, United Paradyne, friends, political statement, etc.)
7. Ask caller to repeat message so that it is fully understood
8. Repeat the message to caller
9. Do not hang up the phone even if the caller terminates call
10. Background noises
11. Unusual speech pattern, gender, voice inflection

13.4 EMERGENCY ACTION (CONT.)

D. When the call has been terminated, immediately contact the facility/area supervisor. **Remember under no circumstance should you hang up the phone**. Attempt to keep the line open.

E. Contact UPC Operations Control Center and advise them of the threat and all relevant information.

F. **Contact the VAFB Security Police and stand ready to provide all information you have obtained and answer all their questions fully**.

G. If bomb is located in the area where you received the call immediately evacuate all personnel from the area and assemble at an authorized staging area.

Facility/Area Supervisor

A. Evaluate situation and information received.

B. Ensure that the person who received the call has obtained as much information as possible and recorded the information for subsequent transmittal to the appropriate law enforcement organization.

C. **Notify VAFB Security at 911**.

D. Initiate safing/securing emergency actions as appropriate. If in an operational phase, secure per Appendix Z of the procedure.

E. Ensure personnel are evacuated to authorized assembly areas.

F. Report status to the Operations Manager.

1. Call sign and Name
2. Nature of Call and Location
3. Personnel Injured
4. Status of Equipment and Facilities
5. Actions Taken

G. Ensure headcount has been conducted at assembly area.

H. Notify Operations Control Center of headcount status.

I. Maintain chronological log of events.

J. Complete incident report.

K. Complete post-emergency instructions.

13.5 POST-EMERGENCY ACTION

A detailed report of all events and time sequences will need to be completed by both the receiver of the bomb threat and Facility/Area Supervisor in charge. Additionally, UPC Bomb Threat Report will need to be completed and submitted to UPC Security.

Obtain permission from VAFB Security Police to release all support elements and to open any controlled areas for normal business.

13.6 POST-EMERGENCY EVALUATION

The UPC Operations Manager will convene a meeting to critique the Incident/EOC Exercise with the affected Facility/Area Supervisor, Safety, Quality/Environmental Specialist, Engineering and the OCC Representatives. The purpose of the meeting is to identify lessons learned and develop the following information:

A. What additional personnel support may be needed for similar incidents in the future.

B. Identify any additional equipment or materials that are needed.

C. Any additional coordination needed to accelerate the notification and response.

D. Identify any additional training requirements and determine when the additional training will be provided.

E. Draft a report, as necessary, detailing the incident/exercise and distribute to affected organizations and personnel.

14.0 SECURITY BREACH

14.1 OBJECTIVE

Most operations performed by United Paradyne Corporation are viewed as essential to mission support and the National Defense efforts of the United States Government. It is crucial that our work environment is not interrupted by unauthorized access to facilities, the unwanted disclosure of the processes we perform or the loss of valuable company and Government resources to theft, misappropriation, or unauthorized use. Additionally, disclosure of classified, sensitive or proprietary information can seriously damage the corporation's competitiveness and reputation. Therefore, it is incumbent on each employee to ensure that all resources are adequately protected against loss.

14.2 EMERGENCY ASSESSMENT

The protection of proprietary and Government information and the physical facilities managed for the United States Government must always receive the highest level of attention by UPC personnel. While most of our operations are performed in what is considered a "protected environment", specifically a U.S. military installation, the potential for loss is real and occurs far too frequently. Listed below are actions you should take if you suspect a loss or potential loss of information, resources or intrusion to one of the facilities:

A. Unauthorized Disclosure of Proprietary or Government Information

Immediately determine, if possible, what information may have been compromised, the extent of the suspected compromise, the person or persons having access, the date and time frame of the incident, the method and means of the compromise, and the reasons why the compromise occurred.

B. Theft, Misappropriation or Unauthorized Use of Proprietary or Government Resources

Immediately determine what has been lost including make, model, serial number and property control number, who may have been involved, the time frame for the incident, when it was discovered lost, the method employed to gain entry, and the possible reasons why it has been lost.

C. Physical Breach of UPC Controlled Facilities

In concert with appropriate investigating agencies, immediately determine the method of entry, area of compromise, determine if a crime has been committed, and if the person or persons are still on the premises. If personnel are on site, maintain visual contact until authorized law enforcement officials arrive.

14.3 EMERGENCY NOTIFICATION

For all instances cited above immediately contact the following agencies and personnel:

A. Unauthorized Disclosure of Proprietary or Government Information

Immediately contact the UPC Facility Security Officer (FSO) Operations Control Center and your immediate Facility/Area Supervisor. Subsequent notifications may be required to VAFB Law Enforcement personnel, Federal Bureau of Investigation, and the Defense Investigative Service. The follow-up notifications to the agencies listed will generally be performed by the UPC Facility Security Officer.

B. Theft, Misappropriation, or Unauthorized Use of Proprietary or Government Resources

Immediately contact the UPC Facility Security Officer, Operations Control Center and your Facility/Area Supervisor. Additionally, contact the VAFB Security Police and standby to report all necessary information.

C. Physical Breach of UPC Controlled Facilities

If the person is present on the property and it is determined that they are not authorized, immediately contact the VAFB Security Police and advise them of the situation. Keep the personnel under close observation and attempt to determine the purpose of the intrusion. Contact the UPC Facility Security Officer as soon as practical and advise of the situation and present status. Also contact your Facility/Area Supervisor for any subsequent coordination with Security Police and Law Enforcement.

14.4 EMERGENCY ACTION

It is impossible to accurately determine the level of response that will be required on the part of UPC personnel when responding to situations that involve a suspected compromise of security or the loss of valuable resources. As a general rule UPC personnel should do the following:

A. Unauthorized Disclosure of Proprietary or Government Information

1. Upon discovery, immediately contact the UPC Facility Security Officer and your immediate Facility/Area Supervisor.

2. Determine the level of compromise as listed in Section II and provide this information to the FSO and other law enforcement agencies as deemed appropriate by the FSO.

3. Protect the area of compromise from all unauthorized persons.

4. Do not disturb any physical evidence that may be in the area of compromise.

5. Law Enforcement personnel will advise UPC when the area can be returned for normal business.

14.4 EMERGENCY ACTION (CONT.)

B. Theft, Misappropriation, or Unauthorized Use of Proprietary or Government Resources

1. Determine the level of compromise as listed in Section II.
2. Immediately contact the UPC FSO and VAFB Law Enforcement.
3. Report all relevant information pertaining to the theft or misappropriation.
4. Secure the crime scene if appropriate.
5. Protect any physical evidence that may be associated with the crime scene or the crime itself.
6. Standby to assist VAFB and local law enforcement as appropriate.
7. Notify the UPC Property Custodian of the theft or misappropriation.

C. Physical Breach of UPC Controlled Facilities

1. Determine if a physical breach has occurred.
2. Search property for any unauthorized personnel.
3. If unauthorized personnel are discovered, detain personnel for VAFB Law Enforcement.
4. Report security breach and apprehension to UPC FSO and Law Enforcement.
5. If no personnel are discovered, report breach to FSO and provide information as listed in Section II.
6. Document for FSO your findings and observations.
7. Make yourself available for follow-up investigations by Law Enforcement.

14.5 POST-EMERGENCY ACTION

Due to the nature and complexity of a security breach, extensive investigations by DOD Law Enforcement, FBI and UPC may be warranted. It is a condition of employment that all UPC personnel cooperate fully with authorized investigative resources in the performance of their duties.

> *NOTE*
>
> *During emergency conditions, Base Emergency Response Personnel (Fire, Medical, Security Police, Law Enforcement) may need to enter your facility unannounced. In an effort to maintain control, particularly in USAF Restricted Areas, do the following:*

14.5 POST-EMERGENCY ACTION (CONT.)

A. Permit entry of all emergency personnel into the hazard area unless it can be demonstrated that they do not have the proper personal protective equipment for such entry. In that event, immediately contact the incident commander and advise accordingly.

B. Attempt to maintain an accurate account of the number of personnel who have entered an emergency area.

C. After the emergency, and when it is safe to do so, conduct a sweep of the area to ensure that all personnel are safely out.

D. Keep the Operations Control Center and UPC Safety informed of all response actions prior to committing UP personnel and resources.

14.6 POST-EMERGENCY EVALUATION

The Operations Manager will convene a meeting to critique the Incident/EOC Exercise with the affected Facility/Area Supervisor, Safety, Quality/Environmental Specialist, and OCC representatives. The purpose of the meeting is to identify lessons learned from the Incident/EOC Exercise and develop the following information to be shared with all UPC personnel:

A. What additional personnel support may be needed for similar incidents in the future.

B. Identify any additional equipment or materials that are needed.

C. Any additional coordination needed to accelerate the notification, response and clean-up activities.

D. Identify any additional training requirements and when the additional training will be conducted.

E. Draft a report, as necessary, detailing the incident/exercise and distribute to affected organizations and personnel.

15.0 MEDICAL EMERGENCY

15.1 OBJECTIVE

UPC believes that all injuries and illnesses are preventable. As such, UPC will do everything possible to eliminate the unsafe acts and conditions which contribute to accidents. However, should an accident occur, it is essential that prompt and professional medical service is provided to any injured person.

15.2 EMERGENCY ASSESSMENT

When an injury or illness occurs, it is imperative that a proper assessment is made to determine the extent and severity of the injury. Often this is one of the most critical phases of emergency first aid. Once you have determined that an injury has occurred you must do the following.

15.3 EMERGENCY NOTIFICATION

A. If the injury involves simple first aid no notification is necessary except for the injured employee to make notification to the facility/area supervisor and UPC Safety.

B. If the injury goes beyond immediate first aid, telephone **911** and advise them of the employee's status and condition.

C. Contact the Operations Control Center and advise on the actions you have taken and what emergency assistance you will need.

15.4 EMERGENCY ACTION

Person Making Discovery

A. Sound alarm and make verbal notification in affected area.

B. If a person is in need of rescue and they are in a suspected oxygen deficient atmosphere, or confined space, obtain oxygen levels prior to entering environment or don SCBA and appropriate personal protective equipment/clothing.

C. Do not remove victim if there is no threat to their safety.

D. Contact the Area Hospital at **911** for emergency life support services.

E. If qualified, immediately render emergency first aid to your level of training and understanding. If you are not qualified in emergency first aid, attempt to locate someone who is and make notification to OCC. ***Due to possible exposure to bloodborne pathogens, universal precautions must be used by all personnel rendering first aid services. When providing first aid, you must assume that the patient may have HIV antibodies and protect yourself first!***

F. Do not leave victim until medical assistance has arrived and you have been released.

15.4 EMERGENCY ACTION (CONT.)

G. If victim is in a contaminated area (cryogenic, hypergolic or toxic) do the following after you have donned the appropriate PPE:

  1. Remove the victim from the contaminated area.
  2. Decontaminate the protective clothing if it has been exposed to hazardous materials.
  3. If the victim is in SCAPE, remove suit from victim at once if injury is caused by liquid breathing air.
  4. Wash down the affected area for at least 15 minutes with copious amounts of fresh water.
  5. If the victim is not suffering a cryogenic burn, open SCAPE suit to provide ventilation and eliminate anxiety.

H. Evacuate non-essential personnel from accident area.

I. Report to the facility/area supervisor the following information:

  1. Call sign and Name
  2. Nature of Call and Location
  3. Personnel Injured
  4. Status of Equipment and Facilities
  5. Actions Taken

Facility/Area Supervisor

A. Evaluate situation and information which has been provided.

B. Ensure that appropriate emergency first aid has been provided.

C. Evaluate need to initiate safing/securing emergency actions.

D. If the situation involves an operational phase, direct engineer to secure operation per Appendix Z of the procedure.

E. Independently verify that Fire/Rescue/Emergency Medical Support services are enroute to the accident area, contact emergency operator at for verification.

F. Coordinate with UPC safety personnel on the accident investigation and reporting requirements.

15.4 EMERGENCY ACTION (CONT.)

Facility/Area Supervisor (Cont.)

G. Report status to the Operations Manager:

1. Nature and Location of accident
2. Type of injury involved
3. Description of incident
4. Number of personnel involved
5. Status of personnel, equipment, and facility
6. Actions taken prior to call
7. Additional support requirements

15.5 POST-EMERGENCY ACTION

A. Check with Area Hospital on status of victim.

B. Notify immediate family as appropriate.

C. Due to possible contamination and the exposure to bloodborne pathogens, all dressings and blood or fluid contaminated materials must be disposed of as biohazard waste through the Area Hospital.

D. All contaminated areas where bodily fluids may have come into contact with the work environment must be sanitized and disinfected.

E. Complete incident and accident reports and submit to UPC Safety.

F. Complete post-emergency instructions.

15.6 POST-EMERGENCY EVALUATION

The UPC Operations Manager will convene a meeting to critique the Incident/EOC Exercise with the affected Facility/Area Supervisor, Safety, Quality/Environmental Specialist, Engineering and the OCC Representatives. The purpose of the meeting is to identify lessons learned and develop the following information:

A. What additional personnel support may be needed for similar incidents in the future.

B. Identify any additional equipment or materials that are needed.

C. Any additional coordination needed to accelerate the notification and response.

D. Identify any additional training requirements and determine when the additional training will be provided.

E. Draft a report, as necessary, detailing the incident/exercise and distribute to affected organizations and personnel.

16.0 UPC EMERGENCY OPERATIONS CENTER COMPREHENSIVE EMERGENCY RESPONSE PLAN 10-2

16.1 OBJECTIVE

This emergency response plan outlines a general course of emergency action to be initiated by United Paradyne Corporation, and the personnel, equipment and resource preparations necessary to provide Unconventional Propellant Support to the Emergency Operation Center (EOC) at Vandenberg Air Force Base.

16.2 EMERGENCY ASSESSMENT

The Vandenberg Air Force Base Command Post (30 SW/CP) serves as the focal point for base response to disasters, keeps notification rosters of Emergency Operations Center (EOC) personnel, and sets up a system to alert unit and contractor control centers of necessary response actions.

The Base Command Post (30 SW/CP) will be the single point of contact for notification of Primary/Standby Personnel AFTER NORMAL DUTY HOURS. The Base Command Post will notify in sequence, the personnel listed on the Emergency Call-Out Roster until contact is made.

UPC will provide technical evaluation, SCAPE suits and personnel to support the Vandenberg Air Force Base contingency operations and exercises, as required.

16.3 EMERGENCY NOTIFICATION

During normal duty hours this plan will be initiated by the UPC Operations Control Center (OCC) after contact by the Crash Net, and used as a guide for emergencies or accidents/incidents involving base facilities, equipment or off-base incidents as requested by the Base Command Post (30 SW/CP). The Missile Maintenance Operations Center (30 LSS/LGLOJ), previously known as Job Control, will be notified when activities involve the Aerospace Support Services Contractor.

16.4 EMERGENCY ACTION

A. <u>Response During Normal Duty Hours</u>

1. **UPC OPERATIONS CONTROL CENTER (OCC),** Bldg 7525 (606-7451), upon notification of an accident/incident from the Base Command Post (30 SW/CP), via the Crash Net Phone System, or appropriate agency, will immediately initiate a chronological log of all transmissions, actions, updates, and any pertinent information (phone calls, messages, anomalies, etc.) on the OCC EOC Log, UPC-P-018 (Figure 15). Messages received via the Crash Net or from the Base Command Post will be in one of the two categories as listed below.

   a. Actual emergency messages - 30 SW Instruction 10-105.

   b. Exercise messages - 30 SW Instruction 10-105.

   Refer to the appropriate 30 SW Instruction 20-105 attachment and notify the UPC/EOC Representative as shown in the Emergency Call-Out Roster of this document (Recall roster is an example, updated rosters are distributed to key personnel).

A. Response During Normal Duty Hours (Cont.)

2. **UPC EMERGENCY OPERATIONS CENTER (UPC/EOC) REPRESENTATIVE:** Will report to the Primary Assembly Point or the Alternate Assembly Point and sign in with the Disaster Preparedness Representative. The UPC/EOC Representative will respond to the requests of the Incident Commander and advise the Incident Commander as required. The UPC EOC Representative will relay all updated information to the UPC OCC Monitor. Under the Aerospace Support Services Contract, UPC must respond within 60 minutes to the EOC assembly area.

NOTE: On Base EOC Assembly Points are:

• Primary	11165 CES Readiness Flight Room
• Alternate	Bldg. 16158 Parking Lot
• For Off Base Incidents	Assemble at the Base Command Post (30 SW/CP)

The Primary Assembly Point is located at Building 11165 CES Readiness Flight Room on the corner of New Mexico and Midway. The Alternate Assembly Point is located off Korina Street, in the old commissary parking lot, Building 16158. The Base Command Post is located on the Second Floor of Building 10577 Rm. B-204, on Nebraska Avenue.

UPC DISASTER SUPPORT TEAM MEMBERS: Will report to the UPC Operations Control Center to provide tech support to the UPC EOC representative, and the EOC Operations Team in the field.

3. **The Emergency Operation Center/Support Team:** Will consist of the following:

OPERATIONS TEAM

EOC Response Representative
Task Coordinator
Team Chief
EOC SCAPE Response Team
    Primary (2)
    Backup (2)
Life Support Technicians (2)

SUPPORT TEAM

Operations Control Center
Safety Representative
Engineering Representative
Environmental Representative

A. Response During Normal Duty Hours (Cont.)

4. **PEMO PERSONNEL** (Shop 605-1085): Will be notified during call-up at the PEMO shop during duty hours by the UPC OCC, or at home after duty hours by the UPC EOC representative to prepare equipment and personnel for dispatch according to the established call out roster.

> *NOTE*
>
> *Building 875 (Phone 605-5000) will be used by the EOC Operations Team if Building 871 is not accessible for use.*
>
> *A Back-Up Response Vehicle is located at Bldg. 875. This vehicle is equipped with PEMO equipment as listed in Appendix F. The keys for this vehicle are located in the Bldg. 875 Key Control Box to which the UPC/EOC Representatives have access.*
>
> *The equipment in the Back-up Vehicle will be inspected and serviced on Mondays, Wednesdays and Fridays, or the day after if one falls on a holiday.*

5. **DISASTER CONTROL OPERATIONS TEAM MEMBERS:** Will report to Bldg. 871 and contact the UPC Operations Control Center to await further direction. Disaster Control Support Team Members will report to the UPC Operations Control Center Bldg. 7525 to provide technical support to the EOC Operations Team in the field.

6. **UPC DISASTER CONTROL OPERATIONS TEAM MEMBERS:** Will assemble at Building 871 (PEMO) with required accessories for contingency operations, etc. Four (4) members will don thermal underwear, and all personnel will stand by for instructions to disperse.

   a. UPC Disaster Control Operations Team Members will be in contact with the UPC Control Center by radio or telephone 606-7451 and will have the information relayed to them from the UPC/EOC Representative on where to report and by which route. EOC Representative will also be equipped with a portable telephone to enhance communication.

   b. Upon notification to proceed, team members will load up in the Support or SCAPE Van for transportation to the Designated Assembly Point by the route provided by the UPC/EOC Representative.

7. **RESPONSE VEHICLE - LOCATED AT BUILDING 871:** Will proceed with the Operations Team Members by the route provided by the UPC/EOC Representative to the Designated Assembly Point. After arriving on scene, position the Response Vehicle as directed by the Incident Commander or Designated Representative.

8. **UPC DISASTER CONTROL TEAM MEMBERS:** Will work under the direction of the EOC Director or Incident Commander and will advise the EOC Director as required.

B. Response During Other Than Normal Duty Hours

1. **UPC/EOC REPRESENTATIVE:** Receiving the call from the Base Command Post (30 SW/CP) will ask for the following information:

   a. Location of operation/exercise

   b. Any other pertinent information

   c. Initiate Chronological Log

2. **UPC/EOC REPRESENTATIVE:** Will initiate the technician RECALL ROSTER, after noting the above information. The first technician contacted will be provided information received from Base Command Post (30 SW/CP).

3. **AFTER HOURS REPORTING:** The UPC/EOC representative will notify the 30 SW/CP when the operations section has been staffed. Upon the arrival of the UPC Operations Control Center, the OCC will get in contact with the Command Post and EOC Representative and begin coordinating support activities.

   When the Operations Control Center arrives, (if the monitor wasn't the first to arrive), this individual shall be briefed on all activities that have happened, by the UPC, EOC Representative, and assume the control of the Running Time Log, with updates from the UPC EOC Representative.

4. **PEMO TECHNICIANS REPORTING:** To Building 871, will be aware of the equipment requirements and shall immediately commence check-off of the UPC Contingency Checklist (Appendix C of this document), to assure that equipment requirements received from Base Command Post are available.

5. **PEMO TECHNICIANS:** Will enter on the Checklist the following:

   a. Types and Quantities of equipment.

   b. Names of individuals to be supported, if available.

   c. Vehicle Checklist items.

   If problems are found with the Primary Response Vehicle, other available vehicles shall be used. If none are available, the Mobile Maintenance Unit, Transportation Squadron, shall be notified for a Priority Response by calling the Command Post at 606-9961.

6. **PEMO TECHNICIANS:** Will refer to Section 1 and 2 of the Checklist and commence the following:

   a. Gathering and preparation of required equipment,

   b. Filling ECU's as required.

   c. Visually checking all suits on the "Ready Rack".

   d. Checking the quantity of liquid air and Oxygen content percentage in the 160L Dewar to be used at the site, by using the Beckman analyzer.

   e. Assist Technicians with donning of Category I Ensembles.

B. Response During Other Than Normal Duty Hours (Cont.)

7. **UPC OPERATIONS CONTROL CENTER:** Will advise personnel of an actual or simulated emergency situation.

8. **RESPONSE VEHICLE DRIVER:** Upon completion of equipment preparation or when the Checklist is complete, will stand by, with the Team Members, until notified to proceed to the Assembly Point by the route provided by the UPC EOC Representative. After arriving at the Assembly Point, the Response Vehicle will be positioned as directed by the EOC Director or Incident Commander or. The team shall then be under the EOC Director direction and will advise the EOC Director as required.

   a. Minimum PEMO personnel to accompany the Response Vehicle to the Assembly Point will be two (2) technicians.

   b. Another PEMO Technician will remain at Building 871.

   c. At no time will the transporting of SCAPE personnel in SCAPE vans exceed 15 MPH speed limit. The cargo net will be secured to the back entrance to the SCAPE van prior to transporting passengers.

16.5 POST- EMERGENCY ACTIONS

Once the emergency has been abated or UPC personnel and resources have been released by the Base Emergency Operations Center it is important to immediately begin preparations for the next exercise scenario or actual event. All materials and resources which have been expended will need to be replaced and properly located on each vehicle. All SCAPE and SCBA will be returned to PEMO and exchanged for operational units.

All required regulatory and contractual reporting will need to be prepared and submitted to the Operations Manager and Program Manager for approval. All reports that are time sensitive will need to be prepared and submitted per contractual direction.

16.6 POST-EMERGENCY EVALUATION

The UPC Operations Manager will convene a meeting to critique the Incident/EOC Exercise with the affected Facility/Area Supervisor, Safety, Quality/Environmental Specialist, Engineering and the OCC Representatives. The purpose of the meeting is to identify lessons learned and develop the following information:

A. What additional personnel support may be needed for similar incidents in the future.

B. Identify any additional equipment or materials that are needed.

C. Any additional coordination needed to accelerate the notification and response.

D. Identify any additional training requirements and determine when the additional training will be provided.

E. Draft a report, as necessary, detailing the incident/exercise and distribute to affected organizations and personnel.

17.0 IN-FLIGHT AIRCRAFT EMERGENCY

17.1 OBJECTIVE

In-Flight Aircraft Emergencies (IFE) are a very rare occurrence at Vandenberg Air Force Base due to the fact an active aircraft wing does not operate from the Base. When IFE's occur, it is absolutely essential that Transient Alert personnel be prepared to respond in concert with other base-wide emergency services to assist in the mitigation of the emergency condition in an expeditious and safe manner. For flight line emergencies that might require services i.e., assisting in analyzing systems malfunction and securing of aircraft, tow or removal of aircraft from flightline, use of follow-me vehicle as a control tower escort for emergency team, operation and maintenance of AGE equipment in support of recovery operations etc., please refer to PWI-20-O-035 and/or AFOSH 91-100.

2. EMERGENCY ASSESSMENT

Base Operations will normally notify TAM/AGE personnel that they have received official notification that an arriving aircraft or diverted aircraft that must land at VAFB, has declared an IFE. If TAM/AGE receives independent information of an IFE, notify Base Operations immediately and OCC.

17.3 EMERGENCY ACTION

Person Making Discovery or Receiving Notification

A. Contact OCC and advise of the IFE and verify with Base Operations that a true IFE has been declared and determine the extent of the emergency condition if known.

B. Based upon nature of IFE, begin mobilization of personnel that will be required to assist.

C. Attempt to obtain an estimated time of arrival of the affected aircraft.

D. Ensure proper assets and personnel have been mobilized for the IFE.

E. Ensure contact has been made to AFQA.

F. If IFE involves a Potential Broken Arrow, a chemical emergency involving a hazardous material, or an on-board fire, ensure proper notifications are made and ensure unauthorized personnel are excluded from the emergency zone.

17.3 EMERGENCY ACTION (CONT.)

Facility/Area Supervisor

A. Evaluate the situation and the information that has been provided by Base Operations or TAM/AGE Dispatch personnel.

B. Ensure OCC and AFQA has been notified.

C. Determine if appropriate personnel and resources have been activated.

D. Determine if a Tow Team will be required. If required, ensure activation of this unit.

E. Assist Base Ops as needed to determine if heavy equipment is required and advise OCC accordingly.

F. Coordinate with UPC Safety personnel on the accident investigation and regulatory reporting requirements if necessary.

G. Report all relevant information to Operations Manager and Program Manager when time permits.

17.4 POST EMERGENCY ACTION

As soon as the declared emergency is over and all personnel have been accounted for, contact OCC and advise the emergency situation has been contained or mitigated.

Ensure reporting and brief chronology of events is provided to the Operations Manager and Program Manager.

17.5 POST EMERGENCY EVALUATION

The Operations Manager and TAM/AGE Lead will convene a meeting to critique the IFE with all TAM/AGE personnel. The purpose of the meeting is to identify lessons learned and develop modified response strategies for future IFE conditions. At a minimum the following areas should be addressed:

A. What additional personnel support may be needed for similar incidents.

B. What resources were required, the availability of resources, and were they employed in this IFE.

C. Any additional coordination required from ASSC or the Base.

D. Identify additional training requirements that need to be addressed and determine schedule for such training.

18.0 EMERGENCY PROTECTIVE ACTIONS TO DECLARED HAZARDOUS MATERIALS INCIDENTS

18.1 OBJECTIVE

Each year there are hundreds of incidents in the United States in which airborne hazards are released. These hazards are commonly referred to as hazardous fumes, noxious chemicals, or mysterious odors. They permeate buildings and cause illness, injuries, or disruption of activities. In most cases, these incidents result in building or area evacuations. This action is the natural response in such emergencies and usually the only practical course of action by which the occupants can reach clean air and safety. In some situations, emergency response personnel may direct people to remain inside buildings or vehicles and implement shelter-in-place actions.

Protective actions for airborne hazards include actions taken when people are outside of a building and actions taken when they are inside. The inside building actions, known as sheltering or protecting in-place, depend upon whether the hazard release occurred inside or outside the building. Protective actions for both situations are covered within this emergency response plan. The purpose for Shelter-In-Place is to minimize employee and personnel exposure to hazardous materials in the event of an external hazardous materials accident or terrorist use of a weapon of mass destruction (WMD).

Shelter in-place actions can provide short-term (one-to-two hours in some cases) protection to the occupants and are most effective when building occupants plan and practice their actions in advance. Although the primary reason to shelter inside buildings is to increase protection, these actions also provide external emergency responders with the time they need to control or contain the release and coordinate evacuation strategies.

18.2 EMERGENCY ASSESSMENT

Buildings can provide protection in varying degrees against airborne hazards that originate from the outside. Such protection is limited, however, and effective only under certain conditions. Conversely, the hazards produced by a release inside a building can be much more severe than a similar release outside. Because buildings allow only a limited exchange of air between the inside and outside, not only can higher concentrations occur when there is a release inside or directly into a building, but inside hazards are more likely to last longer.

Most of these incidents will likely involve accidental releases of industrial materials such as toxic industrial or agricultural chemicals. They may also involve releases of biological or radiological material. Some may be the result of malicious acts -- vandalism, pranks, or terrorism. These incidents will likely occur with little or no warning and require employees to quickly implement protective actions based upon their assessment of the situation or directions from emergency response personnel.

Each Facility Manager and Lead within all UPC operations at Vandenberg Air Force Base is responsible to ensure Material Safety Data Sheets are on file and current for each chemical used or stored on our facilities. Annually, each employee is to review the MSDS information on hazardous materials to be aware of the protective measures required. By knowing the emergency response actions associated with the chemicals we use it will assist in mitigating employee exposure.

18.3 EMERGENCY NOTIFICATION

A. For serious injury, threat to life or health, fire or explosion, or serious circumstances requiring immediate assistance, call **911**. Be prepared to provide description of location and nature of injuries, and circumstances of spill/release. Keep the line open until **911** personnel release you.

B. If there is a **major** spill/release, and no personnel injuries or fire, call the **OCC 606-7451**, and request the Base Command Post 606-9961 be notified and the Base HAZMAT Team respond.

C. For all **minor** spills/releases call the **OCC 606-7451**, and request that 30 CES/CEVCC (606-0016/605-0544) be notified. Be prepared to provide an incident report regarding the circumstances of the incident.

D. For all above instances, notify 30 SW/SE Range Safety by both email and phone at the earliest convenience.

- Email: 30swse.report@vandenberg.af.mil
- Phone: 606-4052 (leave voice message)

18.4 EMERGENCY ACTION

<u>Person Making Discovery</u>

A. Sound the alarm and make emergency notification as required above.

B. Determine if evacuation and/or PPE is required. Evacuate all non-essential personnel until the situation is controlled and operations can return to normal, pre-release conditions. If PPE is required, evacuate to a safe area (upwind) to don equipment.

C. Within level of training and capabilities provide first aid to injured.

D. If spill occurred during a procedure, attempt to secure the operation following Appendix Z of the procedure.

E. Within level of training and capabilities attempt to contain release (diking, adsorbents). For releases of known chemicals, obtain the applicable MSDS and follow the recommendations on the “Spills” section.

F. Within level of training and capabilities, stop release, if possible (righting a drum, closing a valve). Aggressive spill control response is to be taken only by those trained in emergency response operations. Simple clean up of a routine, small spill is not considered emergency response.

G. Continue to keep the OCC and/or EOC informed as containment and clean up progress.

H. Notify facility/area supervisor, and keep supervisor informed as situation progresses.

18.4 EMERGENCY ACTION (CONT.)

OCC Personnel

A. Perform communication links and notifications as required by circumstances and company and base policy and procedures (Reference paragraph 2.4.1 of this procedure).

B. Keep UPC Operations Manager and Program Manager informed about spill/release actions and responses.

C. Maintain a chronological log of all events and communications.

UPC Emergency Response Team

A. Respond as directed by the Operations Manager/ Program Manager or as directed by the 30th Space Wing Emergency Operations Center under the Base's Incident Command System.

B. Within level of training and capabilities contain and stop release. Use MSDS and other resources to evaluate the situation before response actions begin. During course of response retain a flexible plan for personnel egress should the situation exceed Team capabilities.

C. Assess clean up requirements and report them to the OCC or Operations Manager. Do not proceed with clean up until directed to do so by Operations Manager, or competent government authority (EOC Director, ACO, or Space Fuels Flight Project Officer).

D. Perform decontamination of equipment and supplies. Identify items requiring restocking for subsequent responses.

E. Support after-action investigations and reporting.

Facility/Area Supervisor

A. Evaluate situation and the information provided by those at the scene. From this information, or if directed by either Base Emergency Response Personnel or Project Management, shelter-in-place until directed otherwise.

B. Ensure proper response has been initiated, to include medical support, fire fighting, HAZMAT Team, etc. Independently verify response actions by contacting **911** and/or the Base Command Post **606-9961**.

C. Coordinate evacuation activities, and obtain "head count" at the evacuation assembly area or within your respective facility.

D. In conjunction with the Operations Manager and the Program Manager mobilize company resources to the extent required to control the situation.

E. If the situation involves an operational/procedural activity, direct securing of the operation per Appendix Z of the procedure in progress.

F. Coordinate with UPC Safety personnel on incident investigation and reporting requirements.

G. Follow up with 30 CES/CEV to verify that all required environmental and or emergency release reporting has been accomplished.

18.4 EMERGENCY ACTION (CONT.)

<u>Shelter In Place Procedures to Be Utilized In Concert With Above Actions</u>

A. Take cover if needed to protect from fire, explosive hazards or falling objects.
B. Notify other personnel in vicinity.
C. Close and lock windows and vents.
D. Turn OFF heating systems and exhaust fans.
E. Move to a designated safe area or room within your facility.
F. Seal room with plastic duck tape (seal vents, doors and electrical outlets).
G. Seal door thresholds with a wet towel.
H. Stay away from outer walls and windows
I. Do not use any item with an open flame
J. Use telephone system, cell phones or intrinsically safe portable radios for communication.
K. Shelter In Place Kits will be provided for each facility as required.

18.5 POST EMERGENCY ACTION

A. Check with medical facility on status of injured personnel.
B. Notify immediate family, as appropriate.
C. Complete incident/accident reports and submit to UPC Safety for reviewing or forwarding to appropriate Base and governmental agencies.
D. Gather all records/documents associated with the emergency.
E. Obtain Safety approval to return to normal operations.
F. Provide personnel with re-entry and return to work instructions.

18.6 POST EMERGENCY EVALUATION

The UPC Operations Manager will convene a meeting to evaluate and critique responses and actions related to the emergency response and shelter in place actions. The Operations Manager will be supported by the facility/area affected, Safety, Quality/Environmental Specialist, Engineering, UPC Response Team Chief, and the OCC representative. A report will be written to identify lessons learned, and evaluate effectiveness of emergency planning and response. The purpose of the report is to improve emergency response and shelter in place actions. The following information will be developed:

A. Identify any additional personnel support that may be needed for similar incidents in the future.
B. Identify any additional equipment or materials that are required.
C. Identify any additional training that may be required.
D. Identify any means to improve communication and coordination processes.
E. Identify any weaknesses in planning or response documentation.
F. Submit report, as required, on the incident or emergency to affected organizations and personnel.

19.0 LPART EMERGENCY RESPONSE IN SUPPORT OF BOEING GMD TANKING OPERATIONS

19.1 OBJECTIVE

A. To identify the emergency response actions required by UPC Employees whenever an unplanned, non-routine Hypergolic Fuel or Oxidizer Propellant liquid release occurs at the GMD Missile Assemble Building (MAB), Facility 980 or Building 1819 GMD Consolidated Interceptor Facility (CIF).

The UPC Emergency Response Team will be activated In the event a propellant mishap occurs during the GMD tanking operation at the MAB facility 980 or CIF 1819. UPC will have the Emergency Response Team on standby status with all support equipment staged to immediately respond to an unplanned incident involving the potential release hydrazine or Dinitrogen Tetroxide commodity as a result of a mishap during the Tank installation process. The UPC team shall also respond to any mishaps involving the personal injury and/or exposure of team members that were participating in the tank installation process. UPC will provide personnel rescue of individuals involved in the mishap, remove them from the facility and assist in the emergency showering of the exposed individuals as required.

Incidents that are beyond the immediate response of the UPC Emergency Response Team will be managed by the VAFB Disaster Preparedness Emergency Operations Center (EOC) and UPC will follow instructions from the EOC Representative (30th MSG Commander) and Base Fire Chief. UPC will still respond to a toxic propellant release be it liquid or vapor but will be under the control of the EOC Representative (reference the UPC, PWI 10-S-003 Emergency Response Plan.

Upon the release, it will be the UPC Operations Managers responsibility to perform alert notification for UPC response team and any individual that is aware of an emergency situation will dial 911 for Emergency Services. The release will then be immediately reported via telephone to United Paradyne's Operations Control Center. OCC shall notify Base Command Post (**606-9961),** 30 CES/CEIEC **(606-0016/605-0544**) and Range Safety **(588-9389)** and the Vandenberg Operations Support Center (VOSC), (**606-8914**).

19.2 MAJOR SPILL/RELEASE EMERGENCY ASSESSMENT

Although the Toxicity and personnel hazards of commodity does not meet the reportable spill amount of a major release this information is still being provided as reference.

Upon discovery of an unplanned and/or non-routine Hypergolic liquid release of any quantity at MAB immediately perform the following actions:

A. Boeing team will **Verbally** Sound Alarm in the immediate area and notify on-site personnel to immediately evacuate the facility. Hypergolic sensors will activate and blue light will be activated and audible alarm will sound.

B. All personnel will vacate the facility immediately IAW the Boeing Emergency Evacuation Plan and make the appropriate emergency notification by dialing 911. The UPC Operations Manager will notify the UPC OCC to activate the emergency response team.

C. Personnel shall **Activate** Fire Alarm Pull Stations IAW the Facility Emergency Evacuation Plan as necessary based on the situation. Activate Red area warning light and verify it is flashing.

19.2 MAJOR SPILL/RELEASE EMERGENCY ASSESSMENT (CONT.)

D. All personnel will evacuate in an upwind or cross wind direction at a minimum distance of 2000 feet and report to the designated facility assembly areas. Once all personnel are at the designated assembly area account for personnel and report status to the UPC Operations Manager who will in turn notify the OCC. At that time the UPC response team will be informed of how many individuals are left inside prior to proceeding with the entry, rescue or clean up actions.

For Building 980 tanking operations, the UPC Emergency Response Team will be positioned at the South Base Truck Scales Facility 969 located adjacent to the HSF and respond with the Emergency Response Team within 10 minutes (this time reflects receiving the notification, donning SCAPE and transporting the SCAPE team suited up) and ready to enter facility 980 upon direction of the UPC emergency response supervisor. For tanking operations being performed at the facility 1819 CIF the response team will be staged at CIF parking lot and will respond within 10 minutes after notification with the SCAPE team suited up and ready to enter facility 1819.

The UPC Emergency Response Manager will verify all doors are unlocked during the pre-task briefing and will be on site during the tank loading operation and will coordinate all response activity with the Boeing team. The response team will consist of two SCAPE suited individuals and two back up SCAPE team members standing by at the entry control point for additional support as required. The response team will be supervised and receive direction from the UPC Emergency Response Manager on site for the tanking operations.

Equipment that will be pre-staged for the tank loading operation will be a standard UN1H2 over pack drum with an open top, the container will be filled at least ½ full of water. In the event of a liquid propellant release from the tank that is in transit from the drum storage container to the booster. The propellant tank will be retrieved by the propellant emergency response team and submerged in the over pack drum containing a sufficient level of water to dilute the commodity. The container will then be transported to the HSF so that the material can be safely managed at a later date.

Prior to the tanking operations being performed at MAB/CIF 980 or 1819, UPC will setup and functionally test a portable shower outside the designated egress door. SCAPE personnel will use approved intrinsically safe VAFB authorized Motorola ASTRO XTS-500 radios for communications equipment while inside the MAB. **Cellular phones are strictly forbidden inside the MAB and CIF and will not be used under any circumstances.**

UPC personnel will utilize the mop and sop kit and water to wash down and clean up any propellant residual released. After cleanup actions are completed UPC will perform air monitoring using a portable vapor detector to declare the area safe for re-entry without PPE.

19.2 MAJOR SPILL/RELEASE EMERGENCY ASSESSMENT (CONT.)

19.2.1 Notify supervisor and/or operations manager if not already notified, and wait for instructions on appropriate steps to stop liquid spill/release. If rate of liquid release is a rate that will exceed the 20 PPM IDLH limit before operations can stop the release, it is to be categorized as a major release and dealt with accordingly per 19.0 of this plan.

19.2.2 Using appropriate Personal Protective Equipment, SCAPE, perform directed actions to stop liquid spill/release and to safe the contaminated area.

19.2.3 UPC Safety and Quality personnel will prepare an incident report involving the actions taken to mitigate the hazardous condition and provide a written report to the GMD Management and Base Safety.

19.2.4 UPC will notify 30 CEA, regardless of the size of liquid spill/release in accordance with 30 SW 32-4002. UPC, OCC, or UPC Management personnel will also immediately notify 30 SW/SE Range Safety by both phone and email of the incident.

- 30swse.report@vandenberg.af.mil
- 588-9389 (leave voice message)

19.3 MAJOR EMERGENCY NOTIFICATION

OCC will call the **911** Operator and provide the following information via telephone. This will be the responsibility of the facility management to perform.

A. Name

B. Nature and Location of Spill

C. Type of commodity spilled (Fuel or Oxidizer)

D. Report as detailed a description of the situation as possible and include the following:

1. Personnel injured or exposed.
2. State concentration of the vapor cloud and estimated size of wetted area from the liquid spill inside the MAB/CIF facility.
3. Status of equipment and facility hardware.
4. If a catastrophic release of commodity has occurred, immediately report to the UPC OCC one of the following “worst case” scenarios. This information is necessary so that Base Weather can be notified to plot an OHZ based on the following analysis:
    a. An Oxidizer Tank is leaking with a wetted area, maximum spill quantity is approximately one gallon, or
    b. A Fuel Tank leak has occurred with a wetted area, maximum spill quantity is approximately one gallon.

19.4 MAJOR EMERGENCY ACTION

A. **UPC Response Team**, immediately initiate safing/securing emergency steps. If the EOC has been formed, access to the facility/equipment must be approved by the EOC Director and the Base Fire Chief assigned to the incident.

   1. Upon access to incident location, provide status of facility/equipment and actions taken to the UPC OCC and/or EOC Director. Do not perform any additional actions unless procedures have been approved by Boeing, 30 RMS, GMD, 30 SW, SEAT.

B. **UPC OCC** will maintain a log of all events and communications, and coordinate with the appropriate VAFB agencies and the GMD Management as specified in this Plan.

   1. Notify Base Command Post 606-9961.
   2. Obtain Toxic Hazard Zone information for an OHZ from base weather and transmit original and continuous updates to Facility/Area Supervisor.
   3. Notify 30 SW/SE Range Safety by both email and phone.
      - 30swse.report@vandenberg.af.mil
      - 588-9389 (leave voice message)
   4. Continually update the UPC Program Manager and Operations Manager.

C. **UPC Operations Manager**, will report to facility assembly area or EOC Assembly Point to approve and direct incident response actions in coordination with Facility/Area Supervisor and EOC team representatives.

D. **UPC Safety**, will report to the designated assembly area and coordinate all Safety issues with Facility/Area Supervisor, UPC EOC Representative and Contractor Safety Representatives.

E. **UPC Environmental Specialist**, will coordinate with the Facility/Area Supervisor, Operations Manager and 30 CES/CEIEC with regards to the Hazardous Materials (HAZMAT) Emergency Response Plan, 30 SW Plan 32-4002 requirements. In concert with Environmental Management Flight, Environmental Specialist will assess the environmental impact of the emergency and initiate coordinated efforts with VAFB EOC.

19.5 MAJOR POST-EMERGENCY ACTION

A. **UPC OCC**

1. Prepare the summary of events from the OCC EOC Log (UPC-P-018), and present to the UPC Operations Manager for preparation of the Incident or EOC Report.

2. Notify appropriate base support agencies, UPC Program Manager and Operations

B. **UPC Operations Manager**

1. Coordinate with Boeing Facility/Area Supervisor, UPC Safety, on actions required to perform clean-up and containerizing of spill residue, including re-entry precautions into affected facilities that define conditions for returning to normal work activities at the facility.

2. Prepare the report on the Incident/EOC Summary and publish the report within five (5) working days after the event. Reports should be sent to Boeing, 30 RMS, GMD, Management and consolidate customer incident report with the customers report prior to submittal to Base Safety Office.

C. **UPC Environmental Specialist**

Due to the release of a hypergolic chemical, report the incident in writing to 30 CES/CEA as soon as possible. The report should include the following:

1. Chemical name or identity of any material involved in the release.
2. Quantity released (in pounds).
3. Time and duration of release.
4. Location and type of area into which the release occurred.
5. Actions taken to contain the release.
6. Name and telephone of person(s) to be contacted for further information.
7. Obtain the name and rank of all personnel contacted regarding the incident and annotate this information for future reference.

19.6 MAJOR POST-EMERGENCY EVALUATION

The Operations Manager will support any GMD meetings to critique the EOC Incident with the affected Facility/Area Supervisor and UPC Safety Representative will support as required. The purpose of the meeting is to identify lessons learned from the Incident and develop the following information to be shared with all GMD and UPC personnel:

A. What additional personnel support may be needed for similar incidents in the future.

B. Identify any additional equipment or materials that are needed.

C. Any additional coordination needed to accelerate the notification response and clean-up activities.

D. Identify any additional training requirements and when the additional training will be conducted.

E. Draft a report, as necessary, detailing the incident/exercise and distribute to affected organizations and personnel.

FIGURE 1
AUTHORIZATION ORDER FOR MEDICAL SERVICES
UPC-A-026

United PARADYNE
CORPORATION

AUTHORIZATION ORDER FOR MEDICAL SERVICES

DATE:______________________________ ORDER NO:______________________
(SLIN-FY-NBR)

TO: ______________________________

____

____

This form is your authority to render treatment or medical evaluation to the following United Paradyne Corporation (UPC) employee,______________________________ in accordance with the terms and
(UPC Employee Name)

price schedule of **Subcontract No.: F04684-20-C-0008**, and the conditions prescribed by the Workmen's Compensation Act, for the following checked service(s)*:

1. ____Technical Physical
2. ____Administrative Physical
3. ____DMV Physical
4. ____Titmus Vision Test
5. ____Pulmonary Function Test
6. ____Audiometry, Booth
7. ____EKG
8. ____PA Chest X-Ray
9. ____Urinalysis w/ Micro
10. ____Sedimentation Rate
11. ____Hematocrit
12. ____Drug Screen w/ Lab Anal.
13. ____Treadmill Test
14. ____Blood Test
15. ____Blood Test Lab Analysis

TOTAL NOT-TO-EXCEED COST:____________________

**NOTE:* *Unless an emergency, please obtain authorization from the insurance carrier for surgery, radical procedures, hospitalization, or any other services not listed above.*

____
Authorized UPC Representative

Date of Injury______________________ Location______________________

How Injury Occurred (If Applicable):

____

____

____

____

(over)

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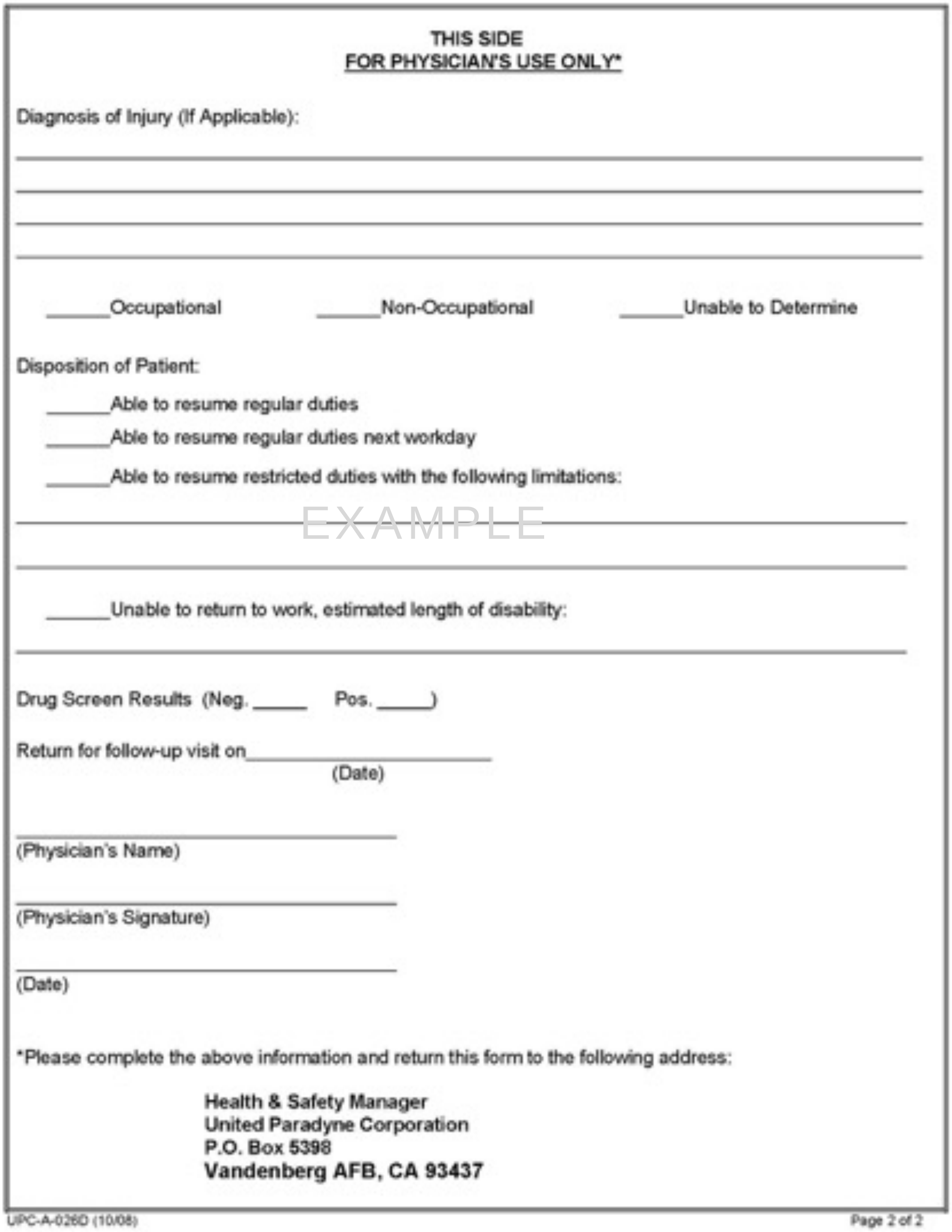
FIGURE 1 (CONT.)
AUTHORIZATION ORDER FOR MEDICAL SERVICES
UPC-A-026



THIS SIDE
FOR PHYSICIAN'S USE ONLY*

Diagnosis of Injury (If Applicable):

______Occupational ______Non-Occupational ______Unable to Determine

Disposition of Patient:

______Able to resume regular duties
______Able to resume regular duties next workday
______Able to resume restricted duties with the following limitations:

______Unable to return to work, estimated length of disability:

Drug Screen Results (Neg. _____ Pos. _____)

Return for follow-up visit on________________________
(Date)

(Physician's Name)

(Physician's Signature)

(Date)

*Please complete the above information and return this form to the following address:

Health & Safety Manager
United Paradyne Corporation
P.O. Box 5398
Vandenberg AFB, CA 93437

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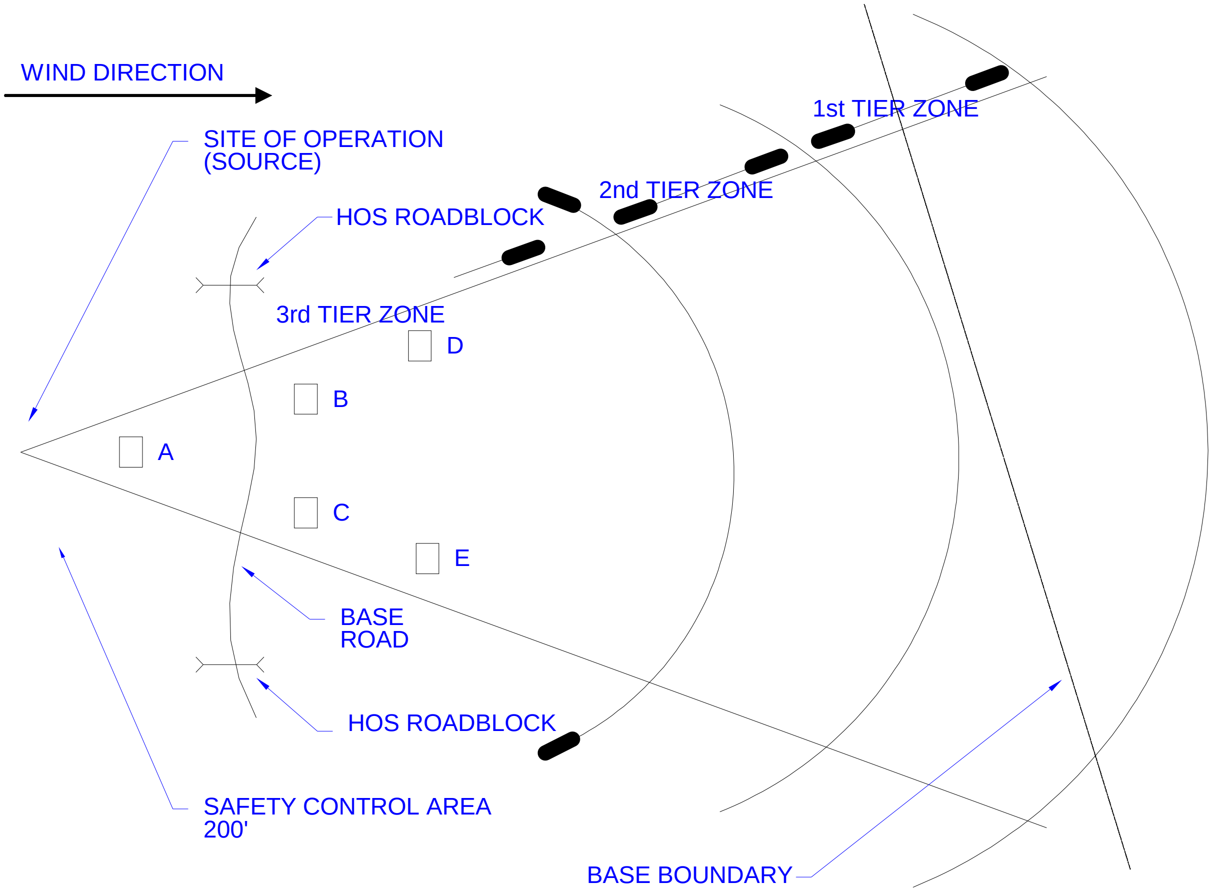
FIGURE 2
TOXIC HAZARD ZONE CHART
(PROPELLANT TRANSFER OPERATION)



TOXIC HAZARD ZONE
(PROPELLANT TRANSFER OPERATION)

FIGURE 3
UPC FACILITY MAP
HYPERGOLIC STORAGE FACILITY FUEL SITE

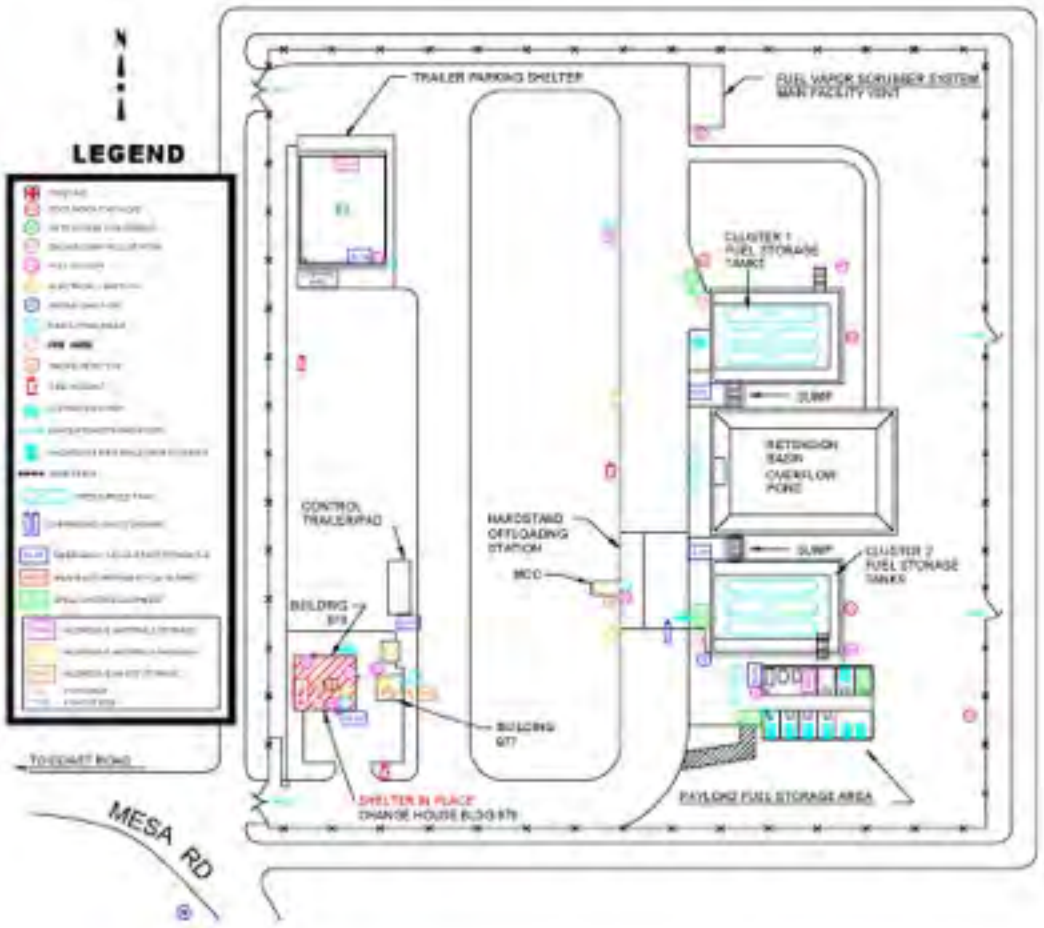


FIGURE 4
UPC FACILITY MAP
HYPERGOLIC STORAGE FACILITY OXIDIZER SITE

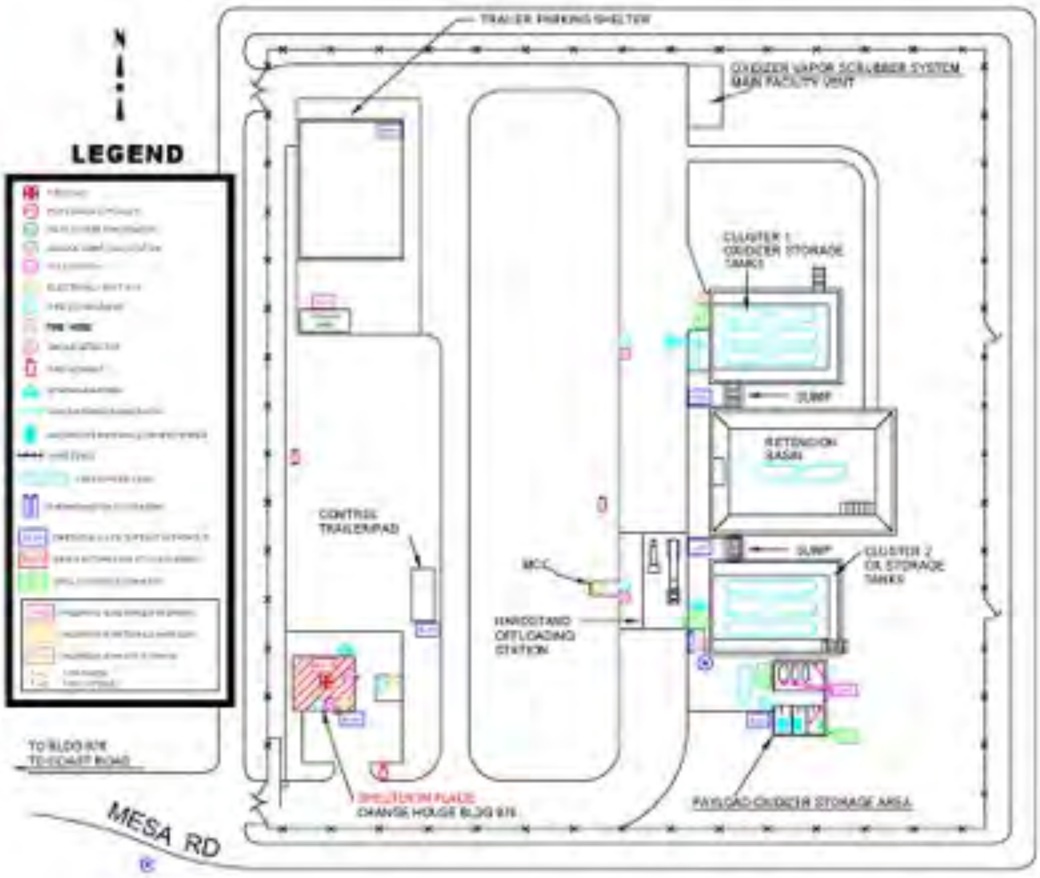


FIGURE 5
UPC FACILITY MAP
HELIUM TRANSFER FACILITY

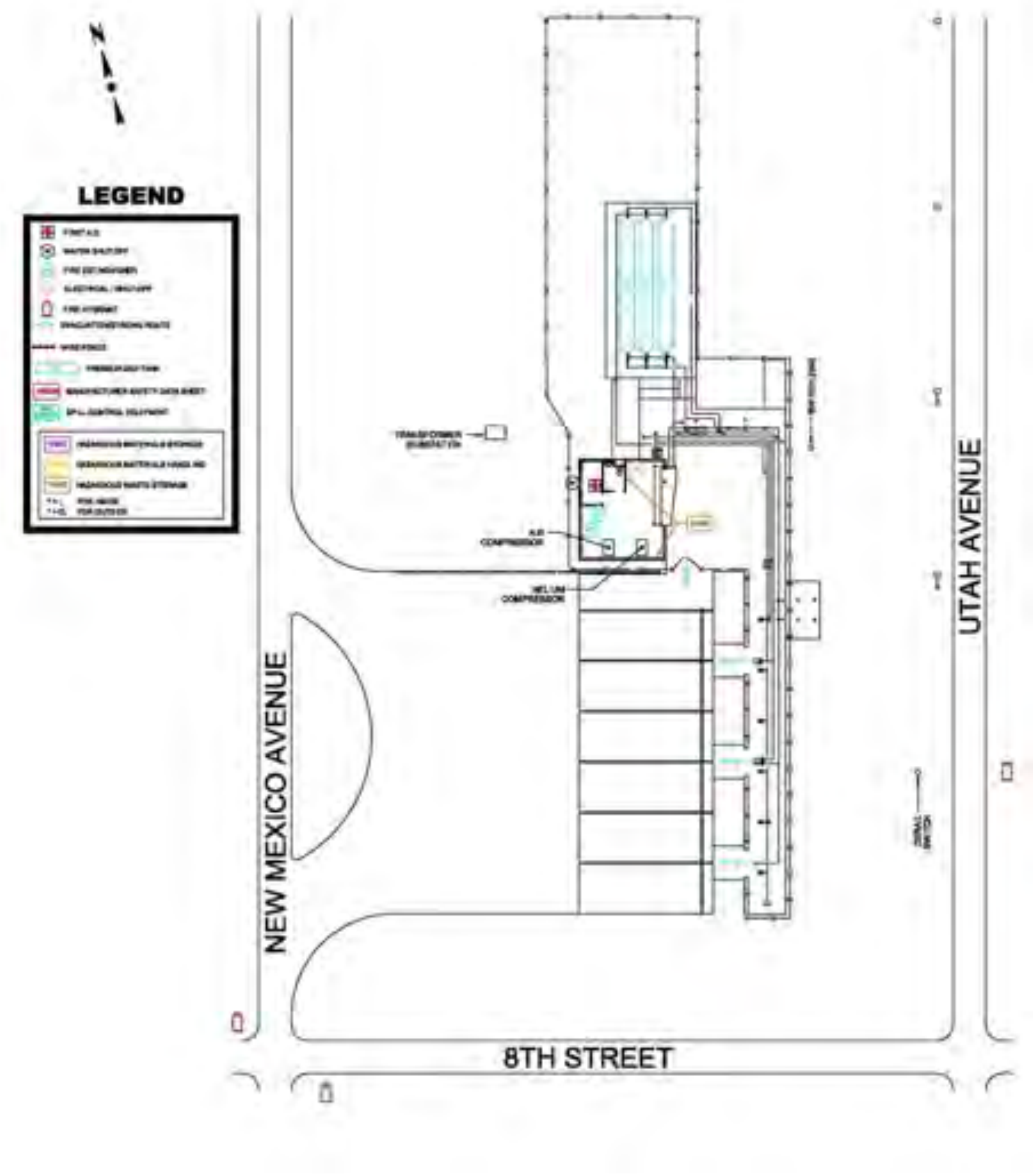


FIGURE 6
UPC FACILITY MAP
PEMO BUILDING

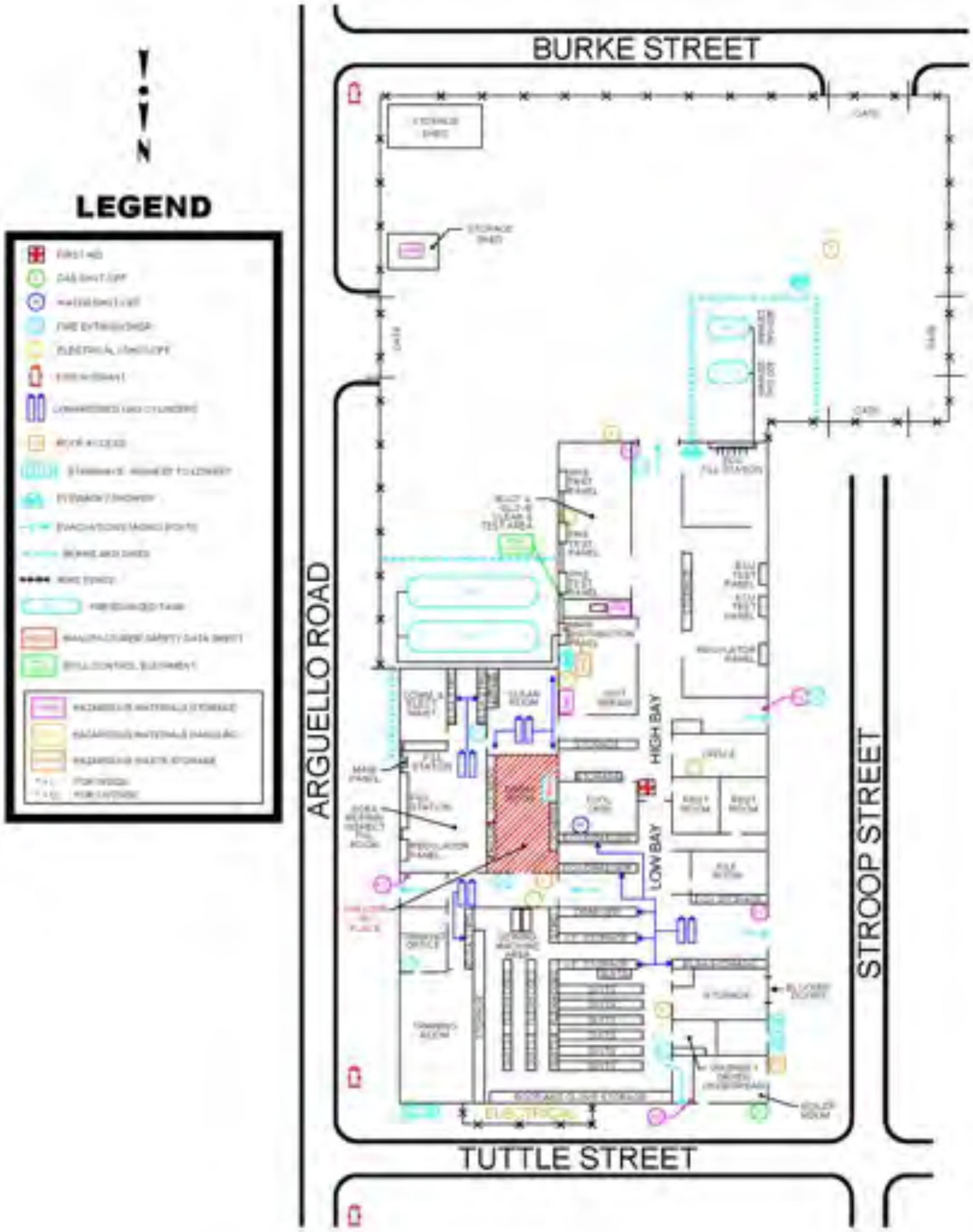


FIGURE 7
UPC FACILITY MAP
OPERATIONS AND MAINTENANCE
CRYOGENICS AND GASES

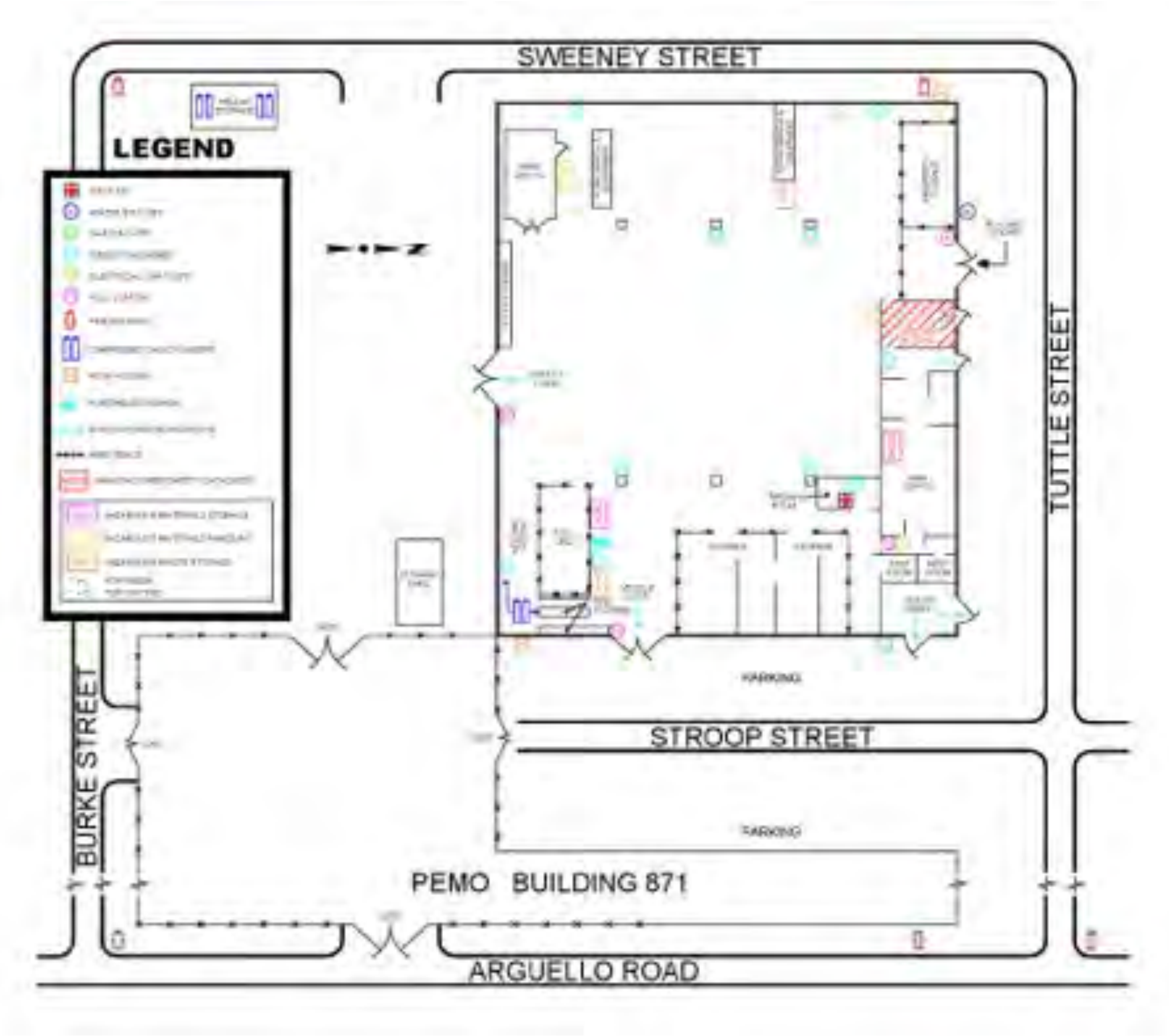


FIGURE 8
UPC FACILITY MAP
ADMINISTRATION BUILDING - 7525, 1ST FLOOR

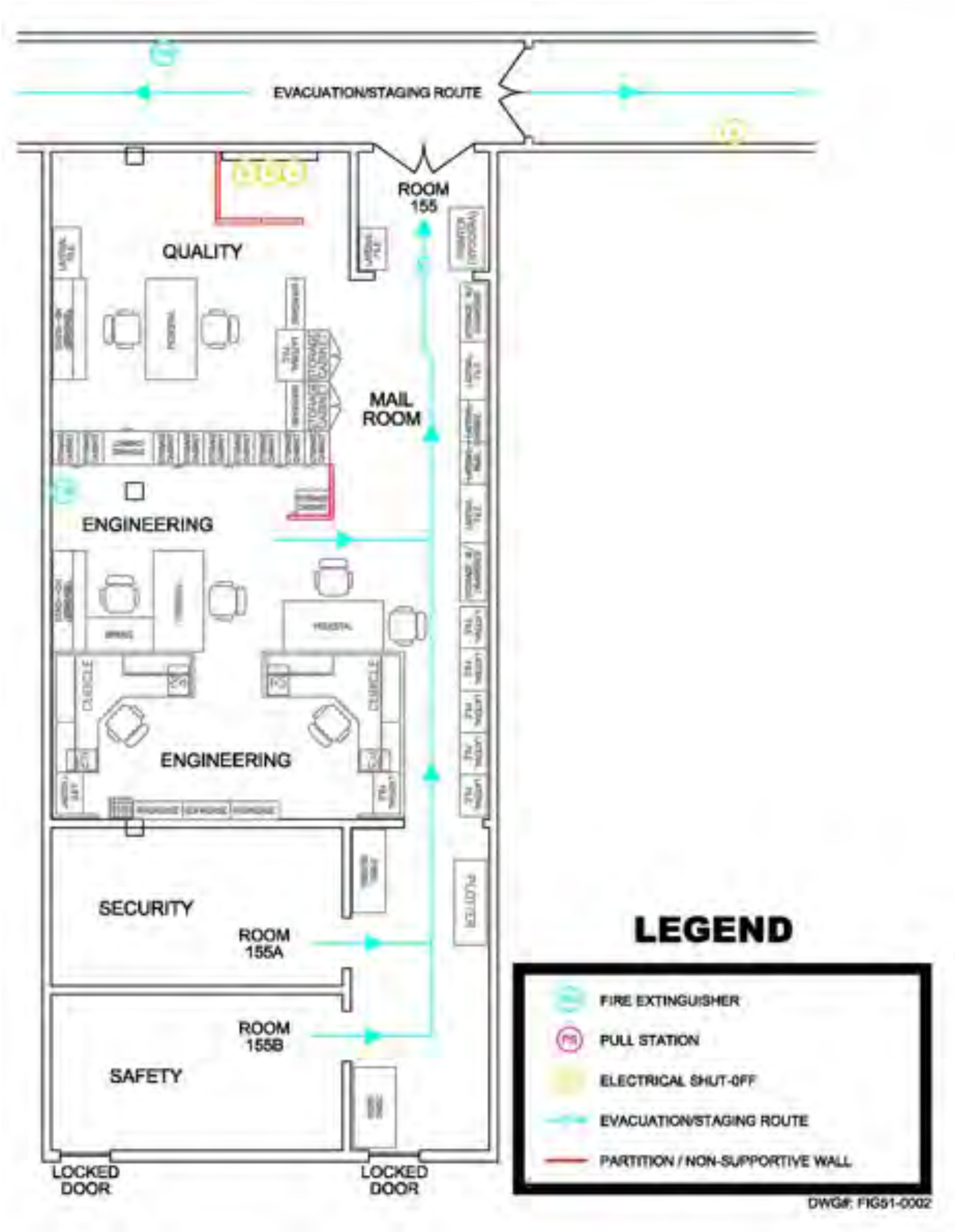


FIGURE 9
UPC FACILITY MAP
ADMINISTRATION BUILDING - 7525, 2ND FLOOR

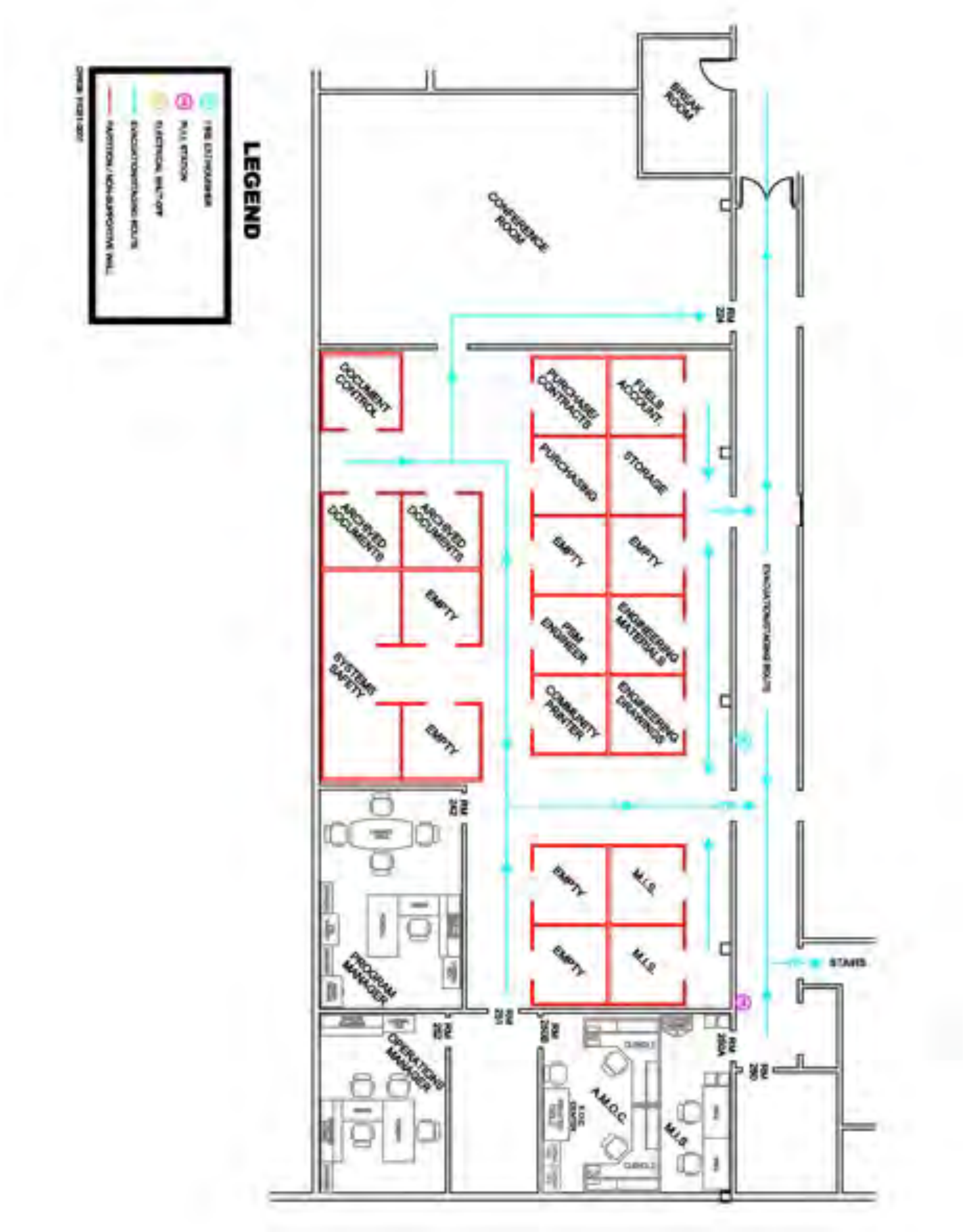


FIGURE 10
UPC FACILITY MAP
PEML BUILDING 1737

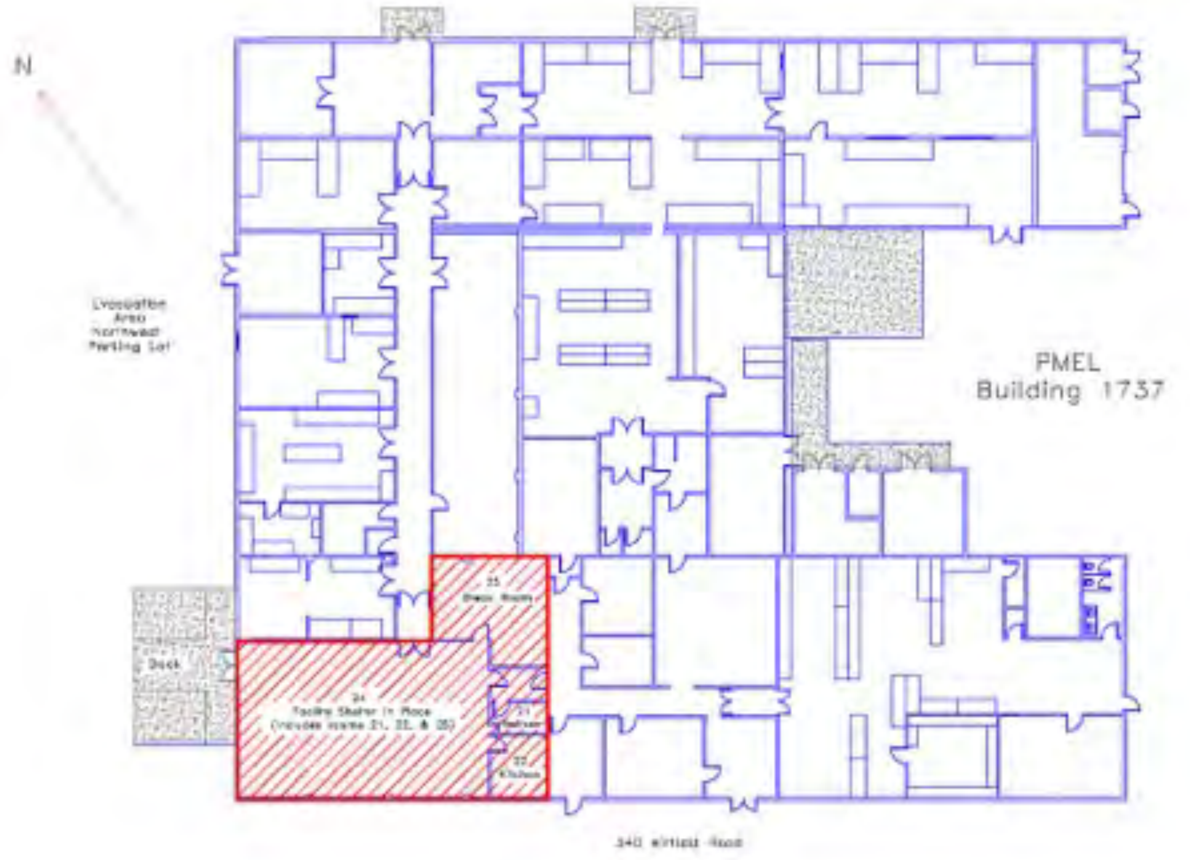


FIGURE 11
UPC FACILITY MAP
TRANSIENT ALERT
BLDG 1749

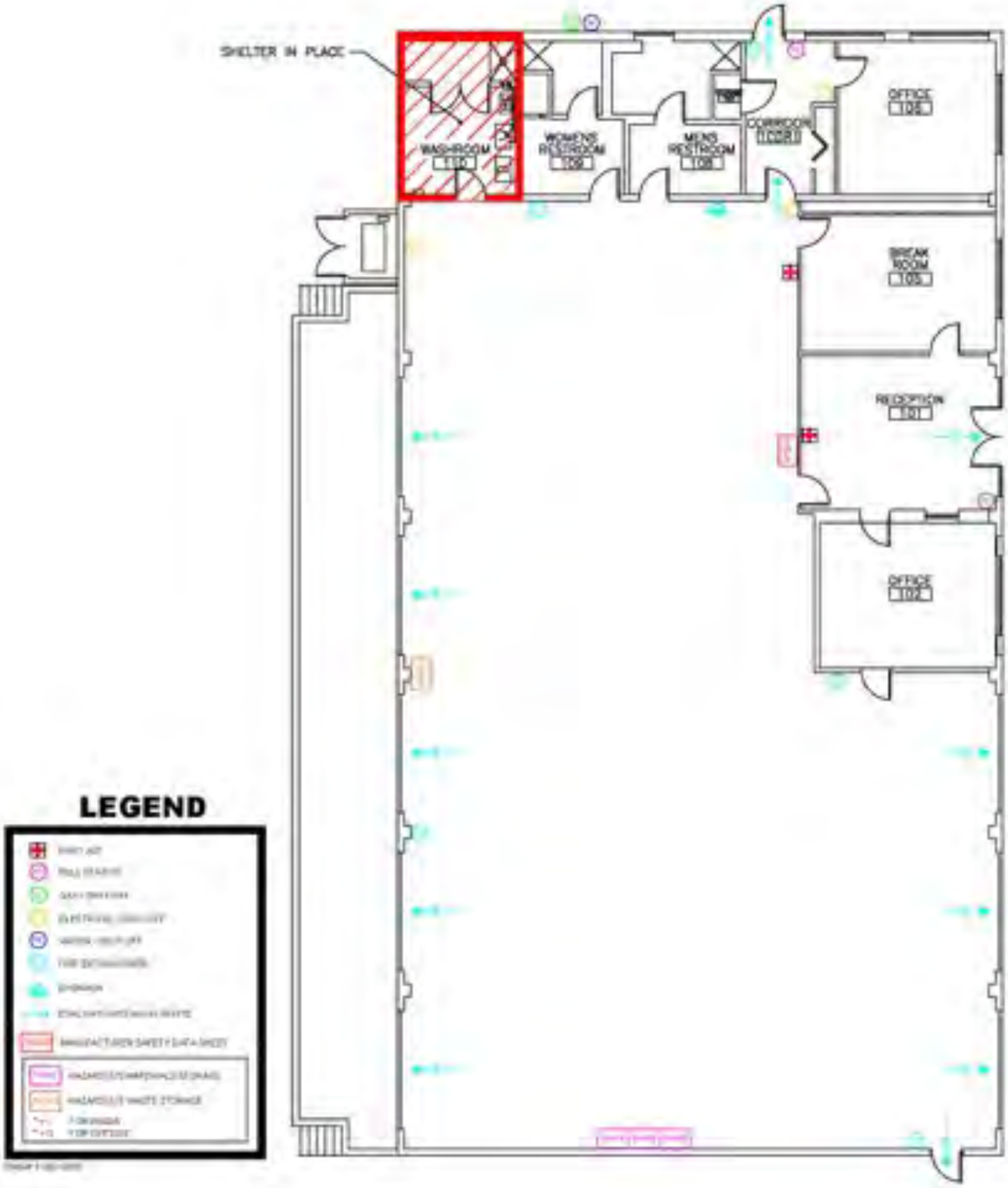


FIGURE 12
UPC FACILITY MAP
SUPPORT HANGER
BLDG 1755

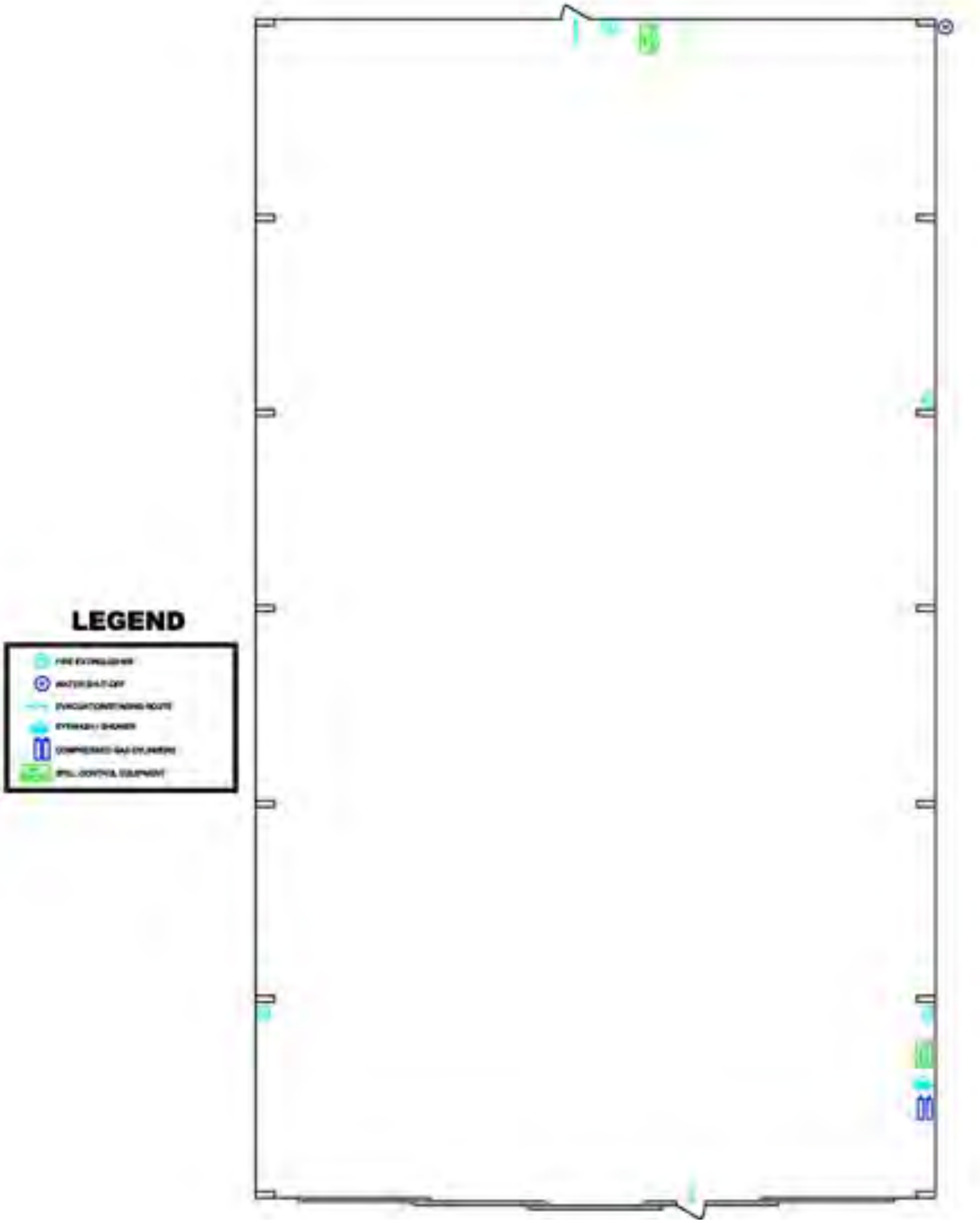


FIGURE 13
UPC FACILITY MAP
B-YARD

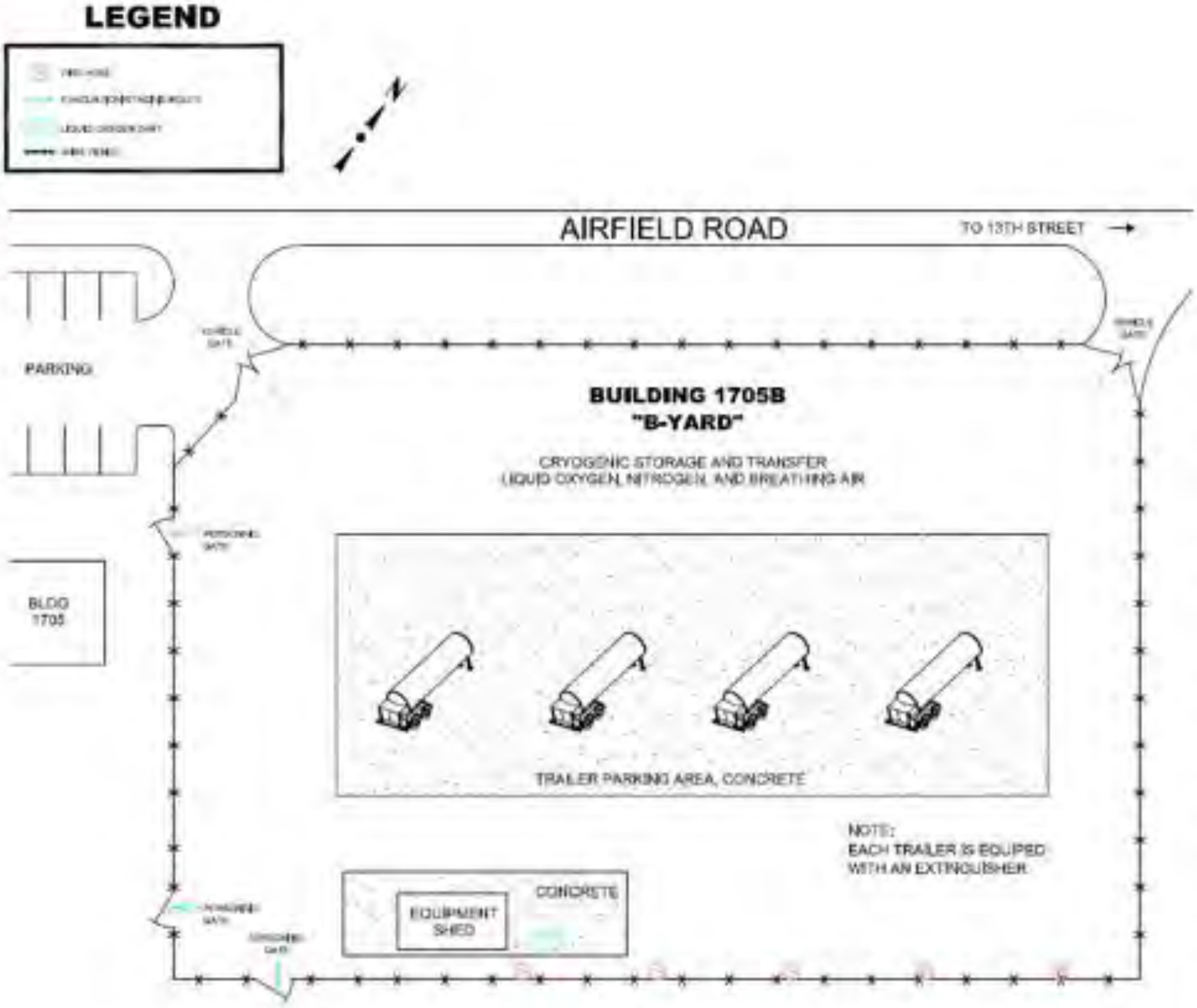


FIGURE 14
INFLIGHT EMERGENCIES (EXERCISES)
UPC-S-010

United PARADYNE
CORPORATION

INFLIGHT EMERGENCIES (EXERCISES)

When transient is notified of an Inflight Emergency (Actual / Exercise) the following will be performed:

1. Verify Type (Actual/Exercise).

2. Annotate the Following:

TIME NOTIFIED:________________________ BY WHOM:________________________

TYPE AIRCRAFT:________________________ CALL SIGN:________________________

ETA:________________________ NO OF PERSONNEL:________________________

EXPLOSIVES:________________________

CARGO:________________________

DESCRIPTION:

4. Notify the following:

   a. TAM/AGE Personnel.
   b. To form a tow team and stand-by for release from On-Scene Commander.
   c. All teams will await further instructions in case they are needed to move equipment within the affected area.

5. Check for aircraft & equipment within 2000 feet radius of the accident. Coordinate with the OCC on what aircraft to move out of the area.

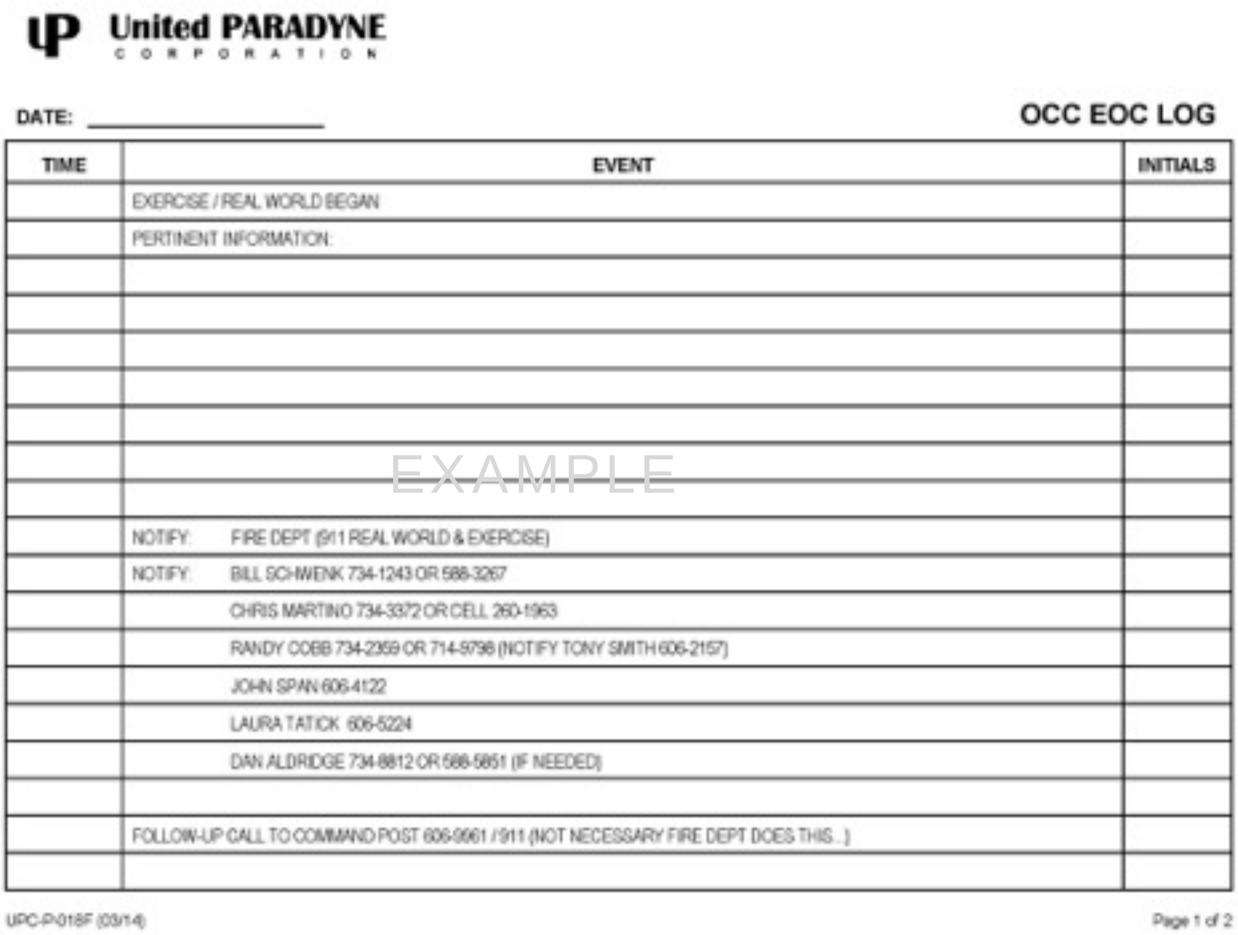
6. If the crane is needed, request it from Base Civil Engineers (606-3641), Horizontal Section.

7. Maintain a log of problems, events, changes, & times during the course of the Accident/Exercise.

8. Notify OCC when Accident / Exercise is terminated.

UPC-S-010B (02/12)

FIGURE 15
OCC EOC LOG
UPC-P-018



United PARADYNE
CORPORATION

DATE: ____________________

OCC EOC LOG

TIME	EVENT	INITIALS
	EXERCISE / REAL WORLD BEGAN	
	PERTINENT INFORMATION:	
	NOTIFY: FIRE DEPT (911 REAL WORLD & EXERCISE)	
	NOTIFY: BILL SCHWENK 734-1243 OR 588-3267	
	CHRIS MARTINO 734-3372 OR CELL 260-1963	
	RANDY COBB 734-2359 OR 714-9798 (NOTIFY TONY SMITH 606-2157)	
	JOHN SPAN 606-4122	
	LAURA TATICK 606-5224	
	DAN ALDRIDGE 734-8812 OR 588-5851 (IF NEEDED)	
	FOLLOW-UP CALL TO COMMAND POST 606-9961 / 911 (NOT NECESSARY FIRE DEPT DOES THIS...)	

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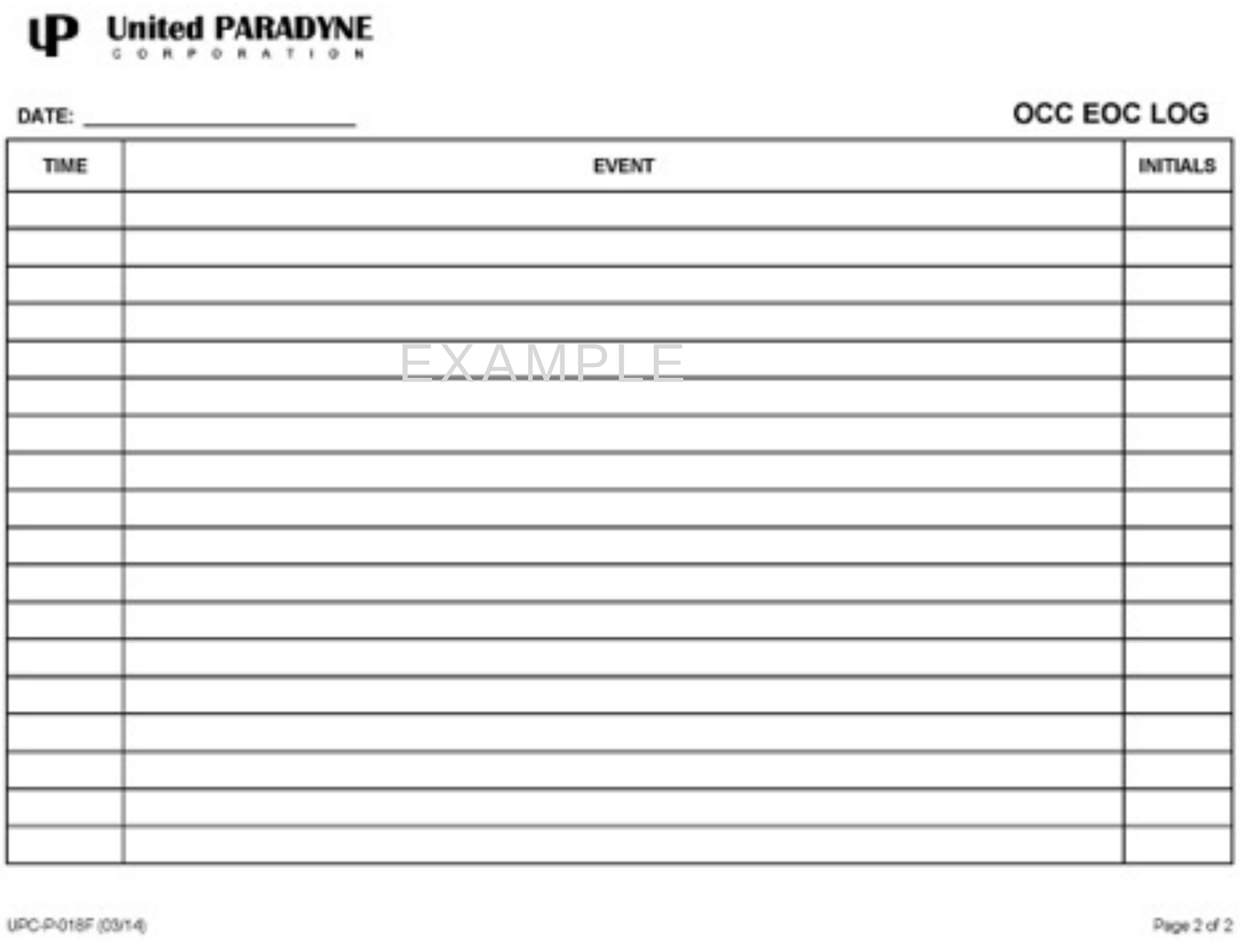
FIGURE 15 (CONT.)
OCC EOC LOG
UPC-P-018



United PARADYNE CORPORATION

DATE: ______________________

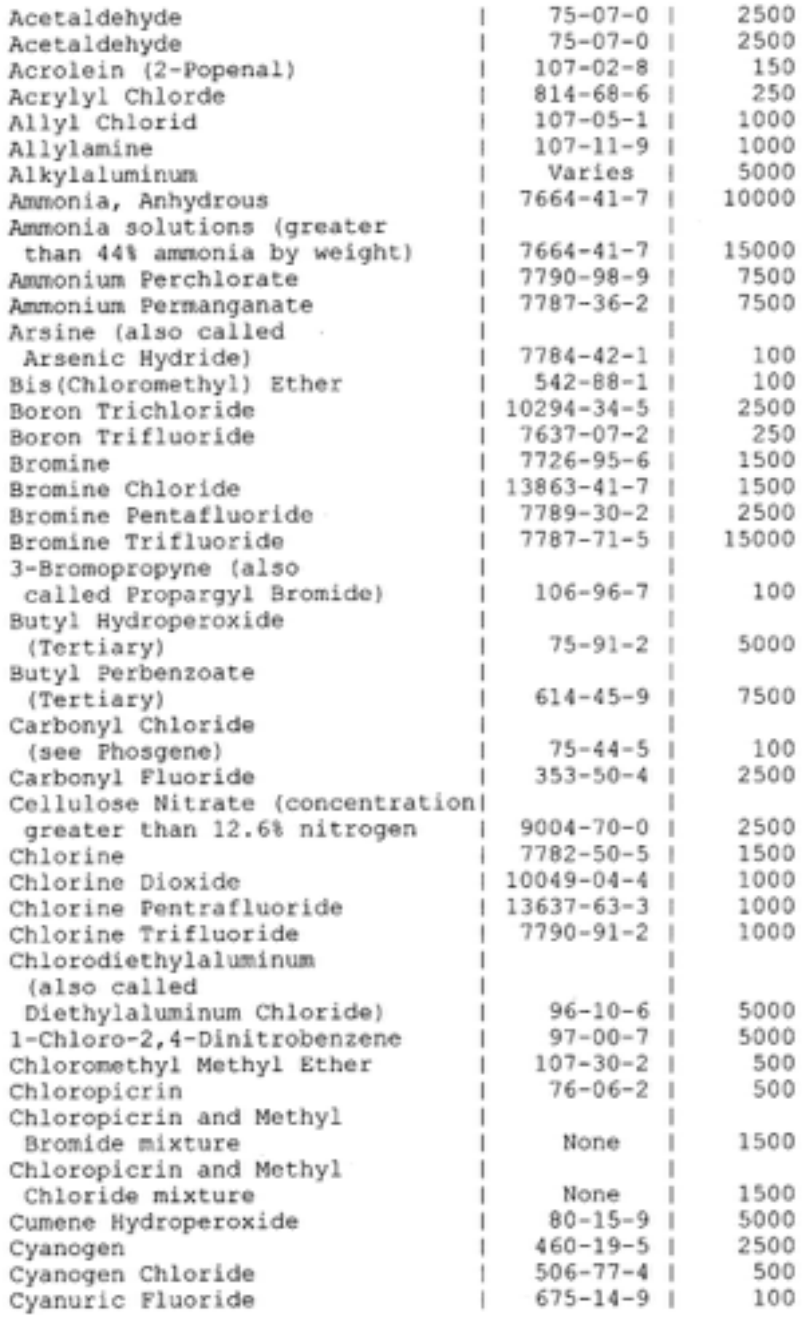
OCC EOC LOG

TIME	EVENT	INITIALS

UPC-P-018F (03/14) Page 2 of 2

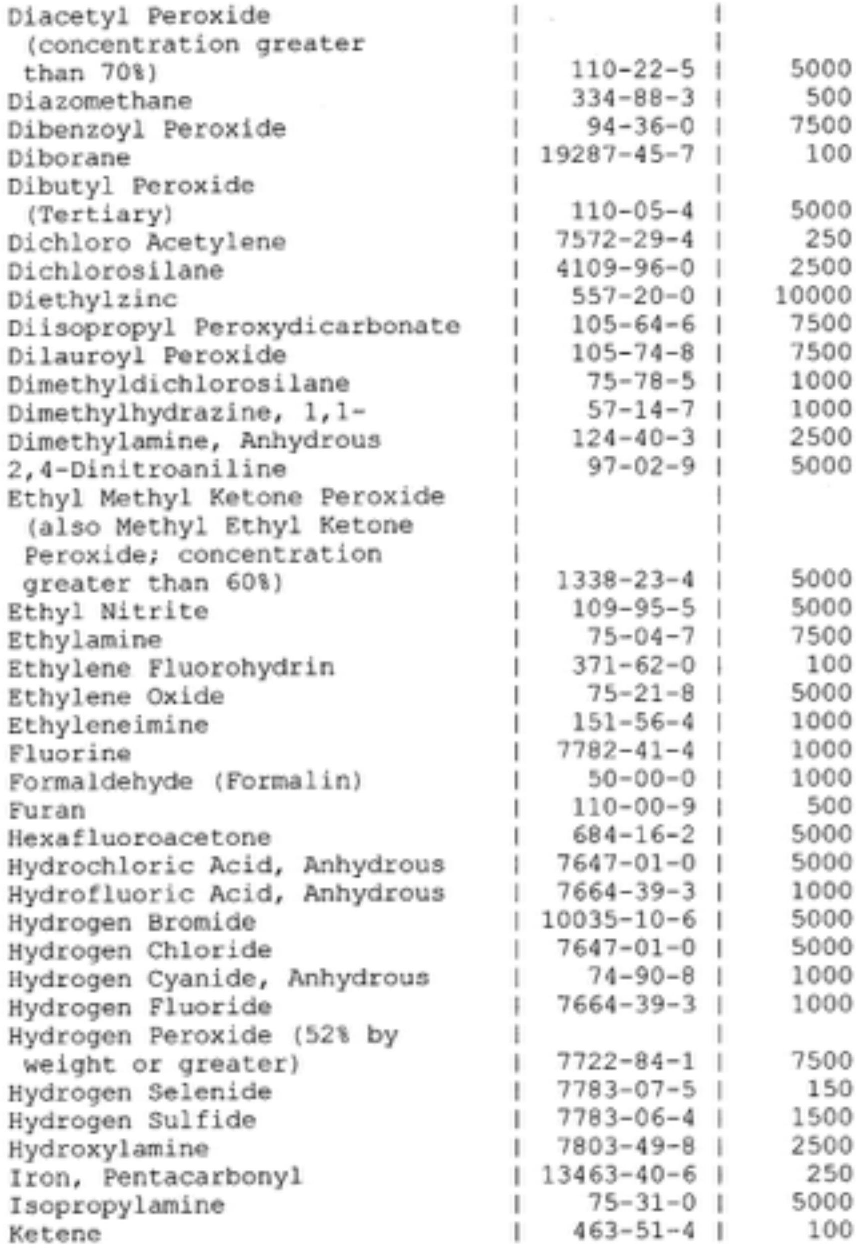
APPENDIX A
LIST OF HIGHLY HAZARDOUS CHEMICALS, TOXICS AND REACTIVES
PAGE 1 of 4

This Appendix contains a listing of toxic and reactive highly hazardous chemicals which present a potential for a catastrophic event at or above the threshold quantity.



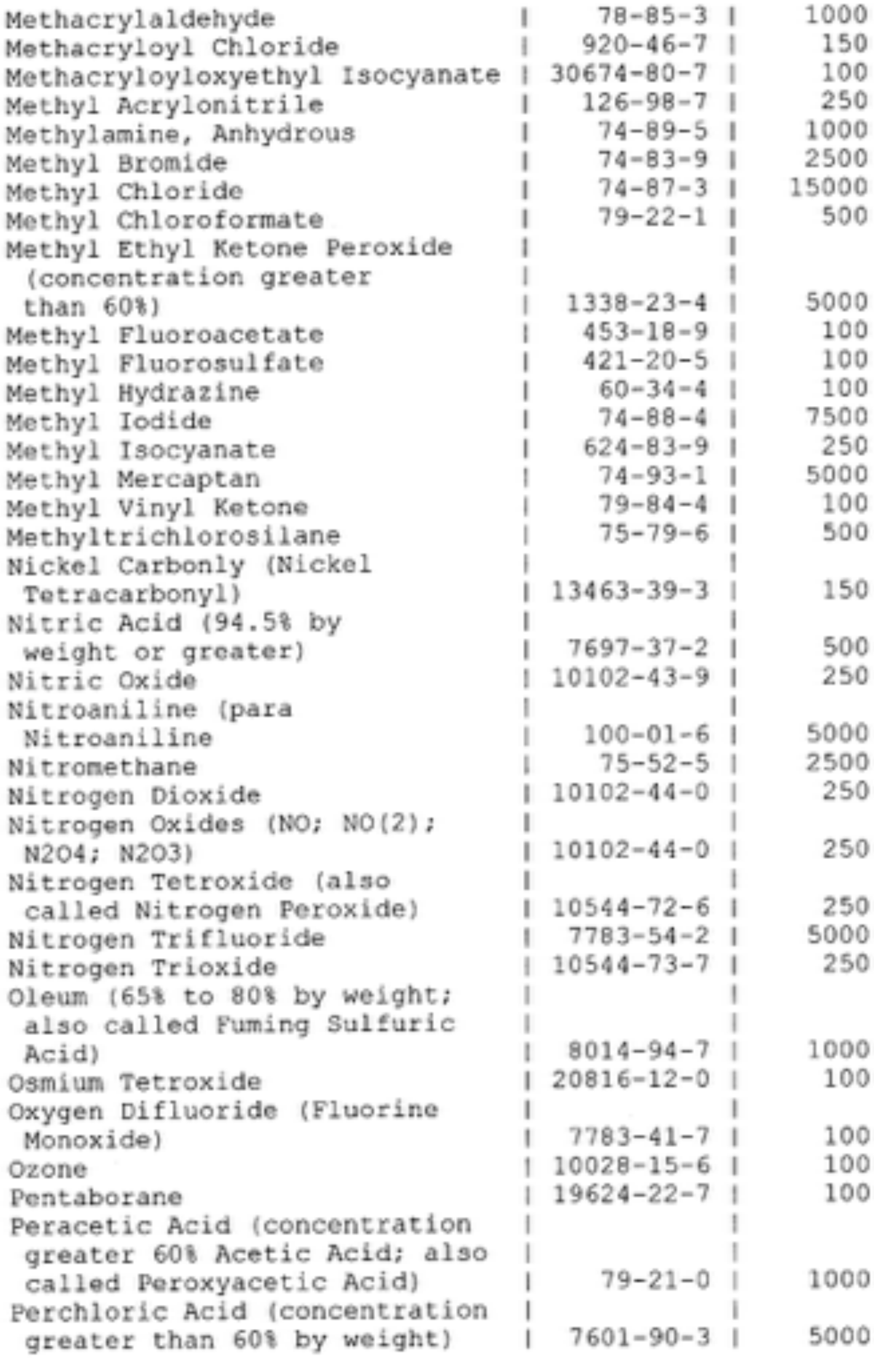
CHEMICAL NAME	CAS*	TQ**
Acetaldehyde	75-07-0	2500
Acetaldehyde	75-07-0	2500
Acrolein (2-Popenal)	107-02-8	150
Acrylyl Chlorde	814-68-6	250
Allyl Chlorid	107-05-1	1000
Allylamine	107-11-9	1000
Alkylaluminum	Varies	5000
Ammonia, Anhydrous	7664-41-7	10000
Ammonia solutions (greater than 44% ammonia by weight)	7664-41-7	15000
Ammonium Perchlorate	7790-98-9	7500
Ammonium Permanganate	7787-36-2	7500
Arsine (also called Arsenic Hydride)	7784-42-1	100
Bis(Chloromethyl) Ether	542-88-1	100
Boron Trichloride	10294-34-5	2500
Boron Trifluoride	7637-07-2	250
Bromine	7726-95-6	1500
Bromine Chloride	13863-41-7	1500
Bromine Pentafluoride	7789-30-2	2500
Bromine Trifluoride	7787-71-5	15000
3-Bromopropyne (also called Propargyl Bromide)	106-96-7	100
Butyl Hydroperoxide (Tertiary)	75-91-2	5000
Butyl Perbenzoate (Tertiary)	614-45-9	7500
Carbonyl Chloride (see Phosgene)	75-44-5	100
Carbonyl Fluoride	353-50-4	2500
Cellulose Nitrate (concentration greater than 12.6% nitrogen	9004-70-0	2500
Chlorine	7782-50-5	1500
Chlorine Dioxide	10049-04-4	1000
Chlorine Pentrafluoride	13637-63-3	1000
Chlorine Trifluoride	7790-91-2	1000
Chlorodiethylaluminum (also called Diethylaluminum Chloride)	96-10-6	5000
1-Chloro-2,4-Dinitrobenzene	97-00-7	5000
Chloromethyl Methyl Ether	107-30-2	500
Chloropicrin	76-06-2	500
Chloropicrin and Methyl Bromide mixture	None	1500
Chloropicrin and Methyl Chloride mixture	None	1500
Cumene Hydroperoxide	80-15-9	5000
Cyanogen	460-19-5	2500
Cyanogen Chloride	506-77-4	500
Cyanuric Fluoride	675-14-9	100

APPENDIX A (CONT.)
LIST OF HIGHLY HAZARDOUS CHEMICALS, TOXICS AND REACTIVES
PAGE 2 OF 4



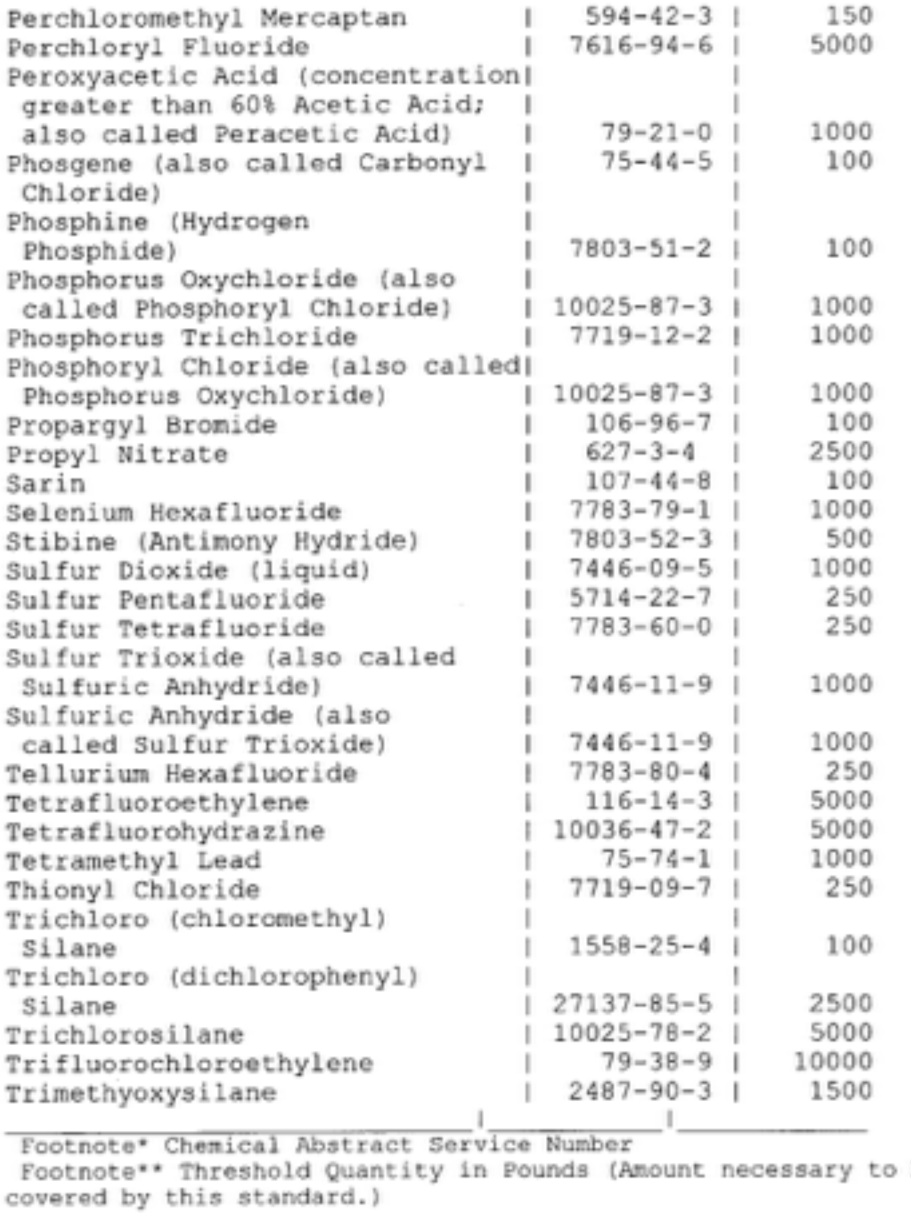
CHEMICAL NAME	CAS*	TQ**
Diacetyl Peroxide (concentration greater than 70%)	110-22-5	5000
Diazomethane	334-88-3	500
Dibenzoyl Peroxide	94-36-0	7500
Diborane	19287-45-7	100
Dibutyl Peroxide (Tertiary)	110-05-4	5000
Dichloro Acetylene	7572-29-4	250
Dichlorosilane	4109-96-0	2500
Diethylzinc	557-20-0	10000
Diisopropyl Peroxydicarbonate	105-64-6	7500
Dilauroyl Peroxide	105-74-8	7500
Dimethyldichlorosilane	75-78-5	1000
Dimethylhydrazine, 1,1-	57-14-7	1000
Dimethylamine, Anhydrous	124-40-3	2500
2,4-Dinitroaniline	97-02-9	5000
Ethyl Methyl Ketone Peroxide (also Methyl Ethyl Ketone Peroxide; concentration greater than 60%)	1338-23-4	5000
Ethyl Nitrite	109-95-5	5000
Ethylamine	75-04-7	7500
Ethylene Fluorohydrin	371-62-0	100
Ethylene Oxide	75-21-8	5000
Ethyleneimine	151-56-4	1000
Fluorine	7782-41-4	1000
Formaldehyde (Formalin)	50-00-0	1000
Furan	110-00-9	500
Hexafluoroacetone	684-16-2	5000
Hydrochloric Acid, Anhydrous	7647-01-0	5000
Hydrofluoric Acid, Anhydrous	7664-39-3	1000
Hydrogen Bromide	10035-10-6	5000
Hydrogen Chloride	7647-01-0	5000
Hydrogen Cyanide, Anhydrous	74-90-8	1000
Hydrogen Fluoride	7664-39-3	1000
Hydrogen Peroxide (52% by weight or greater)	7722-84-1	7500
Hydrogen Selenide	7783-07-5	150
Hydrogen Sulfide	7783-06-4	1500
Hydroxylamine	7803-49-8	2500
Iron, Pentacarbonyl	13463-40-6	250
Isopropylamine	75-31-0	5000
Ketene	463-51-4	100

APPENDIX A (CONT.)
LIST OF HIGHLY HAZARDOUS CHEMICALS, TOXICS AND REACTIVES
PAGE 3 OF 4



CHEMICAL NAME	CAS*	TQ**
Methacrylaldehyde	78-85-3	1000
Methacryloyl Chloride	920-46-7	150
Methacryloyloxyethyl Isocyanate	30674-80-7	100
Methyl Acrylonitrile	126-98-7	250
Methylamine, Anhydrous	74-89-5	1000
Methyl Bromide	74-83-9	2500
Methyl Chloride	74-87-3	15000
Methyl Chloroformate	79-22-1	500
Methyl Ethyl Ketone Peroxide (concentration greater than 60%)	1338-23-4	5000
Methyl Fluoroacetate	453-18-9	100
Methyl Fluorosulfate	421-20-5	100
Methyl Hydrazine	60-34-4	100
Methyl Iodide	74-88-4	7500
Methyl Isocyanate	624-83-9	250
Methyl Mercaptan	74-93-1	5000
Methyl Vinyl Ketone	79-84-4	100
Methyltrichlorosilane	75-79-6	500
Nickel Carbonly (Nickel Tetracarbonyl)	13463-39-3	150
Nitric Acid (94.5% by weight or greater)	7697-37-2	500
Nitric Oxide	10102-43-9	250
Nitroaniline (para Nitroaniline	100-01-6	5000
Nitromethane	75-52-5	2500
Nitrogen Dioxide	10102-44-0	250
Nitrogen Oxides (NO; NO(2); N2O4; N2O3)	10102-44-0	250
Nitrogen Tetroxide (also called Nitrogen Peroxide)	10544-72-6	250
Nitrogen Trifluoride	7783-54-2	5000
Nitrogen Trioxide	10544-73-7	250
Oleum (65% to 80% by weight; also called Fuming Sulfuric Acid)	8014-94-7	1000
Osmium Tetroxide	20816-12-0	100
Oxygen Difluoride (Fluorine Monoxide)	7783-41-7	100
Ozone	10028-15-6	100
Pentaborane	19624-22-7	100
Peracetic Acid (concentration greater 60% Acetic Acid; also called Peroxyacetic Acid)	79-21-0	1000
Perchloric Acid (concentration greater than 60% by weight)	7601-90-3	5000

APPENDIX A (CONT.)
LIST OF HIGHLY HAZARDOUS CHEMICALS, TOXICS AND REACTIVES
PAGE 4 OF 4

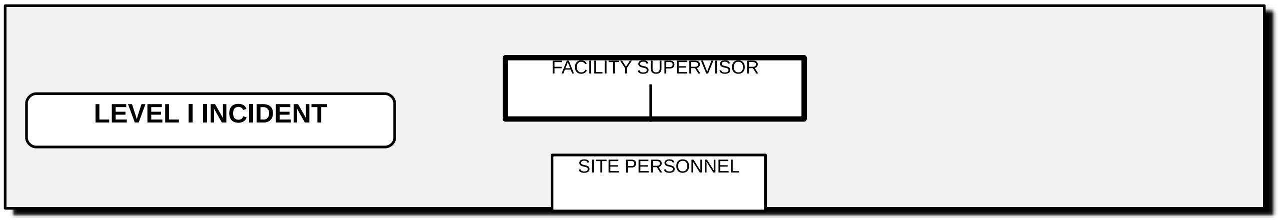


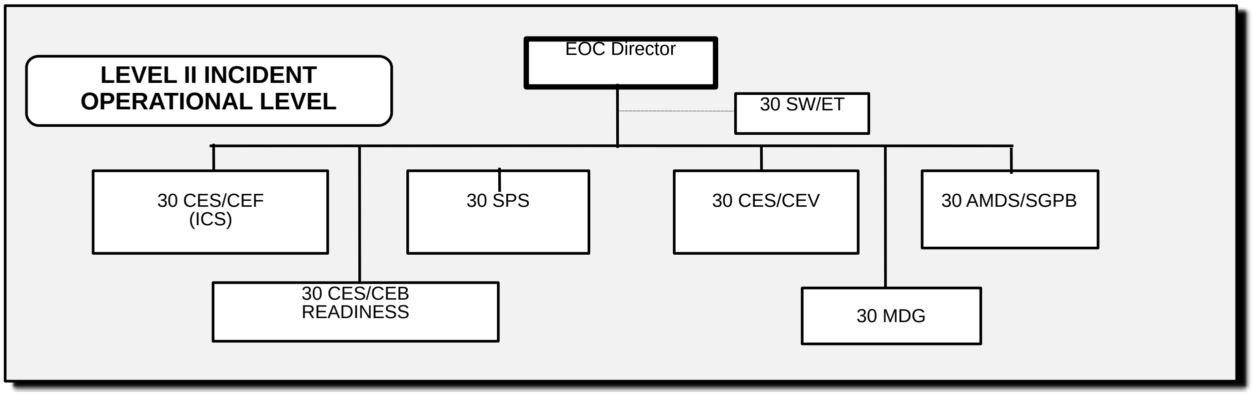
CHEMICAL NAME	CAS*	TQ**
Perchloromethyl Mercaptan	594-42-3	150
Perchloryl Fluoride	7616-94-6	5000
Peroxyacetic Acid (concentration greater than 60% Acetic Acid; also called Peracetic Acid)	79-21-0	1000
Phosgene (also called Carbonyl Chloride)	75-44-5	100
Phosphine (Hydrogen Phosphide)	7803-51-2	100
Phosphorus Oxychloride (also called Phosphoryl Chloride)	10025-87-3	1000
Phosphorus Trichloride	7719-12-2	1000
Phosphoryl Chloride (also called Phosphorus Oxychloride)	10025-87-3	1000
Propargyl Bromide	106-96-7	100
Propyl Nitrate	627-3-4	2500
Sarin	107-44-8	100
Selenium Hexafluoride	7783-79-1	1000
Stibine (Antimony Hydride)	7803-52-3	500
Sulfur Dioxide (liquid)	7446-09-5	1000
Sulfur Pentafluoride	5714-22-7	250
Sulfur Tetrafluoride	7783-60-0	250
Sulfur Trioxide (also called Sulfuric Anhydride)	7446-11-9	1000
Sulfuric Anhydride (also called Sulfur Trioxide)	7446-11-9	1000
Tellurium Hexafluoride	7783-80-4	250
Tetrafluoroethylene	116-14-3	5000
Tetrafluorohydrazine	10036-47-2	5000
Tetramethyl Lead	75-74-1	1000
Thionyl Chloride	7719-09-7	250
Trichloro (chloromethyl) Silane	1558-25-4	100
Trichloro (dichlorophenyl) Silane	27137-85-5	2500
Trichlorosilane	10025-78-2	5000
Trifluorochloroethylene	79-38-9	10000
Trimethyoxysilane	2487-90-3	1500

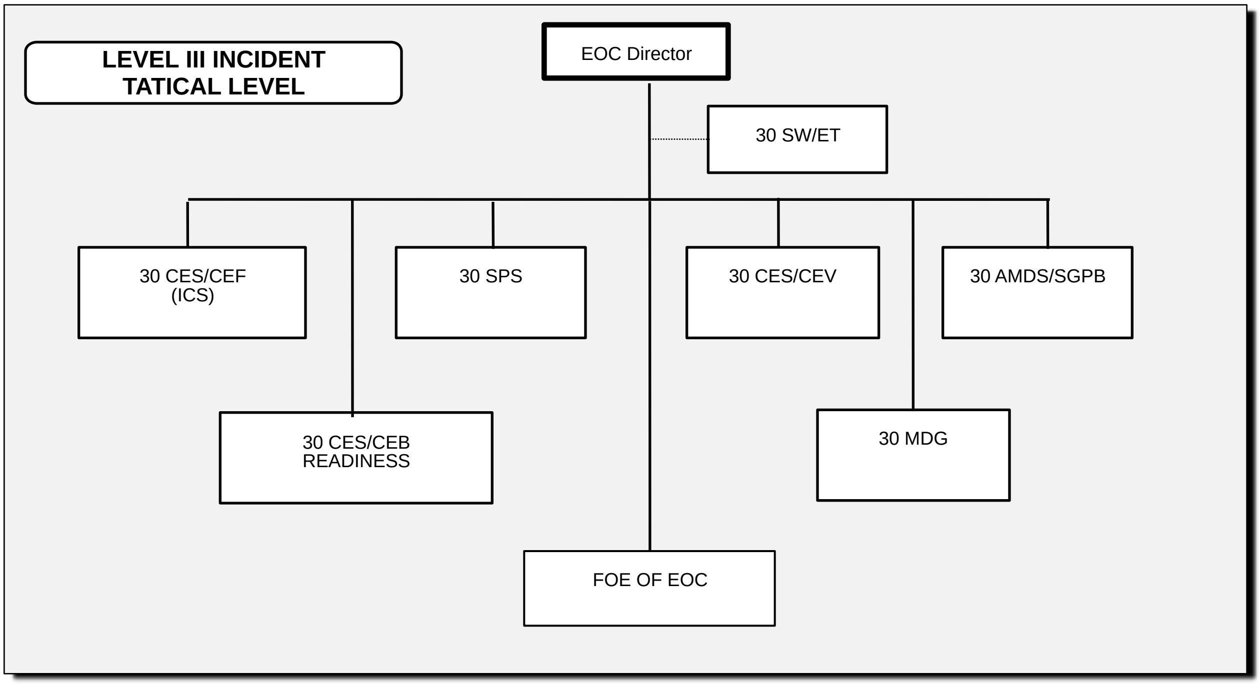
Footnote* Chemical Abstract Service Number
Footnote** Threshold Quantity in Pounds (Amount necessary to
covered by this standard.)

APPENDIX B
EMERGENCY OPERATIONS CENTER AND INCIDENT RESPONSE LEVELS

The Base Emergency Operations Center (EOC) responds across a variety of circumstances and levels of incident severity. The following diagram extracted from the 30 SW HAZMAT Plan illustrates how the EOC can be applied to different levels of emergencies.







APPENDIX B
EMERGENCY OPERATIONS CENTER AND INCIDENT RESPONSE LEVELS

Further details for activation of the EOC and organizational responsibilities are found in 30th Space Wing Comprehensive Emergency Management Plan (CEMP) 10-2. The EOC is activated with either through call to 911 or the base Command Post 606-9961. The EOC Director receives information concerning the incident and then determines what level of activation is required. The EOC elements report to a designated assembly point and then respond to the scene of the incident. At the incident scene the EOC director collects information and directs actions of the EOC team. UPC personnel are members of the EOC team, supporting the EOC Director in the area of hypergol emergencies. While members of the EOC, UPC personnel take their direction from the EOC Director. Should the EOC respond to a UPC operated facility, without UPC personnel as part of the EOC, UPC personnel will follow the directions of competent Air Force personnel who are directing actions at the scene. Should and direction place people in jeopardy or direction action beyond the scope of the contract UPC Managers will be notified immediately so that the situation can be resolved safety and within the limits of the Aerospace Support Services Contract.

Determining the Level of Response.

(a) Minor and Major Incidents. The level of response to a specific release is dependent upon the amount of material that is released and the hazard that it poses to personnel the environment, and to base facilities and equipment. In general, actual or potential releases of hazardous material can be divided into two categories:

- Minor releases that can be safely and competently handled by on-site personnel.
- Major releases that require the support of base emergency response elements to control, contain and/or clean up.

Most hazardous material incidents likely to occur on Vandenberg AFB will not meet the major accident classification and will not require activation of the EOC. However, all accidental releases of hazardous materials that exceed the applicable RQ must be promptly reported to the Environmental Flight.

(b) Response Levels. Responses to an accidental or unauthorized release of a hazardous material will vary depending upon the extent of the spill and the materials involved. Table 2-1, “Planning Guide for Determining Incident Response Levels,” which is derived from NFPA Standard 471, will be used to establish incident response levels for a hazardous materials release.

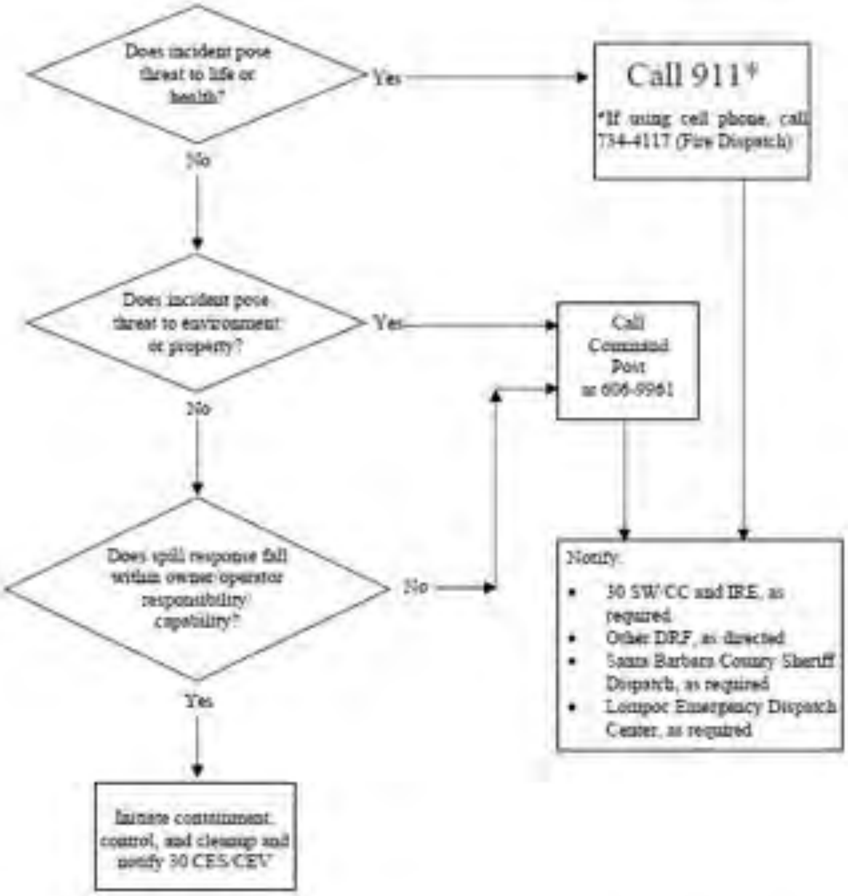
1. Level I. Level I designates a response to a minor release that can be safely and competently controlled, contained, and cleaned up by on-site personnel and that at most requires evacuation of only the immediate area. Typically, the incident is confined to a small area, involves small quantities of hazardous materials, and does not pose an immediate threat to life or property. No assistance is required to identify the material.

2. Level II. Level II designates a response to a significant on-site emergency, involving a threat to life and property and may require a limited evacuation of the surrounding area. Typically, control, containment, and cleanup of the release is beyond the capability and/or competence of facility personnel and the Initial Response Element of the EOC is required, at a minimum, to respond to and manage the incident.

APPENDIX B (CONT.)
EMERGENCY OPERATIONS CENTER AND INCIDENT RESPONSE LEVELS

3. Level III. Level III designates a response to an incident involving a severe hazard an/or a large area posing a significant threat to personnel safety, the environment, and property. Typically, the release could possibly affect both on-base and off-base locations. An evacuation of a substantial number of nearby facilities may be required. Incident response would include Vandenberg AFB emergency response elements and may also require mutual aid assistance.

Incident Reporting Decision Chart



Procedures are posted and available electronically via the ASSC Internet Home page located on the Vandenberg Air Force Base Network. No hard copy distribution is made.

Any printed versions in use must be verified for currency prior to use in accordance with statement on the front page of this procedure.

APPENDIX D

N-NITROSODIMETHYLAMINE (NDMA)

Technical Fact Sheet – N-Nitroso-dimethylamine (NDMA)

November 2017

TECHNICAL FACT SHEET– NDMA

At a Glance

- Formerly used in the production of rocket fuel, antioxidants and softeners for copolymers. Currently used only for research purposes.
- Unintended byproduct of chlorination of wastewater at wastewater treatment plants that use chloramines for disinfection, raising significant concern as a drinking water contaminant.
- Highly mobile in soil, with potential to leach into groundwater.
- Oral route is the primary human exposure pathway.
- Classified as a B2 (probable human) carcinogen.
- Listed as a priority pollutant by the EPA, but no federal standard has been established for drinking water.
- Detection methods include solid phase extraction, gas chromatography and liquid chromatography.
- Most common NDMA water cleanup method is via photolysis by ultraviolet radiation. Potential for aerobic and anaerobic NDMA biodegradation also exists.

Introduction

This fact sheet, developed by the U.S. Environmental Protection Agency (EPA) Federal Facilities Restoration and Reuse Office (FFRRO), provides a summary of the contaminant N-Nitrosodimethylamine (NDMA), including physical and chemical properties; environmental and health impacts; existing federal and state guidelines; detection and treatment methods; and additional sources of information. This fact sheet is intended for use by site managers and other field personnel who may address NDMA contamination at cleanup sites or in drinking water supplies.

NDMA is a drinking water contaminant of concern because of its miscibility with water, as well as its carcinogenicity and toxicity.

What is NDMA?

- NDMA is a semivolatile organic chemical that forms in both industrial and natural processes (Cal/EPA 2006; Mitch and others 2003b).
- NDMA is not currently produced in pure form or commercially used in the United States, except for research purposes. It was formerly used in production of liquid rocket fuel, antioxidants, additives for lubricants and softeners for copolymers (ATSDR 1989; HSDB 2013).
- NDMA can be unintentionally produced in and released from industrial sources through chemical reactions, such as those that involve alkylamines. Potential industrial sources include amine manufacturing plants, tanneries, pesticide manufacturing plants, rubber and tire manufacturers, fish processing facilities, foundries, dye manufacturers and surfactant industries (ATSDR 1989).
- NDMA is also an unintended byproduct of the chlorination of wastewater and drinking water at treatment plants that use chloramines for disinfection (Bradley and others 2005; Mitch and others 2003).

Disclaimer: The U.S. EPA prepared this fact sheet using the most recent publicly-available scientific information; additional information can be obtained from the source documents. This fact sheet is not intended to be used as a primary source of information and is not intended, nor can it be relied upon, to create any rights enforceable by any party in litigation with the United States. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Exhibit 1: Physical and Chemical Properties of NDMA
(ATSDR 1989; Cal/EPA 2006; HSDB 2013; NIOSH 2016)

Property	Value/Description
Chemical Abstract Systems (CAS) number	62-75-9
Physical description (physical state at room temperature)	Yellow liquid with faint or no odor
Molecular weight (g/mol)	74.08
Water solubility at 25°C	Miscible
Melting point (°C)	-25 (estimated)
Boiling point (°C)	152 to 154
Specific gravity/Density at 20°F/4°C (g/mL)	1.005 to 1.006
Vapor pressure at 20°C (mm Hg)	2.7
Organic carbon partition coefficient (log K_{oc})	1.07 (estimated)
Octanol-water partition coefficient (log K_{ow})	-0.57
Henry's law constant at 20°C (atm-m^3/mol)	2.63×10^{-7} (ATSDR 1989) 1.08×10^{-6} (HSDB 2013)

Abbreviations: g/mol – grams per mole; °C – degrees Celsius; g/mL – grams per milliliter; mm Hg – millimeters of mercury; atm-m^3/mol – atmosphere-cubic meters per mole.

Existence of NDMA in the environment

- NDMA contamination may be found in air, soil and water (ATSDR 1999).
- When released to the air, NDMA is expected to exist solely as vapor in the ambient atmosphere and is broken down quickly by sunlight within minutes (HSDB 2013).
- When released to soil, NDMA can be highly mobile and will either volatilize or leach into groundwater (ATSDR 1999; HSDB 2013).
- In water, NDMA is completely miscible and is not expected to sorb onto solid particles or sediment. NDMA may break down in water as a result of exposure to sunlight or by natural biological processes. The potential for bioconcentration in aquatic organisms is low based on an estimated bioconcentration factor of 3 (ATSDR 1999; HSDB 2013; WHO 2008).
- At rocket engine testing facilities in California, NDMA has been found at high concentrations in groundwater on site (up to 400,000 nanograms per liter [ng/L]) and also in downgradient drinking water wells (up to 20,000 ng/L) (Mitch and others 2003b).
- In a 2002 survey conducted by the California Department of Health Services (CDHS), elevated concentrations of NDMA were detected in locations where wastewater treatment plant effluent was used for aquifer recharge and near facilities that use unsymmetrical dimethylhydrazine (UDMH)-based rocket fuel (CDHS 2002; Mitch and others 2003b).
- As of March 2011, NDMA was the predominant nitrosamine detected in samples obtained from public water systems, which were monitored as part of the unregulated contaminant monitoring rule (UCMR). The EPA uses the UCMR to monitor contaminants that are suspected to be present in drinking water but that do not currently have health-based standards under the Safe Drinking Water Act (EPA 2011a; EPA 2014).
- The second UCMR was analyzed for NDMA occurrence and trends across the U.S. NDMA occurrence was strongly associated with chloramine use. Elevated NDMA was more common in surface water systems than groundwater systems. Smaller utilities were found to have the most extreme NDMA levels (Woods and Dickenson 2015)

What are the routes of exposure and potential health effects of NDMA?

- NDMA exposure may occur through (1) ingesting food that contains nitrosamines, such as smoked or cured meats and fish; (2) ingesting food that contains alkylamines, which can cause NDMA to form in the stomach; (3) drinking contaminated water; (4) drinking malt beverages (such as beer and whiskey) that may contain low levels of nitrosamines formed during processing; (5) using toiletry and cosmetic products such as shampoos and cleansers that contain NDMA; and (6) breathing or inhaling cigarette smoke. Workplace exposure can occur at tanneries, pesticide manufacturing plants and rubber and tire plants (ATSDR 1989, 1999).
- The oral route, including consumption of contaminated food and water, is the primary human exposure pathway for NDMA (ATSDR 1989; Cal/EPA 2006).
- Exposure to high levels of NDMA may cause liver damage in humans (ATSDR 1999; HSDB 2013).
- Potential symptoms of overexposure include headache; fever; nausea; jaundice; vomiting; abdominal cramps; enlarged liver; reduced function of liver, kidneys and lungs; and dizziness (HSDB 2013; OSHA 2005).
- EPA has classified NDMA as a B2 (probable human) carcinogen based on the induction of tumors at multiple sites in different mammal species exposed to NDMA by various routes (EPA IRIS 2002).
- The U.S. Department of Health and Human Services (DHHS) states that NDMA is reasonably anticipated to be a human carcinogen (NTP 2014).
- DHHS states that NDMA caused tumors in numerous species of experimental animals, at several different tissue sites, and by several different routes of exposure. Tumors occurred primarily of the liver, respiratory tract, kidney and blood vessels (NTP 2014; IARC 1998).
- The American Conference of Governmental Industrial Hygienists (ACGIH) has classified NDMA as a Group A3 confirmed animal carcinogen with unknown relevance to humans (HSDB 2013).

Are there any federal and state guidelines and health standards for NDMA?

- EPA has not derived a chronic oral reference dose (RfD) or a chronic inhalation reference concentration (RfC) for evaluating NDMA's noncancer effects in the EPA's Integrated Risk Information System database (EPA IRIS 2002).
- EPA has derived a RfD of 8.0 x 10^{-6} mg/kg-day and an RfC of 4.0 x 10^{-5} mg/m^3 as Provisional Peer-Reviewed Toxicity Values (PPRTVs) for evaluating noncancer effects (EPA 2007).
- EPA has assigned an oral slope factor for carcinogenic risk of 51 milligrams per kilogram per day $(mg/kg\text{-}day)^{-1}$, a drinking water unit risk of 1.4 x 10^{-3} per microgram per liter $(\mu g/L)^{-1}$ and an inhalation unit risk of 1.4 x 10^{-2} µg per cubic meter (m^3) (EPA IRIS 2002).
- For tap water, EPA calculated a screening level of 0.11 ng/L for NDMA, based on a 10^{-6} lifetime excess cancer risk (EPA 2017).
- EPA's screening levels for soil are 2.0 x 10^{-3} milligrams per kilogram (mg/kg) for residential and 3.4 x 10^{-2} mg/kg for industrial (based on 10^{-6} cancer risk). The soil screening level for protection of groundwater is 2.7 x 10^{-8} mg/kg (EPA 2017).
- EPA's screening levels for air are 7.2 x 10^{-5} micrograms per cubic meter (µg/m^3) for residential and 8.8 x 10^{-4} µg/m^3 for industrial (based on 10^{-6} cancer risk) (EPA 2017).
- Various states have established drinking water and groundwater guidelines, including the following:

State	Guideline (µg/L)	Source
Alabama	0.0013	ADEM 2008
Alaska	0.017	AL DEC 2008
California	0.003	Cal/EPA 2006
Colorado	0.00069	CDPHE 2013
Delaware	0.001	DE DNR 1999
Florida	0.0007	FDEP 2005
Indiana	0.0049	IDEM 2015
Massachusetts	0.01	MADEP 2004
Mississippi	0.00131	MS DEQ 2002
New Jersey	0.0007	NJDEP 2015
North Carolina	0.0007	NCDENR 2015
Pennsylvania	0.0014	PADEP 2011
Texas	0.018	TCEQ 2016
Washington	0.000858	WA DEP 2015
West Virginia	0.0013	WV DEP 2009

- EPA included NDMA on the fourth Contaminant Candidate List (CCL4), which is a list of unregulated contaminants that are known to or anticipated to occur in public water systems and may require regulation under the Safe Drinking Water Act (EPA 2016b).
- In addition, EPA added NDMA to its UCMR 2, requiring many large water utilities to monitor for NDMA (EPA 2015).

What detection and site characterization methods are available for NDMA?

- For drinking water, EPA Method 521 uses solid phase extraction (SPE) and capillary column gas chromatography (GC) with large-volume injection and chemical ionization tandem mass spectroscopy (MS) (EPA 2004).
- For wastewater, EPA Method 607 uses methylene chloride extraction, GC and a nitrogen-phosphorus detector (NPD) (EPA 2007; EPA 2016a).
- For wastewater, EPA Method 1625 uses isotope dilution, GC and MS (EPA 2007; EPA 2016a).
- For groundwater, wastewater, soil, sediment and sludges, EPA SW-846 Method 8070 uses methylene chloride extraction, GC and a NPD (EPA 1996).
- For solid waste matrices, soil, air sampling media and water samples, EPA SW-846 Method 8270 uses GC and MS (EPA 1998).
- An analytical method has also been developed specifically to quantify NDMA precursors such as alkylamines in waste or wastewater (Mitch, and others 2003).
- A method using liquid chromatography tandem MS (LC/MS/MS) detects both thermally stable and unstable nitrosamines in drinking water (Zhao and others 2006).
- A study developed a method that is a combination of SPE and LC/MS/MS for determination of NDMA in surface water, groundwater and wastewater samples. The quantification limit identified was 2 ng/L (Topuz and others 2012).
- Modifications to GC-MS and GC-NPD methods including sample evapoconcentration and low concentration instrument calibration can be used to detect NDMA in soil to levels below 1 microgram per kilogram (µg/kg) (USACE 2009).

What technologies are being used to treat NDMA?

- The most common method to treat NDMA in drinking water systems is photolysis by ultraviolet radiation in the wavelength range of 225 to 250 nanometers (nm) (Mitch and others 2003b).
- Biological treatment, microfiltration and reverse osmosis treatment may be used to remove NDMA precursors from wastewater before chlorination (Mitch and others 2003b).
- Activated sludge, biological activated carbon and ultraviolet photolysis were found to be effective for NDMA mitigation in a study investigating 11 sites using ozone-based wastewater treatment trains (Gerrity and others 2015).
- The Department of Defense’s Strategic Environmental Research and Development Program (SERDP) is investigating abiotic, biotic and coupled abiotic/biotic processes to accelerate NDMA degradation in the subsurface (DoD SERDP 2008, 2009, 2012).
- A recent study of NDMA precursors found that photolysis and biodegradation were effective removal mechanisms for precursors in the water column (Woods and Dickenson 2016).
- Laboratory-scale studies have shown that aerobic and anaerobic biodegradation of NDMA to low ng/L concentrations in water and soil may be possible (Bradley and others 2005; DoD SERDP 2008).
- A laboratory-scale study demonstrated the potential for in-situ aerobic cometabolism of NDMA in the presence of methane- and benzene-amended groundwater highlighting possible attenuation mechanisms and rates for NDMA biotransformation in aerobic aquifers undergoing active remediation, natural attenuation or managed aquifer recharge with treated wastewater (Weidhaas and Dupont 2013).
- An Environmental Security Technology Certification Program demonstration project evaluated the technical effectiveness and cost of using a fluidized bed bioreactor (FBR) for treating NDMA in groundwater at a test facility. The FBR was found to be an effective means to treat NDMA, decreasing concentrations from 1 µg/L to 4.2 ng/L. The cost of the full-scale FBR was determined to be significantly less than the comparable ultraviolet system over a 30-year remedial timeframe (ESTCP 2014).
- Laboratory-scale study results suggest that in-situ coupled abiotic/biotic processes may efficiently degrade NDMA in groundwater (DoD SERDP 2009).

- Membrane bioreactor (MBR) treatment was found to be effective in removing NDMA through biodegradation due to the presence of strong electron donating functional groups in their structure (Wijekoon and others 2013).
- An SERDP project was conducted to identify the organisms, enzymes and biochemical pathways involved in the aerobic biodegradation of NDMA. Laboratory-scale study results highlighted the importance of monooxygenases in the degradation of NDMA (DoD SERDP 2012).
- A SERDP field study was recently completed utilizing propane biosparging for in situ remediation of NDMA in groundwater. The field test results support that propane biosparging can be an effective approach to reduce the concentrations of NDMA in a groundwater aquifer by 3 to 4 orders of magnitude, and that concentrations in the low nanograms per liter (ng/L) range can be achieved with continuous treatment (DoD SERDP 2016).
- A laboratory-scale study observed the decomposition of NDMA in water using nanoscale zero-valent iron in the presence of aluminum and iron salts. The highest removal was found at a pH of 5. Improved removal was associated with a higher reaction temperature (Lin Lin and others 2013).

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PUBLIC HEALTH GOALS FOR CHEMICALS IN DRINKING WATER

N-Nitrosodimethylamine

December 2006

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Public Health Goal for
N-Nitrosodimethylamine
in Drinking Water

Prepared by

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December 2006

PREFACE

Drinking Water Public Health Goals
Pesticide and Environmental Toxicology Branch
Office of Environmental Health Hazard Assessment
California Environmental Protection Agency

This Public Health Goal (PHG) technical support document provides information on health effects from contaminants in drinking water. PHGs are developed for chemical contaminants based on the best available toxicological data in the scientific literature. These documents and the analyses contained in them provide estimates of the levels of contaminants in drinking water that would pose no significant health risk to individuals consuming the water on a daily basis over a lifetime.

The California Safe Drinking Water Act of 1996 (Health and Safety Code, Section 116365) requires the Office of Environmental Health Hazard Assessment (OEHHA) to perform risk assessments and adopt PHGs for contaminants in drinking water based exclusively on public health considerations. The Act requires that PHGs be set in accordance with the following criteria:

1. PHGs for acutely toxic substances shall be set at levels at which no known or anticipated adverse effects on health will occur, with an adequate margin of safety.
2. PHGs for carcinogens or other substances that may cause chronic disease shall be based solely on health effects and shall be set at levels that OEHHA has determined do not pose any significant risk to health.
3. To the extent the information is available, OEHHA shall consider possible synergistic effects resulting from exposure to two or more contaminants.
4. OEHHA shall consider potential adverse effects on members of subgroups that comprise a meaningful proportion of the population, including but not limited to infants, children, pregnant women, the elderly, and individuals with a history of serious illness.
5. OEHHA shall consider the contaminant exposure and body burden levels that alter physiological function or structure in a manner that may significantly increase the risk of illness.
6. OEHHA shall consider additive effects of exposure to contaminants in media other than drinking water, including food and air, and the resulting body burden.
7. In risk assessments that involve infants and children, OEHHA shall specifically assess exposure patterns, special susceptibility, multiple contaminants with toxic mechanisms in common, and the interactions of such contaminants.

8. In cases of insufficient data for OEHHA to determine a level that creates no significant risk, OEHHA shall set the PHG at a level that is protective of public health with an adequate margin of safety.
9. In cases where scientific evidence demonstrates that a safe dose response threshold for a contaminant exists, then the PHG should be set at that threshold.
10. The PHG may be set at zero if necessary to satisfy the requirements listed above in items seven and eight.
11. PHGs adopted by OEHHA shall be reviewed at least once every five years and revised as necessary based on the availability of new scientific data.

PHGs adopted by OEHHA are for use by the California Department of Health Services (DHS) in establishing primary drinking water standards (State Maximum Contaminant Levels, or MCLs). Whereas PHGs are to be based solely on scientific and public health considerations without regard to economic cost considerations or technical feasibility, drinking water standards adopted by DHS are to consider economic factors and technical feasibility. Each primary drinking water standard adopted by DHS shall be set at a level that is as close as feasible to the corresponding PHG, placing emphasis on the protection of public health. PHGs established by OEHHA are not regulatory in nature and represent only non-mandatory goals. By state and federal law, MCLs established by DHS must be at least as stringent as the federal MCL, if one exists.

PHG documents are used to provide technical assistance to DHS, and they are also informative reference materials for federal, state and local public health officials and the public. While the PHGs are calculated for single chemicals only, they may, if the information is available, address hazards associated with the interactions of contaminants in mixtures. Further, PHGs are derived for drinking water only and are not intended to be utilized as target levels for the contamination of other environmental media.

Additional information on PHGs can be obtained at the OEHHA Web site at www.oehha.ca.gov.

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PUBLIC HEALTH GOAL FOR N-NITROSODIMETHYLAMINE IN DRINKING WATER

SUMMARY

The Office of Environmental Health Hazard Assessment (OEHHA) has developed a Public Health Goal (PHG) of 3×10^{-6} mg/L (0.003 µg/L, 0.003 parts per billion, or ppb) for N-nitrosodimethylamine (NDMA) in drinking water. Studies by the California Department of Health Services (DHS) have documented the formation of NDMA during the water disinfection treatment process.

The PHG is based on an extra cancer risk of 1 in 1 million for lifetime exposure to NDMA in drinking water. There is no California or federal Maximum Contaminant Level (MCL) for NDMA. The California Notification Level (previously known as Action Level) for NDMA is 0.01 µg/L. Notification levels are defined by DHS as "health-based advisory levels established by DHS for chemicals in drinking water that lack maximum contaminant levels (MCLs)."

Carcinogenic effects observed in animal studies were judged to be the most sensitive endpoint and therefore are the basis of the PHG for NDMA. Significant increases in tumors have been observed in numerous species of animals administered NDMA by oral, inhalation or other routes of exposure. Evidence that specifically links exposure to NDMA to increased incidence of cancer in humans is generally lacking, but the available studies are suggestive. Studies on other nitrosamines support the presumption of potential human carcinogenicity of NDMA.

Using the findings of Peto *et al.* (1991b) a dose-response relationship was derived based on the occurrence of bile duct tumors in female rats using the linearized multistage model. The model was employed to estimate the dose associated with a 10 percent incidence of tumors. A linear relationship between dose and response was then employed to extrapolate to the one in a million cancer risk level, and corrected to human dose equivalents based on the ratio of rat and human body weights to the 3/4 power. Concentrations of NDMA associated with a lifetime theoretical extra cancer risk of 10^{-4} or 10^{-5} are 0.3 and 0.03 ppb, respectively.

Given the low volatility and skin permeability of NDMA, neither inhalation nor dermal exposure routes contribute significant amounts of exposure relative to the oral route. Therefore, the PHG was based on exposure by the oral route. A protective level has not been developed for non-cancer effects due to the lack of adequate toxicological studies that investigated other toxic endpoints. No specific sensitive populations were identified that were substantially at higher risk from the toxic effects of NDMA. The PHG level is judged to be adequately protective of lifetime exposure to NDMA in water.

INTRODUCTION

N-nitrosodimethylamine is a chemical formed in industrial and natural processes and is also created from nitrates and nitrites in the human gut. The nitrosamines are generally considered to be classic carcinogens, and a large amount of basic research on cancer mechanisms has been carried out on them.

NDMA occurs in various foods and alcoholic beverages, and is also detected in cigarette smoke. NDMA has also been detected in California drinking water. This specific chemical has been extensively studied in experimental animals and is considered an animal carcinogen. Because of similarities in its metabolism to reactive intermediates in animals and humans, it is considered as a likely human carcinogen.

NDMA has become more important in California because of its increasing detection in drinking water. It has been associated with the chloramine drinking water disinfection process, and has also been reported to be formed in the chlorination of wastewater used for aquifer recharge. NDMA may be formed from the nitrogen species added for chloramination (DHS, 2003) or from dimethylamine functional groups on polymers used for water filtration (Mitch and Sedlak, 2004). Because of concern over the exposures and the carcinogenic properties of NDMA, California DHS requested that OEHHA develop a PHG for NDMA, to support the development of a California MCL.

California presently has only a notification level (previously known as Action Level) for NDMA, which has been established at 0.01 μg/L. If a chemical is detected above its notification level in a municipal drinking water supply, a utility must provide timely notification of the local governing bodies (e.g., city council, county board of supervisors, or both). If this water is provided to consumers, DHS recommends that the utility inform its customers and consumers about the presence of the chemical, and about health concerns associated with exposure to it. If a chemical is present at concentrations considerably higher than its notification level (the "response level" of Health and Safety Code §116455), DHS recommends that the drinking water system take the source out of service (DHS, 2005).

CHEMICAL PROFILE

Chemical Identity

N-nitrosodimethylamine, also commonly referred to as dimethylnitrosamine, is a yellow oily liquid at room temperature. The Chemical Abstracts Service Registry number for NDMA is 62-75-9; its molecular formula is $C_2H_6N_2O$. The chemical structure of NDMA is shown in Figure 1.

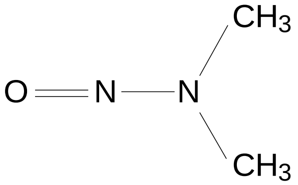


Figure 1. Structure of N-nitrosodimethylamine

Physical and Chemical Properties

Physical and chemical properties of NDMA are summarized in the following table.

Table 1. Physical and Chemical Properties of NDMA

Property	**Value**	**References**
Molecular weight	74.08	Weast, 1989
Color	Yellow	IARC, 1978
Physical state	Liquid	IARC, 1978
Odor	No distinctive odor	Frank and Berry, 1981
Melting point	-25 ^{0}C (estimated)	Lyman, 1985
Boiling point	154 ^{0}C	Weast, 1989
Solubility		
Water	Miscible	Mirvish *et al.*, 1976
Organic solvents	Soluble in water, alcohol, ether	Weast, 1989; IARC, 1978
Specific gravity	1.0059 g/mL	Weast, 1989
Partition coefficients		
Log Octanol-H_2O (Log K_{ow})	-0.57	Hansch *et al.*, 1995
Log soil-organic carbon-H_2O (Log K_{oc})	1.07 (estimate)	ATSDR, 1989
Vapor pressure	2.7 mm Hg (20^{0}C)	Klein, 1982
Henry's law constant (37^{0}C)	1.99 10^{-6} atm-m^3/mol	Mirvish *et al.*, 1976
Conversion factors**:**		
mg/m^3 = 3.08 x ppm (air) (20^{0}C)		ATSDR, 1989
ppm (air) = mg/m^3 x 0.325 (20^{0}C)		ATSDR, 1989

Production and Uses

NDMA does not appear to be currently produced or commercially used (other than for research purposes) in the United States (HSDB, Hazardous Substance Data Base, 2004). It was formerly used in the production of rocket fuels and was used as an antioxidant, additive for lubricants, and a softening agent for copolymers (HSDB, 2004). NDMA can form inadvertently and be released into the environment from a large array of manmade sources including tanneries, pesticide manufacturing plants, rubber and tire plants, foundries and dye manufacturers (ASTDR, 1989). It also appears to be formed in trace levels in the drinking water disinfection process (DHS, 2003; Mitch and Sedlak, 2004).

ENVIRONMENTAL OCCURRENCE AND HUMAN EXPOSURE

Air

NDMA has a low vapor pressure and is not likely to sorb onto particulates to any extent (IPSC, 2002). In the ambient atmosphere, NDMA would be expected to rapidly degrade when exposed to sunlight, with a half-life estimate of 5 to 30 minutes (ATSDR, 1989).

Soil

NDMA is highly mobile in soil and therefore has the potential to leach into groundwater (ATSDR, 1989). Little NDMA would be expected in surficial soils, as photolysis and volatilization would rapidly remove NDMA from the surface (IPSC, 2002).

Water

NDMA is miscible in water. Given its low vapor pressure, very low Henry's constant and low octanol/water partition coefficient, little NDMA would be expected to sorb onto particles or volatilize from water. The California DHS conducted a survey of a number of water systems to determine the extent of NDMA occurrence in drinking water. NDMA was frequently detected in the finished drinking water (Table 2). NDMA may be occurring because it is present in sources of drinking water or may occur as a byproduct of disinfection (DHS, 2003). Chlorination of wastewater used for groundwater recharge and the chloramination process have both been associated with formation of NDMA. Some of the NDMA may be derived from interaction of chlorination chemicals with dimethylamine functional groups on polymers used for water filtration (Mitch and Sedlak, 2004).

NDMA in liquid rocket fuels was the source of contamination of groundwater at rocket testing facilities in California at Baldwin Park in the San Gabriel Valley (see www.epa.gov/superfund/accomp/success/sangabriel.htm) and in Rancho Cordova. At the latter, concentrations of NDMA in groundwater onsite were up to 40,000 ng/L, and offsite at up to 20,000 ng/L (Mitch *et al*., 2003).

Table 2. NDMA Results from Surface Water Treatment Plants[1]

Water System	Location	1st Round NDMA Results (ppt)	2nd Round NDMA results (ppt)
A	Plant Influent	<1	
A	Distribution	<1	
B	Plant Influent	<1	<1
B	Plant Effluent	<1	<1
B	Distribution	<1	<1
C	Plant Influent	<1	
C	Plant Effluent	1.8	<1
C	Distribution	1.3	<1
D	Plant Influent	1.3	<1
D	Plant Effluent	3.9	<1
D	Distribution	<1	<1
E	Plant Influent	<1	<1
E	Plant Effluent	3.3	<1
E	Distribution	<1	<1
F	Plant Influent	1.1	<1
F	Plant Effluent	1.5	<1
F	Distribution	2.5	<1
G	Plant Influent	<1	
G	Plant Effluent	<1	
G	Distribution	<1	
H	Plant Influent	1.8	<1
H	Plant Effluent	<1	<1
H	Distribution	1.4	<1
I	Plant Influent	<1	
I	Plant Effluent	1	2
I	Distribution	4.3	1.6
J	Plant Influent	9.4	<1
J	Plant Effluent	2.3	<1
J	Distribution	1.4	<1
K	Plant Influent	<1	
K	Plant Effluent	<1	1.1
K	Distribution	<1	1.8
L	Plant Influent	1.5	<1
L	Plant Effluent	4.6	<1
L	Distribution	4.4	<1
M	Plant Influent	<1	
M	Plant Effluent	<1	
M	Distribution	<1	
N	Plant Influent	1.2	1.1

N	Plant Effluent	5.3	4.5
N	Distribution	7.4	3.8
O	Plant Influent	<1	
O	Plant Effluent	<1	
O	Distribution	3.2	<1
P	Plant Influent	2.4	<1
P	Plant Effluent	3.2	1.8
P	Distribution	1.1	1.1
Q	Plant Influent	<1	
Q	Plant Effluent	<1	
Q	Distribution	1.8	
R	Plant Influent	1.1	1
R	Plant Effluent	2.4	1.8
R	Distribution	1.8	1.5
S	Plant Effluent	<1	
S	Distribution	1.2	
T	Plant Influent	<1	3.9
T	Plant Effluent	3	1.5
T	Distribution	3.7	1.3
U	Plant Influent	<1	
U	Plant Effluent	2.5	1.9
U	Distribution	6.8	2.6
V	Plant Influent	<1	<1
V	Plant Effluent	1.7	1.8
V	Distribution	1.8	1.8
W	Plant Influent	<1	
W	Plant Effluent	<1	
W	Distribution	1.7	
X	Plant Influent	1.2	<1
X	Plant Effluent	3.9	3.4
X	Distribution	4.4	4.6
Y	Plant Influent	<1	
Y	Plant Effluent	<1	
Y	Distribution	<1	
Z	Plant Influent	1.2	<1
Z	Plant Effluent	1.1	<1
Z	Distribution	<1	<1
AA	Plant Influent	<1	1.7
AA	Plant Effluent	63.7; 26.2; <1	2
AA	Distribution	2.4	2.2
BB	Plant Influent	<1	
BB	Plant Effluent	1.2	
BB	Distribution	2.6	1.8

CC	Plant Influent	<1	
CC	Plant Effluent	2.4	
CC	Distribution	28.3; 1.1	
DD	Plant Influent	<1	
DD	Plant Effluent	<1	
DD	Distribution	<1	1.1
EE	Plant Influent	<1	
EE	Plant Effluent	10.4; <1	<1
EE	Distribution	<1	<1
FF	Plant Effluent	18.3	2
FF	Distribution	15.8	13.4

[1] DHS, 2003

Food

NDMA has been detected in a variety of different foods, but given its low octanol/water partition coefficient, NDMA would not be expected to bioaccumulate to any great extent (IPSC, 2002). IARC (1978) provides a thorough summary of the results of studies that have detected NDMA in various foods. NDMA has been detected in foods such as cheese, meat and fish, and in alcoholic beverages such as beer, rum, whiskey and brandy (IARC, 1978, ATSDR, 1989). NDMA occurs in foods (meats) preserved by the addition of nitrate, nitrite, or cured by smoking. The cooking of cured meats is believed to result in the formation of NDMA.

Nitrates and nitrites appear to be converted to NDMA or other nitrosamines in the stomach (Mirvish, 1975; Pignatelli *et al.*, 1993; Bartsch and Montesano, 1984), and also by bacteria in the gastrointestinal tract (Mirvish, 1975). Other constituents in the diet such as dimethylamine, trimethylamine, or choline and lecithin are converted to dimethylamine or trimethylamine by bacteria, which probably results in NDMA formation (Tannenbaum, 1980). Exposure to high dietary sources of nitrosamines has been associated with higher cancer rates in some populations (ATSDR, 1989).

Other Sources

NDMA has been detected in consumer products such as cosmetics and related personal care products (IPSC, 2002). The curing of tobacco is thought to facilitate the formation of nitrosamines. NDMA also has been detected in the mainstream and side stream smoke of cigarettes (IARC, 1978). The burning of tobacco is believed to foster the conversion of introduced nitrates and nitrites into NMDA.

EXPOSURE ASSESSMENT

Oral exposure

Important sources of exposure to NDMA include the consumption of food and beverages (ATSDR, 1989). The ingestion of drinking water that contains NDMA appears to contribute only a small fraction of the overall NDMA exposure (Environment Canada, 2001). Rough estimates of the exposure to various sources of NDMA in Canada indicate that water contributes less than 10 percent of the overall exposure (IPSC, 2002).). A report from U.S. EPA staff (Fristachi and Rice, 2005) indicates that the trace levels of NDMA in drinking water contribute from 0.001 to 0.55 percent (or less than one percent) of overall human exposure to NDMA. Higher concentrations as observed in groundwater plumes derived from rocket testing facilities could result in much higher exposures in some cases.

Because relative source contribution (RSC) is not utilized in cancer risk calculations, no attempt is made here to formally document the contribution of drinking water relative to other sources (e.g.. food, beer, formation from nitrates and nitrites in the GI tract). Estimation of non-cancer risks, for which RSC is traditionally used, is not appropriate for this chemical because of inadequate data.

Inhalation exposure

No data are available regarding the concentration of NDMA in indoor air associated with the use of a domestic water supply. The potential for inhalation exposure to NDMA during showering can be estimated using Henry's constant, which is a measure of the relative ability of chemicals to partition into air from a water phase. Henry's constants for NDMA have been reported as 2.63×10^{-7} atm-m^3/mole at 20° C, and 1.99×10^{-6} atm-m^3/mole at 37° C (ATSDR, 1989). Given these very low values, negligible quantities of NDMA would be expected to partition from the shower water into the air during showering. Exposure to NDMA entrained in droplets during showering is also expected to be insignificant.

Dermal Exposure

The contribution of dermal exposure to NDMA that occurs during showering relative to exposure due to the ingestion of drinking water can be calculated, based on the dermal permeability constant of NDMA (Kp) of 0.000265 cm/hr (Oak Ridge National Laboratory, 2004). With an average body surface area of 20,000 cm^2, and a showering time of 10 minutes/day, the dermal dose can be estimated for a drinking water concentration of one parts per million (ppm) as follows:

$$\text{Dose (mg/day)} = 1\ \mu\text{g/cm}^3 \times 0.000265\ \text{cm/hr} \times 20{,}000\ \text{cm} \times 1/6\ \text{hr showering/day}$$

$$= 0.88\ \mu\text{g/day or } 8.8\times10^{-4}\ \text{mg/day}$$

The dose from ingestion at the same NDMA concentration would be 2 mg/day (1 mg/L x 2 L/day. The relative contribution from the two exposure routes would therefore be:

$$\text{Dose}_{\text{dermal}}/\text{Dose}_{\text{ingestion}} = 8.8\times10^{-4}\ \text{mg/day} / 2\ \text{mg/day} = 4.4\times10^{-4} \text{ or } 0.04 \text{ percent}$$

The contribution to total dose by the dermal route resulting from showering is therefore judged to be negligible, compared to the oral exposure route.

METABOLISM AND PHARMACOKINETICS

Absorption

NDMA appears to be readily absorbed from the gastrointestinal tract. Less than two percent of a 2 mg/kg oral dose of NDMA was recovered in the stomach and intestine 15 minutes after its administration to fasted female rats (Diaz Gomez *et al.*, 1977). The amount of methylation of DNA in the liver was proportional to dose (up to 10 mg/kg) suggesting oral absorption was not saturated (Diaz Gomez *et al.*, 1977). Following the oral administration of NDMA to rats, approximately 50 percent of a 5 mg/kg dose was recovered as CO_2 after six hours (Agrelo *et al.*, 1978).

Little NDMA administered in saline to the rat was absorbed in the stomach, while the small intestine appeared to be the primary locus of NDMA absorption (Phillips *et al.*, 1975). Less than 10 percent of the dose of NDMA introduced into the small intestine of female rats remained after 20 minutes, while little NDMA introduced into the stomach disappeared after 30 minutes (Phillips *et al.*, 1975). The ligation of the stomach markedly reduced the rate of metabolism of NDMA (generation of CO_2 following intragastric administration) in the female rat compared to unligated animals (Phillips *et al.*, 1975). The co-administration of casein with NDMA had little effect on the adsorption of NDMA (Agrelo *et al.*, 1978).

Percutaneous absorption of NDMA was measured *in vitro* in human cadaver skin in unsealed Franz type diffusion cells using three separate vehicles (Brain *et al.*, 1995). From one to four percent of the administered dose was recovered in the receptor fluid after 48 hours. Most of the dose was not accounted for in the skin or skin wash and was presumed lost due to volatilization. Thus, the rate of absorption of NDMA was greatly influenced by the loss of the compound due to volatilization. The recovery in the receptor fluid, skin or skin wash of nitrosodiethanolamine, a less volatile nitrosamine, was effectively complete.

Distribution

In early studies in rats or mice, similar concentrations of NDMA were observed in various organs one to four hours following intravenous injection (Magee (1956) or 24 hours following subcutaneous injection (Dutton and Heath, 1956), suggesting that the compound was distributed to body water. These findings were confirmed by Wishnok *et al.* (1978) and Johansson and Tjalve (1978). A uniform distribution of radioactivity was observed 30 minutes and one hour following intravenous administration of labeled NDMA to mice treated with compounds that prevented NDMA metabolism in the liver (Johansson and Tjalve, 1978).

Metabolism

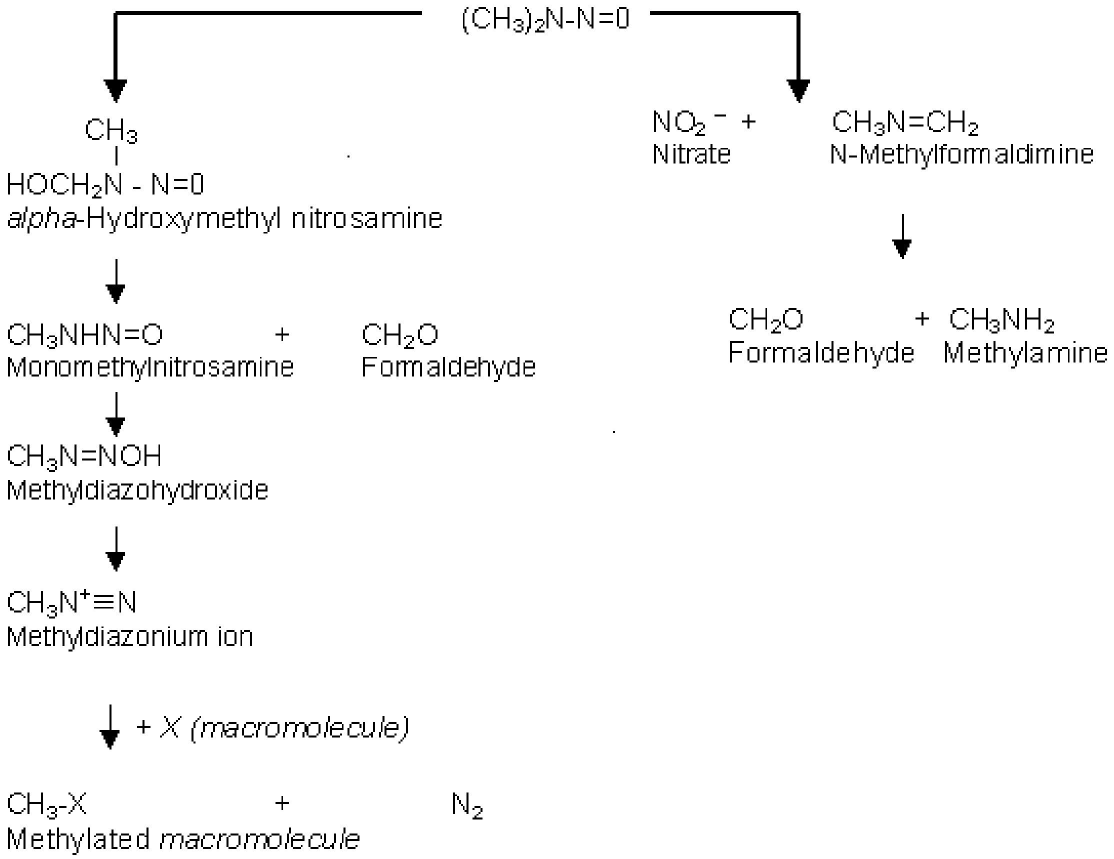
NDMA itself appears to be essentially biologically inert. However, metabolites of NDMA appear to be responsible for the host of toxic effects associated with NDMA exposure. The metabolism of NDMA and other nitrosamines have been extensively studied because this agent is considered a prototype of toxicants that produce toxicity or carcinogenicity due to metabolism to an active form(s) (Magee and Barnes, 1967; Preussmann and Stewart, 1984; Lai and Arcos, 1980). The metabolism of NDMA has been studied *in vitro* in microsomes, in tissue slices, and in cell cultures and isolated organs. I*n vivo*, metabolism has been evaluated in a number of animal species, in male and female, immature and mature animals, using inducers and inhibitors of drug metabolism, and recently by employing transfected and knockout animal models. While a comprehensive review of all these studies is beyond the scope of this document, certain pertinent findings will be discussed.

The observation by Magee (1956) of a rapid decline of NDMA levels in the whole animal (rats or mice) with little recovery of NDMA in the excreta first indicated that this compound was rapidly metabolized. Little of the administered dose was recovered in the urine and the removal of the kidney had little effect of the amount of NDMA recovered (Magee, 1956). In contrast, most of the administered dose was recovered in animals that were hepatectomized, indicating that most of the metabolism occurred in the liver (Magee, 1956).

Only a small fraction (approximately 10 percent) of orally administered NDMA (100 nmole) was recovered in mice as NDMA after 15 minutes, which also suggested very rapid metabolism (Kawanishi *et al.*, 1983). Blocking NDMA metabolism with pyrazole resulted in the recovery of most of the NDMA dose after 60 minutes. Dutton and Heath (1956) recovered 40 percent of a subcutaneously administered dose in the expired air of rats as $^{14}CO_2$ after eight hours, which suggested metabolism of NDMA by a demethylation pathway. In female rats administered 5 mg of NDMA, 48 percent of a intragastrically administered dose was recovered as CO_2 after seven hours, compared to 54 percent recovery when the dose was administered by intravenous injection (Phillips *et al.*, 1975).

Two pathways of NDMA metabolism, α-hydroxylation and denitrosation (Figure 2) have been characterized (Keefer *et al.*, 1987). Studies in the rat have indicated that around 70 percent or more of administered NDMA is metabolized via the α-hydroxylation pathway (Burak *et al.*, 1991). Approximately 20 percent of an intravenous bolus dose of NDMA administered to male Fischer 344 rats appeared to be metabolized by the denitrosation pathway (Streeter *et al.*, 1990a).

Figure 2. Metabolic pathway for NDMA[a]



[a] adapted from IPSC, 2002

The α-hydroxylation metabolic pathway is initiated by the hydroxylation of NDMA at the α carbon yielding hydroxyl NDMA, an unstable intermediate. The metabolite then decomposes to yield formaldehyde and the methyldiazonium ion another unstable and reactive intermediate. The methyl group on the methyldiazonium ion reacts with nucleophiles (e.g. DNA, RNA and proteins) by transferring a methyl group and releasing N_2. Formaldehyde is metabolized to formate and then CO_2.

The other identified route of NDMA metabolism is denitrosation (Keefer *et al.*, 1987; Lorr *et al.*, 1982; Tu and Yang, 1985; Streeter *et al.*, 1990a). NDMA is first metabolized to an unstable imine intermediate and nitric oxide (NO·). The imine ion decomposes to formaldehyde and methylamine while the nitric oxide combines with oxygen to form nitrite (NO_2^-). Both pathways involve a cytochrome P450 dependent mixed-function oxidase system and both pathways appear to be catalyzed mainly by the same cytochrome P450 isoform, CYP2E1 (Yoo *et al.*, 1990; Lorr *et al.*, 1982; Wade *et al.*, 1987; Yang *et al.*, 1985, 1990). While CYP2E1 has been identified as the enzyme mainly responsible for NDMA metabolism at low concentrations (Thomas *et al.*, 1987, Wrighton *et al.*, 1986; Yoo *et al.*, 1990), other cytochrome P450 isoforms also appear to be capable of metabolizing NDMA but principally at higher concentrations (Yamazaki *et al.*, 1992; Yang *et al.*, 1985; Yang *et al.*, 1990). Reconstituted purified CYP2E1 from male New Zealand rabbits, Sprague Dawley or Long Evans rats, or human liver was an effective catalyst of NDMA metabolism to formaldehyde *in vitro* (Yang *et al.*, 1985; Tu and Yang, 1985; Levin *et al.*, 1986; Yamazaki *et al.*, 1992).

Metabolism of NDMA by both pathways was markedly increased in hepatic microsomes from rats treated with inducers of CYP2E1 such as isopropanol, ethanol or pyrazole, compared to control (Lorr *et al.*, 1982). Competitive inhibitors of CYP2E1 (acetone, dioxane, ethanol, isopropanol, pyrazole) reduced NDMA metabolism through each pathway by about the same amount (Lorr *et al.*, 1982; Tu and Yang, 1985). Using an antibody to CYP2E1, both α-hydroxylation and the denitrosation metabolism of NDMA in microsomes was markedly reduced (Yang *et al.*, 1991; Yoo *et al.*, 1990; Dicker and Cederbaum, 1991).

Metabolism of NDMA in humans and rodents appears to be very similar, both qualitatively and quantitatively. Measured NDMA demethylase Km and Vmax values *in vitro* were similar in the human and the rat liver. The human enzyme cross-reacted with an antibody prepared against the rat liver enzyme (Yoo *et al.*, 1990). Most (68-78 percent) of the NDMA demethylase activity in human microsomes was inhibited by antibodies prepared against the rat enzyme (Wrighton *et al.*, 1986).

Comparative *in vitro* metabolism of NDMA in liver slices revealed the hamster with the highest rate of metabolism, with the rat somewhat greater than the human and the monkey and trout with substantially lower rates of metabolism (as measured by CO_2 generation and adduct formation) (Bartsch and Montesano, 1984). Inducers of NDMA metabolism in the rat (ethanol, isoniazid) also appeared to induce human hepatic NDMA demethylase metabolism (Wrighton *et al.*, 1986).

While NDMA appears to be metabolized by two pathways, the α-hydroxylation pathway is believed to be responsible for formation of the active metabolite(s) that is responsible for the observed carcinogenicity and genotoxicity of NDMA (Magee and Barnes, 1967; Preussmann and Stewart, 1984; Lai and Arcos, 1980) but not necessarily its hepatotoxic activity (Archer *et al.*, 1994; Chin *et al.*, 1993). However, Lee and associates linked hepatotoxicity with α-hydroxylation metabolism of NDMA (Lee *et al.*, 1996).

The level of NDMA in the blood following oral administration is primarily controlled by amount metabolized in the liver (virtually all of the dose is absorbed from the gut). The fraction of an orally administered dose of NDMA that occurred in blood (compared to I.V. administration) has been investigated in a number of different species (Table 3). The fraction of the oral dose (the area under the blood concentration time plot) relative to what occurred following I.V. administration (where the entire dose would have initially occurred in the blood) was markedly different in different species. Approximately 10 percent of the oral administered dose was accounted for in the blood of the rat and hamster, while at least 50 percent of the dose was observed in the monkey, dog or pig (Gombar *et al.*, 1987, 1990; Streeter *et al.*, 1990b). This suggests that metabolism was saturated in the larger species while most of the oral dose administered was immediately metabolized in the liver (first pass clearance) in the rat and hamster. No comparable studies were identified in humans.

Table 3. Fraction of Oral Dose Accounted for in the Blood[a]

Species	Fraction of oral dose in blood (%)
Hamster	11
Rat	8
Monkey	49
Dog	93
Pig	67

[a] Area under curve (oral administration)/ Area under curve (i.v. administration)

The concomitant (or prior) administration of ethanol, a competitive inhibitor of NDMA metabolism in the liver, with NDMA resulted in marked increases in the AUC (blood) and decrease in blood clearance in the mouse and monkey (Anderson *et al.*, 1992, 1994). Higher tissue levels were also observed when ethanol was co-administered with NDMA in the mouse (Anderson *et al.*, 1986, 1994).

Consistent with these findings was the observation that co-administration of ethanol with NDMA to the monkey resulted in increased methylation in ovary, esophagus, bladder, spleen and cerebellum, but no increase in methylation in liver, compared to when NDMA was administered alone (Anderson *et al.*, 1996). Increased methylation in the non-hepatic tissues appears to have occurred because ethanol inhibited NDMA metabolism in the liver. Similar findings were observed in the rat (Swann *et al.*, 1984). Increased tumors in extrahepatic organs in mice also occurred when ethanol was co-administered with NDMA, compared to NDMA alone (Anderson, 1988, 1992; Griciute *et al.*, 1987).

A number of agents and interventions can markedly influence the metabolism of NDMA and other nitrosamines. Protein reduced diets and competitive inhibitors such as ethanol, methanol and disulfiram that reduce NDMA metabolism in the liver have been demonstrated to reduce hepatotoxicity and the incidence of liver tumors (Swann and McLean, 1971; Swann *et al.*, 1980; Anderson *et al.*, 1994). When hepatic metabolism is reduced by the inhibitors, the amount of extrahepatic metabolism increases along with increased carcinogenicity in the kidney and other tissues (depending on the nitrosamine) (reviewed by Barsch and Montesano, 1984)). Other agents or interventions such as fasting and ethanol administration to rats induce NDMA metabolism (Tu and Yang, 1983). In humans, microsomes obtained from the livers of alcoholics appear to metabolize NDMA to formaldehyde or nitrite two to three fold faster than in non-alcoholics (Amelizad *et al.*, 1989).

The metabolism of NDMA by demethylation generates the methyldiazonium ion that reacts with DNA, RNA and proteins. O^6-methyl guanine-DNA transferase (MGMT), is an enzyme that repairs O^6-methyl guanine and other O^6-alkyl guanine DNA adducts (Saffhill *et al.*, 1985; Lindahl *et al.*, 1988; Pegg, 1990; Swenberg *et al.*, 1982). The enzyme transfers the methyl group from guanine to a cysteine residue on the transferase (itself), which results in the permanent inactivation of the enzyme (Pegg, 1990; Lindahl *et al.*, 1988; Pegg and Byers, 1992). The level of MGMT activity is quite variable in different tissues and species (Hall *et al.*, 1985, 1990; Gerson *et al.*, 1986). Shiraishi and coworkers observed a high homology of amino acid sequences of the human and mouse liver MGMT enzyme (Shiraishi *et al.*, 1992).

Excretion

Because of its rapid metabolism, little NDMA is expected to be excreted unchanged. No unchanged NDMA that was intravenously administered to hamsters was detected in the urine (Streeter *et al.*, 1990b). Little NDMA was recovered in the excreta, which also indicated that this compound was rapidly metabolized (Magee, 1956). Little of the administered dose was recovered in the urine and the removal of the kidney had little effect on the amount of NDMA recovered.

TOXICOLOGY

Toxicological Effects in Animals

Since the early observation that human exposure to NDMA resulted in cirrhosis of the liver, most toxicity studies of NDMA in animals have focused on the liver.

Acute Toxicity

The oral LD_{50} of NDMA in the rat was reported as 37 mg/kg (RTECS, 2002) and 40 mg/kg (ATSDR, 1989). The oral LD_{50} in hamster was 28 mg/kg, the 4-hour inhalation LC_{50} was 78 ppm in rats and 57 ppm in mice (RTECS, 2002; ATSDR, 1989).

Subchronic Toxicity

Subchronic exposure of rats mice, hamsters, cats, dogs, rabbits, guinea pigs and other animals to NDMA resulted in a variety of adverse effects (e.g. toxicity in the lung, liver, kidney). The predominant effect was hepatotoxicity in a number of species with varying susceptibilities (Maduagwu and Bassir, 1980). Hepatotoxicity was characterized by necrosis and hemorrhage, fibrosis, ascites depending on dose, route and length of exposure (George and Chandrakasan, 2000; George *et al.*, 2001; Desjardins *et al.*, 1992; Jezequel *et al.*, 1987). Decreased survival in these animals is usually linked to severe hepatotoxicity. Gastrointestinal hemorrhage was observed in rats administered 10 mg/kg of NDMA in the diet for 34-37 days (Barnes and Magee, 1954).

Genetic Toxicity

Because NDMA has become a prototypical compound for carcinogenic agents that are believed to act by reacting with DNA, the genotoxicity of NDMA has been extensively studied in a host of *in vitro* or *in vivo* bioassays. Genotoxic effects have been reported, as indicated by increased frequency of sister chromatid exchange, unscheduled DNA synthesis, chromosomal aberrations, micronuclei, DNA strand breaks and the formation of adducts. ATSDR in 1989 summarized some of the available *in vivo* and *in vitro* studies regarding the genotoxicity of NDMA (ATSDR, 1989). Tables 4 and 5 are adopted from the ATSDR summary (ATSDR, 1989). IPSC in 2002 provides a more recent summary of genotoxic studies that buttresses the conclusion that NDMA is genotoxic in most species, cell types and test systems (IPSC, 2002). A comprehensive list of "mutation data" and references can be found in Registry of Toxic Effects of Chemical Substances (RTECS, 2002).

Table 4. *In Vitro* NDMA Genotoxicity Findings [a]

Endpoint	Species/Test System	Results	
		With Activation	Without Activation
Gene mutation	*Salmonella typhimurium*	+	+
	Escherichia coli	+	
	Saccharomyces cerevisiae	+	
	Chinese hamster V79 and ovary cells	+	-
	Mouse lymphoma L5178Y cells	+	-
DNA fragmentation	Rat hepatocytes		+
	Human hepatocytes		
Chromosomal aberrations	Chinese hamster lung cells	+	+
	Rat ascites hepatoma (AH66B) and rat esophageal (R1, R3) tumor cells		+
Sister-chromatid exchange	Rat esophageal tumor, ascites hepatoma		+
	Human lymphocytes	+	-
	Human fibroblasts	+	
	Chinese hamster ovary cells	+	-
	Chinese hamster V79 cells	+	-
	Chinese hamster primary lung cells	+	-
DNA Damage	Rat hepatocytes		+
DNA repair/synthesis	Rat hepatocytes	+	+
	Human lymphoblasts	+	
	Mice hepatocytes		+
	Hamster hepatocytes		+
	Rat pancreatic cells		-

[a] Adapted from ATSDR (1989)

Two notable studies observed genotoxicity in the offspring of animals exposed to NDMA (Chhabra *et al.*, 1995, Diaz Gomez *et al.*, 1986). NDMA was administered (intragastric; 1.0 mg/kg or 0.1 mg/kg) to two pregnant Patas monkeys on gestation day 147 (Chhabra *et al.*, 1995). The animals were anesthetized and the fetuses were removed 2 hours after NDMA administration and DNA was isolated from various maternal and fetal tissues. O^6-methylguanine adducts were detected in all fetal tissues sampled, with highest levels in the liver and placenta. Interestingly, the administration of ethanol reduced adduct levels in the fetal liver and placenta and roughly doubled adduct levels detected in other fetal tissues such as the spleen, kidney, and lung.

Oral administration of NDMA to nursing Sprague-Dawley rat dams (1 or 10 mg/kg) resulted in detectable levels of liver and kidney DNA and RNA adducts in their 14 day old offspring 24 hours post treatment (Diaz Gomez *et al.*, 1986).

Table 5. *In Vivo* NDMA Genotoxicity Findings [a]

Endpoint	Species/Test System	Results
DNA methylation	Rat, mouse, hamster and/or gerbil liver	+
	Human liver	+
DNA fragmentation	Rat liver and kidney elution	+
	Mouse liver and kidney elution	+
+DNA synthesis and repair	Fetal mouse kidney and liver	+
	Mouse testes	+
	Rat liver	+
	Rat respiratory cells	+
	Rat spermatocytes	-
Sex-linked recessive lethal mutations	Drosophila melanogaster	+
Sperm abnormalities	Mouse	-
Sister chromatid exchange	Chinese hamster bone marrow	+/-
	Mouse bone marrow	+
Chromosome aberrations	Hamster embryo fibroblasts	+
Micronucleus	Rat bone marrow	+/-
	Rat hepatocytes	+
	Mouse bone marrow	+
	Hamster embryonic fibroblasts	+

[a] Adapted from ATSDR (1989)

Developmental and Reproductive Toxicity

Few studies were located on the reproductive or developmental effects of NDMA. The available data are inadequate to assess the reproductive or developmental toxicity of

NDMA. Female CD-1 mice were administered 0.1 ppm NDMA in drinking water for 75 days prior to mating, throughout pregnancy and during lactation (Anderson *et al.*, 1978 as reported by IPSC, 2002). The number of stillbirth and newborn deaths increased two-fold compared to control. No other effects were reported and no abnormal histopathology in the fetuses was evident that accounted for the deaths.

Intraperitoneal administration of a very high dose of NDMA (37 mg/kg) to pregnant female mice on gestation day 16 or 19 resulted in the death of all fetuses (Anderson *et al.*, 1989). No information regarding maternal toxicity was provided and the dose used was reported to be in the range of the LD_{50} in mice. In the same study, a dose of 7.4 mg/kg administered to the pregnant mice on either day was reported to be "tolerated," and resulted in a significant increase in the number of female offspring with liver tumors when administered on day 19 (Anderson *et al.*, 1989). Several studies reviewed by ATSDR in which large doses of NDMA were administered during pregnancy (by gavage or in the diet) on unspecified day(s) resulted in increased fetal mortality (ATSDR, 1989). Little information regarding maternal toxicity was reported in these studies.

Immunotoxicity

Immunosuppressive properties of NDMA have been reviewed by Haggerty and Holsapple, 1990. Potential effects of NDMA on immune function were first investigated because many carcinogens are also known to suppress the immune system. Holsapple and coworkers (Holsapple *et al.*, 1984), Duke and associates (Duke *et al.*, 1985), Desjardins *et al.*, 1992, Johnson *et al.*, 1987, Thomas *et al.*, 1985, and Jeong and Lee, 1998 observed that NDMA suppressed various measures of humoral immunity. For example, exposure of female $B6C3F_1$ mice for 14 days to NDMA (1.5, 3.0 or 5.0 mg/kg) by intraperitoneal injection suppressed IgM antibody-forming cell response to sheep red blood cells (on day four) in a dose–dependent manner (Holsapple *et al.*, 1984). In the same study, spleenocyte proliferation in response to lipopolysaccharide was also suppressed by NDMA administration. Other measures of immune dysfunction including reduced host resistance to infectious agents (reduced response to streptococci and influenza challenge) following NDMA administration also indicate effects on humoral immunity (Thomas *et al.*, 1985).

Effects on cell-mediated immunity are more equivocal (Holsapple *et al.*, 1985; Thomas *et al.*, 1985). Exposure of female $B6C3F_1$ mice for 14 days to NDMA (1.5, 3.0 or 5.0 mg/kg) by intraperitoneal injection resulted in depressed T-lymphocyte function as measured by T-cell proliferation in response to T-cell mitogens (Holsapple *et al.*, 1985). NDMA exposure also resulted in a dose-related reduction in mixed lymphocyte response to DBA-2 lymphocytes. However, NDMA-exposed animals exhibited an increased resistance to challenge with *Listeria monocytogenes* bacteria (Holsapple *et al.*, 1985). This was also observed in mice treated with cyclophosphamide. NDMA administration to adult female mice by intraperitoneal injection resulted in increased host resistance to administered melanoma cells (as indicated by a decreased incidence and number of lung nodules in animals injected with $B_{16}F_{10}$ melanoma) (Duke *et al.*, 1985). These somewhat surprising findings of increased cell-mediated immunity following NDMA administration may be the result of increased numbers or activity of monocytes or macrophages (and perhaps natural killer cell activity).

Carcinogenicity

The carcinogenic activity of NDMA in animals was first observed by Magee and Barnes (1956), in the form of liver tumors following oral administration of NDMA to rats. Nineteen of 20 rats fed 50 mg/kg NDMA in their diet developed hepatic tumors within 40 weeks. Numerous investigators have confirmed these findings in the liver and other tissues, employing various routes of administration in a number of species. These studies have been reviewed by IARC (1972, 1978), ATSDR (1989), Lijinsky (1983), and IPSC (2002). A comprehensive list of "tumorigenic data" and references can be found in the Registry of Toxic Effects of Chemical Substances (RTECS, 2002).

In addition to NDMA, other nitrosamines have been shown to produce cancer in several species, using various routes of administration and exposure protocols (reviewed by EPA, 1980; ATSDR, 1989; Lijinsky, 1983). Interestingly, the tumor sites were often different than those caused by NDMA. The liver is not a common target for most nitrosamines (Lijinsky, 1983). For example, while chronic oral exposure to NDMA yielded mainly liver tumors, the administration of N-nitrosodiethylamine yielded esophageal tumors at low doses, with liver tumors only at high doses (Lijinsky, 1983).

Different species and strains respond differently to NDMA (Lijinsky, 1983, Yan *et al.*, 1998). Oral exposure to NDMA yielded lung and liver tumors in the mouse, liver and kidney tumors in the rat, and liver and nasal cavity tumors in the Syrian Hamster (Lijinsky, 1983; Tomatis *et al.*, 1964). Intraperitoneal administration of NDMA to mice yielded lung tumors but no liver tumors (Clapp and Toya, 1970). In the hamster, oral administration of NDMA resulted in elevated hepatocellular carcinomas and cholangiocarcinomas but no lung tumors (Tomatis *et al.*, 1964). These observations were part of investigations on the carcinogenic mechanisms of nitrosamines, in attempts to understand the etiology of cancer. The following discussion will focus on the findings in rats or mice, in which there are superior cancer bioassays.

Inhalation exposure

When NDMA was administered by inhalation to BALB/c mice (0.005 or 0.2 mg/m^3 for 17 months) or Wistar rats (0.005 or 0.2 mg/m^3 for 25 months), tumors were observed in the lung, liver, and kidney (Moiseev and Benemansky, 1975 as reported in IARC, 1978). Marked increases in tumors of the nasal cavity were observed in female Sprague-Dawley rats administered NDMA by inhalation, 0.04, 0.2 or 1.0 ppm, four times a week for 207 days (Klein *et al.*, 1991).

Tumors of the nasal cavity were observed in 4 of 6 BD rats exposed by inhalation to NDMA twice weekly at a concentration which resulted in an equivalent dose of 4 mg/kg, and 8 of 12 rats at half that concentration (Druckrey, 1967 as reported in IARC, 1978).

Oral exposure

Oral administration of NDMA resulted in tumors of the liver and kidney in the mouse; liver, bile duct and kidney in the rat; liver and bile duct in the hamster; and liver in the rabbit and guinea pig (IARC, 1978; Preussmann and Stewart, 1984; Peto *et al.*, 1991a,b). Magee and Barnes (1956) reported that the dietary administration of 50 mg/kg NDMA resulted in hepatic tumors in 19 of 20 rats by 40 weeks. However, when male rats were administered NDMA in their diet at doses of 100 or 200 mg/kg for one to four weeks, or when only one 30 mg/kg dose was administered, kidney tumors occurred, but no hepatic tumors were observed (Magee and Barnes, 1959, 1962).

In a very large cancer bioassay, groups of 60 male or female Colworth-Wistar rats were administered NDMA in their drinking water, beginning at six weeks of age (Peto *et al.*, 1991a; Peto *et al.*, 1991b). The control group contained 240 male or female animals. Sixteen dose groups (Tables 6-9) were included in this study and the exposure continued for the animals' lifetime (no scheduled terminal sacrifices). Body weights and water intakes were recorded weekly. Because there was no correspondence between NDMA concentration and water intake, daily dosage was estimated based on an average of measured water consumption across all dose groups in male or female rats (41 and 72 mL/kg-day respectively).

Survival in the eight lowest dose groups was excellent (up to 3.5 years, median survival for males was 33 months, median survival for females was 30 months). The prolonged survival allowed tumors to develop that probably would not have been detected in a standard two-year bioassay. However, early mortality in the highest eight dose groups, mostly due to liver tumors, would be expected to markedly reduce the detection of tumors at other sites.

The animals were sacrificed and necropsied if moribund or exhibiting palpable liver alterations. In each animal, tumors that were present were judged to be directly or indirectly responsible for the animal's death, or were considered to be incidental to the cause of death. This determination was vital to the statistical treatment of the study findings.

The investigators provided summaries of the occurrence of tumors in various treatment groups. Specific tumor findings were not reported for individual animals. Attempts to obtain such records were unsuccessful, as the records are no longer available, according to one of the investigators (personal communication with R Peto). The study results are shown in Tables 6-9. Tumors were reported in both males and females in four cell types in the liver, the hepatocyte, bile duct, mesenchyme and Kupffer cell (Tables 6 and 7). The authors also summarized hepatic tumor-bearing animals (Tables 8 and 9).

The investigators reported that nearly all of the bile duct neoplasms were benign while nearly all neoplasms of the liver cell were malignant. While the tumors were classified as mostly benign, they were lethal. The investigators reported that at the intermediate dose "…so many animals die prematurely of bile duct neoplasm that few have time to die of hepatocelllar neoplasms." In humans, a majority of primary tumors of the biliary tract are carcinomas (De Groen *et al.,* 1999).

Table 6. Hepatic Tumors by Subtype in Male Rats Administered NDMA

Exposure group	NDMA in drinking water (mg/L)	Estimated intake (mg/kg-day)[a]	Animals with hepatic tumors (tumor bearing animals) [b]			
			Liver cell	Bile duct	Mesenchyme	Kupffer Cell
1	0	0	10	3	0	0
2	0.033	0.001	4	2	0	0
3	0.066	0.003	3	3	0	1
4	0.132	0.005	2	2	1	0
5	0.264	0.011	4	2	1	0
6	0.528	0.022	4	1	0	0
7	1.056	0.044	5	1	1	2
8	1.584	0.065	8	4	0	0
9	2.112	0.087	7	7	7	0
10	2.640	0.109	13	13	5	3
11	3.168	0.131	14	12	12	0
12	4.224	0.174	19	12	10	0
13	5.280	0.218	27	16	3	2
14	6.336	0.261	32	18	7	0
15	8.448	0.348	44	8	4	0
16	16.896	0.697	46	0	10	0

[a] Intakes estimated by authors (Peto *et al.*, 1991a).
[b] From Table 7 (Peto *et al.*, 1991a).

Table 7. Hepatic Tumors by Subtype in Female Rats Administered NDMA

Exposure group	NDMA in drinking-water (mg/L)	Estimated intake (mg/kg-day)[a]	Animals with hepatic tumors (tumor bearing animals)[b]			
			Liver cell	Bile duct	Mesenchyme	Kupffer Cell
1	0	0	11	4	0	1
2	0.033	0.002	2	1	1	0
3	0.066	0.005	2	4	0	0
4	0.132	0.010	4	1	0	0
5	0.264	0.019	2	4	1	0
6	0.528	0.038	6	4	1	1

7	1.056	0.076	6	9	2	1
8	1.584	0.115	3	39	0	0
9	2.112	0.153	7	33	3	1
10	2.640	0.191	7	44	1	0
11	3.168	0.229	4	48	3	0
12	4.224	0.306	7	46	2	0
13	5.280	0.382	13	44	0	0
14	6.336	0.459	20	38	2	0
15	8.448	0.612	40	10	5	0
16	16.896	1.224	41	1	12	0

[a] Intakes estimated by authors (Peto *et al.*, 1991a).
[b] From Table 7 (Peto *et al.*, 1991a).

Table 8. Hepatic Tumors in Male Rats Administered NDMA

Exposure group	NDMA in drinking-water (mg/L)	Estimated intake (mg/kg-day)[a]	Animals with hepatic tumors (Tumor Bearing Animals)[b]
1	0	0	13
2	0.033	0.001	5
3	0.066	0.003	7
4	0.132	0.005	5
5	0.264	0.011	6
6	0.528	0.022	5
7	1.056	0.044	9
8	1.584	0.065	12
9	2.112	0.087	19
10	2.640	0.109	35
11	3.168	0.131	38
12	4.224	0.174	41
13	5.280	0.218	48
14	6.336	0.261	56
15	8.448	0.348	56
16	16.896	0.697	59

[a] Intakes estimated by authors (Peto *et al.*, 1991a).
[b] From Table 8 (Peto *et al.*, 1991a).

Table 9. Hepatic Tumors in Female Rats Administered NDMA

Exposure group	NDMA in drinking-water (mg/L)	Estimated intake (mg/kg-day)[a]	Animals with hepatic tumors (Tumor Bearing Animals)[b]
1	0	0	16
2	0.033	0.002	4
3	0.066	0.005	6
4	0.132	0.010	5
5	0.264	0.019	7
6	0.528	0.038	12
7	1.056	0.076	18
8	1.584	0.115	42
9	2.112	0.153	43
10	2.640	0.191	51
11	3.168	0.229	55
12	4.224	0.306	56
13	5.280	0.382	58
14	6.336	0.459	59
15	8.448	0.612	57
16	16.896	1.224	58

[a] Intakes estimated by authors (Peto *et al.*, 1991a).
[b] From Table 8 (Peto *et al.*, 1991a).

Survival curves for the various dose groups provided by the investigators revealed that tumors in the lower dose groups appeared quite late in the affected animals' lifetime. Had the animals been sacrificed at two years, many of the tumors in the low dose groups may have not been detected. Also notable was that in the higher dose groups the tumors appeared much earlier. Thus, the dose of administered NDMA appeared to govern both the incidence of hepatic tumors and when they occurred.

Given that the appearance of tumors (how many and at what time they appeared) was governed by the NDMA dose, the investigators performed a time-to-tumor analysis. The incidences of liver tumors (all sites) were found to be related to both dose and time in the following manner:

Male rats $CI = 37.43(d + 0.1)^6 t^7$

Female rats $CI = 51.45(d + 0.1)^6 t^7$

Where:

CI = cumulative index (incidence)
d = dose (mg/kg-day)
t = time (yr)

This extensive study was chosen for derivation of the cancer potency and development of the PHG.

In another study, two generations of female BALB/c mice were administered NDMA (3 ppm) in their drinking water for up to 80 weeks (Terracini *et al.*, 1973). Exposure to NDMA began when the mice were weaned at 4-5 weeks of age. Lung tumors were observed in 44 of 62 NDMA-treated mice compared to 20 of 62 control mice in the first generation, and 44 of 66 treated mice compared to 15 of 69 control mice in the second generation.

Female Fischer 344 rats were administered NDMA (5.5 or 13 mg/L) in their drinking water, 5 days a week for 7 months (Lijinsky and Reuber, 1984). The rats were then maintained for the duration of their lifetime, as no terminal sacrifice was undertaken. Mortality occurred earlier in rats treated with NDMA. Liver tumors were observed in 2 of 20 control rats, in 14 or 20 at the low dose, and 17 of 20 rats at the high dose.

Male and female Wistar rats were provided with 0, 0.1, 1.0, or 10 ppm NDMA in their diet for 96 weeks (Arai *et al.*, 1979). Hepatocellular carcinomas were observed in 3 of 17 females receiving 1.0 ppm and 2 of 9 receiving 10 ppm of NDMA, with 1 of 17 and 3 of 9 females displaying hemangioendothelioma in the liver at the aforementioned doses. Three of 17 males receiving 10 ppm NDMA displayed hemangioendothelioma. No tumors were detected in control rats.

NDMA was administered in the diet of female Porton rats (0, 2, 5, 10, 20 or 50 ppm) for up to 120 weeks, although most animals were sacrificed by 120 weeks (Terracini *et al.*, 1967). A marked increase in liver tumors was observed in the female rats administered NDMA, which appeared to be dose related (Table 10). No kidney tumors were observed in these animals.

Table 10. Liver Tumors in Female Porton Rats Administered NDMA[1]

Concentration in diet (ppm)	Liver tumors weeks 0-60	Liver tumors weeks 61-120
0	0 of 4	0 of 25
2	0 of 5	0 of 13
5	0 of 8	7 of 69
10	--	2 of 5
20	5 of 10	10 of 13
50	10 of 12	--

[1] Terracini *et al.*, 1967.

Other routes of exposure

NDMA was administered subcutaneously to male or female Chinese hamsters once weekly at doses of 3.4, 1.8 or 0.9 mg/kg. Mean survival was 29 to 36 weeks in treated animals and 82-87 weeks in controls. Most of the treated animals developed liver tumors, but there were very few tumors at other sites (Reznik *et al.*, 1976). The administration of a single dose of NDMA by the intraperitoneal route (5, 10, 15 mg/kg) to male mice resulted in 9/18, 16/19 and 4/5 mice with lung tumors, respectively, compared to 25/52 in the control group (Clapp, 1973).

Wistar rats were subcutaneously administered 0.125, 10, 20 or 30 mg/kg NDMA on day one, seven, 21 or 70 (Campbell *et al.*, 1974). Significant increases in kidney tumors were observed in animals injected on day one or day seven at the lower doses, while only the highest dose yielded significant number of kidney tumors on day 21 and 70. No kidney tumors were detected in control animals.

Weekly subcutaneous or intraperitoneal injections of 0.15 mg of NDMA to various strains of mice for 1 to 25 weeks resulted in very high incidences of liver (hemangioendothelial sarcomas) and lung tumors (Kuwahara *et al.*, 1972; Otsuka and Kuwahara, 1971). No control groups were utilized in these studies but the investigators reported that these strains of mice had very low incidence of spontaneous tumors.

Intraperitoneal injection of neonatal C57BL/6 mice (selected because of their relative insensitivity to carcinogens) with 10.5 or 26.2 mg/kg (total dose) of NDMA on day eight and day fifteen resulted in a statistically significant increase in liver tumors at 15 months (Dass *et al.*, 1998). Significant increases in lung tumors were not observed. Thrice weekly intraperitoneal injection of male C3H mice with 3 mg/kg NDMA for seven weeks resulted in 37 of 38 mice with lung tumors, compared to 7 of 28 in animals receiving the vehicle (Devereux *et al.*, 1991). The number of hepatic tumors in treated mice did not appear to be significantly different from that in the control group.

Prenatal/perinatal exposure

Female Strain A mice were administered 10 μg/L NDMA in drinking water from four weeks prior to mating, throughout pregnancy and lactation (Anderson *et al.*, 1979). After weaning, the offspring were then exposed to 10 μg/L NDMA in their drinking water until they were 22 weeks of age. Eight of 25 treated male mice compared to 1 of 23 control mice displayed lung tumors, which was reported to be statistically significant. No treatment-related tumors were observed in the female offspring. Significant increases in tumors were not observed in the liver.

Single or repeated injection of 12.5 to 75 mg/kg NDMA to mice during the final days of pregnancy resulted in lung adenomas and hepatomas in the offspring (Smetanin, 1971 as reported by IARC, 1978). Intraperitoneal injection of male Fischer 344 rats with 0-50 mg/kg NDMA three days post-weaning yielded a dose-dependent increase in kidney tumors (Driver *et al.*, 1987).

Tomatis (1973) observed that the administration of NDMA during the final days of pregnancy induced tumors in rats and mice (as reported by U.S. EPA, 1980). The effects were observed following oral, subcutaneous, intraperitoneal, or intravenous administration but were not observed when the compound was administered earlier in the pregnancy.

Mechanism

Metabolism

Extensive research has been focused on the mechanism(s) of tumors induced in animals by NDMA and other nitrosamines. Magee and Hultin (1962) and Magee and Farber (1962) demonstrated *in vitro* and *in vivo* alkylation of nucleic acids and proteins by NDMA and other nitrosamines in the rat and mouse. Subsequently, a number of investigators have linked the appearance of methylated DNA adducts derived from NDMA with the appearance of tumors. Both the ability of a tissue to metabolize NDMA and thereby generate DNA adducts, and the ability of the tissue to repair DNA adducts appear to play important roles in the mechanism of NDMA carcinogenicity.

NDMA metabolism can occur in a number of tissues but occurs primarily in the liver, particularly following oral exposure. Small oral doses of NDMA are essentially removed from the blood by the liver in the first pass, because of its rapid metabolism. Thus, when small doses of NDMA were administered orally to rats, nucleic acid alkylation was detected largely in the liver (Diaz Gomez *et al.*, 1977). The oral administration of higher doses of NDMA (or other nitrosamines) resulted in the methylation of DNA in extrahepatic tissues such as the esophagus or the kidney (Diaz Gomez *et al.*, 1977; Swann *et al.*, 1980; Pegg and Hui, 1978). The occurrence of tumors in extrahepatic tissues following the oral administration of a single large dose of NDMA appears to be related to the saturation of first pass clearance by the liver.

When a single large dose of NDMA was administered by intraperitoneal injection to male rats, tumors were detected in the kidney, particularly in rats provided a protein-deficient diet, but only one rat developed a hepatic tumor (Hard and Butler, 1970). A protein-deficient diet in rats resulted in a marked decrease in *in vitro* NDMA metabolism in the liver slices but not in kidney slices (Swann and McLean, 1971). Furthermore, blood levels of NDMA remained elevated in protein-deprived rats. The methylation of guanine in DNA and RNA increased in the kidney of rats provided a protein-deficient diet compared to a normal diet, while guanine methylation decreased in the liver (Swann and McLean, 1971). As expected from the above findings, the administration of NDMA to rats maintained on a protein–deficient diet resulted in high (100 percent) incidence of renal tumors, while comparably treated rats maintained on a conventional diet exhibited only a 35 percent incidence of renal tumors (Hard and Butler, 1970).

Pretreatment of animals with phenobarbital, which suppressed hepatic NDMA demethylation (Lee *et al.*, 1989), resulted in a reduction of liver tumors (Guengerich, 1988). In contrast, the administration of ethanol, an agent that induced hepatic NDMA metabolism, (Lee *et al.*, 1989) increased rat liver microsomal CYP2E1 content and preneoplastic lesions in the rat liver (Tsutsumi *et al.*, 1993). In addition to inducing NDMA demethylase, ethanol is a competitive inhibitor of NDMA metabolism. Tissue levels (blood, liver, kidney, lung and brain) of NDMA in mice administered 50 ppm

NDMA in drinking water were substantially increased when ethanol was administered (Anderson *et al.*, 1986). The administration of ethanol in combination with NDMA resulted in tumors in extrahepatic tissues such as the lung and kidney (Anderson *et al.*, 1988, 1992). Reduced numbers of hepatomas were observed in animals administered NDMA in combination with ethanol, compared to NDMA alone (Griciute *et al.*, 1987).

DNA Adduct Formation

Diaz Gomez *et al.* (1977) observed that formation of the DNA adduct N-7-methyl guanine was proportional to NDMA dose in the liver and kidney (at higher doses) in female rats orally administered NDMA. O^{6-}Methylguanine DNA adducts that accumulated over 28 days were linearly related to NDMA dose in the rat liver (Souliotis *et al.*, 1995). The administration of 0.25-2.7 ppm NDMA in drinking water to female Wistar rats resulted in a linear increase with dose of N-7-methyl guanine adducts in the liver at 28 days (Souliotis *et al.*, 2002). The findings of these studies suggest that the metabolism of NDMA in the liver was not saturated in the dose range used by Peto *et al.* (1991a,b).

DNA methylation was not observed to begin in the kidney until higher doses of NDMA were administered (orally), whereupon methylation in the kidney was proportional to dose (Diaz Gomez *et al.*, 1977). When small doses of NDMA were administered by intraperitoneal injection, bypassing first pass clearance by the liver, alkylation was observed in both the liver and kidney (Pegg and Hui, 1978; Diaz Gomez *et al.*, 1977). The administration of NDMA to Patas monkeys by gavage yielded levels of O^6-methyl guanine DNA adducts four hours post-administration in various tissues (e.g. kidney, esophagus, stomach, brain) that were similar to what was observed in the liver. This is unlike what is typically observed in rodents, in which adducts occurred primarily in the liver (Anderson *et al.*, 1996). The administration of ethanol prior to NDMA resulted in a marked increase in adducts in the esophagus, pancreas, colon, bladder, brain and uterus, while having little effect on adduct levels in the monkeys' liver (Anderson *et al.*, 1996).

Exposure to NDMA of a human fibroblast cell line transfected with cDNA for rat CYP2E1 resulted in decreased cell viability; and time- and dose-dependent increased methylation of DNA, RNA and proteins (Lin *et al.*, 1998). The viability of the same cell line that was not transfected and displayed no demethylase activity was not altered by NDMA treatment, nor were its macromolecules methylated by the addition of NDMA to the cell culture. Inhibitors of P450 2E1 such as ethanol and 4-methyl pyrazole prevented the alkylation of macromolecules and prevented the NDMA-mediated toxicity in the transfected cells.

The induction of CYP2E1 activity by pretreatment of rats with pyridine (as measured by p-nitrophenol hydroxylase activity) resulted in a marked increase in the methylation of calf thymus DNA by NDMA in microsomes isolated from hepatocytes from the rats (Shu and Hollenberg, 1997). An inhibitor of CYP2E1 activity, diethyldithiocarbamate (DDC), markedly reduced the methylation of calf thymus DNA *in vitro* by NDMA in microsomes obtained from control rats or rats treated with pyridine. Interestingly, pretreatment of rats with phenobarbital, which had little effect on CYP2E1 activity, reduced DNA methylation by NDMA in microsomes prepared from hepatocytes from the treated rats. DDC yielded little inhibition of the low levels of calf thymus DNA methylation by

NDMA in microsomes from rats treated with phenobarbital, suggesting that the metabolism of NDMA involved other cytochrome P450 isoforms. Experiments in intact cultured hepatocytes yielded results similar to these microsomal studies (Shu and Hollenberg, 1997).

While adduct formation occurs at a number of DNA sites, certain sites are preferred. The administration of NDMA to rat and other animals resulted in formation of DNA adducts primarily at the N-7 position (70 percent of the total) and O^6 position (7 percent of the total) of guanine (Beranek, 1990). Adducts have also been detected at the N-3 position of adenine (3 percent of the total) (Beranek, 1990) and O^4-methylthymine (0.1 percent of the total) (Hall *et al.*, 1990). While the majority of adducts occur at the N-7 guanine position, the adducts at the O^6 position of guanine have been associated with the mutagenic and carcinogenic response (Loveless, 1969; Archer, 1989; Pegg and Byers, 1992). The O^6 alkylation leads to a GC-AT transition during DNA replication (Swann, 1990; Pegg, 1990).

An O^6-methylguanine mutation in a specific codon in the *k-ras* oncogene was observed in lung tumors from mice treated with NDMA (Belinsky *et al.*, 1989). Spontaneous lung tumors from control mice were not characterized by this mutation. Mutations in an activated *k-ras* oncogene were observed in lung tumors in C3H and A/J strains of mice treated with NDMA (Devereux *et al.*, 1991; Belinsky *et al.*, 1989).

DNA Repair

O^6-methylguanine-DNA transferase (MGMT), is an enzyme that repairs O^6-methyl guanine and other O^6-alkyl guanine DNA adducts (Saffhill *et al.*, 1985; Lindahl *et al.*, 1988; Pegg, 1990; Swenberg *et al.*, 1982). The enzyme transfers the methyl group from guanine to a cysteine residue on the transferase (itself), which results in the permanent inactivation of the enzyme (Pegg, 1990; Lindahl *et al.*, 1988; Pegg and Byers, 1992). The level of MGMT activity in tissues and species is quite variable (Hall *et al.*, 1985; Hall *et al.*, 1990; Gerson *et al.*, 1986).

Gerson *et al.* (1986) measured MGMT activity (normalized to protein and DNA) in human, rat, and mouse tissues. The liver had the highest levels of MGMT in all three species; the levels in human tissues were substantially higher than that observed in the rodents. These findings suggest that the mouse and rat may be more sensitive to the carcinogenic effects of NDMA.

Differences in the basal level on MGMT, how much of the enzyme is depleted, and ability of NDMA to induce MGMT synthesis may explain the sensitivity of various species, tissues and cell types to the toxicity and carcinogenicity induced by NDMA (and other nitrosamines). Dolan *et al.* (1990) demonstrated significant increases in cell toxicity using agents that inhibited DNA repair by MGMT. A number of studies have linked the ability of the tissue to repair O^6-methylguanine DNA adducts (or alkylguanine adducts for other nitrosamines) to the level or activity of MGMT in the tissue or a particular cell type within the tissue (Swenberg *et al.*, 1982; Pegg and Byers, 1992; Pegg, 1990; Magee *et al.*, 1975; Nicoll *et al.*, 1975; Pegg, 1977; Kamendulis and Corcoran, 1994 ; Swenberg *et al.*, 1982).

Following the administration of sufficiently large dose(s) of NDMA to overcome first pass clearance, alkylation of DNA occurred in both the liver and kidney but the adducts appeared to be more persistent in the kidney (Nicoll *et al.*, 1975; Fan *et al.*, 1991). The occurrence of tumors in the kidney but not in the liver in the rat following the administration of a single large dose of NDMA appears to be the consequence of the rat liver having a much higher level of MGMT activity than the kidney (Barsch and Montesano, 1984). Renal tumors probably occurred in the kidney because of the inability of the kidney but not the liver to rapidly repair DNA methylated by a single large dose of NDMA (Magee *et al.*, 1975; Nicoll *et al.*, 1975; Pegg, 1977).

In the female Syrian Golden hamster, a single dose of 21 mg/kg of NDMA by gavage resulted in a 35 percent incidence of liver tumors but no kidney tumors (Tomatis and Cefis, 1967). The hamster and rat liver are characterized by similar constitutional levels of MGMT but there is a marked difference in the recovery of the enzyme following NDMA administration. There is a very slow recovery in the hamster after 10 mg/kg or 25 mg/kg of NDMA. The much more rapid repair of DNA adducts in the liver of rats compared to the hamster may account for the occurrence of tumors only in the hamster when a single large dose of NDMA was administered (Hall *et al.*, 1990).

Transgenic C3H male or female mice with high levels of liver MGMT activity had markedly reduced carcinogenic response in the liver (tumor bearing animals, carcinoma bearing animals) following NDMA administration compared to control (Nakatsuru *et al.*, 1993). Transgenic mice with high levels of human MGMT had markedly lower levels of lymphomas induced by N-methyl-N-nitrosourea, another carcinogen that appears to act by methylating O^6-guanine (Dumenco *et al.*, 1993). MGMT-deficient female mice (knockout mice) given one 5 mg/kg dose of NDMA by intraperitoneal injection had increased numbers of liver or lung tumors compared to control (wild type mice) (Iwakuma *et al.*, 1997). No information regarding kidney tumors was provided.

However, other studies indicate that the ability (or lack thereof) of liver cells to repair DNA damage does not appear to be responsible for the increase in tumors in the rat liver. MGMT levels in the rat liver were not depleted, but appear to have increased when NDMA exposure continued for at least 120 days (Souliotis *et al.*, 2002). MGMT levels also appeared to increase with dose in the rat liver after 180 days of exposure to NDMA (Souliotis *et al.*, 2002). In an earlier study, MGMT levels seemed to slightly increase with dose while O^6-methylguanine DNA adduct levels were proportional to dose in the liver of rats chronically exposed to NDMA in their drinking water (at doses similar to those employed by Peto) (Souliotis *et al.*, 1995).

Neither the depletion of MGMT nor a marked increase in DNA adducts at higher doses appeared to explain the marked increase in tumors observed in rats at higher doses of NDMA in studies by Peto and coworkers (Peto *et al.*, 1991a,b). The observation that the pattern of DNA adduct accumulation (linear with dose) in rats (Souliotis *et al.*, 1995) was not consistent with the increase in liver tumors with dose (sublinear) in the Peto study (Peto *et al.*, 1991a.b) suggests that other factors are involved in governing the pattern of the carcinogenic response.

Using immunohistochemical staining analysis, Takahashi *et al.* (1996) observed that the basal level of MGMT mRNA was quite low in the rat hepatocytes while other cell types in the liver (e.g., bile duct cells, fibrous tissue, and vascular endothelial cells) had elevated basal MGMT mRNA levels. Following NDMA administration, a marked increase in MGMT mRNA levels occurred in centrilobular hepatocytes, while there was no evidence of an induction of mRNA in other cell types (bile duct cells, fibrous tissue and vascular endothelial cells). The levels of MGMT mRNA in the other cell types did remain elevated.

Dose-dependent increases in O^6-methylguanine adducts were observed in hepatocytes, particularly centrilobular hepatocytes, while only low levels of adducts were detected in the other cell types (Takahashi *et al.*, 1996). The adducts also appeared to persist longer in the hepatocytes. The investigators suggested that other factors appear to be modulating the carcinogenic process in the hepatocytes, after noting that tumors occur in hepatocytes, the only cells where MGMT mRNA levels were induced. However, the levels of MGMT mRNA in other tissues were already elevated, perhaps preventing adduct formation in these tissues, while the induced level of MGMT mRNA may have been inadequate to repair the increase adduct formation that occurred in hepatocytes due to high levels of NDMA metabolism by CYP2E1. Interestingly, high levels of MGMT mRNA were detected in bile duct cells, which were not induced by the administration of NDMA. Peto and coworkers observed a high incidence of tumors in this cell type in their study (Peto *et al.*, 1991b; Peto *et al.*, 1991a).

The Souliotis *et al.* (2002) observation of modest increases in hepatic cell proliferation in female rats at high dose levels of NDMA administered in drinking water (0.2-2.64 ppm) suggests another possible mechanism for the pattern of carcinogenic response in the rat liver observed by Peto and coworkers (Peto *et al.*, 1991b; Peto *et al.*, 1991a). These investigators employed a dose range that was consistent with that employed in the Peto study. While the labeling index increased only at higher doses of NDMA (which was consistent with the dose-response relationship observed in the Peto *et al.* (1991a,b) study), adduct accumulation was proportional to dose, which was not consistent with the dose and tumor response observed by Peto and coworkers. Depletion of MGMT also did not appear to explain the increase in tumors at higher doses in the Peto study, as MGMT activity appeared to be higher in animals receiving the higher NDMA doses in this study.

Craddock (1975) only observed hepatocellular carcinoma in animals receiving partial hepatectomy following the treatment of female rats with a single high dose of NDMA, which also suggests a role for cellular proliferation. Lindamood *et al.* (1984) investigated DNA alkylation and cell proliferation in the liver of C3H and C57BL mice and F-344 rats administered NDMA in their drinking water. These investigators observed increased alkylation of DNA with dose of NDMA (0, 10, 30 and 100 ppm in their drinking water) in both the rat and mice, but only observed evidence of cell proliferation (increases in labeled thymidine in DNA) in the high dose group of the C3H mice (30 ppm) after 16 day of exposure to NDMA. No evidence of cell proliferation was observed in any dose group in the F-344 rat or the C57BL mouse (Lindamood *et al.*, 1984).

Toxicological Effects in Humans

Acute Toxicity/Subchronic Toxicity

Toxic effects of NDMA on liver of workers were reported as long ago as 1937 (Freund, 1937, as reported in U.S. EPA, 1980). The development of liver cirrhosis in two laboratory workers following the introduction of NDMA to the laboratory triggered the study of NDMA toxicity (Barnes and Magee, 1954).

Carcinogenicity

IARC reviewed the data regarding human cancer studies in 1972 and 1978 and concluded that “no case reports or epidemiological studies were available to the Working Group” (IARC, 1978). The International Programme on Chemical Safety's (IPCS) INCHEM service recently summarized the epidemiology studies that investigated the link between nitrosamines exposure (NDMA in particular) and cancer in humans (IPSC, 2002). The findings included the following statement: “Although the database is rather limited, data from epidemiological studies are at least suggestive of an association between exposure to NDMA and several forms of cancer (i.e., gastric and lung), with some consistency of evidence for gastric cancer and for exposure–response for lung cancer, the latter in studies in which matching or control for confounders was most extensive. Although estimated intakes in these investigations were based on dietary recall, and although confounding factors such as alcohol were not accounted for, the data fulfill, at least in part, some of the traditional criteria for causality of an association between ingestion of NDMA and cancer.”

Case-control studies investigated the link between NDMA exposure and stomach, esophageal or lung cancer. Because nitrate and nitrite can be converted *in vivo* to nitrosamines, some studies have also investigated the link between exposure to these compounds and cancer in humans. Estimates of intake of NDMA, nitrate or nitrite, that were at best uncertain, were based on dietary recall and estimated concentrations of nitrosamines in dietary items. While certain confounders such as smoking were considered, others, such as other constituents in the diet, were generally not considered.

Two case control studies indicated a positive relationship between oral exposure to NDMA (Pobel *et al.*, 1995) or nitrosamines (Gonzalez *et al.*, 1994) and the occurrence of gastric cancer. One study did not find a relationship between NDMA exposure and stomach cancer (Risch *et al.*, 1985) while another study did link exposure to NDMA with cancer in the oral cavity, esophagus and larynx (Rogers *et al.*, 1995). De Stefani and coworkers (De Stefani *et al.*, 1996) and Goodman and associates (Goodman *et al.*, 1992) linked exposure of NDMA in the diet with increased risk of lung cancer .

Knekt and coworkers conducted a prospective study, which investigated the link between dietary NDMA, nitrate and nitrite intake, and gastrointestinal cancers (Knekt *et al.*, 1999). Detailed food consumption data were collected from approximately 10,000 participants. Beer consumption was also noted. A significant positive correlation was observed between exposure to NDMA and colorectal cancer. There was also a significant association between the intake of smoked and salted fish but not cured meat and meat products, and colorectal cancer. No positive association between nitrate or nitrite consumption and cancer was observed. No statistically significant association between beer consumption and gastrointestinal cancers was observed in this study.

Other studies have looked at exposure to workers, particularly rubber workers, to nitrosamines (Sorahan *et al.*, 1989; Delzell *et al.*, 1981; Straif *et al.*, 2000). Rubber workers have a very high documented workplace exposure to nitrosamines. In a study of rubber workers, Straif and coworkers reported a link between inhalation exposure to nitrosamines and cancers of the esophagus, oral cavity and pharynx (Straif *et al.*, 2000).

Examination of the Evidence of Carcinogenic Activity of NDMA

Animal Studies

NDMA has been evaluated in numerous animal bioassays using various routes of exposure and experimental protocols. Significant increases in tumors were observed in male and female, mature and immature animals and in essentially all species that were evaluated (mice, rats, hamsters, rabbits, guinea-pigs). Carcinogenic activity was observed following oral or inhalation exposure to NDMA as well as following intraperitoneal or subcutaneous injection of animals. Significant increases in tumors have been observed when as little as one dose was administered or when NDMA was administered for the lifetime of the animal.

Human Studies

A series of epidemiological studies have linked exposure to NDMA or other nitrosamines with cancer in the gastrointestinal tract. The estimates of exposure are highly uncertain and other constituents in the diet could be responsible for the higher incidence of cancer in these studies. One study suggested an increase in lung cancer associated with dietary exposure to NDMA. Estimates of exposure are uncertain in these studies, so potency estimates based on these studies would be very tenuous.

Genotoxicity

NDMA displayed genotoxicity in a host of *in vitro* and *in vivo* assays. NDMA displayed positive results (e.g. micronuclei, sister chromatid exchange) *in vivo,* in rodents administered NDMA in a variety of tissues: hepatocytes, bone marrow lymphocytes, esophageal and kidney cells. DNA mutations (adducts) have been detected in numerous studies in which animals were administered NDMA.

NDMA displayed genotoxicity (e.g., unscheduled DNA synthesis, sister chromatid exchange, gene mutations) *in vitro* with or without metabolic activation in bacteria, human, and rodent cells. Adduct formation has been detected *in vitro* in tissue slices and in reconstituted microsomal cytochrome P450 systems incubated with DNA.

Mechanism

Considerable effort has been focused on understanding the mechanism of action of NDMA-induced carcinogenesis. Tumors typically occur only in tissues that have the ability to metabolize NDMA. The occurrence of tumors appears to be related to occurrence of significant levels of cytochrome P450 (principally CYP2E1) within the cell and the ability of cells to metabolize NDMA by the alpha hydroxylation pathway. The metabolism of NDMA results in the formation of an unstable metabolite (the methyldiazonium ion) that reacts with DNA to form DNA adducts. The formation of O^6methyl-guanine DNA adducts from NDMA metabolism has been linked to the appearance of tumors. Repair of DNA by MGMT (or lack of repair) also appears to have a key role in the development of cancer. Other factors also appear to modulate NDMA ability to produce tumors in experimental animals.

Conclusion

Given the strong evidence of carcinogenic activity in animals, suggestive evidence in humans, substantial evidence of genotoxicity, and considerable knowledge regarding the mechanism of carcinogenicity of NDMA, it is prudent to conclude that NDMA in drinking water is a carcinogenic risk and, therefore, develop a PHG based on this toxic endpoint.

Sensitive Populations

Studies in animals have demonstrated an increase in tumors in the mouse administered ethanol in combination with NDMA, compared to NDMA alone (Anderson *et al.*, 1992). Markedly increased levels of adducts have been detected in extrahepatic tissues in Patas monkeys administered ethanol prior to NDMA (Anderson *et al.*, 1996). Smoking, an important source of exposure to nitrosamines such as NDMA, in combination with ethanol, has been associated with an increased incidence of cancer in humans (NTP, 2000).

The consumption of alcoholic beverages has been linked to an increase in cancer in humans (IARC, 1978; Mirvish, 1995; NTP, 2000; OEHHA, 2004). The consumption of alcoholic beverages in combination with smoking has also been linked to a higher risk of cancer (NTP, 2000). However, the evidence specifically linking exposure to ethanol with an increase in tumors in experimental animals is lacking (NTP, 2000). There is also a lack of genotoxic and mechanistic findings that link exposure to ethanol to cancer. Consequently, Swann and coworkers (Driver and Swann, 1987) and Anderson and associates (Anderson *et al.*, 1995) proposed that ethanol's carcinogenic actions might be related to its ability to induce and/or inhibit nitrosamine metabolism. Many other carcinogenic agents could also be affected by ethanol influence on metabolism in the liver.

Given these findings, individuals exposed to NDMA who consume alcoholic beverages may be at greater risk of cancer. But a number of other substances also stimulate metabolism of xenobiotics. Therefore, individuals that consume alcohol are not considered as a uniquely sensitive population.

DOSE-RESPONSE ASSESSMENT

Noncarcinogenic Effects

Because of the well-known carcinogenic activity of NDMA, few investigators have conducted animal studies aimed at evaluating other toxic endpoints. NDMA has been observed to produce severe hepatotoxicity resulting in cirrhosis at high doses. Other less severe toxic endpoints in the liver have not been adequately characterized. Effects on the immune system in animals at high NDMA doses have also been demonstrated. Due to the lack of information regarding NDMA toxicity at lower doses, the development of a dose-response relationship for NDMA for non-carcinogenic effects is problematic.

Carcinogenic Effects

The findings of recent studies in humans are suggestive of a link between exposure to NDMA and an increase in gastrointestinal or lung tumors. In these studies, exposure to NDMA is poorly characterized. In addition, most of these studies are characterized by exposure to other nitrosamines or other carcinogens as well. The limitations of these studies complicate attempts to develop a dose-response relationship between NDMA exposure and incidence of cancer in humans. Therefore, the findings of animal studies will be employed to develop a dose-response relationship for NDMA.

A number of cancer bioassays in animals have linked exposure of NDMA to a statistically significant increase in tumors. The study of Peto and coworkers is judged the best study to develop a dose-response relationship between exposure to NDMA and the occurrence of liver tumors in the rat (Peto *et al.*, 1991a,b). In their study, Peto and associates employed 16 dose groups of both male and female rats. The animals were allowed to survive to the “natural” end of their lifetime (there was no terminal sacrifice at two years). Limitations of this study are few. The investigators focused on tumors in the liver so tumors that may have occurred at other sites did not appear to be carefully assessed. The investigators conducted a time-to-tumor analysis based on all tumor sites in the liver. The risk associated with tumors at each site is needed. The investigators did not publish individual animal results and efforts to obtain these data were unsuccessful (personal communication with R Peto). Without individual animal data, a time-to-tumor analysis for individual tumor sites cannot be undertaken.

Two approaches to develop a dose-response relationship for NDMA will be performed. Both approaches will rely on models to obtain the dose associated with a 10 percent increased incidence of tumors above background.. A ten percent incidence of tumor or roughly five tumors per 48 rats is a statistically significant increase in tumors above control in this study (based on Fisher’s Exact test) although it is not considered a notable increase in tumors. A ten percent increase in tumors is considered to be in the observable range (borderline observable) in this study.

The first approach will rely on the time-to tumor-analysis conducted by the investigators. A second approach will employ various models to develop dose-response relationships for tumors at specific sites. Once the dose associated with a ten percent increased incidence of tumors is determined, a simple linear extrapolation is employed to estimate the cancer potency of NDMA.

Time-to-Tumor Model

The findings of Peto and coworker revealed a statistically significant increase in liver tumors in both male and female rats, with females being more sensitive than males. The findings of their study also suggest that the development of a dose-response relationship based solely on the incidence of tumors at a given site may underestimate risk (by not considering other sources of mortality that could influence the incidence of tumors at a specific site). The early mortality in the animals (which was mainly due to tumors), particularly at higher doses, would be expected to result in less time for tumors to develop and therefore fewer tumors may have been detected than if the animals survived longer. Furthermore, almost all of the animals developed tumors in the higher dose groups. The incidence of tumors did not change with dose in the higher dose groups, because essentially all animals had tumors. However, the tumors appeared earlier in the higher dose groups.

Given these findings, a dose-response relationships based on a time-to-tumor analysis would appear to be sensible because the model accounts for the effect of dose on the survival in the animals and how survival alters the incidence of tumors. Also the model considers the effect of dose on when the tumors appeared. Peto and coworkers' time-to-tumor analysis of liver tumors yielded the following relationship between the cumulative incidence (CI) of tumors at all sites in the liver, and dose and time in the female rat:

$$\mathrm{CI} = 51.45(d + 0.1)^6 t^7$$

where:

d = dose (mg/kg-day)

t = time (yr)

Solving for the dose associated with 10 percent incidence of liver tumors at two years, the standard lifetime of a rat, yielded:

d = 0.06 mg/kg-day in the female rat

The equivalent dose in humans can be calculated as the ratio of rat to human body weight to the ¾ power:

$$\mathrm{dose}_{\mathrm{human}} = \mathrm{dose}_{\mathrm{rat}}\ (0.06\ \mathrm{mg/kg\text{-}day}) \times (0.25\ \mathrm{kg}/70\ \mathrm{kg})^{1/4} = 0.0145\ \mathrm{mg/kg\text{-}day}$$

A linear dose-response relationship is derived using the dose associated with a 10 percent incidence of tumors, and zero response at zero exposure (the origin). The slope of the linear relationship, the oral cancer potency, is:

$$\text{Oral potency} = \frac{(0.1 - 0)}{(0.0145\ \text{mg/kg-day} - 0)} = 6.9\ (\text{mg/kg-day})^{-1}$$

The dose associated with 10^{-6} risk is therefore:

$10^{-6} / 6.9\ (\text{mg/kg-day})^{-1} = 1.4 \times 10^{-7}$ mg/kg-day

Alternative Approach

While Peto and coworkers did not publish their data on the effects of NDMA on individual animals, they did provide a complete summary of the incidence of tumors at various sites in the liver. These data can be employed to develop dose-response relationships at specific tumor sites, although this analysis of cancer potency requires the use of models that do not consider when the animal died, what caused the death, or when the tumors occurred.

The administration of NDMA to rats resulted in a marked increase in hepatocellular tumors and tumors of the bile duct (Table 7). Given that the incidence of bile duct tumors was much higher than that of hepatocellular tumors at lower doses, this dose-response analysis focused on the bile duct tumors for a low-dose extrapolation. The incidences of bile duct tumors were essentially 100 percent in the higher dose groups (groups 8-11) (Table 7). At the highest doses (groups 14-16), the incidence of bile duct tumors were markedly lower due to early deaths from liver cell tumors. Therefore, the higher dose groups were not particularly useful for developing a dose-response relationship at lower doses. In the lowest dose groups (groups 1-6), there was no evidence of a statistically significant increase in tumors. Thus, the dose response relationship was constrained to include at least one dose group where there was a statistically significant and notable increase in bile duct tumors. In addition, it was deemed desirable to include the maximum number of the dose groups (maximizing the amount of data used) to derive a dose response-relationship when it was prudent to do so (i.e., when it improved the fit for the dose-response extrapolation.).

The increases in bile duct tumors above the rates in controls were evaluated using the Fisher's Exact test and a Mantel-Haenszel test for trend components of the Tox-Risk Software (Crump *et al*., 2000). Because the study included 16 dose groups, an α of 0.05 was adjusted (for the Fisher's Exact test) to address multiple comparisons using a Bonferroni correction ($\alpha/16$ or 0.003). The increase in tumors was considered statistically significant when the addition of a dose group resulted in both the Fisher's Exact test and the Mantel-Haenszel test for trend indicating statistical significance, and when the increase in tumors was judged to be notable. When seven or more doses were evaluated (or when doses greater than 0.038 mg/kg/day were included in the statistical analysis), the observed increases in bile duct tumors were statistically significant and notable. This finding constrained the dose-response relationship to a minimum of seven dose groups.

Dose response relationships were investigated for seven or more doses in the Peto *et al.* study (1991a,b) using various models in the U.S. EPA BMDS software version 1.2.1 (U.S. EPA, 2000). When the lowest seven dose groups were evaluated, all of the models yielded acceptable fits ($p > 0.1$) (Table 11). When eight doses were evaluated, only one of the models, the linearized multistage model, yielded an acceptable fit to incidence of bile duct tumors ($p > 0.1$) (Table 11). Using the lowest eight dose groups, the multistage model yielded an acceptable fit with a lower 95 percent confidence limit on the dose associated with 10 percent incidence of bile duct tumors of 0.032 mg/kg/day. The linearized multistage model did not yield an acceptable fit using the nine or ten lowest dose groups.

Table 11. Goodness of Fit of the Modeled[a] Dose-Response Relationships Associated with Bile Duct Tumors. Seven vs. Eight Lowest Dose Levels

Model	Seven Doses p-value[b]	Eight Doses p-value[b]
Gamma	0.4	0.06
Quantal linear	0.4	0
Logistic	0.2	0.02
Log logistic	0.4	0.04
Probit	0.2	0.01
Log probit	0.1	0.03
Quantal quadratic	0.1	0.001
Linearized Multistage	0.25	0.25
Weibull	0.4	0.04

[a] Models from U.S. EPA Benchmark Dose Software.
[b] p- value of Chi-Square goodness of fit test.

The equivalent dose in humans is the ratio of rat to human body weight to the ¾ power:

$$\text{dose}_{\text{human}} = \text{dose}_{\text{rat}} (0.032 \text{ mg/kg-day}) \times (0.25 \text{ kg}/70 \text{ kg})^{1/4} = 0.0078 \text{ mg/kg-day}$$

A linear dose-response relationship is derived using the dose associated with a 10 percent incidence of tumors, and zero response at zero exposure (the origin). The slope of the linear relationship, the oral cancer potency, is:

$$\text{Oral potency} = \frac{(0.1 - 0)}{(0.0078 \text{ mg/kg-day} - 0)} = 12.8 \text{ (mg/kg-day)}^{-1}$$

The dose associated with 10^{-6} risk is therefore:

$$10^{-6} / 12.8 \text{ (mg/kg-day)}^{-1} = 7.8 \times 10^{-8} \text{ mg/kg-day}$$

Strengths and weaknesses of the two approaches

Time to Tumor Model - The findings of Peto and coworkers revealed that the dose-response relationship did not appear to be linear in the observable range. In the observable range, an increase in dose resulted in a marked increase in the incidence of tumors and a decrease in the time to appearance of the tumors. At higher doses, the incidences of tumors were near 100 percent, and the time when the tumors occurred continued to decrease. The time-to-tumor analysis conducted by the investigators utilized all dose groups, accounting for both the incidence of tumors and when the tumors occurred. Competing mortality, principally from tumors at other locations, was also accounted for by the time-to-tumor model. The time-to-tumor model predicted a relationship between dose, the incidence of liver tumors, and when they appeared that appeared to be consistent with the apparent non-linearity of the dose-response relationship in the range of observation. Unfortunately, the modeling was based on combined tumors at four liver cell sites (although in reality significant numbers of tumors occurred only in two cell types, hepatocytes and bile duct). Typically, tumors would be segregated by tissue type in the liver and a dose-response relationship would be developed for each cell type. The risk associated with tumors at a specific site, while preferred, cannot be obtained from these data using a time-to-tumor model because the results in individual animals are not available. Another limitation of developing a dose-response relationship using a time-to-tumor model is that the dose-response calculation provided by the investigators could not be confirmed, as the data were not available. In addition, a lower bound estimate of the dose associated with a ten percent incidence of tumors could not be determined.

Linearized Multistage Model - The dose response relationship derived using the linearized multistage model is based on tumors of the bile duct and not total liver tumors, which is methodologically preferable. A dose-response relationship for tumors at individual sites could be obtained because the investigators published complete summary tables of the incidence of tumors at each of the four liver sites (although not the times when they occurred). Another advantage of using the multistage model is that the calculation of the dose-response relationship can be independently confirmed. Limitations of this approach are important. The dose response relation uses only a portion of the data (eight of 16 dose groups) because the model does not appear to describe the shape of the dose-response relationship throughout the observable range, particularly at higher doses (dose levels nine to sixteen). The relationship does not consider the effect of dose on when the tumors occurred or sources of competing mortality. On the other hand, the potency determined from these bile duct tumors is somewhat greater than that derived from the time-to-tumor analysis of Peto *et al*., and might for that reason be considered the preferable value (more health-protective).

Because the time-to-tumor analysis does not describe a lower bound of dose associated with a 10 percent increase in bile duct tumors, we have chosen to use the results of the linearized multistage method to derive the PHG. We conclude that the two approaches are supportive of each other with a difference of less than 2-fold.

CALCULATION OF THE PHG

Non-Carcinogenic Effects

A protective level has not been developed for non-cancer effects due to the lack of adequate toxicological studies that investigated non-carcinogenic toxic endpoints. The high cancer potency and unequivocal nature of this chemical as a carcinogen would make a non-cancer health-protective value of very limited relevance.

Carcinogenic Effects

The health-protective concentration for NDMA for drinking water is based on the ingestion route only. The Henry's Law constant for NDMA is 1.99×10^{-6} atm-m^3/mole at 37 ^oC, indicating that almost no NDMA will partition into the air during showering. The NDMA skin permeability constant, Kp, of 0.000265 cm/hr is very low, and therefore dermal exposure in the shower would not contribute significantly to the overall exposure.

Two approaches were employed to obtain a dose response relationship for NDMA, a time–to tumor model provided by Peto and coworkers and an alternative approach based on a multistage model of the incidence of tumors in the bile duct. The dose-response relationship based on the linearized multistage model was judged preferable because it provided a lower confidence bound on the dose associated with 10 percent incidence of bile duct tumors. A health-protective concentration, C, is therefore calculated as follows:

$$C = \frac{10^{-6} \times BW\ (kg)}{P_{oral}\ (mg/kg\text{-}day)^{-1} \times L_{ingest}/day}$$

where:

BW = body weight (a default of 70 kg);

P_{oral} = oral cancer potency = 6.9 $(mg/kg\text{-}day)^{-1}$;

L_{ingest}/day = daily amount of water ingested (2 L/day).

Thus,

$$C = \frac{10^{-6} \times 70\ kg}{12.8\ (mg/kg\text{-}day)^{-1}) \times 2\ L/day} = 3 \times 10^{-6}\ mg/L = 0.003\ \mu g/L\ (ppb)$$

The PHG for NDMA is therefore set at 3×10^{-6} mg/L, or 0.003 ppb, representing a lifetime upper-bound cancer risk of 1 in 1 million. Other toxic effects associated with NDMA were observed at very high exposure levels. The PHG for NDMA is presumed protective against these other toxic effects, although non-cancer effects are poorly characterized for this chemical.

There is evidence that agents such as ethanol that can alter metabolism of chemicals in human liver, can thereby influence the rate of NDMA metabolism and hence its toxicity. The data in humans are sparse but there is some evidence to indicate that individuals who consume large amounts of alcohol may have higher levels of NDMA demethylase; they could therefore be considered at somewhat higher risk of adverse effects of NDMA. A quantitative assessment of this potential effect is not feasible. This phenomenon should not be considered unique to NDMA. Many xenobiotics are metabolized by enzymes that are subject to induction and therefore the toxicity of these chemicals can be altered by exposure to other chemicals.

Given the lack of specific information on the existence of any other subpopulations that may be sensitive to the toxic effects of NDMA, the PHG of 0.003 ppb is considered protective of lifetime exposure to NDMA. Levels of NDMA in drinking water associated with a lifetime theoretical extra cancer risk of 10^{-4} or 10^{-5} are 0.3 and 0.03 ppb, respectively.

RISK CHARACTERIZATION

The PHG for NDMA is based on risk associated with the lifetime ingestion of drinking water. Various sources of uncertainty regarding the development of health-protective criteria for the oral route are discussed.

Hazard Identification - There is overwhelming evidence that exposure to NDMA resulted in increased incidence of cancer in animals. An increase in tumors associated with NDMA exposure has been observed in a variety of animal species, in both males and females, by both oral and inhalation exposure routes, in immature and mature animals, and using a number of experimental protocols. Studies of human exposure are much more limited and are suggestive but certainly not conclusive that human exposure to NDMA results in an increase in cancer.

Considerable effort has been directed at understanding the carcinogenic process associated with NDMA, particularly in rats and mice. Metabolism to an active metabolite appears to be a prerequisite. Studies have demonstrated that DNA is methylated as the result of NDMA metabolism and the formation of adducts, particularly at the O^6-guanine position, is involved in the carcinogenic process. These studies have also revealed that repair or the lack of repair of the O^6-methyl guanine adducts by the enzyme MGMT is also involved in the carcinogenic process.

While there are very few studies that have specifically investigated the carcinogenic effect of NDMA in humans, NDMA metabolism in animals and humans is very similar. The cytochrome P450 isoform CYP2E1 that generates the active metabolites in rodents is detected in the human liver and reacts with an antibody prepared against the rat enzyme. The generation of adducts from NDMA *in vitro* has been detected in liver slices from human livers. In addition, adducts have been detected in human liver DNA following a NDMA poisoning episode (Herron and Shank, 1980). MGMT, the enzyme responsible for the repair of O^6-methyl guanine DNA adducts, has been detected in the liver of humans. Therefore, it is likely that the findings of animal studies of an increase in risk associated with exposure to NDMA is relevant to human exposure to the chemical.

<u>Dose Response</u> – A number of animal studies could have been employed to develop a dose-response relationship for NDMA. The study of Peto and associates was judged the best study and therefore was employed to describe a dose-response relationship for oral exposure to NDMA. The results of this study were provided in tabular form (tumor incidence at four separate sites), although individual animal results are no longer available (personal communication with RP). Thus a dose-response relationship for tumors at individual sites could be obtained including a lower confidence bound on dose, because the investigators published complete summary tables of the incidence of tumors at each of the four liver sites. Neither the linearized multistage model nor any of the models in the BMD software use all 16 dose groups because the models did not appear to describe the shape of the dose-response relationship throughout the observable range, particularly at higher doses (dose levels nine to sixteen). The linearized multistage model also did not consider the effect of dose on when the tumors occurred nor sources of competing mortality at a given tumor site that could influence the incidence of tumors at that site (animals may have died from tumors at other sites or early mortality could have prevented a tumor from developing in the animal at the given site).

While the Peto *et al*. (1991a,b) study is well-conducted, there is always uncertainty associated with employing the results of an animal study to estimate risk in humans. Metabolism of NDMA appears to be similar in rats and humans, mediated by the same enzyme, CYP2E1. However, there are some differences in the metabolism of NDMA in rodents and humans. Humans appear to have higher basal levels of MGMT than the rat, suggesting differences in susceptibility. However, this enzyme is inducible and increased levels of MGMT would be expected to have occurred in rodents in the cancer bioassays, because NDMA induces MGMT. Another indication of a possible difference in metabolism is indicated by adducts occurring in extra-hepatic tissue in the monkey, while occurring mainly in the liver in the rat.

<u>Exposure Assessment</u> – An upper-bound estimate of drinking water consumption (2 L/day) and a default 70 kg adult body weight were employed to develop the health-based criteria for oral exposure to NDMA. Given its very low volatility and skin permeability, little NDMA would be expected to partition into the air and be inhaled during showering, or be absorbed by the skin. Therefore, the PHG is based only on the oral route of exposure.

Sources of NDMA other than drinking water are possible. For estimation of cancer risk, it has been customary not to incorporate an estimate of relative source contribution (RSC), and therefore RSC is not utilized here. The rationale for excluding explicit consideration of other sources is that the cancer risk assessment is based on extra risk (in addition to other exposure sources), and that cancer risk estimation methods are conservative enough already. For non-cancer effects, relative source contribution must be explicitly considered in order to judge whether total exposures exceed a dose-effect threshold. This is not germane to the linear extrapolation cancer risk estimation method utilized in derivation of the PHG.

<u>Risk Characterization</u> - The various sources of uncertainty attendant in the hazard identification, dose response, and exposure assessment are reflected in the estimates of risk. While the study of Peto and associates, which was performed in animals, was judged to be a superior toxicological study, better estimates of human risk could

theoretically be obtained from human studies. Available epidemiological studies are inadequate, but future studies could be employed to better characterize the human impact of this chemical.

OTHER REGULATORY STANDARDS

The U.S. EPA recommends that levels (Ambient Water Criterion for humans) in lakes and streams should be limited to 0.0014 ppb of N-nitrosodimethylamine at a 10^{-6} risk level, to prevent possible health effects from drinking water or eating fish contaminated with N-nitrosodimethylamine (U.S. EPA, 1980).

The U.S. EPA requires that spills or accidental releases of 10 pounds or more of N-nitrosodimethylamine be reported to the U.S. EPA (2001). The California Notification Level (previously known as Action Level) for NDMA is 0.01 µg/L. Notification levels are defined by the California Department of Health Services as “health-based advisory levels established by DHS for chemicals in drinking water that lack maximum contaminant levels” (DHS, 2005).

IARC (1978) evaluated the evidence for carcinogenicity and determined “there is sufficient evidence of a carcinogenic effect of N-nitrosodimethylamine in many experimental animal species. Similarities in its metabolism by human rodent tissues have been demonstrated. Although no epidemiological data were available (and efforts should be directed toward this end), N-nitrosodimethylamine should be regarded for practical purposes as if it were carcinogenic to humans.”

NDMA was added to the list of chemicals known to the State to cause cancer [Title 22, California Code of Regulations, Section 12000] as of October 1, 1987, pursuant to California's Safe Drinking Water and Toxic Enforcement Act of 1986. The no-significant-risk-level for NDMA is 0.04 µg/day (22 CCR 12705b).

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APPENDIX E

HYDRAZINE AND NDMA ANALYSIS

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Hydrazine and NDMA Analysis

Hydrazines by EPA 8315 (LC/MS/MS)

Hydrazines are most commonly known for their use in rocket fuels. They are highly toxic, colorless, flammable liquids with an ammonia-like odor. There are several types of hydrazines, including hydrazine, monomethylhydrazine (MMH) and 1,1-dimethylhydrazine, also known as unsymmetrical dimethylhydrazine (UDMH). Hydrazine is unstable and is usually handled as an aqueous solution for safety reasons.

Exposure to hydrazines can cause central nervous system effects as well as kidney and liver damage. Hydrazine and UDMH are listed as probable human carcinogens and classified under Group B2 by the U.S. EPA. UDMH has been linked to the generation of *n*-nitrosodimethylamine, another suspected human carcinogen.

The U.S. EPA has not established a reference concentration or dose for hydrazine; however, hydrazine is on the Contaminant Candidate List (CCL 3). The California EPA has calculated a chronic inhalation reference exposure level of .0002 milligrams per cubic meter.

Eurofins Lancaster Laboratories Environmental offers trace level analysis of hydrazine, methylhydrazine and 1,1-dimethylhydrazine in water and soil. We are able to obtain the following limits of quantitation (LOQ):

	Water	Soil
Hydrazine	0.1 µg/L	2 ng/g
Monomethylhydrazine	0.5 µg/L	5 ng/g
1,1-Dimethylhydrazine	0.5 µg/L	5 ng/g

Low-Level NDMA by EPA 1625

NDMA (*n*-nitrosodimethylamine) is used in the production of 1,1-dimethylhydrazine for liquid rocket fuel and in many other industrial uses such as cutting oils and disinfection products. Environmental contamination can be from liquids such as rocket fuel or formed from chemical reactions.

The U.S. EPA has classified NDMA as a Class B-2 probable human carcinogen, and the California Department of Health Services (CA DHS) has established a notification level of 10 ng/L or ppt.

	Water	Soil
MDL	0.5 ppt	16.67 ng/kg
LOQ	1 ppt or ng/L	33.3 ng/kg

An MCL is currently not available for NDMA.

Note: This analysis must be prearranged with the laboratory prior to sample submission.

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Perchlorate Analysis

Background

Perchlorate, ClO4-, is a common salt anion of ammonium, potassium and sodium. It can be found in rocket fuel, explosives, airbag inflators, leather finishing and fertilizers. A majority of the perchlorate produced in the U.S. is used as the primary ingredient of solid rocket fuel.

Perchlorate salts dissociate very readily and are not affected by pH or temperature. The resulting perchlorate ion is very mobile and persistent in aqueous systems and is very difficult to treat.

Releases have been identified in 18 states as well as the Colorado River, which is the main source of drinking water for millions of residents in the Southwest United States.

For many years it was believed that perchlorate was not dangerous; however, there is a growing concern that even small amounts may cause thyroid tumors, decrease thyroid function and adversely affect neurological growth and development in fetuses and infants.

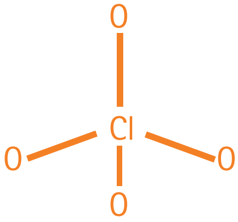
Regulations

In order to gather needed exposure information and consideration for possible regulation, perchlorate was placed on the Contaminant Candidate List (CCL) in March 1998 and on the Unregulated Contaminants Monitoring Rule (UCMR) in March 1999.

As a result of being placed on the CCL and UCMR, numerous projects are being conducted to determine the extent of perchlorate occurrence in the environment.

Since the physical and chemical nature (see structure below) of perchlorate effectively blocks reductants from attacking the chlorine, treatment of contaminated water is complicated.

CAS RN: 14797-73-0
Molecular Weight: 99.4506
Structure: Tetrahedral



Sample Analysis

We offer trace-level analysis of perchlorate in water, using EPA Method SW-846 6850 (LC/MS/MS), which provides excellent sensitivity and selectivity. We are able to obtain the following limits:

Method detection limit (MDL)	0.2 µg/L
Limit of quantitation (LOQ)	1.0 µg/L

Another option is Ion Chromatography (IC) using EPA 314.0 with the following limits:

Method detection limit (MDL)	0.7 µg/L
Limit of quantitation (LOQ)	2.0 µg/L

Samples exhibiting high conductivity due to large concentrations of interfering anions can be very challenging by IC. We perform several sample pretreatment techniques to remove matrix interferences, which allows us to maintain low detection limits and preserve expensive chromatographic supplies.

Note: This analysis must be prearranged with the laboratory prior to sample submission.

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PCB Congeners
Hydrazines/NDMA
Explosives
Perchlorate
Alkyl PAHs, Alkanes, Biomarkers
PFC (PFOA)
Organic Acids
Aldehydes
1,4-Dioxane (low level)
Low-Level Mercury
PMI
Method 25D

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Laboratories Environmental, LLC
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Lancaster, PA 17601
717-656-2300

24/7 Emergency Response
717-556-7300

APPENDIX F

EPA METHOD 1625 REVISION B: SEMIVOLATILE ORGANIC COMPOUNDS BY ISOTOPE DILUTION GC/MS

United States
Environmental Protection
Agency

Office of Water

www.epa.gov Promulgated 1984

Method 1625, Revision B: Semivolatile Organic Compounds by Isotope Dilution GC/MS

APPENDIX A TO PART 136
METHOD 1625 REVISION B—SEMIVOLATILE ORGANIC COMPOUNDS BY ISOTOPE DILUTION GC/MS

1. Scope and Application

1.1 This method is designed to determine the semivolatile toxic organic pollutants associated with the 1976 Consent Decree and additional compounds amenable to extraction and analysis by capillary column gas chromatography-mass spectrometry (GC/MS).

1.2 The chemical compounds listed in Tables 1 and 2 may be determined in municipal and industrial discharges by this method. The method is designed to meet the survey requirements of Effluent Guidelines Division (EGD) and the National Pollutants Discharge Elimination System (NPDES) under 40 CFR Part 136.1. Any modifications of this method, beyond those expressly permitted, shall be considered as major modifications subject to application and approval of alternate test procedures under 40 CFR Parts 136.4 and 136.5.

1.3 The detection limit of this method is usually dependent on the level of interferences rather than instrumental limitations. The limits listed in Tables 3 and 4 represent the minimum quantity that can be detected with no interferences present.

1.4 The GC/MS portions of this method are for use only by analysts experienced with GC/MS or under the close supervision of such qualified persons. Laboratories unfamiliar with analyses of environmental samples by GC/MS should run the performance tests in Reference 1 before beginning.

2. Summary of Method

2.1 Stable isotopically labeled analogs of the compounds of interest are added to a one liter wastewater sample. The sample is extracted at pH 12-13, then at pH <2 with methylene chloride using continuous extraction techniques. The extract is dried over sodium sulfate and concentrated to a volume of 1 mL. An internal standard is added to the extract, and the extract is injected into the gas chromatograph (GC). The compounds are separated by GC and detected by a mass spectrometer (MS). The labeled compounds serve to correct the variability of the analytical technique.

2.2 Identification of a compound (qualitative analysis) is performed by comparing the GC retention time and background corrected characteristic spectral masses with those of authentic standards.

2.3 Quantitative analysis is performed by GC/MS using extracted ion current profile (EICP) areas. Isotope dilution is used when labeled compounds are available; otherwise, an internal standard method is used.

2.4 Quality is assured through reproducible calibration and testing of the extraction and GC/MS systems.

3. Contamination and Interferences

3.1 Solvents, reagents, glassware, and other sample processing hardware may yield artifacts and/or elevated baselines causing misinterpretation of chromatograms and spectra. All materials shall be demonstrated to be free from interferences under the conditions of analysis by running method blanks initially and with each sample lot (samples started through the extraction process on a given eight hour shift, to a maximum of 20). Specific selection of reagents and purification of solvents by distillation in all-glass systems may be required. Glassware and, where possible, reagents are cleaned by solvent rinse and baking at 450°C for one hour minimum.

3.2 Interferences coextracted from samples will vary considerably from source to source, depending on the diversity of the industrial complex or municipality being samples.

4. Safety

4.1 The toxicity or carcinogenicity of each compound or reagent used in this method has not been precisely determined; however, each chemical compound should be treated as a potential health hazard. Exposure to these compounds should be reduced to the lowest possible level. The laboratory is responsible for maintaining a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of data handling sheets should also be made available to all personnel involved in these analyses. Additional information on laboratory safety can be found in References 2-4.

4.2 The following compounds covered by this method have been tentatively classified as known or suspected human or mammalian carcinogens: benzidine benzo(a)anthracene, 3,3′-dichlorobenzidine, benzo(a)pyrene, dibenzo(a,h)anthracene, N-nitrosodimethylamine, and b-naphtylamine. Primary standards of these compounds shall be prepared in a hood, and a NIOSH/MESA approved toxic gas respirator should be worn when high concentrations are handled.

5. Apparatus and Materials

5.1 Sampling equipment for discrete or composite sampling.

5.1.1 Sample bottle, amber glass, 1.1 L minimum. If amber bottles are not available, samples shall be protected from light. Bottles are detergent water washed, then solvent rinsed or baked at 450°C for one hour minimum before use.

5.1.2 Bottle caps—threaded to fit sample bottles. Caps are lined with Teflon. Aluminum foil may be substituted if the sample is not corrosive. Liners are detergent water washed, then reagent water (Section 6.5) and solvent rinsed, and baked at approximately 200°C for one hour minimum before use.

5.1.3 Compositing equipment—automatic or manual compositing system incorporating glass containers for collection of a minimum 1.1 L. Sample containers are kept at 0-4°C during sampling. Glass or Teflon tubing only shall be used. If the sampler uses a peristaltic pump, a minimum length of compressible silicone rubber tubing may be used in the pump only. Before use, the tubing is thoroughly rinsed with methanol, followed by repeated rinsings with reagent water (Section 6.5) to minimize sample contamination. An integrating flow meter is used to collect proportional composite samples.

5.2 Continuous liquid-liquid extractor—Teflon or glass conncecting joints and stopcocks without lubrication (Hershberg-Wolf Extractor) one liter capacity, Ace Glass 6841-10, or equivalent.

5.3 Drying column—15-20 mm i.d. Pyrex chromatographic column equipped with coarse glass frit or glass wool plug.

5.4 Kuderna-Danish (K-D) apparatus

5.4.1 Concentrator tube—10 mL, graduated (Kontes K-570050-1025, or equivalent) with calibration verified. Ground glass stopper (size 19/22 joint) is used to prevent evaporation of extracts.

5.4.2 Evaporation flask—500 mL (Kontes K-570001-0500, or equivalent), attached to concentrator tube with springs (Kontes K-662750-0012).

5.4.3 Snyder column—three ball macro (Kontes K-503000-0232, or equivalent).

5.4.4 Snyder column—two ball micro (Kontes K-469002-0219, or equivalent).

5.4.5 Boiling chips—approx 10/40 mesh, extracted with methylene chloride and baked at 450°C for one hour minimum.

5.5 Water bath—heated, with concentric ring cover, capable of temperature control ±2°C, installed in a fume hood.

5.6 Sample vials—amber glass, 2-5 mL with Teflon-lined screw cap.

5.7 Analytical balance—capable of weighing 0.1 mg.

5.8 Gas chromatograph—shall have splitless or on-column injection port for capillary column, temperature program with 30°C hold, and shall meet all of the performance specifications in Section 12.

5.8.1 Column—30 ±5 m x 0.25 ±0.02 mm i.d. 5% phenyl, 94% methyl, 1% vinyl silicone bonded phase fused silica capillary column (J & W DB-5, or equivalent).

5.9 Mass spectrometer—70 eV electron impact ionization, shall repetitively scan from 35-450 amu in 0.95-1.00 second, and shall produce a unit resolution (valleys between m/z 441-442 less than 10% of the height of the 441 peak), backgound corrected mass spectrum from 50 ng decafluorotriphenylphosphine (DFTPP) introduced through the GC inlet. The spectrum shall meet the mass-intensity criteria in Table 5 (Reference 5). The mass spectrometer shall be interfaced to the GC such that the end of the capillary column terminates within one centimeter of the ion source but does not intercept the electron or ion beams. All portions of the column which connect the GC to the ion source shall remain at or above the column temperature during analysis to preclude condensation of less volatile compounds.

5.10 Data system—shall collect and record MS data, store mass-intensity data in spectral libraries, process GC/MS data, generate reports, and shall compute and record response factors.

5.10.1 Data acquisition—mass spectra shall be collected continuously throughout the analysis and stored on a mass storage device.

5.10.2 Mass spectral libraries-user created libraries containing mass spectra obtained from analysis of authentic standards shall be employed to reverse search GC/MS runs for the compounds of interest (Section 7.2).

5.10.3 Data processing—the data system shall be used to search, locate, identify, and quantify the compounds of interest in each GC/MS analysis. Software routines shall be employed to compute retention times and peak areas. Displays of spectra, mass chromatograms, and library comparisons are required to verify results.

5.10.4 Response factors and multipoint calibrations—the data system shall be used to record and maintain lists of response factors (response ratios for isotope dilution) and multipoint calibration curves (Section 7). Computations of relative standard deviation (coefficient of variation) are useful for testing calibration linearity. Statistics on initial (Section 8.2) and on-going (Section 12.7) performance shall be computed and maintained.

6. Reagents and Standards

6.1 Sodium hydroxide—reagent grade, 6 N in reagent water.

6.2 Sulfuric acid—reagent grade, 6 N in reagent water.

6.3 Sodium sulfate—reagent grade, granular anhydrous, rinsed with methylene chloride (20 mL/g) and conditioned at 450°C for one hour minimum.

6.4 Methylene chloride—distilled in glass (Burdick and Jackson, or equivalent).

6.5 Reagent water—water in which the compounds of interest and interfering compounds are not detected by this method.

6.6 Standard solutions—purchased as solutions or mixtures with certification to their purity, concentration, and authenticity, or prepared from materials of known purity and composition. If compound purity is 96% or greater, the weight may be used without correction to compute the concentration of the standard. When not being used, standards are stored in the dark at -20 to -10°C in screw-capped vials with Teflon-lined lids. A mark is placed on the vial at the level of the solution so that solvent evaporation loss can be detected. The vials are brought to room temperature prior to use. Any precipitate is redissolved and solvent is added if solvent loss has occurred.

6.7 Preparation of stock solutions-prepare in methylene chloride, benzene, p-dioxane, or a mixture of these solvents per the steps below. Observe the safety precautions in Section 4. The large number of labeled and unlabeled acid, base/neutral, and Appendix C compounds used for combined calibration (Section 7) and calibration verification (Section 12.5) require high concentrations (approx 40 mg/mL) when individual stock solutions are prepared, so that dilutions of mixtures will permit calibration with all compounds in a single set of solutions. The working range for most compounds is 10-200 µg/mL. Compounds with a reduced MS response may be prepared at higher concentrations.

6.7.1 Dissolve an appropriate amount of assayed reference material in a suitable solvent. For example, weigh 400 mg naphthalene in a 10 mL ground glass stoppered volumetric flask and fill to the mark with benzene. After the naphthalene is completely dissolved, transfer the solution to a 15 mL vial with Teflon-lined cap.

6.7.2 Stock standard solutions should be checked for signs of degradation prior to the preparation of calibration or performance test standards. Quality control check samples that can be used to determine the accuracy of calibration standards are available from the US Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio 45268.

6.7.3 Stock standard solutions shall be replaced after six months, or sooner if comparison with quality control check samples indicates a change in concentration.

6.8 Labeled compound spiking solution—from stock standard solutions prepared as above, or from mixtures, prepare the spiking solution at a concentration of 200 µg/mL, or at a concentration appropriate to the MS response of each compound.

6.9 Secondary standard—using stock solutions (Section 6.7), prepare a secondary standard containing all of the compounds in Tables 1 and 2 at a concentration of 400 µg/mL, or higher concentration appropriate to the MS response of the compound.

6.10 Internal standard solution—prepare 2,2′-difluorobiphenyl (DFB) at a concentration of 10 mg/mL in benzene.

6.11 DFTPP solution—prepare at 50 µg/mL in acetone.

6.12 Solutions for obtaining authentic mass spectra (Section 7.2)—prepare mixtures of compounds at concentrations which will assure authentic spectra are obtained for storage in libraries.

6.13 Calibration solutions—combine 0.5 mL of the solution in Section 6.8 with 25, 50, 125, 250, and 500 µL of the solution in Section 6.9 and bring to 1.00 mL total volume each. This will produce calibration solutions of nominal 10, 20, 50, 100, and 200 µg/mL of the pollutants and a constant nominal 100 µg/mL of the labeled compounds. Spike each solution with 10 µL of the internal standard solution (Section 6.10). These solutions permit the relative response (labeled to unlabeled) to be measured as a function of concentration (Section 7.4).

6.14 Precision and recovery standard—used for determination of initial (Section 8.2) and on-going (Section 12.7) precision and recovery. This solution shall contain the pollutants and labeled compounds at a nominal concentration of 100 µg/mL.

6.15 Stability of solutions—all standard solutions (Sections 6.8-6.14) shall be analyzed within 48 hours of preparation and on a monthly basis thereafter for signs of degradation. Standards will remain acceptable if the peak area at the quantitation mass relative to the DFB internal standard remains within ±15% of the area obtained in the initial analysis of the standard.

7. Calibration

7.1 Assemble the GC/MS and establish the operating conditions in Table 3. Analyze standards per the procedure in Section 11 to demonstrate that the analytical system meets the detection limits in Tables 3 and 4, and the mass-intensity criteria in Table 5 for 50 ng DFTPP.

7.2 Mass spectral libraries—detection and identification of compounds of interest are dependent upon spectra stored in user created libraries.

7.2.1 Obtain a mass spectrum of each pollutant, labeled compound, and the internal standard by analyzing an authentic standard either singly or as part of a mixture in which there is no interference between closely eluted components. That only a single compound is present is determined by examination of the spectrum. Fragments not attributable to the compound under study indicate the presence of an interfering compound.

7.2.2 Adjust the analytical conditions and scan rate (for this test only) to produce an undistorted spectrum at the GC peak maximum. An undistorted spectrum will usually be obtained if five complete spectra are collected across the upper half of the GC peak. Software algorithms designed to “enhance” the spectrum may eliminate distortion, but may also eliminate authentic masses or introduce other distortion.

7.2.3 The authentic reference spectrum is obtained under DFTPP tuning conditions (Section 7.1 and Table 5) to normalize it to spectra from other instruments.

7.2.4 The spectrum is edited by saving the five most intense mass spectral peaks and all other mass spectral peaks greater than 10% of the base peak. This edited spectrum is stored for reverse search and for compound confirmation.

7.3 Analytical range—demonstrate that 20 ng anthracene or phenanthrene produces an area at m/z 178 approx one-tenth that required to exceed the linear range of the system. The exact value must be determined by experience for each instrument. It is used to match the calibration range of the instrument to the analytical range and detection limits required, and to diagnose instrument sensitivity problems (Section 15.4). The 20 µg/mL calibration standard (Section 6.13) can be used to demonstrate this performance.

7.3.1 Polar compound detection—demonstrate that unlabeled pentachlorophenol and benzidine are detectable at the 50 µg/mL level (per all criteria in Section 13). The 50 µg/mL calibration standard (Section 6.13) can be used to demonstrate this performance.

7.4 Calibration with isotope dilution—isotope dilution is used when (1) labeled compounds are available, (2) interferences do not preclude its use, and (3) the quantitation mass extracted ion current profile (EICP) area for the compound is in the calibration range. If any of these conditions preclude isotope dilution, internal standard methods (Section 7.5 or 7.6) are used.

7.4.1 A calibration curve encompassing the concentration range is prepared for each compound to be determined. The relative response (pollutant to labeled) vs concentration in standard solutions is plotted or computed using a linear regression. The example in Figure 1 shows a calibration curve for phenol using phenol-d5 as the isotopic diluent. Also shown are the ±10% error limits (dotted lines). Relative Reponse (RR) is determined according to the procedures described below. A minimum of five data points are employed for calibration.

7.4.2 The relative response of a pollutant to its labeled analog is determined from isotope ratio values computed from acquired data. Three isotope ratios are used in this process:

R_x = the isotope ratio measured for the pure pollutant.
R_y = the isotope ratio measured for the labeled compound.
R_m = the isotope ratio of an analytical mixture of pollutant and labeled compounds.

The m/z's are selected such that $R_x > R_y$. If R_m is not between $2R_y$ and $0.5R_x$, the method does not apply and the sample is analyzed by internal or external standard methods.

7.4.3 Capillary columns usually separate the pollutant-labeled pair, with the labeled compound eluted first (Figure 2). For this case, R_x = [area m_1/z]/1, at the retention time of the pollutant (RT_2). R_y = 1/[area m_2/z, at the retention time of the labeled compound RT_1). R_m = [area at m_1/z (at RT_2)]/[area at RT_1)], as measured in the mixture of the pollutant and labeled compounds (Figure 2), and RR = R_m.

7.4.4 Special precautions are taken when the pollutant-labeled pair is not separated, or when another labeled compound with interfering spectral masses overlaps the pollutant (a case which can occur with isomeric compounds). In this case, it is necessary to determine the respective contributions of the pollutant and labeled compounds to the respective EICP areas. If the peaks are separated well enough to permit the data system or operator to remove the contributions of the compounds to each other, the equations in Section 7.4.3 apply. This usually occurs when the height of the valley between the two GC peaks at the same m/z is less than 10% of the height of the shorter of the two peaks. If significant GC and spectral overlap occur, RR is computed using the following equation:

$RR = (R_y - R_m)(R_x + 1)/(R_m - R_x)(R_y + 1)$, where R_x is measured as shown in Figure 3A, R_y is measured as shown in Figure 3B, and R_m is measured as shown in Figure 3C. For example, $R_x = 46100/4780 = 9.644$, $R_y = 2650/43600 = 0.0608$, $R_m = 49200/48300 = 1.019$. amd RR = 1.114.

7.4.5 To calibrate the analytical system by isotope dilution, analyze a 1.0 µL aliquot of each of the calibration standards (Section 6.13) using the procedure in Section 11. Compute the RR at each concentration.

7.4.6 Linearity—if the ratio of relative response to concentration for any compound is constant (less than 20% coefficient of variation) over the five point calibration range, and averaged relative response/concentration ratio may be used for that compound; otherwise, the complete calibration curve for that compound shall be used over the five point calibration range.

7.5 Calibration by internal standard—used when criteria for istope dilution (Section 7.4) cannot be met. The internal standard to be used for both acid and base/neutral analyses is 2,2′-difluorobiphenyl. The internal standard method is also applied to determination of compounds having no labeled analog, and to measurement of labeled compounds for intra-laboratory statistics (Sections 8.4 and 12.7.4).

7.5.1 Response factors—calibration requires the determination of response factors (RF) which are defined by the following equation:

$$RF = \frac{(A_s)\ (C_{is})}{(A_{is})\ (C_s)}$$

where:

A_s = the area of the characteristic mass for the compound in the daily standard.

A_{is} = the area of the characteristic mass of the internal standard (µg/mL).

C_{is} = the concentration of the internal standard (µg/mL).

C_s = the concentration of the compound in the daily standard (µg/mL).

7.5.1.1 The response factor is determined for at least five concentrations appropriate to the response of each compound (Section 6.13); nominally, 10, 20, 50, 100, and 200 µg/mL. The amount of internal standard added to each extract is the same (100 µg/mL) so that C_{is}

remains constant. As/Ais is plotted vs. Cs/Cis for each compound in the standard (C_s) to produce a calibration curve.[*] .

7.5.1.2 Linearity—if the response factor (RF) for any compound is constant (less than 35% coefficient of variation) over the five point calibration range, an averaged response factor may be used for that compound; otherwise, the complete calibration curve for that compound shall be used over the five point range.

7.6 Combined calibration—by using calibration solutions (Section 6.13) containing the pollutants, labeled compounds, and the internal standard, a single set of analyses can be used to produce calibration curves for the isotope dilution and internal standard methods. These curves are verified each shift (Section 12.5) by analyzing the 100 0g/mL calibration standard (Section 6.13). Recalibration is required only if calibration verification (Section 12.5) criteria cannot be met.

8. Quality Assurance/Quality Control

8.1 Each laboratory that uses this method is required to operate a formal quality assurance program. The minimum requirements of this program consist of an initial demonstration of laboratory capability, analysis of samples spiked with labeled compounds to evaluate and document data quality, and analysis of standards and blanks as tests of continued performance. Laboratory performance is compared to established performance criteria to determine if the results of analyses meet the performance characteristics of the method.

8.1.1 The analyst shall make an initial demonstration of the ability to generate acceptable accuracy and precision with this method. This ability is established as described in Section 8.2.

8.1.2 The analyst is permitted to modify this method to improve separations or lower the costs of measurements, provided all performance specifications are met. Each time a modification is made to the method, the analyst is required to repeat the procedure in Section 8.2 to demonstrate method performance.

8.1.3 Analyses of blanks are required to demonstrate freedom from contamination. The procedures and criteria for analysis of a blank are described in Section 8.5.

8.1.4 The laboratory shall spike all samples with labeled compounds to monitor method performance. This test is described in Section 8.3. When results of these spikes indicate atypical method performance for samples, the samples are diluted to bring method performance within acceptable limits (Section 15).

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[*] This equation corrects an error made in the original method publication (49 FR 43234, October 26, 1984). This correction will be formalized through a rulemaking in FY97.

8.1.5 The laboratory shall, on an on-going basis, demonstrate through calibration verification and the analysis of the precision and recovery standard (Section 6.14) that the analysis system is in control. These procedures are described in Sections 12.1, 12.5, and 12.7.

8.1.6 The laboratory shall maintain records to define the quality of data that is generated. Development of accuracy statements is described in Section 8.4.

8.2 Initial precision and accuracy—to establish the ability to generate acceptable precision and accuracy, the analyst shall perform the following operations:

8.2.1 Extract, concentrate, and analyze two sets of four 1 L aliquots (eight aliquots total) of the precision and recovery standard (Section 6.14) according to the procedure in Section 10.

8.2.2 Using results of the first set of four analyses, compute the average recovery ($\bar{X}$) in µg/mL and the standard deviation of the recovery (s) in 0g/µL for each compound, by isotope dilution for pollutants with a labeled analog, and by internal standard for labeled compounds and pollutants with no labeled analog.

8.2.3 For each compound, compare s and $\bar{X}$ with the corresponding limits for initial precision and accuracy in Table 8. If s and $\bar{X}$ for all compounds meet the acceptance criteria, system performance is acceptable and analysis of blanks and samples may begin. If, however, any individual s exceeds the precision limit or any individual $\bar{X}$ falls outside the range for accuracy, system performance is unacceptable for that compound.

NOTE: The large number of compounds in Table 8 present a substantial probability that one or more will fail the acceptance criteria when all compounds are analyzed. To determine if the analytical system is out of control, or if the failure can be attributed to probability, proceed as follows:

8.2.4 Using the results of the second set of four analyses, compute s and $\bar{X}$ for only those compounds which failed the test of the first set of four analyses (Section 8.2.3). If these compounds now pass, system performance is acceptable for all compounds and analysis of blanks and samples may begin. If, however, any of the same compoulds fail again, the analysis system is not performing properly for these compounds. In this event, correct the problem and repeat the entire test (Section 8.2.1).

8.3 The laboratory shall spike all samples with labeled compounds to assess method performance on the sample matrix.

8.3.1 Analyze each sample according to the method in Section 10.

8.3.2 Compute the percent recovery (P) of the labeled compounds using the internal standard method (Section 7.5).

8.3.3 Compare the labeled compound recovery for each compound with the corresponding limits in Table 8. If the recovery of any compounds falls outside its warning limit, method performance is unacceptable for that compound in that sample. Therefore, the sample is complex and is to be diluted and reanalyzed per Section 15.4.

8.4 As part of the QA program for the laboratory, method accuracy for wastewater samples shall be assessed and records shall be maintained. After the analysis of five wastewater samples for which the labeled compounds pass the tests in Section 8.3, compute the average percent recovery ($\bar{P}$) and the standard deviation of the percent recovery (s_p) for the labeled compounds only. Express the accuracy assessment as a percent recovery interval from $\bar{P}-2s_p$ to $\bar{P}+2s_p$. For example, if $\bar{P}$ = 90% and s_p = 10%, the accuracy interval is expressed as 70-100%. Update the accuracy assessment for each compound on a regular basis (e.g., after each 5-10 new accuracy measurements).

8.5 Blanks—reagent water blanks are analyzed to demonstrate freedom from contamination.

8.5.1 Extract and concentrate a blank with each sample lot (samples started through the extraction process on the same eight hour shift, to a maximum of 20 samples). Analyze the blank immediately after analysis of the precision and recovery standard (Section 6.14) to demonstrate freedom from contamination.

8.5.2 If any of the compounds of interest (Tables 1 and 2) or any potentially interfering compound is found in a blank at greater than 10 µg/L (assuming a response factor of 1 relative to the internal standard for compounds not listed in Tables 1 and 2), analysis of samples is halted until the source of contamination is eliminated and a blank shows no evidence of contamination at this level.

8.6 The specifications contained in this method can be met if the apparatus used is calibrated properly, then maintained in a calibrated state. The standards used for calibration (Section 7), calibration verification (Section 12.5), and for initial (Section 8.2) and on-going (Section 12.7) precision and recovery should be identical, so that the most precise results will be obtained. The GC/MS instrument in particular will provide the most reproducible results if dedicated to the settings and conditions required for the analysis of semi-volatiles by this method.

8.7 Depending on specific program requirements, field replicates may be collected to determine the precision of the sampling technique, and spiked samples may be required to determine the accuracy of the analysis when internal or external standard methods are used.

9. Sample Collection, Preservation, and Handling

9.1 Collect samples in glass containers following conventional sampling practices (Reference 7). Composite samples are collected in refrigerated glass containers (Section 5.1.3) in accordance with the requirements of the sampling program.

9.2 Maintain samples at 0-4°C from the time collectimn until extraction. If residual chlorine is present, add 80 mg sodium thiosulfate per liter of water. EPA Methods 330.4 and 330.5 may be used to measure residual chlorine (Reference 8).

9.3 Begin sample extraction within seven days of collection, and analyze all extracts within 40 days of extraction.

10. Sample Extraction and Concentration (See Figure 4)

10.1 Labeled compound spiking-measure 1.00 ± 0.01 L of sample into a glass container. For untreated effluents, and samples which are expected to be difficult to extract and/or concentrate, measure an additional 10.0 ± 0.1 mL and dilute to a final volume of 1.00 ± 0.01 L with reagent water in a glass container.

10.1.1 For each sample or sample lot (to a maximum of 20) to be extracted at the same time, place three 1.00 ± 0.10 L aliquots of reagent water in glass containers.

10.1.2 Spike 0.5 mL of the labeled compound spiking solution (Section 6.8) into all samples and one reagant water aliquot.

10.1.3 Spike 1.0 mL of the precision and recovery standard (Section 6.14) into the two remaining reagent water aliquots.

10.1.4 Stir and equilibrate all solutions for one to two hours.

10.2 Base/neutral extraction—place 100-150 mL methylene chloride in each continuous extractor and 200-300 mL in each distilling flask.

10.2.1 Pour the sample(s), blank, and standard aliquots into the extractors. Rinse the glass containers with 50-100 mL methylene chloride and add to the respective extractor.

10.2.2 Adjust the pH of the waters in the extractors to 12-13 with 6N NaOH while monitoring with a pH meter. Begin the extraction by heating the flask until the methylene chloride is boiling. When properly adjusted, one to two drops of methylene chloride per second will fall from the condensor tip into the water. After one to two hours of extraction, test the pH and readjust to 12-13 if required. Extract for 18-24 hours.

10.2.3 Remove the distilling flask, estimate and record the volume of extract (to the nearest 100 mL), and pour the contents through a drying column containing 7-10 cm anhydrous sodium sulfate. Rinse the distilling flask with 30-50 mL of methylene chloride and pour through the drying column. Collect the solution in a 500 mL K-D evaporator flask equipped with a 10 mL concentrator tube. Seal, label as the base/neutral fraction, and concentrate per Sections 10.4 to 10.5.

10.3 Acid extraction—adjust the pH of the waters in the extractors to 2 or less using 6 N sulfuric acid. Charge clean distilling flasks with 300-400 mL of methylene chloride.

Test and adjust the pH of the waters after the first one to two hours of extraction. Extract for 18-24 hours.

10.3.1 Repeat Section 10.2.3, except label as the acid fraction.

10.4 Concentration—concentrate the extracts in separate 500 mL K-D flasks equipped with 10 mL concentrator tubes.

10.4.1 Add one to two clean boiling chips to the flask and attach a three-ball macro Snyder column. Prewet the column by adding approximately 1 mL of methylene chloride through the top. Place the K-D apparatus in a hot water bath so that the entire lower rounded surface of the flask is bathed with steam. Adjust the vertical position of the apparatus and the water temperature as required to complete the concentration in 15-20 minutes. At the proper rate of distillation, the balls of the column will actively chatter but the chambers will not flood. When the liquid has reached an apparent volume of 1 mL, remove the K-D apparatus from the bath and allow the solvent to drain and cool for at least 10 minutes. Remove the Snyder column and rinse the flask and its lower joint into the concentrator tube with 1-2 mL of methylene chloride. A 5 mL syringe is recommended for this operation.

10.4.2 For performance standards (Sections 8.2 and 12.7) and for blanks (Section 8.5), combine the acid and base/neutral extracts for each at this point. Do not combine the acid and base/neutral extracts for samples.

10.5 Add a clean boiling chip and attach a two-ball micro Snyder column to the concentrator tube. Prewet the column by adding approx 0.5 mL methylene chloride through the top. Place the apparatus in the hot water bath. Adjust the vertical position and the water temperature as required to complete the concentration in 5-10 minutes. At the proper rate of distillation, the balls of the column will actively chatter but the chambers will not flood. When the liquid reaches an apparent volume of approx 0.5 mL, remove the apparatus from the water bath and allow to drain and cool for at least 10 minutes. Remove the micro Snyder column and rinse its lower joint into the concentrator tube with approx 0.2 mL of methylene chloride. Adjust the final volume to 1.0 mL.

10.6 Transfer the concentrated extract to a clean screw-cap vial. Seal the vial with a Teflon-lined lid, and mark the level on the vial. Label with the sample number and fraction, and store in the dark at -20 to -10°C until ready for analysis.

11. GC/MS Analysis

11.1 Establish the operating conditions given in Table 3 or 4 for analysis of the base/neutral or acid extracts, respectively. For analysis of combined extracts (Section 10.4.2), use the operating conditions in Table 3.

11.2 Bring the concentrated extract (Section 10.6) or standard (Sections 6.13 through 6.14) to room temperature and verify that any precipitate has redissolved. Verify the level on the extract (Sections 6.6 and 10.6) and bring to the mark with solvent if required.

11.3 Add the internal standard solution (Section 6.10) to the extract (use 1.0 µL of solution per 0.1 mL of extract) immediately prior to injection to minimize the possibility of loss by evaporation, adsorption, or reaction. Mix thoroughly.

11.4 Inject a volume of the standard solution or extract such that 100 ng of the internal standard will be injected, using on-column or splitless injection. For 1 mL extracts, this volume will be 1.0 µL. Start the GC column initial isothermal hold upon injection. Start MS data collection after the solvent peak elutes. Stop data collection after the benzo(ghi)perylene or pentachlorophenol peak elutes for the base/neutral or acid fraction, respectively. Return the column to the initial temperature for analysis of the next sample.

12. System and Laboratory Performance

12.1 At the beginning of each eight hour shift during which analyses are performed, GC/MS system performance and calibration are verified for all pollutants and labeled compounds. For these tests, analysis of the 100 µg/mL calibration standard (Section 6.13) shall be used to verify all performance criteria. Adjustment and/or recalibration (per Section 7) shall be performed until all performance criteria are met. Only after all performance criteria are met may samples, blanks, and precision and recovery standards be analyzed.

12.2 DFTPP spectrum validity—inject 1 µL of the DFTPP solution (Section 6.11) either separately or within a few seconds of injection of the standard (Section 12.1) analyzed at the beginning of each shift. The criteria in Table 5 shall be met.

12.3 Retention times—the absolute retention time of 2,2′-difluorobiphenyl shall be within the range of 1078-1248 seconds and the relative retention times of all pollutants and labeled compounds shall fall within the limits given in Tables 3 and 4.

12.4 GC resolution—the valley height between anthracene and phenanthrene at m/z 178 (or the analogs at m/z 188) shall not exceed 10% of the taller of the two peaks.

12.5 Calibration verification—compute the concentration of each pollutant (Tables 1 and 2) by isotope dilution (Section 7.4) for those compounds which have labeled analogs. Compute the concentration of each pollutant which has no labeled analog by the internal standard method (Section 7.5). Compute the concentration of the labeled compounds by the internal standard method. These concentrations are computed based on the calibration data determined in Section 7.

12.5.1 For each pollutant and labeled compound being tested, compare the concentration with the calibration verification limit in Table 8. If all compounds meet the acceptance criteria, calibration has been verified and analysis of blanks, samples, and precision and recovery standards may proceed. If, however, any compound fails, the measurement system is not performing properly for that compound. In this event, prepare a fresh calibration standard or correct the problem causing the failure and repeat the test (Section 12.1), or recalibrate (Section 7).

12.6 Multiple peaks-each compound injected shall give a single, distinct GC peak.

12.7 On-going precision and accuracy

12.7.1 Analyze the extract of one of the pair of precision and recovery standards (Section 10.1.3) prior to analysis of samples from the same lot.

12.7.2 Compute the concentration of each pollutant (Tables 1 and 2) by isotope dilution (Section 7.4) for those compounds which have labeled analogs. Compute the concentration of each pollutant which has no labeled analog by the internal standard method (Section 7.5). Compute the concentration of the labeled compounds by the internal standard method.

12.7.3 For each pollutant and labeled compound, compare the concentration with the limits for on-going accuracy in Table 8. If all compounds meet the acceptance criteria, system performance is acceptable and analysis of blanks and samples may proceed. If, however, any individual concentration falls outside of the range given, system performance is unacceptable for that compound.

NOTE: The large number of compounds in Table 8 present a substantial probability that one or more will fail when all compounds are analyzed. To determine if the extraction/concentration system is out of control or if the failure is caused by probability, proceed as follows:

12.7.3.1 Analyze the second aliquot of the pair of precision and recovery standard (Section 10.1.3).

12.7.3.2 Compute the concentration of only those pollutants or labeled compounds that failed the previous test (Section 12.7.3). If these compounds now pass, the extraction/concentration processes are in control and analysis of blanks and samples may proceed. If, however, any of the same compounds fail again, the extraction/concentration processes are not being performed properly for these compounds. In this event, correct the problem, re-extract the sample lot (Section 10) and repeat the on-going precision and recovery test (Section 12.7).

12.7.4 Add results which pass the specifications in Section 12.7.2 to initial and previous on-going data. Update QC charts to perform a graphic representation of continued laboratory performance (Figure 5). Develop a statement of laboratory accuracy for each pollutant and labeled compound by calculating the average percent recovery (R) and the standard deviation of percent recovery (s_r). Express the accuracy as a recovery interval from $R-2s_r$ to $R+2s_r$. For example, if R = 95% and s_r = 5%, the accuracy is 85-105%.

13. Qualitative Determination

13.1 Qualititative determination is accomplished by comparison of data from analysis of a sample or blank with data from analysis of the shift standard (Section 12.1) and with data stored in the spectral libraries (Section 7.2.4). Identification is confirmed when spectra and retention times agree per the criteria below.

13.2 Labeled compounds and pollutants having no labeled analog

13.2.1 The signals for all characteristic masses stored in the spectral library (Section 7.2.4) shall be present and shall maximize within the same two consecutive scans.

13.2.2 Either (1) the background corrected EICP areas, or (2) the corrected relative intensities of the mass spectral peaks at the GC peak maximum shall agree within a factor of two (one-half to two times) for all masses stored in the library.

13.2.3 The retention time relative to the nearest eluted internal standard shall be within ±15 scans or ±15 seconds, whichever is greater of this difference in the shift standard (Section 12.1).

13.3 Pollutants having a labled analog

13.3.1 The signals for all characteristic masses stored in the spectral library (Section 7.2.4) shall be present and shall maximize within the same two consecutive scans.

13.3.2 Either (1) the background corrected EICP areas, or (2) the corrected relative intensities of the mass spectral peaks at the GC peak maximum shall agree within a factor of two for all masses stored in the spectral library.

13.3.3 The retention time difference between the pollutant and its labeled analog shall agree within ±6 scans or ±6 seconds (whichever is greater) of this difference in the shift standard (Section 12.1).

13.4 Masses present in the experimental mass spectrum that are not present in the reference mass spectrum shall be accounted for by contaminant or background ions. If the experimental mass spectrum is contaminated, an experienced spectrometrist (Section 1.4) is to determine the presence or absence of the compound.

14. Quantitative Determination

14.1 Isotope dilution—by adding a known amount of a labeled compound to every sample prior to extraction, correction for recovery of the pollutant can be made because the pollutant and its labeled analog exhibit the same effects upon extraction, concentration, and gas chromatography. Relative response (RR) values for mixtures are used in conjunction with calibration curves described in Section 7.4 to determine concentrations directly, so long as labeled compound spiking levels are constant. For the phenol example given in Figure 1 (Section 7.4.1), RR would be equal to 1.114. For this RR value, the phenol calibration curve given in Figure 1 indicates a concentration of 27 µg/mL in the sample extract (C_{ex}).

14.2 Internal standard—compute the concentration in the extract using the response factor determined from calibration data (Section 7.5) and the following equation:

$$C_{ex}\ (\mu g/L) = \frac{(A_s)\ (C_{is})}{(A_{is})\ (RF)}$$

where:

C_{ex} = the concentration of the compound in the extract and the other terms are as defined in Section 7.5.1.

14.3 The concentration of the pollutant in water is computed using the volumes of the original water sample (Section 10.1) and the final extract volume (Section 10.5), as follows:

$$\text{Concentration in water}\ (\mu g/L) = \frac{(C_{ex})\ (V_{ex})}{V_s}$$

where:

V_{ex} = the extract volume in mL.
V_s = the sample volume in liters.

14.4 If the EICP area at the quantitiation mass for any compound exceeds the calibration range of the system, the extract of the dilute aliquot (Section 10.1) is analyzed by isotope dilution; otherwise, the extract is diluted by a factor of 10, 9 µL of internal standard solution (Section 6.10) are added to a 1.0 mL aliquot, and this diluted extract is analyzed by the internal standard method (Section 14.2). Quantify each compound at the highest concentration level within the calibration range.

14.5 Report results for all pollutants and labeled compounds (Tables 1 and 2) found in all standards, blanks, and samples in µg/L, to three significant figures. Results for samples which have been diluted are reported at the least dilute level at which the area at the quantitation mass is within the calibration range (Section 14.4) and the labeled compound recovery is within the normal range for the method (Section 15.4).

15. Analysis of Complex Samples

15.1 Untreated effluents and other samples frequently contain high levels (>1000 µg/L) of the compounds of interest, interfering compounds, and/or polymeric materials. Some samples will not concentrate to 1 mL (Section 10.5); others will overload the GC column and/or mass spectrometer.

15.2 Analyze the dilute aliquot (Section 10.1) when the sample will not concentrate to 1.0 mL. If a dilute aliquot was not extracted, and the sample holding time (Section 9.3) has not been exceeded, dilute an aliquot of the sample with reagent water and re-extract (Section 10.1); otherwise, dilute the extract (Section 14.4) and analyze by the internal standard method (Section 14.2).

15.3 Recovery of internal standard—the EICP area of the internal standard should be within a factor of two of the area in the shift standard (Section 12.1). If the absolute areas of the labeled compounds are within a factor of two of the respective areas in the shift standard, and the internal standard area is less than one-half of its respective area, then internal standard loss in the extract has occurred. In this case, use one of the labeled compounds (perferably a polynuclear aromatic hydrocarbon) to compute the concentration of a pollutant with no labeled analog.

15.4 Recovery of labeled compounds—in most samples, labeled compound recoveries will be similar to those from reagent water (Section 12.7). If the labeled compound recovery is outside the limits given in Table 8, the dilute extract (Section 10.1) is analyzed as in Section 14.4. If the recoveries of all labeled compounds and the internal standard are low (per the criteria above), then a loss in instrument sensitivity is the most likely cause. In this case, the 100 µg/mL calibration standard (Section 12.1) shall be analyzed and calibration verified (Section 12.5). If a loss in sensitivity has occurred, the instrument shall be repaired, the performance specifications in Section 12 shall be met, and the extract reanalyzed. If a loss in instrument sensitivity has not occurred, the method does not work on the sample being analyzed and the result may not be reported for regulatory compliance purposes.

16. Method Performance

16.1 Interlaboratory performance for this method is detailed in References 9 and 10.

16.2 A chromatogram of the 100 µg/mL acid/base/neutral calibration standard (Section 6.13) is shown in Figure 6.

References

1. “Performance Tests for the Evaluation of Computerized Gas Chromatography/Mass Spectrometry Equipment and Laboratories” USEPA, EMSL/Cincinnati, OH 45268, EPA-600/4-80-025 (April 1980).

2. “Working with Carcinogens,” DHEW, PHS, CDC, NIOSH, Publication 77-206, (August 1977).

3. “OSHA Safety and Health Standards, General Industry” OSHA 2206, 29 CFR Part 1910 (January 1976).

4. “Safety in Academic Chemistry Laboratories,” ACS Committee on Chemical Safety (1979).

5. “Reference Compound to Calibrate Ion Abundance Measurement in Gas Chromatography-Mass Spectrometry Systems,” J.W. Eichelberger, L.E. Harris, and W.L. Budde. Anal. Chem., *47,* 955 (1975).

6. “Handbook of Analytical Quality Control in Water and Wastewater Laboratories,” USEPA, EMSL/Cincinnati, OH 45268, EPA-600/4-79-019 (March 1979).

7. “Standard Practice for Sampling Water,” ASTM Annual Book of Standards, ASTM, Philadelphia, PA, 76 (1980).

8. “Methods 330.4 and 330.5 for Total Residual Chlorine,” USEPA, EMSL/ Cincinnati, OH 45268, EPA 600/4-70-020 (March 1979).

9. Colby, B.N., Beimer, R.G., Rushneck, D.R., and Telliard, W.A. “Isotope Dilution Gas Chromatography-Mass Spectrometry for the determination of Priority Pollutants in Industrial Effluents.” USEPA, Effluent Guidelines Division, Washington, DC 20460 (1980).

10. “Inter-laboratory Validation of US Environmental Protection Agency Method 1625,” USEPA, Effluent Guidelines Division, Washington, DC 20460 (June 15, 1984).

Table 1—Base/Neutral Extractable Compounds

Compound	STORET	CAS registry	EPA-EGD	NPDES
Acenaphthene	34205	83-32-9	001 B	001 B
Acenaphthylene	34200	208-96-8	077 B	002 B
Anthracene	34220	120-12-7	078 B	003 B
Benzidine	39120	92-87-5	005 B	004 B
Benzo(a)anthracene	34526	56-55-3	072 B	005 B
Benzo(b)fluoranthene	34230	205-99-2	074 B	007 B
Benzo(k)fluoranthene	34242	207-08-9	075 B	009 B
Benzo(a)pyrene	34247	50-32-8	073 B	006 B
Benzo(ghi)perylene	34521	191-24-2	079 B	008 B
Biphenyl (Appendix C)	81513	92-52-4	512 B	......
Bis(2-chloroethyl)ether	34273	111-44-4	018 B	011 B
Bis(2-chloroethyoxy)methane	34278	111-91-1	043 B	010 B
Bis(2-chloroisopropyl)ether	34283	108-60-1	042 B	012 B
Bis(2-ethylhexyl)phthalate	39100	117-81-7	066 B	013 B
4-bromophenyl phenyl ether	34636	101-55-3	041 B	014 B
Butyl benzyl phthalate	34292	85-68-7	067 B	015 B
n-C10 (Appendix C)	77427	124-18-5	517 B	......
n-C12 (Appendix C)	77588	112-40-2	506 B	......
n-C14 (Appendix C)	77691	629-59-4	518 B	......
n-C16 (Appendix C)	77757	544-76-3	519 B	......
n-C18 (Appendix C)	77804	593-45-3	520 B	......
n-C20 (Appendix C)	77830	112-95-8	521 B	......
n-C22 (Appendix C)	77859	629-97-0	522 B	......
n-C24 (Appendix C)	77886	646-31-1	523 B	......
n-C26 (Appendix C)	77901	630-01-3	524 B	......
n-C28 (Appendix C)	78116	630-02-4	525 B	......
n-C30 (Appendix C)	78117	638-68-6	526 B	......
Carbazole (4c)	77571	86-74-8	528 B	......
2-chloronaphthalene	34581	91-58-7	020 B	016 B
4-chlorophenyl phenyl ether	34641	7005-72-3	040 B	017 B

Table 1—Base/Neutral Extractable Compounds

Compound	STORET	CAS registry	EPA-EGD	NPDES
Chrysene	34320	218-01-9	076 B	018 B
P-cymene (Appendix C)	77356	99-87-6	513 B	......
Dibenzo(a,h)anthracene	34556	53-70-3	082 B	019 B
Dibenzofuran (Appendix C and 4c)	81302	132-64-9	505 B	......
Dibenzothiophene (Synfuel)	77639	132-65-0	504 B	......
Di-n-butyl phthalate	39110	84-74-2	068 B	026 B
1,2-dichlorobenzene	34536	95-50-1	025 B	020 B
1,3-dichlorobenzene	34566	541-73-1	026 B	021 B
1,4-dichlorobenzene	34571	106-46-7	027 B	022 B
3,3′-dichlorobenzidine	34631	91-94-1	028 B	023 B
Diethyl phthalate	34336	84-66-2	070 B	024 B
2,4-dimethylphenol	34606	105-67-9	034 A	003 A
Dimethyl phthalate	34341	131-11-3	071 B	025 B
2,4-dinitrotoluene	34611	121-14-2	035 B	027 B
2,6-dinitrotoluene	34626	606-20-2	036 B	028 B
Di-n-octyl phthalate	34596	117-84-0	069 B	029 B
Diphenylamine (Appendix C)	77579	122-39-4	507 B	......
Diphenyl ether (Appendix C)	77587	101-84-8	508 B	......
1,2-diphenylhydrazine	34346	122-66-7	037 B	030 B
Fluoranthene	34376	206-44-0	039 B	031 B
Fluorene	34381	86-73-7	080 B	032 B
Hexachlorobenzene	39700	118-74-1	009 B	033 B
Hexachlorobutadiene	34391	87-68-3	052 B	034 B
Hexachloroethane	34396	67-72-1	012 B	036 B
Hexachlorocyclopentadiene	34386	77-47-4	053 B	035 B
Indeno(1,2,3-cd)pyrene	34403	193-39-5	083 B	037 B
Isophorone	34408	78-59-1	054 B	038 B
Naphthalene	34696	91-20-3	055 B	039 B
B-naphthylamine (Appendix C)	82553	91-59-8	502 B	......
Nitrobenzene	34447	98-95-3	056 B	040 B
N-nitrosodimethylamine	34438	62-75-9	061 B	041 B
N-nitrosodi-n-propylamine	34428	621-64-7	063 B	042 B
N-nitrosodiphenylamine	34433	86-30-3	062 B	043 B
Phenanthrene	34461	85-01-8	081 B	044 B
Phenol	34694	108-95-2	065 A	010 A
a-Picoline (Synfuel)	77088	109-06-89	503 B	......
Pyrene	34469	129-00-0	084 B	045 B
styrene (Appendix C)	77128	100-42-5	510 B	......
a-terpineol (Appendix C)	77493	98-55-5	509 B	......
1,2,3-trichlorobenzene (4c)	77613	87-61-6	529 B	......
1,2,4-trichlorobenzene	34551	120-82-1	008 B	046 B

Table 2—Acid Extractable Compounds

Compound	STORET	CAS registry	EPA-EGD	NPDES
4-chloro-3-methylphenol	34452	59-50-7	022 A	008 A
2-chlorophenol	34586	95-57-8	024 A	001 A
2,4-dichlorophenol	34601	120-83-2	031 A	002 A
2,4-dinitrophenol	34616	51-28-5	059 A	005 A
2-methyl-4,6-dinitrophenol	34657	534-52-1	060 A	004 A
2-nitrophenol	34591	88-75-5	057 A	006 A
4-nitrophenol	34646	100-02-7	058 A	007 A
Pentachlorophenol	39032	87-86-5	064 A	009 A
2,3,6-trichlorophenol (4c)	77688	93-37-55	530 A	......
2,4,5-trichlorophenol (4c)	......	95-95-4	531 A	......
2,4,6-trichlorophenol	34621	88-06-2	021 A	011 A

Table 3—Gas Chromatography of Base/Neutral Extractable Compounds

EGD No.[1]	Compound	Retention time			Detection limit[2] (µg/L)
		Mean (sec)	EGD Ref	Relative	
164	2,2′-difluorobiphenyl (int std)	1163	164	1.000-1.000	10
061	N-nitrosodimethylamine	385	164	ns	50
603	alpha picoline-d7	417	164	0.326-0.393	50
703	alpha picoline	426	603	1.006-1.028	50
610	styrene-d5	546	164	0.450-0.488	10
710	styrene	549	610	1.002-1.009	10
613	p-cymene-d14	742	164	0.624-0.652	10
713	p-cymene	755	613	1.008-1.023	10
265	phenol-d5	696	164	0.584-0.613	10
365	phenol	700	265	0.995-1.010	10
218	bis(2-chloroethyl)ether-d8	696	164	0.584-0.607	10
318	bis(2-chloroethyl)ether	704	218	1.007-1.016	10
617	n-decane-d22	698	164	0.585-0.615	10
717	n-decane	720	617	1.022-1.038	10
226	1,3-dichlorobenzene-d4	722	164	0.605-0.636	10
326	1,3-dichlorobenzene	724	226	0.998-1.008	10
227	1,4-dichlorobenzene-d4	737	164	0.601-0.666	10
327	1,4-dichlorobenzene	740	227	0.997-1.009	10
225	1,2-dichlorobenzene-d4	758	164	0.632-0.667	10
325	1,2-dichlorobenzene	760	225	0.995-1.008	10
242	bis(2-chloroisopropyl)ether-d12	788	164	0.664-0.691	10
342	bis(2-chloroisopropyl)ether	799	242	1.010-1.016	10
212	hexachloroethane-13C	819	164	0.690-0.717	10
312	hexachloroethane	823	212	0.999-1.001	10
063	N-nitrosodi-n-propylamine	830	164	ns	20
256	nitrobenzene-d5	845	164	0.706-0.727	10

Table 3—Gas Chromatography of Base/Neutral Extractable Compounds

EGD No.[1]	Compound	Retention time			Detection limit[2] (μg/L)
		Mean (sec)	EGD Ref	Relative	
356	nitrobenzene	849	256	1.002-1.007	10
254	isophorone-d8	881	164	0.747-0.767	10
354	isophorone	889	254	0.999-1.017	10
234	2,4-dimethyl phenol-d3	921	164	0.781-0.803	10
334	2,4-dimethylphenol	924	234	0.999-1.003	10
043	bis(2-chloroethoxy)methane	939	164	ns	10
208	1,2,4-trichlorobenzene-d3	955	164	0.813-0.830	10
308	1,2,4-trichlorobenzene	958	208	1.000-1.005	10
255	naphthalene-d8	963	164	0.819-0.836	10
355	naphthalene	967	255	1.001-1.006	10
609	alpha-terpineol-d3	973	164	0.829-0.844	10
709	alpha-terpineol	975	609	0.998-1.008	10
606	n-dodecane-d26	953	164	0.730-0.908	10
706	n-dodecane	981	606	0.986-1.051	10
529	1,2,3-trichlorobenzene	1003	164	ns	10
252	hexachlorobutadiene-13C4	1005	164	0.856-0.871	10
352	hexachlorobutadiene	1006	252	0.999-1.002	10
253	hexachlorocyclopentadiene-13C4	1147	164	0.976-0.986	10
353	hexachlorocyclopentadiene	1142	253	0.999-1.001	10
220	2-chloronaphthalene-d7	1185	164	1.014-1.024	10
320	2-chloronaphthalene	1200	220	0.997-1.007	10
518	n-tetradecane	1203	164	ns	10
612	Biphenyl-d10	1205	164	1.016-1.027	10
712	Biphenyl	1195	612	1.001-1.006	10
608	Diphenyl ether-d10	1211	164	1.036-1.047	10
708	Diphenyl ether	1216	608	0.997-1.009	10
277	Acenaphthylene-d8	1265	164	1.080-1.095	10
377	Acenaphthylene	1247	277	1.000-1.004	10
271	Dimethyl phthalate-d4	1269	164	1.083-1.102	10
371	Dimethyl phthalate	1273	271	0.998-1.005	10
236	2,6-dinitrotoluene-d3	1283	164	1.090-1.112	10
336	2,6-dinitrotoluene	1300	236	1.001-1.005	10
201	Acenaphthene-d10	1298	164	1.107-1.125	10
301	Acenaphthene	1304	201	0.999-1.009	10
605	Dibenzofuran-d8	1331	164	1.134-1.155	10
705	Dibenzofuran	1335	605	0.998-1.007	10
602	Beta-naphthylamine-d7	1368	164	1.163-1.189	50
702	Beta-naphthylamine	1371	602	0.996-1.007	50
280	Fluorene-d10	1395	164	1.185-1.214	10
380	Fluorene	1401	281	0.999-1.008	10
240	4-chlorophenyl phenyl ether-d5	1406	164	1.194-1.223	10
340	4-chlorophenyl phenyl ether	1409	240	0.990-1.015	10
270	Diethyl phthalate-d4	1409	164	1.197-1.229	10
370	Diethyl phthalate	1414	270	0.996-1.006	10

Table 3—Gas Chromatography of Base/Neutral Extractable Compounds

EGD No.[1]	Compound	Retention time			Detection limit[2] (µg/L)
		Mean (sec)	EGD Ref	Relative	
619	n-hexadecane-d34	1447	164	1.010-1.478	10
719	n-hexadecane	1469	619	1.013-1.020	10
235	2,4-dinitrotoluene-d3	1359	164	1.152-1.181	10
335	2,4-dinitrotoluene	1344	235	1.000-1.002	10
237	1,2-diphenylhydrazine-d8	1433	164	1.216-1.248	20
337	1,2-diphenylhydrazine[3]	1439	237	0.999-1.009	20
607	Diphenylamine-d10	1437	164	1.213-1.249	20
707	Diphenylamine	1439	607	1.000-1.007	20
262	N-nitrosodiphenylamine-d6	1447	164	1.225-1.252	20
362	N-nitrosodiphenylamine[4]	1464	262	1.000-1.002	20
041	4-bromophenyl phenyl ether	1498	164	1.271-1.307	10
209	Hexachlorobenzene-13C6	1521	164	1.288-1.327	10
309	Hexachlorobenzene	1522	209	0.999-1.001	10
281	Phenanthrene-d10	1578	164	1.334-1.380	10
520	n-octadecane	1580	164	ns	10
381	Phenanthrene	1583	281	1.000-1.005	10
278	Anthracene-d10	1588	164	1.342-1.388	10
378	Anthracene	1592	278	0.998-1.006	10
604	Dibenzothiophene-d8	1559	164	1.314-1.361	10
704	Dibenzothiophene	1564	604	1.000-1.006	10
528	Carbazole	1650	164	ns	20
621	n-eicosane-d42	1655	164	1.184-1.662	10
721	n-eicosane	1677	621	1.010-1.021	10
268	Di-n-butyl phthalate-d4	1719	164	1.446-1.510	10
368	Di-n-butyl phthalate	1723	268	1.000-1.003	10
239	Fluoranthene-d10	1813	164	1.522-1.596	10
339	Fluoranthene	1817	239	1.000-1.004	10
284	Pyrene-d10	1844	164	1.523-1.644	10
384	Pyrene	1852	284	1.001-1.003	10
205	Benzidine-d8	1854	164	1.549-1.632	50
305	Benzidine	1853	205	1.000-1.002	50
522	n-docosane	1889	164	ns	10
623	n-tetracosane-d50	1997	164	1.671-1.764	10
723	n-tetracosane	2025	612	1.012-1.015	10
067	Butylbenzyl phthalate	2060	164	ns	10
276	Chrysene-d12	2081	164	1.743-1.837	10
376	Chrysene	2083	276	1.000-1.004	10
272	Benzo(a)anthracene-d12	2082	164	1.735-1.846	10
372	Benzo(a)anthracene	2090	272	0.999-1.007	10
228	3,3′-dichlorobenzidine-d6	2088	164	1.744-1.848	50
328	3,3′-dichlorobenzidine	2086	228	1.000-1.001	50
266	Bis(2-ethylhexyl)phthalate-d4	2123	164	1.771-1.880	10
366	Bis(2-ethylhexyl)phthalate	2124	266	1.000-1.002	10
524	n-hexacosane	2147	164	ns	10

Table 3—Gas Chromatography of Base/Neutral Extractable Compounds

EGD No.[1]	Compound	Retention time			Detection limit[2] (µg/L)
		Mean (sec)	EGD Ref	Relative	
269	di-n-octyl phthalate-d4	2239	164	1.867-1.982	10
369	di-n-octyl phthalate	2240	269	1.000-1.002	10
525	n-octacosane	2272	164	ns	10
274	Benzo(b)fluoranthene-d12	2281	164	1.902-2.025	10
354	Benzo(b)fluoranthene	2293	274	1.000-1.005	10
275	Benzo(k)fluoranthene-d12	2287	164	1.906-2.033	10
375	Benzo(k)fluoranthene	2293	275	1.000-1.005	10
273	Benzo(a)pyrene-d12	2351	164	1.954-2.088	10
373	Benzo(a)pyrene	2350	273	1.000-1.004	10
626	N-triacontane-d62	2384	164	1.972-2.127	10
726	N-triacontane	2429	626	1.011-1.028	10
083	Indeno(1,2,3-cd)pyrene	2650	164	ns	20
082	Dibenzo(a,h)anthracene	2660	164	ns	20
279	Benzo(ghi)perylene-d12	2741	164	2.187-2.524	20
379	Benzo(ghi)perylene	2750	279	1.001-1.006	20

[1] Reference numbers beginning with 0, 1 or 5 indicate a pollutant quantified by the internal standard method; reference numbers beginning with 2 or 6 indicate a labeled compound quantified by the internal standard method; reference numbers beginning with 3 or 7 indicate a pollutant quantified by isotope dilution.

[2] This is a minimum level at which the entire GC/MS system must give recognizable mass spectra (background corrected) and acceptable calibration points.

[3] Detected as azobenzene.

[4] Detected as diphenylamine.

ns = specification not available at time of release of method.

Column: 30 ±2 m x 0.25 ±0.02 mm i.d. 94% methyl, 4% phenyl, 1% vinyl bonded phase fused silica capillary.

Temperature program: five minutes at 30°C; 30-280°C at 8°C per minute; isothermal at 280°C until benzo(ghi)perylene elutes.

Gas velocity: 30 ±5 cm/sec.

Table 4—Gas Chromatography of Acid Extractable Compounds

EGD No.[1]	Compound	Retention time			Detection limit[2] (µg/L)
		Mean (sec)	EGD Ref	Relative	
164	2,2′-difluorobiphenyl (int std)	1163	164	1.000-1.000	10
224	2-chlorophenol-d4	701	164	0.587-0.618	10
324	2-chlorophenol	705	224	0.997-1.010	10
257	2-nitrophenol-d4	898	164	0.761-0.783	20
357	2-nitrophenol	900	257	0.994-1.009	20
231	2,4-dichlorophenol-d3	944	164	0.802-0.822	10
331	2,4-dichlorophenol	947	231	0.997-1.006	10
222	4-chloro-3-methylphenol-d2	1086	164	0.930-0.943	10
322	4-chloro-3-methylphenol	1091	222	0.998-1.003	10
221	2,4,6-trichlorophenol-d2	1162	164	0.994-1.005	10
321	2,4,6-trichlorophenol	1165	221	0.998-1.004	10
531	2,4,5-trichlorophenol	1170	164	ns	10
530	2,3,6-trichlorophenol	1195	164	ns	10
259	2,4-dinitrophenol-d3	1323	164	1.127-1.149	50
359	2,4-dinitrophenol	1325	259	1.000-1.005	50
258	4-nitrophenol-d4	1349	164	1.147-1.175	50
358	4-nitrophenol	1354	258	0.997-1.006	50
260	2-methyl-4,6-dinitrophenol-d2	1433	164	1.216-1.249	20
360	2-methyl-4,6-dinitrophenol	1435	260	1.000-1.002	20
264	Pentachlorophenol-13C6	1559	164	1.320-1.363	50
364	Pentachlorophenol	1561	264	0.998-1.002	50

[1] Reference numbers beginning with 0, 1 or 5 indicate a pollutant quantified by the internal standard method; reference numbers beginning with 2 or 6 indicate a labeled compound quantified by the internal standard method; reference numbers beginning with 3 or 7 indicate a pollutant quantified by isotope dilution.

[2] This is a minimum level at which the entire GC/MS system must give recognizable mass spectra (background corrected) and acceptable calibration points.

ns = specification not available at time of release of method.

Column: 30 ±2m x 0.25 ±0.02 mm i.d. 94% methyl, 4% phenyl, 1% vinyl bonded phase fused silica capillary.

Temperature program: five minutes at 30°C; 8°C/min to 250°C or until pentachlorophenol elutes.

Gas velocity: 30 ±5 cm/sec.

Table 5—DFTPP Mass Intensity Specifications

Mass	Intensity required
51	30-60 percent of mass 198.
68	Less than 2 percent of mass 69.
70	Less than 2 percent of mass 69.
127	40-60 percent of mass 198.
197	Less than 1 percent of mass 198.
199	5-9 percent of mass 198.
275	10-30 percent of mass 198.
365	Greater than 1 percent of mass 198.
441	Present and less than mass 443.
442	40-100 percent of mass 198.
443	17-23 percent of mass 442.

Table 6—Base/Neutral Extractable Compound Characteristic Masses

Compound	Labeled analog	Primary m/z
Acenaphthene	d10	154/164
Acenaphthylene	d8	152/160
Anthracene	d10	178/188
Benzidine	d8	184/192
Benzo(a)anthracene	d12	228/240
Benzo(b)fluoranthene	d12	252/264
Benzo(k)fluoranthene	d12	252/264
Benzo(a)pyrene	d12	252/264
Benzo(ghi)perylene	d12	276/288
Biphenyl	d10	154/164
Bis(2-chloroethyl)ether	d8	93/101
Bis(2-chloroethoxy)methane	......	93
Bis(2-chloroisopropyl)ether	d12	121/131
Bis(2-ethylhexyl)phthalate	d4	149/153
4-bromophenyl phenyl ether	......	248
Butyl benzyl phthalate	......	149
n-C10	d22	55/66
n-C12	d26	55/66
n-C14	......	55
n-C16	d34	55/66
n-C18	......	55
n-C20	d42	55/66
n-C22	......	55
n-C24	d50	55/66
n-C26	......	55
n-C28	......	55
n-C30	d62	55/66
Carbazole	d8	167/175
2-chloronaphthalene	d7	162/169

Table 6—Base/Neutral Extractable Compound Characteristic Masses

Compound	Labeled analog	Primary m/z
4-chlorophenyl phenyl ether	d5	204/209
Chrysene	d12	228/240
p-cymene	d14	114/130
Dibenzo(a,h)anthracene	......	278
Dibenzofuran	d8	168/176
Dibenzothiophene	d8	184/192
Di-n-butyl phthalate	d4	149/153
1,2-dichlorobenzene	d4	146/152
1,3-dichlorobenzene	d4	146/152
1,4-dichlorobenzene	d4	146/152
3,3′-dichlorobenzidine	d6	252/258
Diethyl phthalate	d4	149/153
2,4-dimethylphenol	d3	122/125
Dimethyl phthalate	d4	163/167
2,4-dinitrotoluene	d3	164/168
2,6-dinitrotoluene	d3	165/167
Di-n-octyl phthalate	d4	149/153
Diphenylamine	d10	169/179
Diphenyl ether	d10	170/180
1,2-diphenylhydrazine[1]	d10	77/82
Fluoranthene	d10	202/212
Fluorene	d10	166/176
Hexachlorobenzene	13C6	284/292
Hexachlorobutadiene	13C4	225/231
Hexachloroethane	13C	201/204
Hexachlorocyclopentadiene	13C4	237/241
Ideno(1,2,3-cd)pyrene	......	276
Isophorone	d8	82/88
Naphthalene	d8	128/136
B-naphthylamine	d7	143/150
Nitrobenzene	d5	123/128
N-nitrosodimethylamine	......	74
N-nitrosodi-n-propylamine	......	70
N-nitrosodiphenylamile[2]	d6	169/175
Phenanthrene	d10	178/188
Phenol	d5	94/71
a-picoline	d7	93/100
Pyrene	d10	202/212
Styrene	d5	104/109
a-terpineol	d3	59/62
1,2,3-trichlorobenzene	d3	180/183
1,2,4-trichlorobenzene	d3	180/183

[1] Detected as azobenzene.

[2] Detected as diphenylamine.

Table 7—Acid Extractable Compound Characteristic Masses

Compound	Labeled analog	Primary m/z
4-chloro-3-methylphenol	d2	107/109
2-chlorophenol	d4	128/132
2,4-dichlorophenol	d3	162/167
2,4-dinitrophenol	d3	184/187
2-methyl-4,6-dinitrophenol	d2	198/200
2-nitrophenol	d4	139/143
4-nitrophenol	d4	139/143
Pentachlorophenol	13C6	266/272
2,3,6-trichlorophenol	d2	196/200
2,4,5-trichlorophenol	d2	196/200
2,4,6-trichlorophenol	d2	196/200

Table 8—Acceptance Criteria for Performance Tests

EGD No.[1]	Compound	Acceptance criteria				
		Initial precision and accuracy, Section 8.2.3		Labeled compound recovery, Sections 8.3 and 14.2 P (percent)	Calibration verification, Section 12.5 (µg/L)	On-going accuracy, Section 11.6 R (µg/L)
		s	X			
301	Acenaphthene	21	79-134	......	80-125	72-144
201	Acenaphthene-d10	38	38-147	20-270	71-141	30-180
377	Acenaphtylene	38	69-186	......	60-166	61-207
277	Acenaphthylene-d8	31	38-146	23-239	66-152	33-168
378	Anthracene	41	58-174	......	60-168	50-199
278	Anthracene-d10	49	31-194	14-419	58-171	23-242
305	Benzidine	119	16-518	......	34-296	11-672
205	Benzidine-d8	269	ns-ns	ns-ns	ns-ns	ns-ns
372	Benzo(a)anthracene	20	65-168	......	70-142	62-176
272	Benzo(a)anthracene-d12	41	25-298	12-605	28-357	22-329
374	Benzo(b)fluoranthene	183	32-545	......	61-164	20-ns
274	Benzo(b)fluoranthene-d12	168	11-577	ns-ns	14-ns	ns-ns
375	Benzo(k)fluoranthene	26	59-143	......	13-ns	53-155
275	Benzo(k)fluoranthene-d12	114	15-514	ns-ns	13-ns	ns-685
373	Benzo(a)pyrene	26	62-195	......	78-129	59-206
273	Benzo(a)pyrene-d12	24	35-181	21-290	12-ns	32-194
379	Benzo(ghi)perylene	21	72-160	......	69-145	58-168
279	Benzo(ghi)perylene-d12	45	29-268	14-529	13-ns	25-303
712	Biphenyl (Appendix C)	41	75-148	......	58-171	62-176
612	Biphenyl-d12	43	28-165	ns-ns	52-192	17-267
318	Bis(2-chloroethyl)ether	34	55-196	......	61-164	50-213
218	Bis(2-chloroethyl)ether-d8	33	29-196	15-372	52-194	25-222

Table 8—Acceptance Criteria for Performance Tests

EGD No.[1]	Compound	Acceptance criteria				
		Initial precision and accuracy, Section 8.2.3		Labeled compound recovery, Sections 8.3 and 14.2 P (percent)	Calibration verification, Section 12.5 (µg/L)	On-going accuracy, Section 11.6 R (µg/L)
		s	X			
043	Bis(2-chloroethoxy)methane*	27	43-153	......	44-228	39-166
342	Bis(2-chloroisopropyl)ether	17	81-138	......	67-148	77-145
242	Bis(2-chloroisopropyl) ether-d12	27	35-149	20-260	44-229	30-169
366	Bis(2-ethylhexyl)phthalate	31	69-220	......	76-131	64-232
266	Bis(2-ethylhexyl)phthalate-d4	29	32-205	18-364	43-232	28-224
041	4-bromophenyl phenyl ether*	44	44-140	......	52-193	35-172
067	Butyl benzyl phthalate*	31	19-233	......	22-450	35-170
717	n-C10 (Appendix C)	51	24-195	......	42-235	19-237
617	n-C10-d22	70	ns-298	ns-ns	44-227	ns-504
706	n-C12 (Appendix C)	74	35-369	......	60-166	29-424
606	n-C12-d26	53	ns-331	ns-ns	41-242	ns-408
518	n-C14 (Appendix C)*	109	ns-985	......	37-268	ns-ns
719	n-C16 (Appendix C)	33	80-162	......	72-138	71-181
619	n-C16-d34	46	37-162	18-308	54-186	28-202
520	n-C18 (Appendix C)*	39	42-131	......	40-249	35-167
721	n-C20 (Appendix C)	59	53-263	......	54-184	46-301
621	n-C20-d42	34	34-172	19-306	62-162	29-198
522	n-C22 (Appendix C)*	31	45-152	......	40-249	39-195
723	n-C24 (Appendix C)	11	80-139	......	65-154	78-142
623	n-C24-d50	28	27-211	15-376	50-199	25-229
524	n-C26 (Appendix C)*	35	35-193	......	26-392	31-212
525	n-C28 (Appendix C)*	35	35-193	......	26-392	31-212
726	n-C30 (Appendix C)	32	61-200	......	66-152	56-215
626	n-C30-d62	41	27-242	13-479	24-423	23-274
528	Carbazole (4c)*	38	36-165	......	44-227	31-188
320	2-chloronaphthalene	100	46-357	......	58-171	35-442
220	2-chloronaphthalene-d7	41	30-168	15-324	72-139	24-204
322	4-chloro-3-methylphenol	37	76-131	......	85-115	62-159
222	4-chloro-3-methylphenol-d2	111	30-174	ns-613	68-147	14-314
324	2-chlorophenol	13	79-135	......	78-129	76-138
224	2-chlorophenol-d4	24	36-162	23-255	55-180	33-176
340	4-chlorophenyl phenyl ether	42	75-166	......	71-142	63-194
240	4-chlorophenyl phenyl ether-d5	52	40-161	19-325	57-175	29-212
376	Chrysene	51	59-186	......	70-142	48-221
276	Chrysene-d12	69	33-219	13-512	24-411	23-290
713	p-cymene (Appendix C)	18	76-140	......	79-127	72-147
613	p-cymene-d14	67	ns-359	ns-ns	66-152	ns-468
082	Dibenzo(a,h)anthracene*	55	23-299	......	13-761	19-340

Table 8—Acceptance Criteria for Performance Tests

EGD No.[1]	Compound	Acceptance criteria				
		Initial precision and accuracy, Section 8.2.3		Labeled compound recovery, Sections 8.3 and 14.2 P (percent)	Calibration verification, Section 12.5 (µg/L)	On-going accuracy, Section 11.6 R (µg/L)
		s	X			
705	Dibenzofuran (Appendix C)	20	85-136	......	73-136	79-146
605	Dibenzofuran-d8	31	47-136	28-220	66-150	39-160
704	Dibenzothiophene (Synfuel)	31	79-150	......	72-140	70-168
604	Dibenzothiophene-d8	31	48-130	29-215	69-145	40-156
368	Di-n-butyl phthalate	15	76-165	......	71-142	74-169
268	Di-n-butyl phthalate-d4	23	23-195	13-346	52-192	22-209
325	1,2-dichlorobenzene	17	73-146	......	74-135	70-152
225	1,2-dichlorobenzene-d4	35	14-212	ns-494	61-164	11-247
326	1,3-dichlorobenzene	43	63-201	......	65-154	55-225
226	1,3-dichlorobenzene-d4	48	13-203	ns-550	52-192	ns-260
327	1,4-dichlorobenzene	42	61-194	......	62-161	53-219
227	1,4-dichlorobenzene-d4	48	15-193	ns-474	65-153	11-245
328	3,3′-dichlorobenzidine	26	68-174	......	77-130	64-185
228	3,3′-dichlorobenzidine-d6	80	ns-562	ns-ns	18-558	ns-ns
331	2,4-dichlorophenol	12	85-131	......	67-149	83-135
231	2,4-dichlorophenol-d3	28	38-164	24-260	64-157	34-182
370	Diethyl phthalate	44	75-196	......	74-135	65-222
270	Diethyl phthalate-d4	78	ns-260	ns-ns	47-211	ns-ns
334	2,4-dimethylphenol	13	62-153	......	67-150	60-156
234	2,4-dimethylphenol-d3	22	15-228	ns-449	58-172	14-242
371	Dimethyl phthalate	36	74-188	......	73-137	67-207
271	Dimethyl phthalate-d4	108	ns-640	ns-ns	50-201	ns-ns
359	2,4-dinitrophenol	18	72-134	......	75-133	68-141
259	2,4-dinitrophenol-d3	66	22-308	ns-ns	39-256	17-378
335	2,4-dinitrotoluene	18	75-158	......	79-127	72-164
235	2,4-dinitrotoluene-d3	37	22-245	10-514	53-187	19-275
336	2,6-dinitrotoluene	30	80-141	......	55-183	70-159
236	2,6-dinitrotoluene-d3	59	44-184	17-442	36-278	31-250
369	Di-n-octyl phthalate	16	77-161	......	71-140	74-166
269	Di-n-octyl phthalate-d4	46	12-383	ns-ns	21-467	10-433
707	Diphenylamine (Appendix C)	45	58-205	......	57-176	51-231
607	Diphenylamine-d10	42	27-206	11-488	59-169	21-249
708	Diphenyl ether (Appendix C)	19	82-136	......	83-120	77-144
608	Diphenyl ether-d10	37	36-155	19-281	77-129	29-186
337	1,2-diphenylhydrazine	73	49-308	......	75-134	40-360
237	1,2-diphenylhydrazine-d10	35	31-173	17-316	58-174	26-200
339	Fluoranthene	33	71-177	......	67-149	64-194
239	Fluoranthene-d10	35	36-161	20-278	47-215	30-187
380	Fluorene	29	81-132	......	74-135	70-151
280	Fluorene-d10	43	51-131	27-238	61-164	38-172

Table 8—Acceptance Criteria for Performance Tests

EGD No.[1]	Compound	Acceptance criteria: Initial precision and accuracy, Section 8.2.3		Labeled compound recovery, Sections 8.3 and 14.2 P (percent)	Calibration verification, Section 12.5 (μg/L)	On-going accuracy, Section 11.6 R (μg/L)
		s	X			
309	Hexachlorobenzene	16	90-124	......	78-128	85-132
209	Hexachlorobenzene-13C6	81	36-228	13-595	38-265	23-321
352	Hexachlorobutadiene	56	51-251	......	74-135	43-287
252	Hexachlorobutadiene-13C4	63	ns-316	ns-ns	68-148	ns-413
312	Hexachloroethane	227	21-ns	......	71-141	13-ns
212	Hexachloroethane-13C1	77	ns-400	ns-ns	47-212	ns-563
353	Hexachlorocyclopentadiene	15	69-144	......	77-129	67-148
253	Hexachlorocyclo-pentadiene-13C4	60	ns-ns	ns-ns	47-211	ns-ns
083	Ideno(1,2,3-cd)pyrene*	55	23-299	......	13-761	19-340
354	Isophorone	25	76-156	......	70-142	70-168
254	Isophorone-d8	23	49-133	33-193	52-194	44-147
360	2-methyl-4,6-dinitrophenol	19	77-133	......	69-145	72-142
260	2-methyl-4,6-dinitrophenol-d2	64	36-247	16-527	56-177	28-307
355	Naphthalene	20	80-139	......	73-137	75-149
255	Naphthalene-d8	39	28-157	14-305	71-141	22-192
702	B-naphthylamine (Appendix C)	49	10-ns	......	39-256	ns-ns
602	B-naphthylamine-d7	33	ns-ns	ns-ns	44-230	ns-ns
356	Nitrobenzene	25	69-161	......	85-115	65-169
256	Nitrobenzene-d5	28	18-265	ns-ns	46-219	15-314
357	2-nitrophenol	15	78-140	......	77-129	75-145
257	2-nitrophenol-d4	23	41-145	27-217	61-163	37-158
358	4-nitrophenol	42	62-146	......	55-183	51-175
258	4-nitrophenol-d4	188	14-398	ns-ns	35-287	ns-ns
061	N-nitrosodimethylamile*	198	21-472	......	40-249	12-807
063	N-nitrosodi-n-proplyamine*	198	21-472	......	40-249	12-807
362	N-nitrosodiphenylamine	45	65-142	......	68-148	53-173
262	N-nitrosodiphenylamine-d6	37	54-126	26-256	59-170	40-166
364	Pentachlorophenol	21	76-140	......	77-130	71-150
264	Pentachlorophenol-13C6	49	37-212	18-412	42-237	29-254
381	Phenanthrene	13	93-119	......	75-133	87-126
281	Phenanthrene-d10	40	45-130	24-241	67-149	34-168
365	Phenol	36	77-127	......	65-155	62-154
265	Phenol-d5	161	21-210	ns-ns	48-208	ns-ns
703	a-picoline (Synfuel)	38	59-149	......	60-165	50-174
603	a-picoline-d7	138	11-380	ns-ns	31-324	ns-608
384	Pyrene	19	76-152	......	76-132	72-159
284	Pyrene-d10	29	32-176	18-303	48-210	28-196

Table 8—Acceptance Criteria for Performance Tests

EGD No.[1]	Compound	Acceptance criteria				
		Initial precision and accuracy, Section 8.2.3		Labeled compound recovery, Sections 8.3 and 14.2 P (percent)	Calibration verification, Section 12.5 (µg/L)	On-going accuracy, Section 11.6 R (µg/L)
		s	X			
710	Styrene (Appendix C)	42	53-221	......	65-153	48-244
610	Styrene-d5	49	ns-281	ns-ns	44-228	ns-348
709	a-terpineol (Appendix C)	44	42-234	......	54-186	38-258
609	a-terpineol-d3	48	22-292	ns-672	20-502	18-339
529	1,2,3-trichlorobenzene (4c)*	69	15-229	......	60-167	11-297
308	1,2,4-trichlorobenzene	19	82-136	......	78-128	77-144
208	1,2,4-trichlorobenzene-d3	57	15-212	ns-592	61-163	10-282
530	2,3,6-trichlorophenol (4c)*	30	58-137	......	56-180	51-153
531	2,4,5-trichlorophenol (4c)*	30	58-137	......	56-180	51-153
321	2,4,6-trichlorophenol	57	59-205	......	81-123	48-244
221	2,4,6-trichlorophenol-d2	47	43-183	21-363	69-144	34-226

[1] Reference numbers beginning with 0, 1 or 5 indicate a pollutant quantified by the internal standard method; reference numbers beginning with 2 or 6 indicate a labeled compound quantified by the internal standard method; reference numbers beginning with 3 or 7 indicate a pollutant quantified by isotope dilution.

*Measured by internal standard; specification derived from related compound.

ns = no specification; limit is outside the range that can be measured reliably.

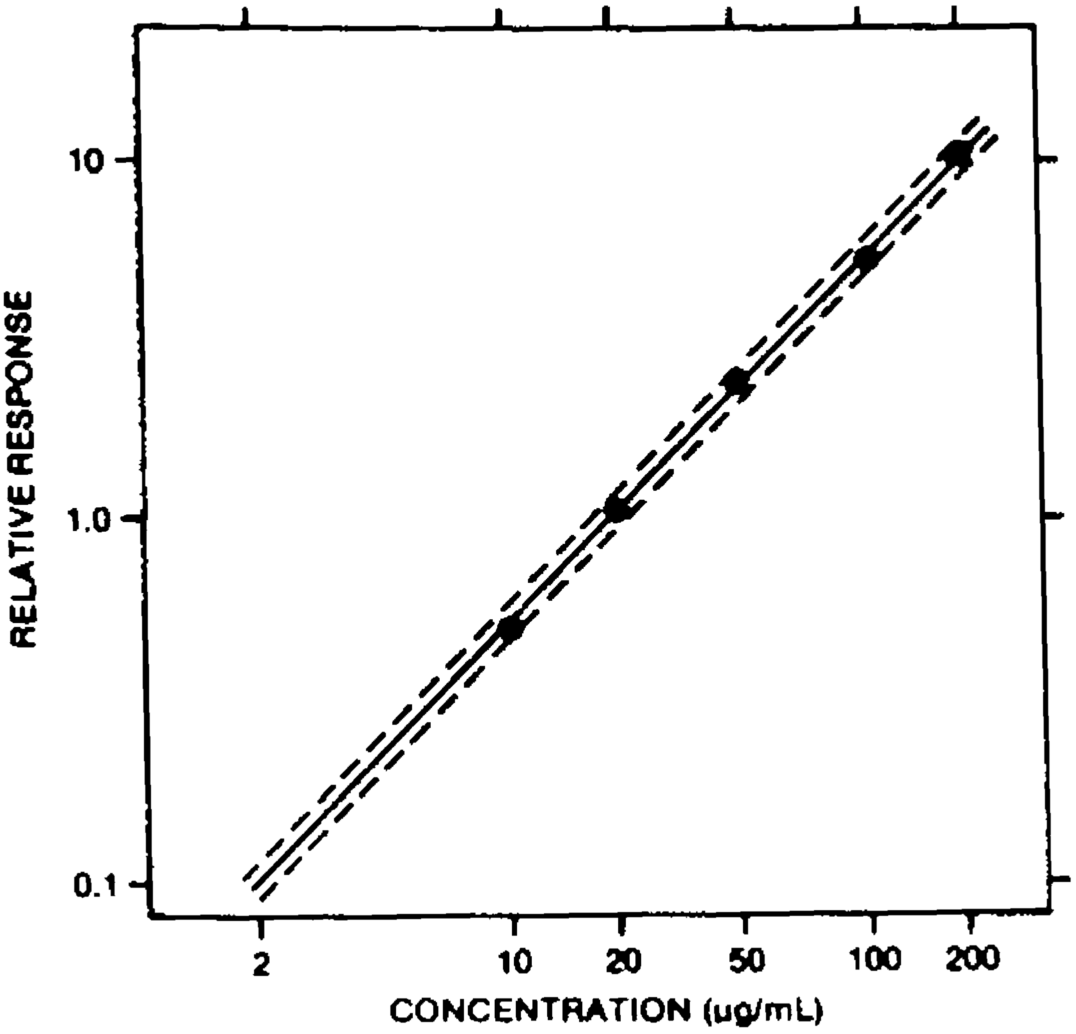


FIGURE 1 Relative Response Calibration Curve for Phenol. The Dotted Lines Enclose a ±10 Percent Error Window.

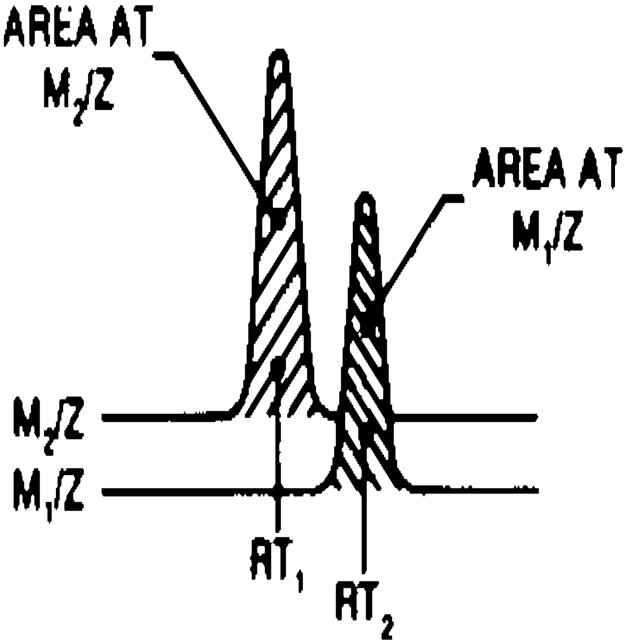


FIGURE 2 Extracted Ion Current Profiles for Chromatographically Resolved Labeled (m_2/z) and Unlabeled (m_1/z) Pairs.

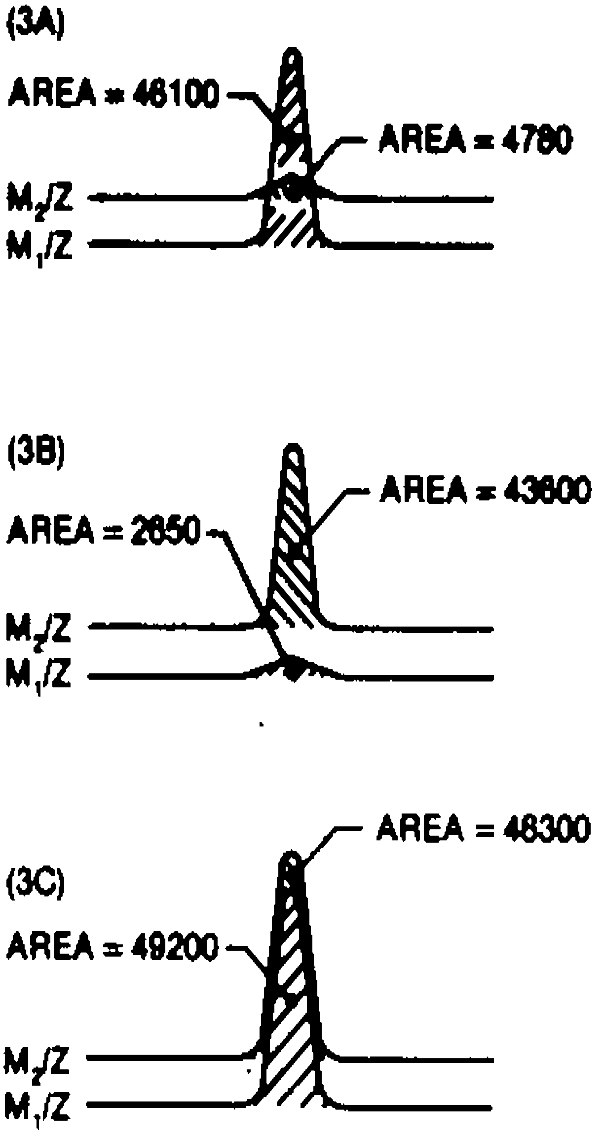


FIGURE 3 Extracted Ion Current Profiles for (3A) Unlabeled Compound, (3B) Labeled Compound, and (3C) Equal Mixture of Unlabeled and Labeled Compounds.

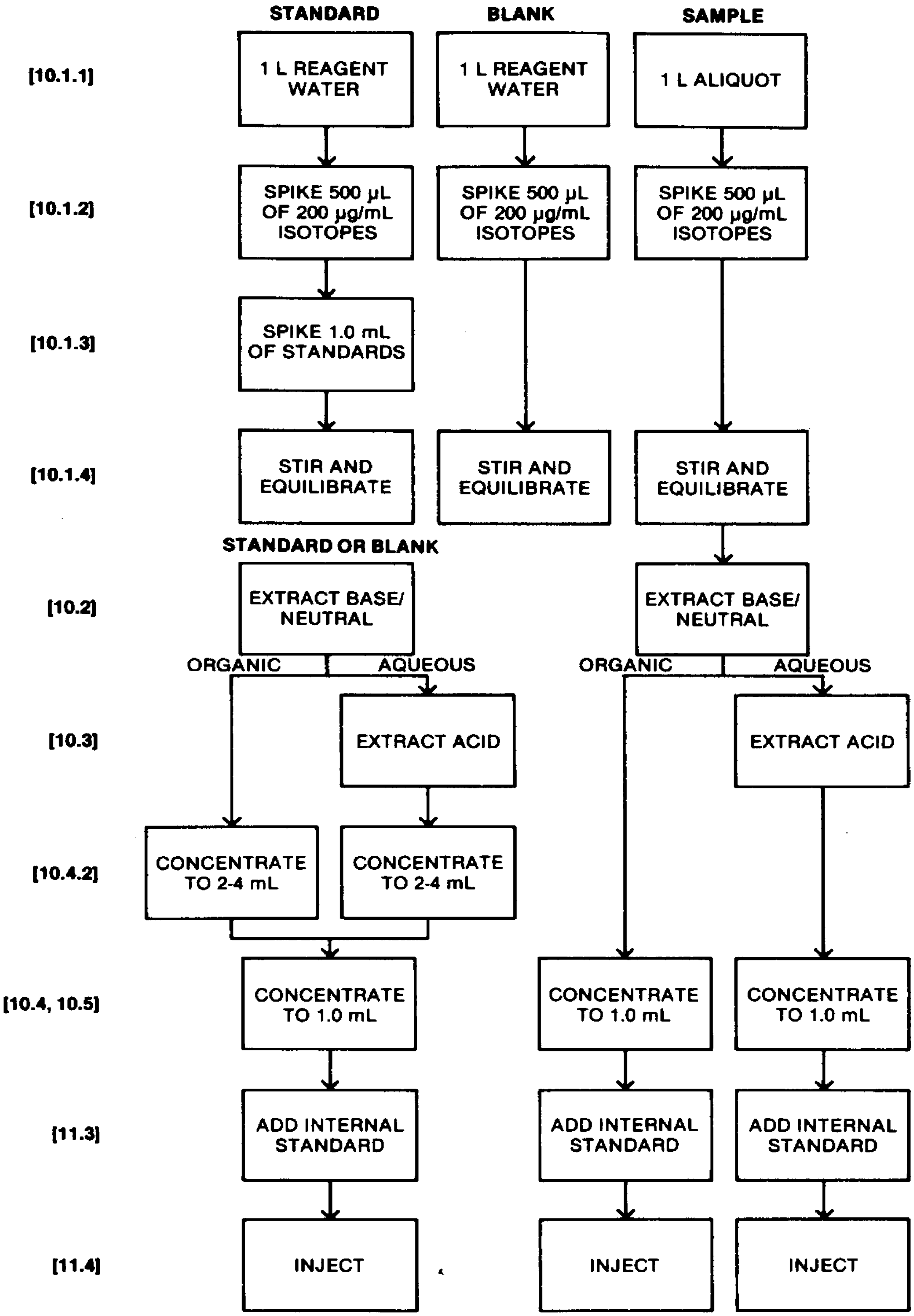


FIGURE 4 Flow Chart for Extraction/Concentration of Precision and Recovery Standard, Blank, and Sample by Method 1625. Numbers in Brackets [ ] Refer to Section Numbers in the Method.

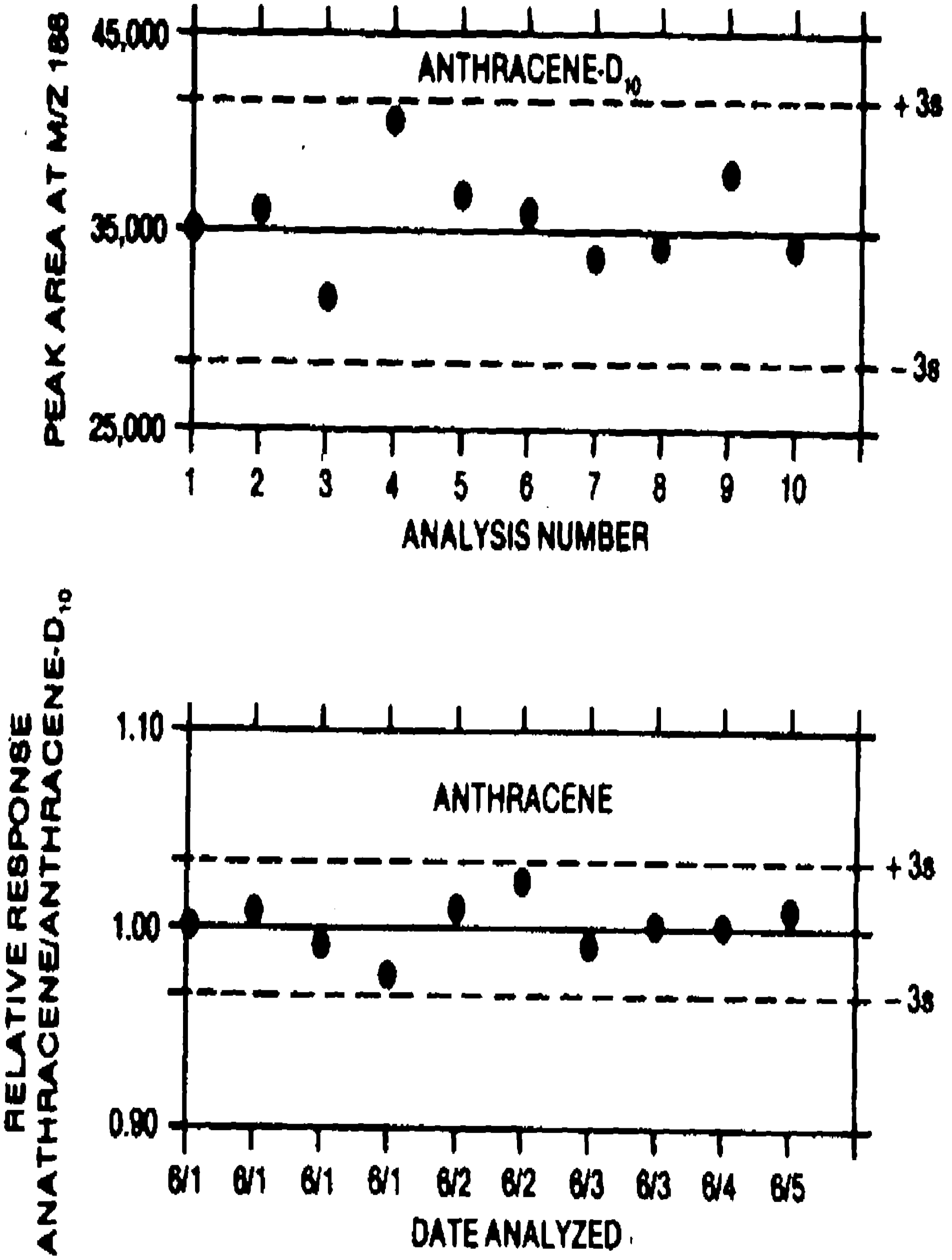
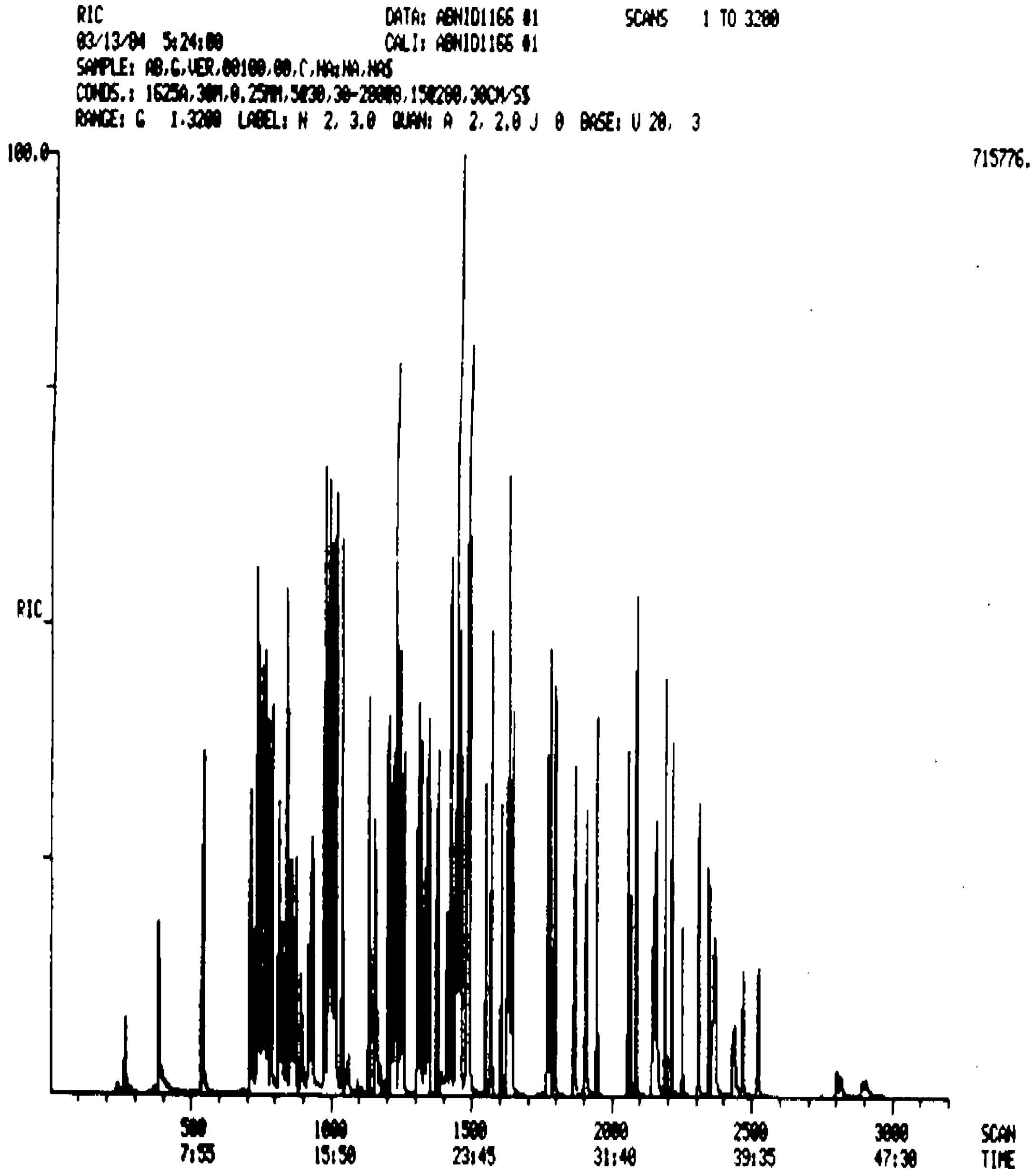


FIGURE 5 Quality Control Charts Showing Area (top graph) and Relative Response of Anthracene to Anthracene-d_{10} (lower graph) Plotted as a Function of Time or Analysis Number.



```
RIC                                  DATA: ABNID1166 #1          SCANS    1 TO 3200
03/13/84  5:24:00                    CALI: ABNID1166 #1
SAMPLE: AB,G,VER,00100,00,C,HA:HA,HAS
CONDS.: 1625A,30M,0.25MM,5030,30-28000,150200,30CM/SS
RANGE: G   1,3200  LABEL: N  2, 3.0  QUAN: A  2, 2.0 J  0  BASE: U 20,  3
```

FIGURE 6 Chromatogram of Combined Acid/base/neutral Standard.

APPENDIX G

MARITIME LAUNCH SERVICES INSURANCE SUMMARY

June 2018

Maritime Launch Services Inc

Table of Contents

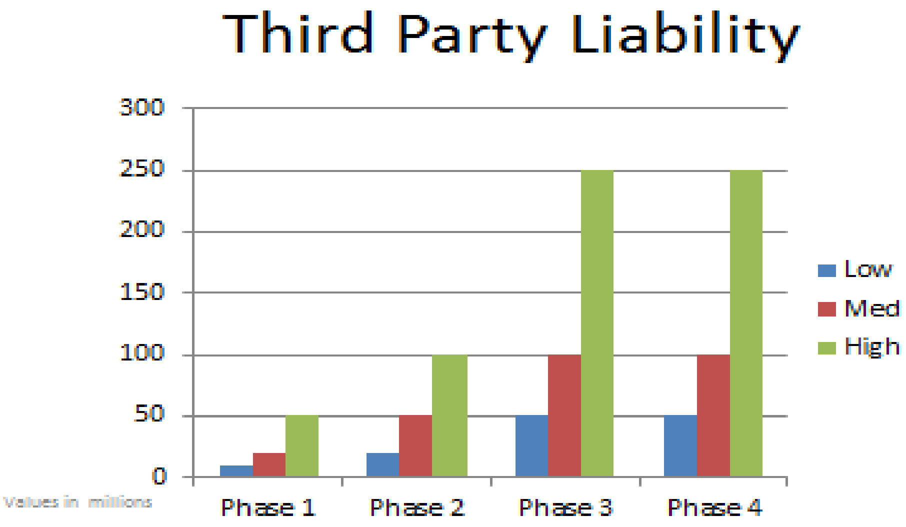
I. General Information

Construction Period	July , 2018 to December, 2021

Named Insured	**Maritime Launch Services Inc** their subsidiaries, project managers, architects, engineers, General Contractor and all sub-contractors.
Mailing Address	Canso, Nova Scotia
Cancellation Clause	120 days' notice of cancellation except non-payment of premium wherein statutory conditions apply.

II. Project Overview

Construction and operation of a satellite delivery / rocket launch service, located in Canso Nova Scotia.


Third Party Liability

III. Coverage Specifications

Coverages will be incorporated in the various stages of the project

1. **Phase 1 - Initial site work including road work and site preparation, office**
2. **Phase 2 – Construction**
3. **Phase 3 – Pre-Launch Coverage Phase including testing and start up**
4. **Phase 4 - Launch and operations.**

Phase 1 – Vacant Land, including initial road work and site preparation, office

Commercial General Liability

Limits of Liability	$ 10,000,000 Bodily Injury and Property Damage $ 10,000,000 Annual Aggregate Products and Completed Operations $ 10,000,000 Personal Injury Liability $ 10,000,000 Non-owned Automobile SEF 94 - $75,000 SEF 99 – Excluding Long Term Leased Vehicles SEF 96 – Blanket Contractual $ 1,000,000 Tenants Legal Liability (project specific) $ 1,000,000 Forest Fire Fighting Expenses $ 50,000 Medical Expense Coverage
Deductible	$5,000 Property Damage except $1,000 TLL, SEF 94
Including	• Broad form property damage • Incidental medical malpractice • Pollution exclusion with hostile fire exception • Separate of insureds, cross liability • Contingent Employers Liability • Cross Liability and severability of interest • Contractual liability (blanket) • Completed operations and product liability for a period of one year beyond completions • Contractors & Owners Protective liability • Waiver of subrogation in favour of Insured, additional insureds • No exclusion for explosion, collapse, underground hazards.

	• Worldwide coverage • Breach of conditions • Blanket Additional Insureds as required by contract • Declaration of emergency agreement

Phase 2 – Construction Phase – Building and launch systems

Commercial General Liability

Limits of Liability	▪ $50,000,000 Bodily Injury and Property Damage ▪ $50,000,000 Annual Aggregate Products and Completed Operations ▪ $50,000,000 Personal Injury Liability ▪ $50,000,000 Non-owned Automobile SEF 94 - $75,000 SEF 99 – Excluding Long Term Leased Vehicles SEF 96 – Blanket Contractual ▪ $1,000,000 Tenants Legal Liability (project specific) ▪ $5,000,000 Forest Fire Fighting Expenses ▪ $ 50,000 Medical Expense Coverage ▪
Deductible	▪ $5,000 Property Damage except ▪ $1,000 TLL, SEF 94
Including	• Broad form property damage • Incidental medical malpractice • Pollution exclusion with hostile fire exception • Separate of insureds, cross liability

	• Contingent Employers Liability • Cross Liability and severability of interest • Contractual liability (blanket) • Completed operations and product liability for a period of one year beyond completions • Contractors & Owners Protective liability • Waiver of subrogation in favour of Insured, additional insureds • No exclusion for explosion, collapse, underground hazards. • Worldwide coverage • Breach of conditions • Blanket Additional Insureds as required by contract • Declaration of emergency agreement

Phase 3 and 4 – Pre-launch and Launch

Commercial General Liability

This is dependent on the Government requirements/regulations and as such there is an offer within the slides to assist you and the Government in this endeavor

Limits of Liability	▪ $50-$250,000,000 Third Party Liability ▪ $50-$250,000,000 Annual Aggregate Products and Completed Operations
Deductible	▪ TBA
Including	Legal liability protection for losses arising out of a launch Property damage to 3rd Party buildings and contents arising out of Launching a customer’s payload is included in TPL coverage Includes all relevant Governments and all Related Parties Stipulated by the Government of the Launch Service Provider Cross Liability and severability of interest

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